Quantitative Health Risk Assessment for Particulate Matter

Second External Review Draft

DISCLAIMER

This draft document has been prepared by staff from the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. Any opinions, findings, conclusions, or recommendations are those of the authors and do not necessarily reflect the views of the EPA. This document is being circulated to obtain review and comment from the Clean Air Scientific Advisory Committee (CASAC) and the general public. Comments on this draft document should be addressed to Dr. Zachary Pekar, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, C504-06, Research Triangle Park, North Carolina 27711 (email: pekar.zachary@epa.gov).

Elements of this report (see Acknowledgements below) have been provided to the U.S. Environmental Protection Agency (EPA) by Abt Associates, Inc. in partial fulfillment of Contract No. EP-D-08-100, Work Assignment 0-02. Any opinions, findings, conclusions, or recommendations are those of the authors and do not necessarily reflect the views of the EPA or Abt Associates, Inc. Any analyses, interpretations, or conclusions presented in this report based on emergency department, hospitalization and mortality baseline incidence data obtained from outside sources, are credited to the authors and not the institutions providing the raw data.

ACKNOWLEDGEMENTS

In addition to EPA staff, personnel from Abt Associates, Inc. contributed to the writing of this document. Specific chapters and appendices where Abt Associates, Inc. made contributions include: chapter 3 (Overview of Methods Used in Estimating Risk for the Urban Case Studies), and appendices A (Air Quality Assessment), C (Epidemiological – Epi - Study Specific Information On $PM_{2.5}$), E (Risk Analysis - Core Analysis), and F (Sensitivity Analysis Results).

EPA-452/P-10-001
February 2010

Quantitative Health Risk Assessment for Particulate Matter

Second External Review Draft

US Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Table of Contents

List of Tables

List of Figures

List of Acronyms/Abbreviations

A/C	Air conditioning
ACS	American Cancer Society
Act	Clean Air Act
AMI	Acute Myocardial Infarction
AQS	EPA's Air Quality System
β	Slope coefficient
BenMAP	Benefits Mapping Analysis Program
BMI	Body Mass Index
BRFSS	Behavioral Risk Factor Surveillance System
CASAC	Clean Air Scientific Advisory Committee
CAA	Clean Air Act
CBSA	Core-based Statistical Area
CDC	Centers for Disease Control
CDF	Cumulative Distribution Function
CFR	Code of Federal Regulations
CHD	Coronary Heart Disease
CMAQ	Community Multiscale Air Quality
CO	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Disease
CPD	Cardio-pulmonary Disease
C-R	Concentration-response
CSA	Consolidated Statistical Area
CV	Cardiovascular
CVD	Cardiovascular Disease
df	Degrees of freedom
ED	Emergency Department
ER	Emergency Room
EPA	United States Environmental Protection Agency
FACA	Federal Advisory Committee Act
FIPS	Federal Information Processing System
GAM	Generalized additive model
GEOS-CHEM	Goddard Earth Observing System-Chemical Model
GLMs	Generalized linear model

HA	Hospital Admissions
HCUP	Healthcare Cost and Utilization Project
HEI	Health Effects Institute
HS	High School
ICD	International Classification of Diseases
IHD	ischemic heart disease
INF	Influence of uncertainty on risk estimates
IRP	Integrated Review Plan
ISA	Integrated Science Assessment Document
KB	Knowledge Base
km	Kilometer
K-S	Kolmogorov-Smirnov
LML	Lowest Measured Level
MCAPS	Medicare Air Pollution Study
MSA	Metropolitan Statistical Area
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NCEA	National Center for Environmental Assessment
NEI	National Emissions Inventory
NCHS	National Center for Health Statistics
NMMAPS	National Morbidity, Mortality, and Air Pollution Study
NOx	Nitrogen oxides
O_3	Ozone
OAQPS	Office of Air Quality Planning and Standards
PA	Policy Assessment Document
PM	Particulate Matter
PM_X	The legal definition for PM_X, as defined in the Code of Federal Regulations, includes both a 50% cut-point and a penetration curve. A 50% cut-point of X µm diameter means that 50% of particles with aerodynamic diameter of X are removed by the inlet and 50% pass through the inlet and are collected on the filter. Depending on the specific penetration curve specified, particles larger than X µm aerodynamic diameter are collected with an efficiently than decreases rapidly for particles larger than X while the collection efficiency for particles smaller than X increases rapidly with decreasing size until 100 % efficiency is reached.
PM_{10}	Particles with a 50% upper cut-point of 10± 0.5 µm aerodynamic diameter and a penetration curve as specified in the Code of Federal Regulations.

$PM_{2.5}$	Particles with a 50% upper cut-point of 2.5 µm aerodynamic diameter and a penetration curve as specified in the Code of Federal Regulations.
$PM_{10-2.5}$	Particles with a 50% upper cut-point of 10 µm aerodynamic diameter and a lower 50% cut-point of 2.5 µm aerodynamic diameter.
PRB	Policy-Relevant Background
RA	Risk Assessment Document
RR	Relative risk
REA	Risk and Exposure Assessment
SAB	Science Advisory Board
SEDD	State Emergency Department Databases
SID	State Inpatient Database
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxides
SES	Socio-economic Status
TRIM	Total Risk Integrated Methodology
TRIM.Risk	Total Risk Integrated Methodology - Risk Assessment component
UFP	Ultrafine Particles
USDA	U.S. Department of Agriculture
VNA	Voronoi Neighbor Averaging
WHI	Women's Health Initiative
WHO	World Health Organization
ZCA	Zip Code Area

1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is presently conducting a review of the national ambient air quality standards (NAAQS) for particulate matter (PM). Sections 108 and 109 of the Clean Air Act (Act) govern the establishment and periodic review of the NAAQS. These standards are established for pollutants that may reasonably be anticipated to endanger public health and welfare, and whose presence in the ambient air results from numerous or diverse mobile or stationary sources. The NAAQS are to be based on air quality criteria, which are to accurately reflect the latest scientific knowledge useful in indicating the kind and extent of identifiable effects on public health or welfare that may be expected from the presence of the pollutant in ambient air. The EPA Administrator is to promulgate and periodically review, at five-year intervals, "primary" (health-based) and "secondary" (welfare-based) NAAQS for such pollutants. Based on periodic reviews of the air quality criteria and standards, the Administrator is to make revisions in the criteria and standards, and promulgate any new standards, as may be appropriate. The Act also requires that an independent scientific review committee advise the Administrator as part of this NAAQS review process, a function performed by the Clean Air Scientific Advisory Committee (CASAC).[1]

The current NAAQS for PM include a suite of standards to provide protection for exposures to fine and coarse particles using $PM_{2.5}$ and PM_{10}, as indicators, respectively (71 FR 61144, October 17, 2006). With regard to the primary and secondary standards for fine particles, in 2006 EPA revised the level of the 24-hour $PM_{2.5}$ standard to 35 $\mu g/m^3$ (calculated as a 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor), retained the level of the annual $PM_{2.5}$ annual standard at 15 $\mu g/m^3$ (calculated as the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors), and revised the form of the annual $PM_{2.5}$ standard by narrowing the constraints on the optional use of spatial averaging.[2] With regard to the primary and secondary standards for PM_{10}, EPA retained the 24-hour PM_{10} standard at 150 $\mu g/m^3$ (not to be exceeded

[1] The Clean Air Scientific Advisory Committee (CASAC) was established under section 109(d)(2) of the Clean Air Act (CAA or Act) (42 U.S.C. 7409) as an independent scientific advisory committee. CASAC provides advice, information and recommendations on the scientific and technical aspects of air quality criteria and NAAQS under sections 108 and 109 of the CAA. The CASAC is a Federal advisory committee chartered under the Federal Advisory Committee Act (FACA). See http://yosemite.epa.gov/sab/sabpeople.nsf/WebCommitteesSubcommittees/CASAC%20Particulate%20Matter%20Review%20Panel for a list of the CASAC PM Panel members and current advisory activities.

[2] In the revisions to the PM NAAQS finalized in 2006, EPA tightened the constraints on the spatial averaging criteria by further limiting the conditions under which some areas may average measurements from multiple community-oriented monitors to determine compliance (see 71 FR 61165-61167, October 17, 2006) .

more than once per year on average over 3 years) and revoked the annual standard because available evidence generally did not suggest a link between long-term exposure to current ambient levels of coarse particles and health or welfare effects. These standards were based primarily on a large body of epidemiological evidence relating ambient PM concentrations to various adverse health endpoints. Secondary standards for $PM_{2.5}$ and PM_{10} were revised to be identical to the primary standards.

The next periodic review of the PM NAAQS is now underway.[3] The review process includes four key phases: planning, science assessment, risk assessment, and policy assessment/rulemaking. A planning document, the *Integrated Review Plan for the National Ambient Air Quality Standards for Particulate Matter* (IRP; EPA, 2008a), outlined the science-policy questions that frame this review, the process and schedule for the review, and descriptions of the purpose, contents, and approach for developing the other key documents for this review.[4] The science assessment document, the *Integrated Science Assessment for Particulate Matter* (ISA; EPA, 2009a and b), includes an evaluation of the scientific evidence on the health effects of PM, including information on exposure, physiological mechanisms by which PM might damage human health, and an evaluation of the epidemiological evidence including information on reported concentration-response (C-R) relationships for PM-related morbidity and mortality associations, including consideration of effects on at-risk populations.[5]

This second draft quantitative health risk assessment (RA) presents the quantitative assessments of PM-related risks to public health being conducted by staff in EPA's Office of Air Quality Planning and Standards (OAQPS) to support the review of the primary PM standards. The development of this document is described below in chapter 2. This draft RA is being released for review by the CASAC PM Panel and the public at a public meeting to be held on March 10-11, 2010. Comments received on this draft will be taken into consideration in preparing a final quantitative health RA for PM, which is scheduled to be completed in April 2010.

The final ISA and final quantitative health RA will inform the policy assessment and rulemaking steps that will lead to final decisions on the primary PM NAAQS. A policy assessment (PA) is now being prepared by OAQPS staff to provide a staff analysis of the scientific basis for alternative policy options for consideration by senior EPA management prior

---

[3] See http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html for more information on the current and previous PM NAAQS reviews.
[4] On November 30, 2007, EPA held a public consultation with the CASAC PM Panel on the draft IRP. The final IRP took into consideration comments received from CASAC and the public on the draft plan as well as input from senior Agency managers.
[5] On October 5-6, 2009, the CASAC PM Panel met to review the second draft ISA (EPA, 2009a). The final ISA took into consideration CASAC and public comments received on that draft.

to rulemaking. The PA is intended to help “bridge the gap” between the Agency’s scientific assessments, presented in the ISA and RA, and the judgments required of the Administrator in determining whether it is appropriate to retain or revise the standards. The PA will integrate and interpret information from the ISA and the RA to frame policy options and to facilitate CASAC’s advice to the Agency and recommendations on any new standards or revisions to existing standards as may be appropriate, as provided for in the Clean Air Act. The first draft PA is planned for release around the end of February 2010 for review by the CASAC PM Panel and the public during a public teleconference being planned for late March. Proposed and final rulemaking notices are now scheduled for November 2010 and July 2011, respectively.

1.1 BACKGROUND

As part of the last PM NAAQS review completed in 2006, EPA’s OAQPS conducted a quantitative risk assessment to estimate risks of various health effects associated with exposure to ambient $PM_{2.5}$ and $PM_{10-2.5}$ in a number of urban study areas selected to illustrate the public health impacts of these pollutants (U.S. EPA, 2005, chapter 4; Abt Associates, 2005). The assessment scope and methodology were developed with considerable input from the CASAC Review Panel and the public, with CASAC concluding that the general assessment methodology and framework were appropriate (Hopke, 2002). The final quantitative risk assessment took into consideration CASAC advice (Hopke, 2004; Henderson, 2005) and public comments on two drafts of the risk assessment.

The extensive quantitative assessment conducted for fine particles in the last review included estimates of risks of mortality (total non-accidental, cardiovascular, and respiratory), morbidity (hospital admissions for cardiovascular and respiratory causes), and respiratory symptoms (not requiring hospitalization) associated with recent short-term (daily) ambient $PM_{2.5}$ levels and risks of total, cardiopulmonary, and lung cancer mortality associated with long-term exposure to $PM_{2.5}$ in nine urban study areas. The quantitative risk assessment included estimates of: (1) risks of mortality, morbidity, and symptoms associated with recent ambient $PM_{2.5}$ levels; (2) risk reductions and remaining risks associated with just meeting the existing suite of $PM_{2.5}$ NAAQS (1997 standards); and (3) risk reductions and remaining risks associated with just meeting various alternative $PM_{2.5}$ standards.

The quantitative risk assessment conducted in the last review for thoracic coarse particles was much more limited than the analyses conducted for fine particles. The $PM_{10-2.5}$ risk assessment included risk estimates for just three urban areas for two categories of health endpoints related to short-term exposure to $PM_{10-2.5}$: hospital admissions for cardiovascular and respiratory causes and respiratory symptoms. While one of the goals of the $PM_{10-2.5}$ risk assessment was to provide estimates of the risk reductions associated with just meeting alternative $PM_{10-2.5}$ standards, OAQPS staff concluded that the nature and magnitude of the uncertainties and concerns associated with this portion of the risk assessment weighed against use of these risk estimates as a basis for recommending specific standard levels (U.S. EPA, 2005, p. 5-69).

Prior to the issuance of a proposed rulemaking in the last review, CASAC presented recommendations to the Administrator supporting revisions of the $PM_{2.5}$ primary standards. These recommendations placed substantial reliance on the results of the quantitative risk assessment (Henderson, 2005, pp 6-7). In a letter to the Administrator following the 2006 proposed rule (71 FR 12592, January 17, 2006), CASAC requested reconsideration of the Agency's proposed decisions and reiterated and elaborated on the scientific bases for its earlier recommendations which included placing greater weight on the result of the Agency's risk assessment. With regard to the quantitative risk assessment, CASAC concluded, "While the risk assessment is subject to uncertainties, most of the PM Panel found EPA's risk assessment to be of sufficient quality to inform its recommendations." (Henderson, 2006a, p. 3).

In the 2006 final rule, the EPA Administrator recognized that the quantitative risk assessment for fine particles was based upon a more extensive body of data and was more comprehensive in scope than the previous assessment conducted for the review completed in 1997. However, as presented in the final rulemaking notice, the Administrator was mindful of significant uncertainties associated with the risk estimates for fine particles. More specifically,

> Such uncertainties generally related to a lack of clear understanding of a number of important factors, including, for example, the shape of the concentration-response functions, particularly when, as here, effect thresholds can neither be discerned nor determined not to exist; issues related to selection of appropriate statistical models for the analysis of the epidemiologic data; the role of potentially confounding and modifying factors in the concentration-response relationships; issues related to simulating how $PM_{2.5}$ air quality distributions will likely change in any given area upon attaining a particular standard, since strategies to reduce emissions are not yet defined; and whether there would be differential reductions in the many components within $PM_{2.5}$ and, if so, whether this would result in differential reductions in risk. In the case of fine particles, the Administrator recognized that for purposes of developing quantitative risk estimates, such uncertainties are likely to [be] amplified by the complexity in the composition of the mix of fine particles generally present in the ambient air. (72 FR 61168, October 17, 2006).

As a result, the Administrator viewed that the quantitative risk assessment provided supporting evidence for the conclusion that there was a need to revise the $PM_{2.5}$ primary standards, but he judged that the assessment did not provide an appropriate basis to determine the level of the standards (72 FR 61168, October 17, 2006).

In a letter to the EPA Administrator following the issuance of the final rule, CASAC expressed "serious scientific concerns" regarding the final PM standards. In particular, CASAC was concerned that the Agency "did not accept our finding that the annual $PM_{2.5}$ standard was not protective of human health and did not follow our recommendation for a change in that standard" (Henderson et al, 2006b, p.1). With respect to the use of the risk assessment to inform EPA's decision on the primary $PM_{2.5}$ standard, CASAC stated, "While there is uncertainty associated with the risk assessment for the $PM_{2.5}$ standard, this very uncertainty suggests a need for a prudent approach to providing an adequate margin of safety" (Henderson et al., 2006b, p.2)

Several parties filed petitions for review following promulgation of the revised PM NAAQS in 2006. These petitions for review addressed the following issues with regard to the primary PM NAAQS: (1) selecting the level of the annual primary $PM_{2.5}$ standard, (2) retaining PM_{10} as the indicator for coarse particles and retaining the level and form of the 24-hour PM_{10} standard, and (3) revoking the PM_{10} annual standard. On judicial review, the D.C. Circuit remanded the annual primary $PM_{2.5}$ NAAQS to EPA because the Agency failed to adequately explain why the standard provided the requisite protection from both short- and long-term exposures to fine particles including protection for at-risk populations. The court upheld the Agency's use of the quantitative risk assessment to inform the decision to revise the $PM_{2.5}$ standards but not to inform the selection of level.[6] The court also upheld the decision to retain the 24-hour PM_{10} standard and revoke the annual PM_{10} standard. *American Farm Bureau Federation v. EPA*, 559 F. 3d 512, (D.C. Cir. 2009).

1.2 CURRENT RISK ASSESSMENT: GOALS AND PLANNED APPROACH

The goals of the current quantitative health risk assessment remain largely the same as those articulated in the risk assessment conducted in the last review. These goals include: (a) to provide estimates of the potential magnitude of premature mortality and/or selected morbidity effects in the population associated with recent ambient levels of PM and with just meeting the current and alternative suites of PM standards considered in selected urban study areas, including, where data are available, consideration of impacts on at-risk populations; (b) to develop a better understanding of the influence of various inputs and assumptions on the risk estimates to more clearly differentiate among alternative suites of standards, including potential impacts on various at-risk populations; and (c) to gain insights into the distribution of risks and patterns of risk reductions and the variability and uncertainties in those risk estimates. In

[6] One petition for review addressed the issue of setting the secondary $PM_{2.5}$ standards identical to the primary standards. On judicial review, the court remanded the secondary $PM_{2.5}$ NAAQS to EPA because the Agency failed to adequately explain why the standards provided the required protection from visibility impairment. *American Farm Bureau Federation v. EPA*, 559 F. 3d 512, (D.C. Cir. 2009).

addition, this assessment includes nationwide estimates of the potential magnitude of premature mortality associated with long-term exposure to recent levels of ambient $PM_{2.5}$ to more broadly characterize this risk on a national scale and to support the interpretation of the more detailed risk estimates generated for selected urban study areas. The overall scope and design of this quantitative risk assessment, discussed below in chapters 2 and 3, reflect efforts to achieve these goals.

This current quantitative risk assessment builds on the approach used and lessons learned in the last PM risk assessment and attempts to reduce and better characterize overall uncertainty associated with the analysis by incorporating a number of enhancements, in terms of both the methods and data used in the analyses. This assessment covers a variety of health endpoints for which, in staff's judgment, there is adequate information to develop quantitative risk estimates that can meaningfully inform the review of the primary PM NAAQS. Evidence of relationships between PM and other health endpoints for which, in staff's judgment, there currently is insufficient information to develop meaningful quantitative risk estimates will be more generally considered in the PA as part of the evidence-based considerations that inform staff's assessment of policy options.

1.3 ORGANIZATION OF DOCUMENT

The remainder of this document is organized as follows. Chapter 2 provides an overview of the scope of the quantitative risk assessment, including a summary of the previous risk assessment, the original planned approach and the key design elements reflected in this second draft assessment, and the rationale for the alternative standard levels evaluated in this assessment. Chapter 3 describes the analytical approach, methods, and data used in conducting the risk assessment, including the approach used to generate risk estimates for the set of urban case studies included in this analysis and the approaches used in addressing variability and uncertainty (Appendices A, B, and C provide supplemental information regarding the data and methods used). Chapter 4 presents selected risk estimates generated for the urban case studies, including the results of single- and multi-factor sensitivity analyses and a national-scale analysis of the representativeness of relevant risk-related factors (Appendix D provides supplemental information on risk-related factors; Appendices E and F provide detailed risk estimates and sensitivity analysis results, respectively). Chapter 5 presents the approach used and results of a national-scale assessment of $PM_{2.5}$-related long-term mortality risks associated with recent air quality (Appendix G provides supplemental information to the national-scale mortality analysis). Chapter 6 provides an integrative discussion of the various risk estimates generated in these assessments that draws on the results of the urban area case studies, the uncertainty/variability characterization, and the national-scale analyses to inform our quantitative characterization of PM-related risks to public health.

2 SCOPE

This chapter provides an overview of the scope and key design elements of this quantitative health risk assessment. The design of this assessment began with a review of the risk assessment completed during the last PM NAAQS review (Abt Associates, 2005; EPA, 2005, chapter 4), with an emphasis on considering key limitations and sources of uncertainty recognized in that analysis.

As an initial step in the this PM NAAQS review, EPA invited outside experts, representing a broad range of expertise (e.g., epidemiology, human and animal toxicology, statistics, risk/exposure analysis, atmospheric science) to participate in a workshop with EPA staff to help inform EPA's plan for the review. The participants discussed key policy-relevant issues that would frame the review and the most relevant new science that would be available to inform our understanding of these issues. One workshop session focused on planning for quantitative risk/exposure assessments, taking into consideration what new research and/or improved methodologies would be available to inform the design of a quantitative health risk assessment and whether, and if so how, it might be appropriate to conduct a quantitative exposure assessment. These workshop discussions informed the preparation of the IRP, which included initial plans for quantitative risk and exposure assessments.

As a next step in the design of these quantitative assessments, OAQPS staff developed a more detailed planning document, *Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Health Risk and Exposure Assessment* (Scope and Methods Plan; EPA, 2009b). This Scope and Methods Plan was the subject of a consultation with the CASAC PM Panel and public review on April 1-2, 2009 (at which the first draft ISA was also reviewed). Based on consideration of CASAC and public comments on the Scope and Methods Plan and information in the first draft ISA, we modified the scope and design of the risk assessment and completed initial analyses that were presented in an initial draft of this RA (first draft RA; EPA, 2009e). The CASAC PM Panel met on October 5-6, 2009 to review the first draft RA (as well as the second draft ISA).[7] Based on consideration of CASAC (Samet, 2009) and public comments on the first draft RA, together with ongoing refinement of elements of the risk assessment approach informed by the second draft ISA, we have prepared this second draft RA.

In presenting the scope and key design elements of the current risk assessment, this chapter first provides a brief overview of the risk assessment completed for the previous PM NAAQS review in section 2.1, including key limitations and uncertainties associated with that

[7] A public teleconference was held on November 12, 2009, during which CASAC reviewed the draft comment letter prepared by the CASAC PM Panel.

analysis. Section 2.2 provides a summary of the initial design of the risk assessment as outlined in the Scope and Methods Plan. Section 2.3 provides an overview of key design elements reflected in this second draft risk assessment that reflect consideration of previous CASAC and public comments. Section 2.4 provides a summary of the alternative air quality scenarios simulated in this assessment, including recent air quality and the current and alternative suites of $PM_{2.5}$ 24-hour and annual standards.

2.1 OVERVIEW OF RISK ASSESSMENT FROM LAST REVIEW

The quantitative risk assessment from the last review included a broad assessment of $PM_{2.5}$-related risk and a much more limited treatment of $PM_{10-2.5}$-related risk. That assessment included estimates of risks of mortality (total non-accidental, cardiovascular, and respiratory), morbidity (hospital admissions for cardiovascular and respiratory causes), and respiratory symptoms (not requiring hospitalization) associated with short-term (24-hour) exposure to ambient $PM_{2.5}$ and risks of total, cardiopulmonary, and lung cancer mortality associated with long-term exposure to $PM_{2.5}$ in selected urban areas. Nine urban areas were selected across the U.S.: Boston, MA; Detroit, MI; Los Angeles, CA; Philadelphia, PA; Phoenix, AZ; Pittsburgh, PA; San Jose, CA; Seattle, WA; and St. Louis, MO.

The EPA recognized that there were many sources of uncertainty and variability inherent in the inputs to the assessment and that there was a high degree of uncertainty in the resulting $PM_{2.5}$ risk estimates. Such uncertainties generally related to a number of important factors, including: (a) the shape of the concentration-response (C-R) function (and whether or not a population threshold exists); (b) issues related to the selection of appropriate statistical models for the analysis of epidemiological data; (c) the role of potentially confounding and modifying factors in the C-R relationships; (d) methods for simulating how daily $PM_{2.5}$ ambient concentrations would likely change in any given area upon meeting a particular suite of standards; and (e) the potential for differences in the relative toxicity of the components within the mix of ambient $PM_{2.5}$.

While some of these uncertainties were addressed quantitatively in the form of estimated confidence ranges around central risk estimates, other uncertainties and the variability in key inputs were not reflected in these confidence ranges, but rather were addressed through separate sensitivity analyses or characterized qualitatively (EPA, 2005, chapter 4; Abt Associates, 2005). The C-R relationships used in the quantitative risk assessment were based on findings from human epidemiological studies that relied on fixed-site, population oriented, ambient monitors as a surrogate for actual ambient $PM_{2.5}$ exposures. The assessment included a series of base case estimates that, for example, included various cutpoints intended as surrogates for alternative potential population thresholds. Other uncertainties were addressed in various sensitivity analyses (e.g., the use of single- versus multi-pollutant models, use of single versus multi-city models, use of a distributed lag model) and had a more moderate and often variable impact on the risk estimates in some or all of the cities.

These same sources of uncertainty and variability were also applicable to the quantitative risk assessment conducted for $PM_{10-2.5}$ in the last review. However, the scope of the risk assessment for $PM_{10-2.5}$ was much more limited than that for $PM_{2.5}$ reflecting the much more limited body of epidemiological evidence and air quality information available for $PM_{10-2.5}$. The $PM_{10-2.5}$ risk assessment included risk estimates for just three urban areas for two categories of health endpoints related to short-term exposure to $PM_{10-2.5}$: hospital admissions for cardiovascular and respiratory causes and respiratory symptoms. While one of the goals of the $PM_{10-2.5}$ risk assessment was to provide estimates of the risk reductions associated with just meeting alternative $PM_{10-2.5}$ standards, EPA staff concluded that the nature and magnitude of the uncertainties and concerns associated with this portion of the risk assessment weighed against use of these risk estimates as a basis for recommending specific standard levels (EPA, 2005, see p. 5-69). These uncertainties and concerns were summarized in the proposal notice (see FR 71 2662, January 17, 2006) and discussed more fully in the Staff Paper (EPA, 2005, chapter 4) and associated technical support document (Abt Associates Inc., 2005).

2.2 ORIGINAL ASSESSMENT PLAN

The Scope and Methods Plan outlined a planned approach for conducting the current quantitative PM risk assessment, including broad design issues as well as more detailed aspects of the analyses. That document also outlined plans for a population exposure analysis based on micro-environmental exposure modeling. The planned approaches for conducting both analyses are briefly summarized below.

2.2.1 Risk Assessment

Key design elements for the quantitative risk assessment, as presented in the Scope and Methods Plan, included:

- **PM size fractions**: We planned to focus primarily on estimating risk associated with exposure to $PM_{2.5}$ with a much more limited assessment of $PM_{10-2.5}$. Regarding PM components and ultrafine particles, we concluded that, based on review of evidence in the first draft ISA, there was insufficient data to support quantitative risk assessment at this time.
- **Selection of health effects categories ($PM_{2.5}$):** We planned to focus primarily on categories for which the evidence supports a judgment that there is at least a *likely causal* relationship. We also planned to consider including additional categories for which evidence supports a judgment that there is a *suggestive* causal relationship

(e.g., reproductive, developmental outcomes), if sufficient information was available to develop meaningful risk estimates for these additional categories.

- **Selection of health effect categories ($PM_{10-2.5}$)**: We planned to build on the limited risk assessment conducted in the last review (EPA, 2005) with a focus on health effect categories that staff judged to be sufficiently *suggestive* of a causal relationship with short-term exposure to warrant analysis.

- **Selection of urban study areas**: We planned to expand the number of urban study areas to between 15 and 20, with selection of these study areas being based on consideration of a number of factors (e.g., availability of location-specific C-R functions and baseline incidence data, coverage for geographic heterogeneity in PM risk-related attributes, coverage for areas with more vulnerable populations). We also discussed the possibility of including more refined risk assessments for locations where more detailed exposure studies had been completed (e.g., L.A., where a zip code level analysis of long-term $PM_{2.}$-exposure related mortality was presented in Krewski et al., 2009).

- **Simulation of air quality levels that just meet current or alternative suites of standards**: We planned to consider the use of non-proportional air quality adjustment methods in addition to the proportional approach that has been used previously. These non-proportional adjustment methods could be based on (a) historical patterns of reductions in urban areas, if these result in support for non-proportional reductions across monitors and/or (b) model-based (e.g., CMAQ) rollback designed to more realistically reflect patterns of PM reductions across monitors in an urban area.

- **Characterization of policy relevant background (PRB)**: We planned to use modeling (combination of the global-scale circulation model, GEOS-Chem, with the regional scale air quality model, CMAQ) as presented in the first draft ISA, rather than empirical data to characterize PRB levels for use in the risk assessment model.

- **Selection of epidemiological studies to provide C-R functions**: We planned to include both multi- and single-city studies (given advantages associated with both designs) as well as multi- and single-pollutant studies, placing greater weight on the use of C-R functions reflecting adjusted single-city estimates obtained from multi-city studies.

- **Shape of the functional form of the risk model**: We planned to emphasize non-threshold C-R functions in the risk assessment model, based on the first draft ISA conclusion that there was little support in the literature for population thresholds for mortality effects associated with either long-term or short-term $PM_{2.5}$ ambient concentrations.[8] We also stated that we may consider population thresholds as part of the sensitivity analysis.

---

[8] In discussing short-term exposure mortality studies, the first draft ISA (U.S. EPA, 2009a) indicated support for no-threshold log-linear models, while acknowledging that the possible influence of exposure error and heterogeneity of shapes across cities remains to be resolved.

- **Modeling of risk down to PRB versus lowest measured level (LML)**: We planned to model risk down to LML for estimating risk associated with long-term $PM_{2.5}$ exposures and down to PRB for estimating risks associated with short-term $PM_{2.5}$ exposures.
- **Characterization of uncertainty and variability**: We planned to include a discussion in the risk assessment report on the degree to which the risk assessment covers key sources of variability related to PM risk. For uncertainty, we planned to include a qualitative discussion of key sources of uncertainty and provide ratings (low, medium and high) in terms of their potential impact on risk estimates. We also described the use of sensitivity analysis methods planned both to characterize the potential impact of sources of uncertainty on risk estimates and to provide an alternative set of reasonable estimates to supplement the main ("core") set of risk estimates generated for the urban study areas.
- **National-scale assessment**: We planned to conduct a limited national-scale assessment of mortality associated with long-term exposure to recent ambient $PM_{2.5}$ levels.
- **Representativeness analysis for the urban study areas**: We planned to conduct an analysis to evaluate the representativeness of the selected urban study areas against national distributions for key PM risk-related attributes to determine whether they are nationally representative or more focused on a particular portion of the distribution for a given attribute.

2.2.2 Population Exposure Analysis

The Scope and Methods Plan also described a population exposure analysis based on micro-environmental exposure modeling using the Air Pollution Exposure Model (APEX). The planned analysis would have focused on $PM_{2.5}$ and have involved a subset of the urban study areas included in the risk assessment. The results of this analysis were planned to focus on providing insights on population exposure with respect to informing the interpretation of available epidemiological studies.

Following release of the Scope and Methods Plan, we continued development of the approach for conducting a population exposure analysis, with the goal of completing the analysis as part of the current PM review. However, this additional design work highlighted the need to more clearly define the intended purpose of the analysis, including specific ways in which the results would be used to interpret the estimates generated from the risk assessment (e.g., potentially identifying sources of exposure measurement error associated with the epidemiological studies from which C-R functions were drawn for the risk assessment and the magnitude of the impact of those sources of error on risk estimates). Taking CASAC comments into consideration, which emphasized the same point regarding the importance of more clearly defining how the exposure assessment results would be used, as well as the complexities associated with designing and conducting such an assessment, we decided to continue methods development work rather than attempt to complete a preliminary population exposure analysis as part of this review. Development of the population exposure analysis methodology is ongoing, and we anticipate that such an assessment could be conducted as part of the next PM NAAQS review.

2.3 CURRENT SCOPE AND KEY DESIGN ELEMENTS

An overview of the scope and key design elements that are the basis for this second draft RA are presented below, focusing on those aspects of the risk assessment approach which differ from the originally planned approach.

- **PM size fractions**: This quantitative risk assessment characterizes risk associated with $PM_{2.5}$-related exposures only. With regard to $PM_{10-2.5}$, we have concluded that continued limitations in data available for characterizing $PM_{10-2.5}$ exposure and risk would introduce significant uncertainty into a $PM_{10-2.5}$ risk assessment such that the risk estimates generated would be of limited utility in informing review of the standard. This conclusion was reached by reviewing the set of limitations cited in the last PM NAAQS risk assessment for not using the $PM_{10-2.5}$ risk estimates in recommending specific standard levels. We then considered whether health effects data released since the last review (as summarized in the final PM ISA) as well as any enhancements to the $PM_{10-2.5}$ monitoring network would fundamentally address these limitations. We concluded that significant limitations in both health effects data and the $PM_{10-2.5}$ monitoring network continue to exist such that a quantitative risk assessment for $PM_{10-2.5}$ is not supported at this time (a more in-depth discussion of the rationale behind the decision not to conduct a quantitative risk assessment for $PM_{10-2.5}$ is presented in Appendix H). Furthermore, based on the final PM ISA, we continue to conclude that available data are too limited to support a quantitative risk assessment for any specific PM components or for ultrafine particles (UFPs). We note, however, that the evidence for health effects associated with thoracic coarse particles, PM components, and UFPs will be included in the evidence-based considerations that will be presented in the draft PA..

- **Selection of health effects categories ($PM_{2.5}$):** A multi-factor decision framework was used to select the final set of health effects categories included in the risk assessment for $PM_{2.5}$ (section 3.3.1). This set of endpoints is consistent with those outlined in the Scope and Methods Plan for $PM_{2.5}$ (i.e., all of the selected endpoints are from categories classified in the ISA as having a *causal* or *likely causal* relationship with $PM_{2.5}$ exposure), although selecting endpoints limited to these two classifications is a consequence of applying our multi-factor decision framework and not the sole determining factor. A number of health effect categories classified as *suggestive* of a casual relationship in the ISA (e.g., reproductive effects) were considered, but were not selected for inclusion due in part to limited information available to support selection of C-R functions for specific endpoints within these health effect categories and/or lack of available baseline incidence data. Inn addition, CASAC members expressed differing views as to the appropriateness of including these categories.

- **Selection of urban study areas**: We have included 15 urban study areas in the risk assessment, with the selection of these areas being based on a number of criteria including: (a) consideration of urban study areas evaluated in the last PM risk assessment; (b) consideration of locations evaluated in key epidemiological studies; (c) preference for locations with relatively elevated 24-hour and/or annual $PM_{2.5}$ monitored levels so that the assessment can provide potential insights into the degree of risk reduction associated with just meeting the current and alternative suites of standards; and (d) preference to include locations in different regions across the country, reflecting potential differences in PM sources, composition, and potentially other factors which might impact PM-related risk (section 3.3.2). Due in part to time and resource limitations, we have not included a specialized analysis of risk based on epidemiology studies using more highly-refined exposure analysis (e.g., the study of L.A. involving zip code-level effect estimates, as presented in Krewski et al., 2009). We have included consideration of studies with more refined surrogate measures of exposure in our discussion of uncertainty related to long-term mortality, since they can inform our interpretation of the degree of potential bias associated with the effect estimates used to model risks (section 3.5.3).

- **Method used to develop composite monitor values:** Ongoing methods development has resulted in revisions to the methods used to derive composite monitor values for both the annual and 24-hour distributions (section 3.2.1). The revised methods ensure that monitors contributing to a composite calculation in a particular study area are given equal weight, in contrast to the approach used in the first draft RA, which effectively weighted monitors by their sampling frequency, potentially leading to estimates that were biased high.

- **Simulation of air quality levels that just meet current or alternative suites of standards**: In addition to applying the proportional rollback approach used in the first draft RA (and in the last risk assessment) to simulate $PM_{2.5}$ ambient levels that would "just meet" the current and alternative suites of standards, we have developed and applied two alternative approaches (hybrid and peak-shaving) to help characterize the uncertainty associated with this aspect of the assessment (section 3.2.3). We have also refined our rollback approach for the Pittsburgh study area, using a dual-zone approach to take into account monitor locations and the related topography in that area (section 3.2.3).

- **Characterization of PRB**: Consistent with the planned approach, we have used regional PRB estimates generated using a combination of GEOS-Chem and CMAQ modeling as presented in the ISA (section 3.2.2).

- **Selection of epidemiological studies to provide C-R functions**: In modeling risk associated with both short-term and long-term $PM_{2.5}$ exposures, we have focused on larger multi-city studies based on our conclusion that these studies provided more defensible effect estimates. In modeling short-term exposure-related mortality and morbidity, we obtained more spatially-refined effect estimates at the city- and regional-levels, respectively (in both cases, these effects estimates are based on application of Bayesian methods). We also included C-R functions selected from several single city studies to provide coverage for additional health effect endpoints associated with short-term $PM_{2.5}$ exposures (e.g., emergency department visits). Modeling of long-term exposure-related mortality focused on the latest reanalysis of the ACS dataset (Krewski et al., 2009). This study expands upon previous publications presenting evaluations of the ACS long-term cohort study and in particular includes rigorous examination of different model forms for estimating effects estimates (in addition to including updated and expanded datasets on incidence and exposure). Our rationale for selecting the specific studies used in the assessment, as well as our rationale for not selecting alternative studies, is discussed below in section 3.3.3.

- **Characterization of uncertainty and variability**: Our approach to characterizing uncertainty and variability is based on application of the WHO Guidance on Characterizing and Communicating Uncertainty In Exposure Assessment (WHO, 2008). This guidance provides a four-tiered approach for characterizing uncertainty (and to a lesser extent variability) in the context of a risk assessment, with tiers ranging from qualitative characterization (Tier 1) to use of full-probabilistic Monte Carlo-based simulation (Tier 3). Sensitivity analysis methods, which are used in the RA to assess sources of uncertainty and variability, represent a Tier 2 approach. The application of single- and multi-factor sensitivity analysis methods in the RA serves two purposes: (a) to characterize the potential magnitude of impact that a source(s) of uncertainty and/or variability can have on risk estimates and (b) to provide an additional set of reasonable risk estimates to supplement the "core" risk estimates in characterizing the potential magnitude of uncertainty in the risk estimates. The "core" risk estimates produced in this assessment refer to those generated using the combination of modeling elements and input datasets in which we had the highest confidence relative to other modeling choices (section 3.5.1 and 3.5.4).

- **National-scale assessment**: As planned, we have conducted a limited national-scale assessment of (chapter 5). This analysis provides estimates of mortality associated with long-term exposure to recent ambient $PM_{2.5}$ levels at the national scale, which provides some context for considering the risks estimated for the urban study areas. We continue to conclude that any expansion of this assessment (e.g., to include additional health endpoints or additional air quality scenarios that simulate just meeting alternative suites of standards), as suggested by some CASAC Panel members, was beyond the scope of what was needed or could reasonably be done within the time and resources available for this review (section 5.1).

- **Representativeness analysis for the urban study areas**: As planned, we have conducted an analysis to evaluate the representativeness of the selected urban study areas against national distributions for key PM risk-related attributes to determine whether they are nationally representative or more focused on a particular portion of the distribution for a given attribute (section 4.4).

- **Consideration of patterns in design values and ambient $PM_{2.5}$ monitoring data across urban areas:** We have included in this second draft assessment an examination of how 24-hour and annual design values, together with patterns in $PM_{2.5}$ monitoring data within an area, can influence the degree of risk reduction estimated to occur upon just meeting the current or alternative suites of standards. This analysis has resulted in a better understanding of the factors behind specific patterns of risk reduction. We have also compared patterns of design values for the urban study areas with patterns across the broader set of urban areas in the U.S. in order to help place core risk estimates generated for the set of urban study areas in a broader national context.

- **Integrated discussion of results and key observations:** To enhance the utility of the risk estimates generated for the 15 urban study areas in supporting the review of the PM NAAQS, we have added a new chapter 6: Integrative Discussion of $PM_{2.5}$-Related Risks. This chapter integrates the core risk estimates generated for the 15 urban study areas with information from the sensitivity analyses and the qualitative analysis of uncertainty, analyses of representativeness and patterns of design values, and the national-scale mortality analysis.

2.4 ALTERNATIVE SUITES OF $PM_{2.5}$ STANDARDS EVALUTATED

In developing estimates of risks associated with just meeting alternative suites of $PM_{2.5}$ standards, we selected alternative levels for the annual and 24-hour $PM_{2.5}$ standards during the development of the first draft RA that we judged to be appropriate, drawing from the information available to us at that time from the second draft ISA. In defining alternative suites of standards to be evaluated, we identified alternative standard levels in conjunction with the averaging times (24-hour and annual) and forms for the current suite of standards.[9] We note that all of the basic elements of the standards (e.g., indicator, averaging time, level, and form) will be discussed in a forthcoming draft Policy Assessment which will present staff conclusions based on both evidence-based and risk-based considerations to inform judgments that the EPA Administrator must make in deciding whether to retain or revise the existing suite of PM standards.

In selecting alternative levels for the annual and 24-hour $PM_{2.5}$ standards for the purpose of evaluation in the quantitative risk assessment, we considered ambient air quality levels associated with health effects in epidemiological studies of long- and short-term exposure to $PM_{2.5}$, as assessed in the second draft ISA. As discussed further below (section 3.3.3), in selecting alternative levels for consideration in the risk assessment, we placed emphasis on air quality information from multi-city studies because these studies have a number of advantages compared to single-city studies including: (1) multi-city studies reflect ambient $PM_{2.5}$ levels and potential health impacts across a range of diverse locations; (2) multi-city studies "clearly do not suffer from potential omission of negative analyses due to 'publication bias'" (EPA, 2004a, p. 8-30); and (3) multi-city studies generally have higher statistical power.

[9] The "form" of a standard defines the air quality statistic that is compared to the level of the standard in determining whether an area attains the standard. The form of the 24-hour $PM_{2.5}$ standard is the 98th percentile of the distribution of 24-hour $PM_{2.5}$ concentrations at each population-oriented monitor within an area, averaged over 3 years. The form of the annual $PM_{2.5}$ standard is an annual arithmetic mean, averaged over 3 years, from single or multiple community-oriented monitors.

Specifically, regarding alternative levels for the annual $PM_{2.5}$ standard to be evaluated in this risk assessment, we first considered long-term average $PM_{2.5}$ concentrations associated with health effects observed in long-term epidemiological studies, as summarized in Figure 2-2 of the second draft ISA. The second draft ISA concluded that the association between increased risk of mortality and long-term $PM_{2.5}$ exposure becomes more precise and consistently positive in locations with mean $PM_{2.5}$ concentrations of 13.5 $\mu g/m^3$ and above. (EPA, 2009a, section 2.3.1.2). The second draft ISA also concluded that the strongest evidence for cardiovascular-related effects related to long-term $PM_{2.5}$ exposures has been reported in large, multi-city U.S.-based studies and, specifically, one of these studies, the Women's Health Initiative (WHI) Study, reports associations between $PM_{2.5}$ and cardiovascular effects among post-menopausal women with a mean annual average $PM_{2.5}$ concentration of 13.5 $\mu g/m^3$ (EPA, 2009a, section 2.3.1.2). In addition, we evaluated long-term average $PM_{2.5}$ concentrations in short-term exposure studies that reported statistically significant effects. More specifically, as reported in the second draft ISA, both cardiovascular and respiratory morbidity effects (e.g., emergency department visits, hospital admissions) have been observed and become more precise and consistently positive in locations with mean $PM_{2.5}$ concentrations of 13 $\mu g/m^3$ and above (EPA, 2009a, section 2.3.1; also see Figure 2-1).[10]

Based on the available epidemiological evidence indicating effects associated with a range of annual averaged $PM_{2.5}$ concentrations, as briefly described above, we selected levels of 12 and 13 $\mu g/m^3$ as the alternative annual standard levels to be evaluated in the quantitative risk assessment. We have added 14 $\mu g/m^3$ to the set of annual levels evaluated in this second draft RA to provide fuller coverage for the range of values between the current annual standard level of 15 $\mu g/m^3$ and the lowest level evaluated.

In identifying alternative levels for the 24-hour $PM_{2.5}$ standard to be evaluated in this risk assessment, we considered the ambient $PM_{2.5}$ levels associated with mortality and morbidity effects as reported in key short-term epidemiological studies. We focused on the 98th percentile $PM_{2.5}$ ambient levels reported in two multi-city studies that provided C-R functions used in the core risk assessment, Zanobetti and Schwartz (2009) and Bell et al. (2008). The focus on the 98th percentile of the 24-hour $PM_{2.5}$ concentrations observed in the epidemiological studies is consistent with the approach used in the prior PM NAAQS review and is consistent with the current form of the 24-hour $PM_{2.5}$ standard.

[10] We note that the association between long-term mean ambient $PM_{2.5}$ levels and statistically-significant health effects reported in short-term exposure studies would be dependent on the specific relationship between day-to-day variation in the 24-hour $PM_{2.5}$ levels (in the underlying study counties) and the associated long-term mean $PM_{2.5}$ levels (i.e., the association between mean $PM_{2.5}$ levels and short-term health effects, would not hold for counties with notably different relationships between short-term day-to-day variation and longer-term mean $PM_{2.5}$ levels).

The second draft ISA presented 98th percentile 24-hour $PM_{2.5}$ values for each of the 112 urban areas included in the Zanobetti and Schwartz (2009) short-term mortality study (EPA, 2009a, Figure 6-22). We evaluated the trend in these county-level 98th percentile 24-hour $PM_{2.5}$ levels in conjunction with the statistical significance of the associated county-level effect estimates. If we had found an association between the air quality levels and statistically significant effect estimates (i.e., higher 98th percentile $PM_{2.5}$ levels were consistently associated with statistically significant effect estimates), then it would have been reasonable to consider the lowest 98th percentile $PM_{2.5}$ level associated with the set of counties for which a statistically significant effect estimates was observed as the basis for selecting an alternative standard level for evaluation in this risk assessment. However, no such association was observed. Rather, we observed mixed results with no clear correlation between 98th percentile air quality levels and statistically significant effect estimates. Therefore, we focused on the overall range of 98th percentile values across the entire set of counties and considered the lower quartile of that distribution as representative of a reasonably precautionary approach for identifying alternative levels for consideration in the risk assessment. The 10th and 25th percentiles values were 25.5 and 29.8 $\mu g/m^3$, respectively (Zanobetti, 2009). We note that the overall 98th percentile value across the entire set of urban areas analyzed in Zanobetti and Schwartz. (2009) was 34.3 $\mu g/m^3$ (EPA, 2009a, Figure 2-1; Zanobetti and Schwartz, 2009)

We also completed a similar analysis of the county-level ambient air quality data (Bell, 2009) for the 202 counties associated with the Bell et al. (2008) study. Analysis of the overall distribution of 98th percentile values across the entire dataset resulted in identifying 10th and 25th percentile values of about 24.4 and 29.3 $\mu g/m^3$, respectively. We note that the overall 98th percentile value across the entire set of counties analyzed in Bell et al. (2008)) was 34.2 $\mu g/m^3$ (EPA, 2009a, Table 6-11; Bell, 2009).

Based on the available epidemiological evidence indicating effects associated with a range of 98th percentile 24-hour $PM_{2.5}$ concentrations, as briefly described above, we selected levels of 25 and 30 $\mu g/m^3$ as the alternative 24-hour standard levels to be evaluated in this quantitative risk assessment.

Once alternative levels were identified for the annual and 24-hour PM standards, we then identified specific combinations of these standard levels to be considered in evaluating suites of alternative standards in the risk assessment. In selecting the pairing of annual and 24-hour standard levels, we considered which standard was likely to be controlling across the set of 15 urban study areas (either the annual or 24-hour standard will be the "controlling standard" at a given location, depending on the design value associated with that location).[11] For this risk assessment, the goal was to select combinations of annual and 24-hour levels that would result in a mixture of behavior in terms of which standards would control across the various urban study areas. For example, with the 12/35 combination (i.e., an annual standard level of 12 $\mu g/m^3$ and a 24-hour standard level of 35 $\mu g/m^3$), the annual level of 12 $\mu g/m^3$ is the controlling standard for all 15 urban study areas, while with the 12/25 combination, the annual standard is the controlling standard at some locations and the 24-hour standard is the controlling standard at other locations. Consideration of these factors resulted in a set of five alternative combinations of annual and 24-hour standards being identified for inclusion in the risk assessment.

The full set of air quality scenarios included in the risk assessment, including the recent conditions air quality scenario and current standards scenario along with the five alternative sets of standards are as follows:

- Recent conditions (risk estimates based on ambient $PM_{2.5}$ monitoring data for the analysis period – 2005 to 2007)
- Current $PM_{2.5}$ NAAQS: annual 15 $\mu g/m^3$; 24-hour 35 $\mu g/m^3$
- Alternative $PM_{2.5}$ standards: annual 14 $\mu g/m^3$; 24-hour 35 $\mu g/m^3$
- Alternative $PM_{2.5}$ standards: annual 13 $\mu g/m^3$; 24-hour 35 $\mu g/m^3$
- Alternative $PM_{2.5}$ standards: annual 12 $\mu g/m^3$; 24-hour 35 $\mu g/m^3$
- Alternative $PM_{2.5}$ standards: annual 13 $\mu g/m^3$; 24-hour 30 $\mu g/m^3$
- Alternative $PM_{2.5}$ standards: annual 12 $\mu g/m^3$; 24-hour 25 $\mu g/m^3$.

[11] The controlling standard is the standard which requires the greatest percentage reduction to get the design value monitor to meet that standard - see section 3.3.3 for additional detail on the issue of controlling standards.

3 URBAN CASE STUDY ANALYSIS METHODS

This chapter provides an overview of the methods used in the risk assessment. Section 3.1 discusses the basic structure of the risk assessment, identifying the modeling elements and related sources of input data needed for the analysis. Section 3.2 discusses air quality considerations. Section 3.3 discusses the selection of health endpoints, urban study areas and C-R functions from key epidemiological studies used in modeling those endpoints. Section 3.4 discusses baseline health effects incidence rates. Finally, section 3.5 describes how uncertainty and variability are addressed in the risk assessment.

3.1 GENERAL APPROACH

3.1.1 Basic Structure of the Risk Assessment

The general approach used in both the prior and the current PM risk assessment relies upon C-R functions which have been estimated in epidemiological studies. Since these studies estimate C-R functions using ambient air quality data from fixed-site, population-oriented monitors, the appropriate application of these functions in a PM risk assessment similarly requires the use of ambient air quality data at fixed-site, population-oriented monitors.

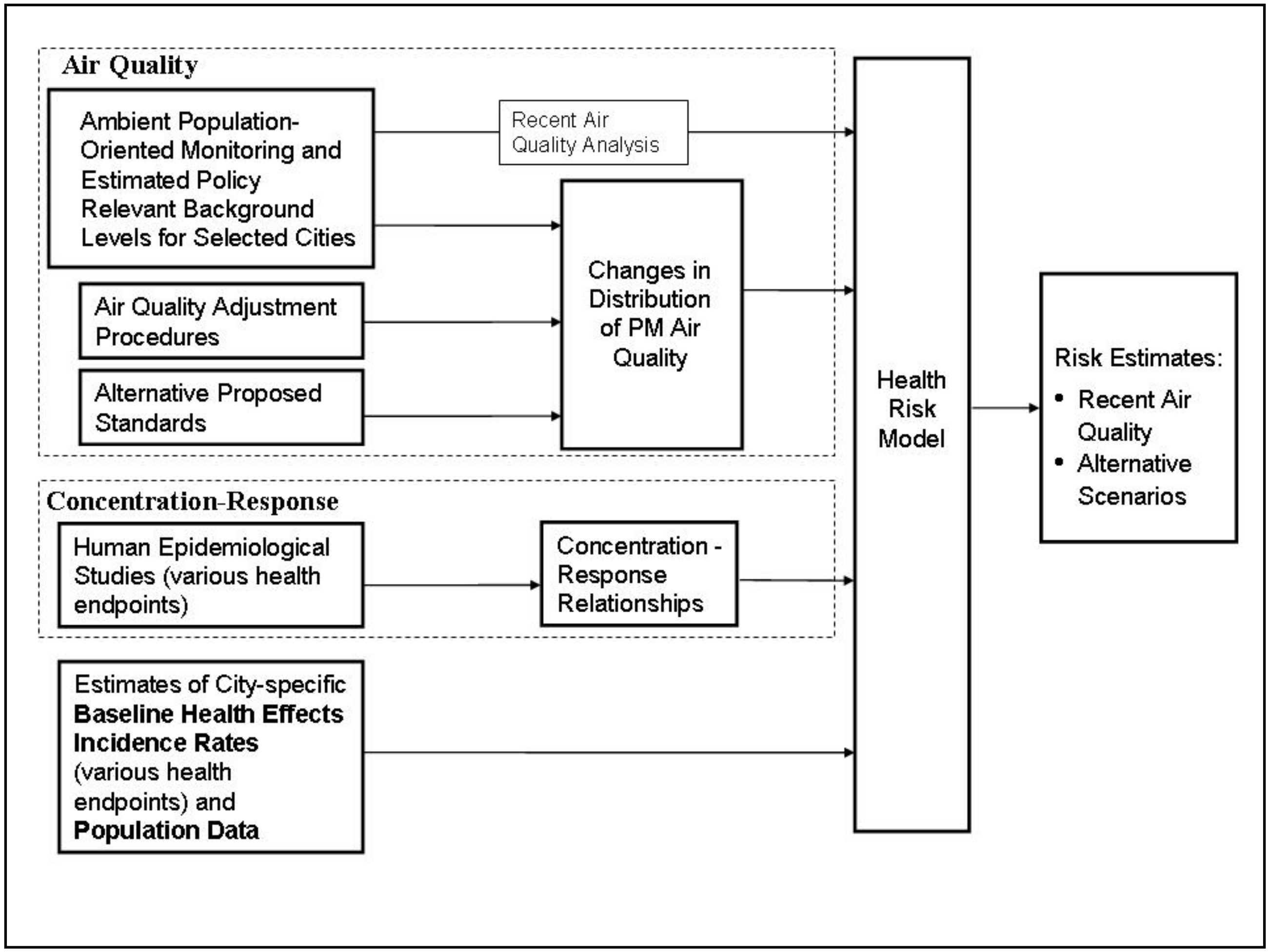
The general PM health risk model, illustrated in Figure 3-1, combines information about PM air quality for specific urban areas with C-R functions derived from epidemiological studies, baseline health incidence data for specific health endpoints, and population estimates to derive estimates of the annual incidence of specified health effects attributable to ambient PM concentrations under different air quality scenarios. This assessment was implemented within TRIM.Risk, the component of EPA's Total Risk Integrated Methodology (TRIM) model that estimates human health risks.[12]

The analyses conducted for this review focused on estimating risks associated with recent $PM_{2.5}$ air quality and estimating changes in these risks associated with air quality simulated to reflect just meeting the current suite of $PM_{2.5}$ ambient standards, as well as any additional reductions in incidence estimated to occur upon just meeting alternative suites of $PM_{2.5}$ standards.

Consistent with past risk assessments for NAAQS reviews, this risk assessment is intended to estimate risks attributable to anthropogenic sources and activities only. Therefore, for all health endpoints associated with short-term exposure to $PM_{2.5}$, the risk assessment considers only the incidence of health effects associated with $PM_{2.5}$ concentrations in excess

[12] For more detailed information about TRIM.Risk, see: http://www.epa.gov/ttn/fera/trim_risk.html

Figure 3-1. Major components of particulate matter health risk assessment.



of policy relevant background (PRB) levels. In the studies estimating a relationship between mortality and long-term exposure to $PM_{2.5}$, however, the lowest measured levels (LMLs) reported in the epidemiological studies were substantially above PRB. Thus, estimating risk down to PRB would have required substantial extrapolation of the estimated C-R functions below the range of the data on which they were estimated. Therefore, we estimated risk only down to the LML to avoid introducing additional uncertainty related to this extrapolation into this analysis. To provide consistency for the different C-R functions selected from the long-term exposure studies, and, in particular, to avoid the choice of LML unduly influencing the results of the risk assessment, we selected a single LML – 5.8 $\mu g/m^3$ from the later exposure period evaluated in Krewski et al. (2009) -- to be used in estimating risks associated with long-term $PM_{2.5}$ exposures.

For each health effect that has been associated with $PM_{2.5}$, the risk assessment may be viewed as assessing the incidence of the health effect associated with $PM_{2.5}$ concentrations under a given air quality scenario (e.g., a scenario in which $PM_{2.5}$ concentrations just meet a specified suite of standards) above PRB or the LML . Equivalently, the risk assessment may be viewed as assessing the change in incidence of each health effect associated with a change in $PM_{2.5}$ concentrations from some higher level (e.g., $PM_{2.5}$ concentrations that just meet a specified suite of standards) to specified lower levels (PRB levels or the LML).

The risk assessment procedures described in more detail below are diagramed in Figure 3-2 for analyses based on short-term exposure studies and in Figure 3-3 for analyses based on long-term exposure studies. To estimate the change in incidence of a given health effect resulting from a given change in ambient $PM_{2.5}$ concentrations in an assessment location, the following analysis inputs are necessary:

- **Air quality information including:** (1) $PM_{2.5}$ air quality data from one or more recent years from population-oriented monitors in the assessment location, (2) estimates of $PM_{2.5}$ PRB concentrations appropriate to this location, and (3) a method for adjusting the air quality data to reflect patterns of air quality changes to simulate just meeting the current or alternative suite of $PM_{2.5}$ standards. (These air quality inputs are discussed in more detail in section 3.2).
- **C-R function(s)** which provide an estimate of the relationship between the health endpoint of interest and $PM_{2.5}$ concentrations (preferably derived in the assessment location, although functions estimated in other locations can be used at the cost of increased uncertainty -- see section 3.5.3). For $PM_{2.5}$, C-R functions are available from epidemiological studies that assessed $PM_{2.5}$-related health effects associated with either short- or long-term exposures. (Section 3.1.2 describes the role of C-R functions in estimating health risks associated with $PM_{2.5}$).
- **Baseline health effects incidence rate and population**. The baseline incidence rate provides an estimate of the incidence rate (number of cases of the health effect per year,

usually per 10,000 or 100,000 general population) in the assessment location corresponding to recent ambient $PM_{2.5}$ levels in that location. To derive the total baseline incidence per year, this rate must be multiplied by the corresponding population number (e.g., if the baseline incidence rate is number of cases per year per 100,000 population, it must be multiplied by the number of 100,000s in the population). (Section 3.4 summarizes considerations related to the baseline incidence rate and population data inputs to the risk assessment).

Figure 3-2. Flow diagram of risk assessment for short-term exposure studies.

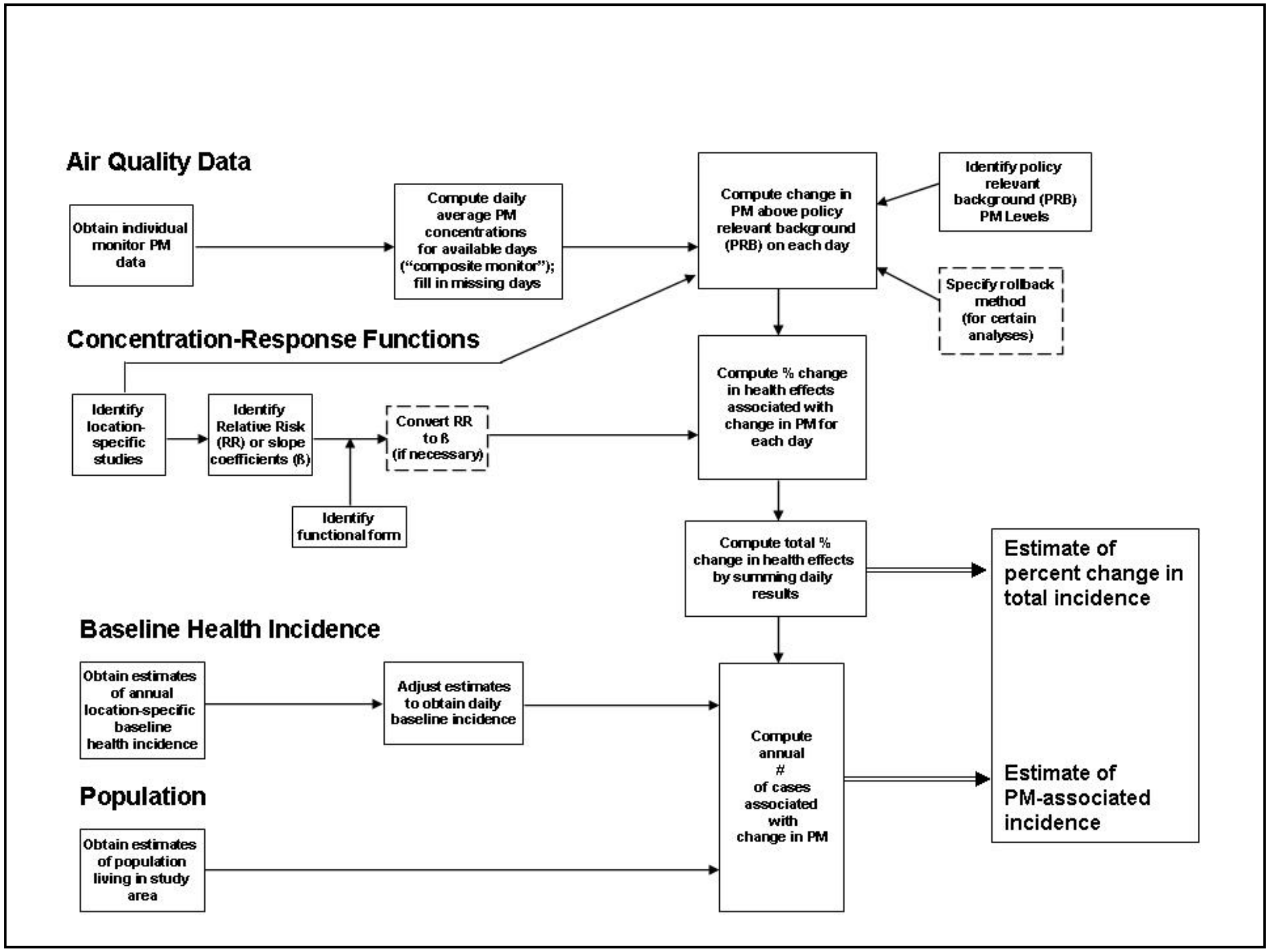
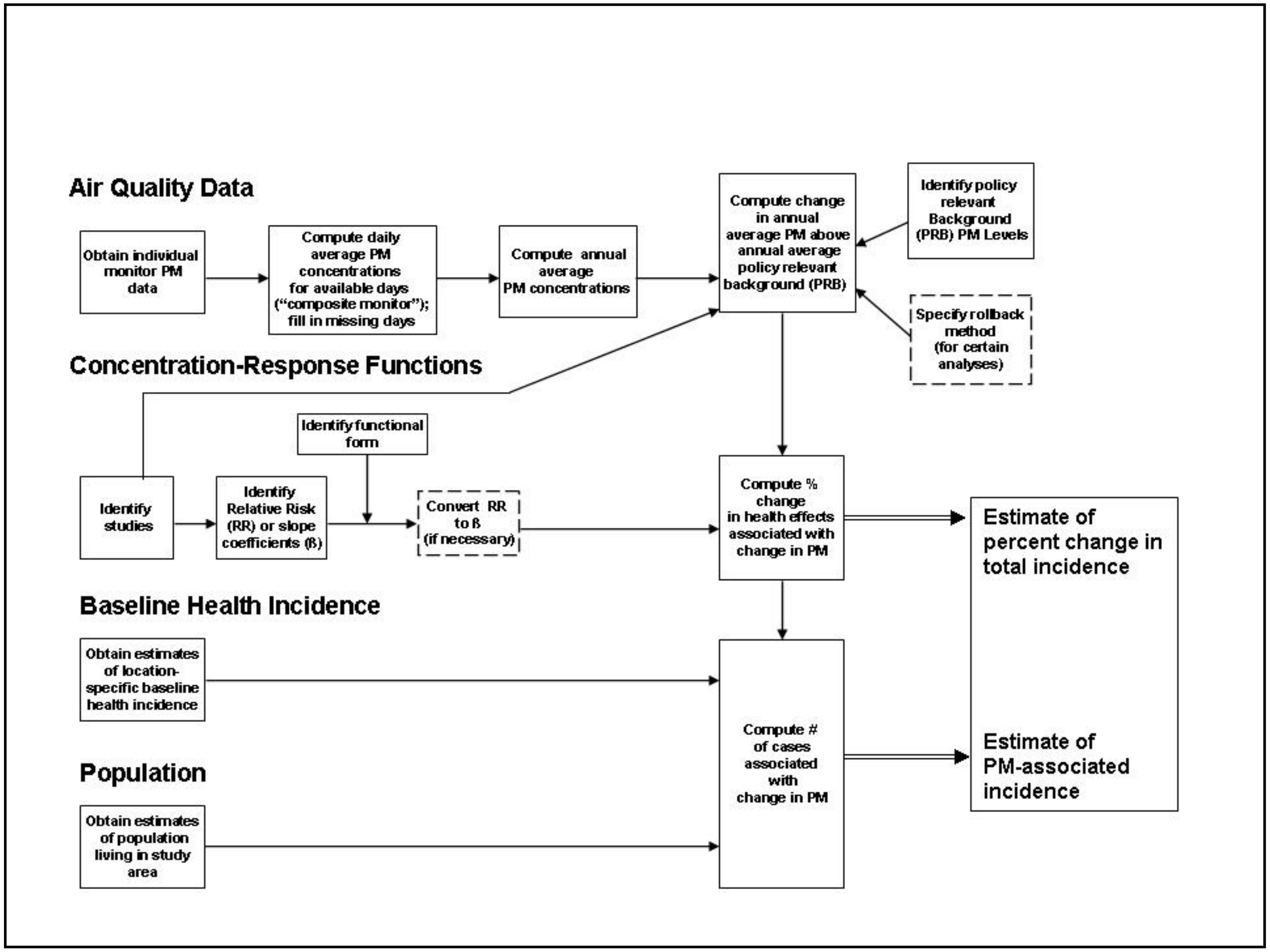


Figure 3-3. Flow diagram of risk assessment for long-term exposure studies.



The risk assessment was carried out using three years of recent air quality data from 2005, 2006, and 2007 (see section 3.2.1). We matched the population data used in the risk assessment to the year of the air quality data. For example, when we used 2005 air quality data, we used 2005 population estimates. It was not possible to obtain the necessary data to calculate baseline incidence rates separately for each of the three years for each of the risk assessment locations, therefore, we calculated these rates for a single year, under the assumption that these rates are unlikely to have changed significantly from 2005 to 2007. The calculation of baseline incidence rates is described in detail in section 3.4.

For this risk assessment, we developed a core (primary) set of risk results based on the application of modeling element choices (e.g., C-R functions, lag periods) that we believe have the greatest overall support in the literature (hereafter referred to as the "core" results). While it is not possible at this time to assign quantitative levels of confidence to these core risk estimates, we do believe these estimates are generally based on inputs having higher overall levels of confidence relative to risk estimates that could have been generated using other inputs identified in the literature.

In addition, as discussed above in section 2.1 and later in section 3.5, we have also used single-element and multi-element sensitivity analysis techniques to generate a set of reasonable alternative risk estimates based on the application of alternative modeling element choices that, while not having as much support in the literature as those used in the core analysis, do still represent plausible inputs. The results of these sensitivity analyses allow us to gain insights into which sources of uncertainty and variability may have the greatest impact on risk estimates when acting alone, or in combination with other sources of uncertainty. The sensitivity analysis-based risk estimates also provide us with an additional set of reasonable risk results that allow us to place the results of the core analysis in context with regard to uncertainty. A number of modeling elements were used in differentiating core analyses from sensitivity analyses (e.g., C-R function shape, alternative effect estimates, alternative lag structures, different methods used to rollback air quality to simulate attainment to current or alternative standard levels, application of PRB versus LML). Specific choices made in relation to individual modeling elements in differentiating the core analysis from sensitivity analyses are described, as appropriate, in the sections that follow, which cover specific aspects of the risk assessment design. The potential utility of the sensitivity analysis-based risk estimates in informing consideration of uncertainty and variability in the core results is discussed in section 4.5.2.

3.1.2 Calculating $PM_{2.5}$-Related Health Effects Incidence

The C-R functions used in the risk assessment are empirically estimated relations between average ambient concentrations of $PM_{2.5}$ and the health endpoints of interest (e.g., mortality or hospital admissions reported by epidemiological studies for specific locations). This section describes the basic method used to estimate changes in the incidence of a health endpoint associated with changes in $PM_{2.5}$, using a "generic" C-R function of the most common functional form.

Although some epidemiological studies have estimated linear C-R functions and some have estimated logistic functions, most of the studies used a method referred to as "Poisson regression" to estimate exponential (or log-linear) C-R functions in which the natural logarithm of the health endpoint is a linear function of $PM_{2.5}$:

$$y = Be^{\beta x} \qquad (1)$$

where x is the ambient $PM_{2.5}$ level, y is the incidence of the health endpoint of interest at $PM_{2.5}$ level x, β is the coefficient of ambient $PM_{2.5}$ concentration, and B is the incidence at x=0, i.e., when there is no ambient $PM_{2.5}$. The relationship between a specified ambient $PM_{2.5}$ level, x_0, for example, and the incidence of a given health endpoint associated with that level (denoted as y_0) is then

$$y_0 = Be^{\beta x_0} \qquad (2)$$

Because the log-linear form of a C-R function (equation (1)) is by far the most common form, we use this form to illustrate the "health impact function" used in the $PM_{2.5}$ risk assessment.

If we let x_0 denote the baseline (upper) $PM_{2.5}$ level, and x_1 denote the lower $PM_{2.5}$ level, and y_0 and y_1 denote the corresponding incidences of the health effect, we can derive the following relationship between the change in x, $\Delta x = (x_0 - x_1)$, and the corresponding change in y, Δy, from equation (1).[13]

$$\Delta y = (y_0 - y_1) = y_0[1 - e^{-\beta \Delta x}]. \qquad (3)$$

Alternatively, the difference in health effects incidence can be calculated indirectly using relative risk. Relative risk (RR) is a measure commonly used by epidemiologists to characterize the comparative health effects associated with a particular air quality comparison. The risk of mortality at ambient $PM_{2.5}$ level x_0 relative to the risk of mortality at ambient $PM_{2.5}$ level x_1, for

[13] If $\Delta x < 0$ – i.e., if $\Delta x = (x_1 - x_0)$ – then the relationship between Δx and Δy can be shown to be $\Delta y = (y_1 - y_0) = y_0[e^{\beta \Delta x} - 1]$. If Δx < 0, Δy will similarly be negative. However, the *magnitude* of Δ*y* will be the same whether Δ*x* > 0 or Δ*x* < 0 – i.e., the absolute value of Δ*y* does not depend on which equation is used.

example, may be characterized by the ratio of the two mortality rates: the mortality rate among individuals when the ambient $PM_{2.5}$ level is x_0 and the mortality rate among (otherwise identical) individuals when the ambient $PM_{2.5}$ level is x_1. This is the RR for mortality associated with the difference between the two ambient $PM_{2.5}$ levels, x_0 and x_1. Given a C-R function of the form shown in equation (1) and a particular difference in ambient $PM_{2.5}$ levels, Δx, the RR associated with that difference in ambient $PM_{2.5}$, denoted as $RR_{\Delta x}$, is equal to $e^{\beta\Delta x}$. The difference in health effects incidence, Δy, corresponding to a given difference in ambient $PM_{2.5}$ levels, Δx, can then be calculated based on this $RR_{\Delta x}$ as:

$$\Delta y = (y_0 - y_1) = y_0[1 - (1/RR_{\Delta x})]\,. \tag{4}$$

Equations (3) and (4) are simply alternative ways of expressing the relationship between a given difference in ambient $PM_{2.5}$ levels, $\Delta x > 0$, and the corresponding difference in health effects incidence, Δy. These health impact equations are the key equations that combine air quality information, C-R function information, and baseline health effects incidence information to estimate ambient $PM_{2.5}$ health risk.

3.1.2.1 Short-term vs. Long-term Exposure

Concentration-response (C-R) functions that use as input annual average $PM_{2.5}$ levels (or some function of these, such as the average over a period of several years) relate these to the annual incidence of the health endpoint – i.e., in such studies *x* in equation (1) above is the average $PM_{2.5}$ concentration over a period of one or more years, meant to represent long-term exposure, and *y* is the annual incidence of the health effect associated with that long-term exposure.

Concentration-response (C-R) functions that use as input 24-hour average $PM_{2.5}$ levels (or some function of these, such as the average over one or more days) relate these to the daily incidence of the health endpoint – i.e., in such studies *x* in equation (1) above is the average $PM_{2.5}$ concentration over a period of one or a few days (short-term exposure), and *y* is the daily incidence of the health effect associated with that short-term exposure.

There are several variants of the short-term (daily) C-R function. Some C-R functions were estimated by using moving averages of ambient $PM_{2.5}$ to predict daily health effects incidence. Such a function might, for example, relate the incidence of the health effect on day *t* to the average of $PM_{2.5}$ concentrations on days *t* and (*t*-1). Some C-R functions consider the relationship between daily incidence and daily average $PM_{2.5}$ lagged a certain number of days. For example, a study might estimate the C-R relationship between mortality on day *t* and average $PM_{2.5}$ on a prior day (*t*-1). A few studies have estimated distributed lag models, in which health effect incidence is a function of $PM_{2.5}$ concentrations on several prior days – that is, the incidence of the health endpoint on day *t* is a function of the $PM_{2.5}$ concentration on day *t*, day (*t*-1), day (*t*-2), and so forth. Such models can be reconfigured so that the sum of the coefficients of the different $PM_{2.5}$ lags in the model can be used to predict the changes in incidence on several days. For example, corresponding to a change in PM on day *t* in a distributed lag model with 0-day, 1-day, and 2- day lags considered, the sum of the coefficients of the 0-day, 1-day, and 2-day lagged $PM_{2.5}$ concentrations can be used to predict the sum of incidence changes on days *t*, (*t*+1) and (*t*+2).

Most daily time-series epidemiological studies estimated C-R functions in which the PM-related incidence on a given day depends only on same-day PM concentration(i.e. lag 0), the previous-day PM concentration (i.e. lag 1), or some variant of those, such as a two-day average concentration (e.g. lag 0-1). Such models necessarily assume that the longer pattern of PM levels preceding the PM concentration on a given day does not affect mortality or morbidity on that day. To the extent that PM-related mortality on a given day is affected by PM concentrations over a longer period of time, then these models would be mis-specified, and this mis-specification would affect the predictions of daily incidence based on the model.

The extent to which time-series studies using single-day $PM_{2.5}$ concentrations may under or over-estimate the relationship between short-term $PM_{2.5}$ exposure and risk of mortality is unknown. However, there is some evidence, based on analyses of PM_{10} data, that mortality or morbidity on a given day is influenced by prior PM exposures up to more than a month before the date of death (Schwartz, 2000). The extent to which short-term exposure studies (including those that consider distributed lags) may not capture the full impact of long-term exposures to $PM_{2.5}$ is similarly not adequately understood, although the current evidence (e.g., Krewski et al., 2009; Krewski et al., 2000) suggests that there is a substantial impact of long-term exposures on health effects that is not picked up in the short-term exposure studies.

3.1.2.2 Calculating Annual Incidence

The risk assessment estimated health effects incidence, and changes in incidence, on an annual basis, for 2005, 2006, and 2007. For mortality, both short-term and long-term exposure studies have reported estimated C-R functions. As noted above, most short-term exposure C-R functions estimated by daily time-series epidemiological studies relate daily mortality to same-day $PM_{2.5}$ concentration or previous-day $PM_{2.5}$ concentration (or some variant of those).

To estimate the daily health impacts of 24-hour average ambient $PM_{2.5}$ levels above PRB, C-R functions from short-term exposure studies were used together with estimated changes in 24-hour ambient $PM_{2.5}$ concentrations to calculate the daily changes in the incidence of the health endpoint. After daily changes in health effects were calculated, an annual change was calculated by summing the daily changes.

The mortality associated with long-term exposure is likely to include mortality related to short-term exposures as well as mortality related to longer-term exposures. As discussed previously, estimates of daily mortality based on the time-series studies also are likely influenced by prior PM exposures. Therefore, the estimated annual incidences of mortality calculated based on the short- and long-term exposure studies are not likely to be completely independent and should not be added together. While we can characterize the statistical uncertainty surrounding the estimated $PM_{2.5}$ coefficient in a reported C-R function, there are other sources of uncertainty associated with the C-R functions used in the risk assessment that are addressed via sensitivity analyses and/or qualitatively discussed in section 3.5.3.

3.2 AIR QUALITY INPUTS

3.2.1 Characterizing Recent Conditions

As noted earlier, a major input to the $PM_{2.5}$ risk assessment is ambient $PM_{2.5}$ air quality data for each assessment location. Twenty-four hour $PM_{2.5}$ air quality data for 2005, 2006, and 2007 were obtained for each of the urban study areas from monitors in EPA's Air Quality System (AQS). To characterize $PM_{2.5}$ air quality in each risk assessment location as accurately as possible, we used only those monitors that were located within the county or counties that were analyzed in the epidemiological studies used to select C-R functions. In a few cases, an urban area was delineated differently by two or more epidemiological studies used in the risk assessment. For example, Birmingham, AL was defined as Blount, Jefferson, Shelby, St. Clair, and Walker Counties in one study and as only Jefferson County in another study. In such cases, we matched our delineation of the urban study area to that used in each study, resulting in two or more different delineations of the urban study area and identified them as, for example, Birmingham 1 and Birmingham 2. The counties and the number of air quality monitors included within each urban area are given in Table 3-1.

In order to be consistent with the approach generally used in the epidemiological studies that estimated $PM_{2.5}$ C-R functions, the average ambient $PM_{2.5}$ concentration on each day for which measured data were available was deemed most appropriate for use in the risk assessment (i.e., we created a composite monitor average). Consistent with the approach used in the prior PM risk assessment, a composite monitor data set was created for each assessment location based on a composite of all monitors located within each urban study area. For this risk assessment, we have used an approach for creating composite monitors (see description below) that reflects equal weighting of monitors in computing both 24-hour and annual composite monitor values. (This reflects a change from the approach used in the first draft RA which weighted monitors by sampling frequency – an approach which could result in bias being introduced into the analysis.)

To calculate daily averages at the composite monitor for a location, we first checked the number of observations at each monitor at that location. If a monitor had fewer than 11 observations in a quarter of the year (three months, the first quarter being January, February, and March), we left the days in that quarter without observations as missing. If a monitor had at least 11 observations in a quarter, we filled in the missing days at that monitor in that quarter as follows: For each series of seven or fewer consecutive days with missing values, we took the average of the closest day with a reported value before the missing days and the closest day with a reported value after the missing days, and we assigned that average to all days in the series of missing days. If a series of consecutive missing days was greater than seven, we did not fill them in. After the missing days at monitors had been filled in as described, we calculated the composite monitor value for a given day as the average of values across all monitors for that day. If there were any days for which the composite monitor value was missing, we filled them in with 7-day moving averages (i.e., an average of the 3 days before and the 3 days after the missing day). Given the approach for interpolating missing days at individual monitors (just described), the incidence of missing days at composite monitors was very low. The numbers of monitors in the risk assessment locations are given in Table 3-1.

To calculate annual averages at the composite monitor for a location, we first checked the number of observations in each quarter of each year at each monitor at the location. If a monitor had fewer than 11 observations in a quarter of the year, we set the quarterly average at that monitor to "missing." If the monitor had at least 11 observations in a quarter, we calculated the quarterly average at the monitor as the average of the reported observations at the monitor in that quarter. For each quarter of the year, we then calculated the composite monitor quarterly average as the average of the monitor-specific quarterly averages. The annual average at the composite monitor was then calculated as the average of the four composite monitor quarterly averages.[14]

[14] Pittsburgh was treated somewhat differently from the other locations because there are effectively two attainment areas in Pittsburgh – one containing ten of the monitors we're using in the risk assessment ("Pittsburgh-1"), and the other containing the remaining 2 monitors ("Pittsburgh-2"). We treated each of these two sets of monitors as a separate "location," and calculated both daily and annual composite monitor values in each "location." We then calculated composite monitor values for Pittsburgh as weighted averages of the composite monitor values for "Pittsburgh-1" and "Pittsburgh-2", where the weights were the proportion of the monitors in each (i.e., 10/12 and 2/12).

Table 3-1. Numbers of Monitors in Risk Assessment Locations From Which Composite Monitor Values Were Calculated*

Risk Assessment Location	Counties	Number of Monitors
Atlanta, GA - 1	Cobb, De Kalb, Fulton, Gwinnett	8
Atlanta, GA - 2	Cobb, De Kalb, Fulton	7
Atlanta, GA - 3	20-County MSA**	10
Baltimore, MD	Baltimore city, Baltimore county	8
Birmingham, AL – 1	Blount, Jefferson, Shelby, St. Clair, Walker	10
Birmingham, AL – 2	Jefferson	8
Dallas, TX	Dallas	6
Detroit, MI	Wayne	9
Fresno, CA	Fresno	3
Houston, TX	Harris	6
Los Angeles, CA	Los Angeles	10
New York, NY – 1***	Kings, New York City (Manhattan), Queens, Richmond, Bronx	12
Philadelphia, PA	Philadelphia	7
Phoenix, AZ	Maricopa	5
Pittsburgh, PA	Allegheny	12
Salt Lake City, UT	Salt Lake	7
St. Louis, MO - 1	Jefferson, Madison (IL), St. Louis, St. Louis City, St. Clair (IL)	15
St. Louis, MO - 2	Madison (IL), St. Louis, St. Louis City, St. Clair (IL)	14
Tacoma, WA	Pierce	1

* Calculation of composite monitor values is described in the text above.
** Barrow, Bartow, Carroll, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinett, Henry, Newton, Paulding, Pickens, Rockdale, Spalding, and Walton.
*** The sets of monitors for New York (Manhattan) have 1-in-3 day sampling, with sampling schedules synced across monitors. This means that for the three year simulation period, roughly 2/3 of the days (i.e., 731) had no monitor coverage for the New York urban study area, resulting in a need to interpolate estimates for these days (for the composite monitor) using the approach described above. Similarly, with Tacoma, the single monitor at that location also has 1 in 3 day sampling, resulting again, in 2/3 of the days not having data with interpolation being used to derive estimates for those days (for the composite monitor).

Appendix A summarizes the $PM_{2.5}$ air quality data that were used in each of the assessment locations, including quarterly and annual counts, quarterly and annual averages, and the 98th percentile of the daily (24-hour) averages.

3.2.2 Estimating Policy Relevant Background

Policy-relevant background estimates used in the risk assessment model (see Table 3-2 below) were obtained from the ISA (Table 3-23, final ISA, EPA, 2009d). These values were generated based on a combination of Community Multiscale Air Quality model (CMAQ) and Goddard Earth Observing System (GEOS)-Chem modeling as described in the draft ISA (see section 3.7.1.2). Annual values presented in Table 3-2 were used in modeling health endpoints associated with long-term exposure (in those sensitivity analysis scenarios where risk was modeled down to PRB – see section 3.5.4). For health endpoints associated with short-term exposure (which involved modeling down to PRB, exclusively), quarterly values presented in Table 3-2 were used to represent the appropriate block of days within a simulated year.

Table 3-2 Regional Policy-Relevant Background Estimates Used in the Risk Assessment.

U.S. Region	Annual	January-March	April-June	July-September	October-December
Northeast	0.74	0.85	0.78	0.67	0.68
Southeast	1.72	2.43	1.41	1.41	1.64
Industrial Midwest	0.86	0.89	0.89	0.94	0.73
Upper Midwest	0.84	0.79	0.93	0.99	0.66
Southwest	0.62	0.61	0.76	0.70	0.40
Northwest	1.01	0.48	0.81	1.42	1.32
Southern California	0.84	0.54	0.92	1.21	0.67

3.2.3 Simulating Air Quality to Just Meet Current and Alternative Standards

This section describes the methodologies used to simulate ambient $PM_{2.5}$ levels in an area that would just meet specified $PM_{2.5}$ standards. The form of the current $PM_{2.5}$ standards requires that the 3-year average (rounded to the nearest 0.1 µg/m^3) of the annual means from each single monitor or the average of multiple monitors must be at or below the level of the annual standard and the 3-year average (rounded to the nearest 1 µg/m^3) of the ninety-eighth percentile values at each monitor cannot exceed the level of the 24-hour standard. In determining attainment of the annual average standard, an area may choose to use either the spatially averaged concentrations across all population-oriented monitors, subject to meeting certain criteria detailed in Part 50, Appendix N, of the CFR, or it may use the highest 3-year average based on individual monitors. The most realistic simulation of just meeting both the annual and the 24-hour $PM_{2.5}$ standards in a location would require changing the distribution of 24-hour $PM_{2.5}$ concentrations at each monitor separately, based on the specific mix of local and regional controls impacting that particular location. This would require extensive analysis and assumptions about the nature of future control strategies that is beyond the scope of quantitative risk assessments done as part of the review of the NAAQS.[15]

In the last PM risk assessment, just meeting the current or alternative $PM_{2.5}$ standards was simulated by changing 24-hour $PM_{2.5}$ concentrations at a "composite monitor," which represented the average of the monitors in a location. In the current PM risk assessment, just meeting the current or alternative $PM_{2.5}$ standards was simulated by changing 24-hour $PM_{2.5}$ concentrations at each monitor separately. This change was made because the current PM risk assessment considers three alternative approaches to simulating $PM_{2.5}$ concentrations that just

[15] Such modeling analyses are done by States in developing state implementation plans that demonstrate how areas will come into attainment with standards that have been promulgated.

meet a given suite of standards (i.e., proportional, hybrid and peak-shaving – see below), and two of these methods (hybrid and peak-shaving) involve making monitor-specific changes of 24-hour $PM_{2.5}$ concentrations to simulate just meeting standards. All three of these methods start with monitor-specific series of $PM_{2.5}$ concentrations in which missing days have been filled in as described above.

In simulating ambient $PM_{2.5}$ levels that would just meet current and alternative suites of standards, we have applied the following approaches to rolling back air quality levels: (a) *proportional rollback,* in which the same proportional adjustment is applied to all monitors in a study area, has traditionally been used in the NAAQS risk assessments since it generally reflects historical patterns in how air quality has changed over time, (b) *hybrid rollback*, which involves an initial localized reduction to bring higher monitors down to the range of their neighbors, followed by proportional reduction, if needed, to just meet a given suite of standards; and (c) *peak-shaving rollback,* in where each monitor that exceeds the 24-hour standard is simulated to just meet the 24-hour standard through proportional reduction of its annual 24-hour $PM_{2.5}$ distribution (with no impact on monitors that are meeting the 24-hour standard). The proportional rollback approach is applied to each of the 15 urban study areas, while the other two rollback approaches are applied to a subset of areas as appropriate (e.g., the peak-shaving approach is only used for those study areas where the 24-hour standard is both controlling and being exceeded by one or more monitors).

The proportional rollback approach was used in generating the core risk estimates in light of its use in past risk assessments, while the other two rollback approaches (hybrid and peak shaving) were considered in sensitivity analyses to characterize potential variability in the way urban areas may respond to suites of current or alternative standards. As described below, the proportional rollback reflects a regional pattern of ambient $PM_{2.5}$ reduction, the hybrid approach reflects a combination of local and regional patterns in ambient $PM_{2.5}$ reduction, and the peak shaving approach reflects a localized pattern of ambient $PM_{2.5}$ reduction. We have not ascribed greater confidence to the proportional approach, since we have no basis for predicting which approach would likely be most reflective of future patterns of ambient $PM_{2.5}$ reductions in each study area.

3.2.3.1 Proportional Rollback Method

The proportional approach, which reflects a regional pattern of reductions in ambient $PM_{2.5}$ concentrations, was used in previous $PM_{2.5}$ risk assessments. This approach involves proportional adjustments to monitor levels, in which $PM_{2.5}$ concentrations are reduced (“rolled back”) by the same percentage each day. When this approach is used, it does not matter whether (1) $PM_{2.5}$ concentrations are first rolled back by the same percentage each day at each monitor, and then the composite monitor values are calculated from these monitor-specific values or (2) first the composite monitor values are calculated and then these are rolled back by the same percentage each day – the results will be the same.

The percent reduction of 24-hour $PM_{2.5}$ concentrations in the proportional rollback approach (and in the second step of the hybrid rollback approach, described below) at each monitor each day to simulate just meeting current and alternative set of standard levels is determined by the $PM_{2.5}$ annual and 24-hour design values. The annual design value (in µg/m^3) was calculated as follows:

- At each monitor, the annual average $PM_{2.5}$ concentration was calculated for each of the years 2005, 2006, and 2007, and these three annual average concentrations were then averaged.
- The maximum of these monitor-specific 3-year averages of annual averages is the annual design value, denoted dv_{annual};

The 24-hour design value (in µg/m^3) was similarly calculated as follows:

- At each monitor, the 98th percentile 24-hour $PM_{2.5}$ concentration was calculated for each of the years 2005, 2006, and 2007, and these three 98th percentile concentrations were then averaged.
- The maximum of these monitor-specific 3-year averages of 98th percentile concentrations is the 24-hour design value, denoted $dv_{daily\ 98}$ (note, we will refer to the 98th percentile design value as the 24-hour design value throughout the rest of the document).

The annual and 24-hour design values used in assessing the current and alternative standards for $PM_{2.5}$ are given in Table 3-3. Note that monitors that were closed in 2005 (and therefore, did not include monitoring data for the majority of the three year simulation period), or which were missing an entire year's worth of monitoring data during any of the three simulation years (2005, 2006 or 2007) were excluded from consideration as design value monitors, although these monitors were still used to construct composite monitors for purposes of estimating risks.

Table 3-3. EPA Design Values for Annual and \24-hour $PM_{2.5}$ Standards for the Period 2005-2007.*

Location	Annual (µg/m^3)	24-hour (µg/m^3)
Atlanta	16.2	35
Baltimore	15.6	37
Birmingham	18.7	44
Dallas	12.8	26

Location	Annual ($\mu g/m^3$)	24-hour ($\mu g/m^3$)
Detroit	17.2	43
Fresno	17.4	63
Houston	15.8	31
Los Angeles	19.6	55
New York	15.9	42
Philadelphia	15.0	38
Phoenix	12.6	32
Pittsburgh	19.8	60
Salt Lake City	11.6	55
St. Louis	16.5	39
Tacoma	10.2	43

*The calculation of design values is explained in the text above.

The percent reduction required to meet a standard (annual or 24-hour) was determined by comparing the design value for that standard with the level of the standard. Because pollution abatement methods are applied largely to anthropogenic sources of $PM_{2.5}$, rollbacks were applied only to $PM_{2.5}$ above estimated PRB levels. The percent reduction was determined by the controlling standard. For example, suppose both annual and 24-hour $PM_{2.5}$ standards are being simulated. Suppose p_a is the percent reduction required to just meet the annual standard (i.e., the percent reduction of daily $PM_{2.5}$ above background necessary to get the annual design value down to the current or alternative annual standard). Suppose p_d is the percent reduction required to just meet the 24-hour standard (i.e., the percent reduction of daily $PM_{2.5}$ above background necessary to get the 24-hour $PM_{2.5}$ design value down to the 24-hour standard). If p_d is greater than p_a, then all 24-hour average $PM_{2.5}$ concentrations above background are reduced by p_d percent. If p_a is greater than p_d, then all 24-hour average $PM_{2.5}$ concentrations are reduced by p_a percent. The method of rollbacks to meet a set of annual and 24-hour $PM_{2.5}$ standards is summarized as follows:

1. The percent by which the above-*PRB* portion of all daily $PM_{2.5}$ concentrations (at the composite monitor) would have to be reduced to just meet the annual standard (denoted std_a) is

$$p_a = 1 - \frac{(std_a - PRB_{avg})}{dv_{annual} - PRB_{avg})} ,$$

where PRB_{avg} is the average of the daily PRB concentrations.[16]

2. The percent by which the above-*PRB* portion of all 24-hour $PM_{2.5}$ concentrations (at the composite monitor) would have to be reduced to just meet the current or alternative 24-hour standard (denoted std_{d98}) is:

$$p_{d98} = 1 - \frac{(std_{d98} - PRB_{avg})}{dv_{daily98} - PRB_{avg})}$$

Let p_{max} = maximum of (maximum of p_a and p_{d98}) and zero.[17]

3. Then if PM_o denotes the original PM value on a given day (at the composite monitor), the rolled back PM value on that day, denoted PM_{rb}, is:

$$PM_{rb} = PRB + (PM_o - PRB)*(1 - p_{max}).$$

Results of the simulations done in each urban study area using the proportional rollback approach, as well as the hybrid and peak shaving approaches discussed below, are presented in Appendix F, Tables F-49 and F-50. For each urban study area and suite of standards, two sets of values are presented in each table based on application of each rollback approach including: (a) the maximum monitor-specific three-year (2005-2007) annual average (i.e., "Max. M-S" in both tables) and (b) the composite monitor value for 2007 (i.e., "2007 CM" in both tables). The first estimate (Max M-S) allows us to see how the design value changes in just meeting each suite of standards based on application of the different rollback methods, while the second estimate (2007 CM) is the surrogate for long-term exposure-related mortality, as described below in section 3.5.4. The tables differ in terms of the information presented in the last set of columns, with Table F-49 showing the percent reduction in the composite monitor values given application of a particular rollback approach (allows comparison of the pattern of risk reduction

[16] In the previous PM risk assessment, a constant PRB level was assumed for all days, and that constant PRB level was used in the formulas to calculate percent rollbacks necessary to just meet a standard. It can be shown that, if PRB levels vary from day to day, the average PRB level takes the place of the constant PRB level in the previous formula, as shown in the above equation.

[17] If the percent rollback necessary to just meet the annual standard and the percent rollback necessary to just meet the 24-hour standard were both negative -- i.e., if both standards were already met -- then the percent rollback applied in the risk assessment was zero. That is, PM values were never increased, or "rolled up."

across standard levels generated using each rollback approach), and Table F-50 showing the percent difference in the composite monitor values in comparing the hybrid and peak shaving results to that obtained with the proportional rollback approach for a given standard level (allows comparison of residual risk estimates generated using the different rollback approaches for each standard level). The information in the last set of columns in each table is considered below in the sensitivity analysis (section 3.5.4).

3.2.3.2 Hybrid Rollback Method

The hybrid rollback approach reflects a combination of first localized and then regional patterns of reductions in ambient $PM_{2.5}$ concentrations. In comparison to the proportional rollback approach, this approach has two steps: (1) first $PM_{2.5}$ concentrations are reduced at a specific monitor location within an urban study area and then additional monitors within that urban study area are adjusted to a lesser extent (with the magnitude of adjustment based on a distance-decay function); then (2) a proportional rollback of the adjusted $PM_{2.5}$ concentrations at all of the different monitors is carried out, as described in Section 3.2.3.1 above. Because the initial step reflecting localized controls is non-proportional, this needs to be completed on the monitor datasets (associated with a particular study area) prior to construction of the composite monitor. However, once those non-proportional reductions have been implemented, a composite monitor can then be constructed (as described earlier) and the second step of conducting proportional adjustment to simulate the current or alternative suites of standards can be calculated for the composite monitor. New design values are calculated for the hybrid rollback approach based on the $PM_{2.5}$ concentrations that have been adjusted in the first step of the two-step process.[18] The hybrid approach is described in more details in Appendix B.

3.2.3.3 Peak Shaving Rollback Method

The peak shaving approach reflects localized patterns of reduction in ambient $PM_{2.5}$ concentrations and has only been applied in cases where the 24-hour standard is controlling (i.e., the percent rollback necessary to meet the daily standard is greater than the percent rollback necessary to meet the annual standard in that location). This approach was used to calculate annual averages for 2005, 2006, and 2007 at composite monitors for comparison with the composite monitor annual averages calculated using the proportional and hybrid rollback

[18] As with the composite monitor values representing recent air quality, "rolled back" composite monitor values in Pittsburgh, for both the proportional rollback and the hybrid rollback methods, were calculated based on the division of monitors into the 10 in "Pittsburgh-1" and the remaining 2 in "Pittsburgh-2" (see footnote in Section 3.2.1). Daily and annual composite monitor values in "Pittsburgh-1" and "Pittsburgh-2" were rolled back as described in Sections 3.2.3.1 and 3.2.3.2; rolled back composite monitor values for Pittsburgh were calculated as weighted averages of the rolled back composite monitor values for "Pittsburgh-1" and "Pittsburgh-2", where the weights were the proportion of the monitors in each (i.e., 10/12 and 2/12).

approaches. Because of time constraints, we did not calculate health risks with the application of the peak shaving rollback approach. Because the C-R functions used in the risk assessment are almost linear, a comparison of annual averages at composite monitors using the three different approaches for simulating just meeting alternative standards provides a good surrogate for estimates of health risks when alternative standards are just met (see Section 3.5.4 for additional detail on the composite monitor-based comparison of the three rollback strategies completed as part of the sensitivity analysis).

As with the proportional and hybrid rollback approaches, the peak shaving approach for calculating annual averages at composite monitors starts with monitor-specific quarterly averages that have been calculated as described above in Section 3.2.1. In contrast to the proportional and hybrid rollback approaches, the peak shaving method uses monitor-specific design values. For each monitor, we compared the monitor-specific 24-hour design value to the level of the 24-hour standard and calculated the percent rollback necessary to reduce the concentration at each monitor to the standard level (using a formula that is analogous to the proportional rollback formula given above in Section 3.2.3.1). We then rolled back each quarterly average at the monitor by this percent rollback. We calculated the average quarterly average across all monitors in the location, for each quarter. Finally, we calculated the annual average at the composite monitor under the standard by averaging the four quarterly averages calculated on the previous step.[19]

3.3 SELECTION OF MODEL INPUTS

3.3.1 Health Endpoints

The selection of health effect endpoints reflects consideration for a number of factors. The specific set of factors considered in selecting health effects endpoints to model in this assessment included:

- The overall weight of evidence from the collective body of epidemiological, controlled human exposure, and toxicological studies and the determination made in the final ISA regarding the strength of the causal relationship between $PM_{2.5}$ and the more general health effect category;

[19] As with the rolled back composite monitor values in Pittsburgh using both the proportional and hybrid rollback methods, rolled back composite monitor values in Pittsburgh using the peak shaving method were calculated based on the division of monitors into the 10 in "Pittsburgh-1" and the remaining 2 in "Pittsburgh-2" (as explained in the footnote in Section 3.2.3.2). However, unlike in the other locations, if the annual standard was controlling in one of the Pittsburgh attainment areas (i.e., in "Pittsburgh-1" or "Pittsburgh-2"), monitor-specific quarterly averages in that attainment area were rolled back by the percent rollback necessary to just meet the annual standard there. Once monitors in "Pittsburgh-1" and "Pittsburgh-2" were rolled back, the procedure to calculate annual composite monitor values in Pittsburgh was the same as in the other risk assessment locations.

- The extent to which particular health effect endpoints within these broader health effect categories are considered significant from a public health standpoint;
- The availability of well-conducted epidemiological studies providing C-R functions for specific health effect endpoints;
- The availability of sufficient air quality monitoring data in areas that were evaluated in the epidemiological studies;
- The availability of baseline incidence data to support population risk (incidence) modeling; and
- The anticipated value of developing quantitative risk estimates for the health effect endpoint(s) to inform decision-making in the context of the PM NAAQS review.

In selecting the set of health effect endpoint categories (and associated endpoints and related at-risk populations) to include in the $PM_{2.5}$ risk assessment, we considered the health effects evidence presented in the final ISA (EPA, 2009d), as well as CASAC (Samet, 2009a) and public comments received on the Scope and Methods Plan and CASAC (Samet, 2009b) and public comments received on the first draft RA. In reviewing the final ISA in relation to $PM_{2.5}$, we focused on the following sections: (a) section 2.3.1.1 (Effects of Short-Term Exposure to $PM_{2.5}$), (b) section 2.3.1.2 (Effects of Long-Term Exposure to $PM_{2.5}$), (c) section 2.3.2 (Integration of $PM_{2.5}$ Health Effects), and (d) subsections in Chapter 6 and 7 of the final ISA providing summaries of causal determination (for both morbidity and mortality endpoints) related to short-term and long-term exposure, respectively. We also considered information in the ISA on at-risk populations, which identified the life stages of children and older adults, people with pre-existing cardiovascular and respiratory diseases, and people with lower socioeconomic status as populations at increased risk for PM-related health effects.

Based on the evidence presented in the ISA and application of the above criteria, we identified the following health effects endpoints for inclusion in the risk assessment:

Health effects associated with short-term $PM_{2.5}$ exposure:

- Mortality (causal relationship)
    - non-accidental,
    - cardiovascular-related
    - respiratory-related,
- Cardiovascular effects (causal relationship)
    - cardiovascular-related hospital admissions
- Respiratory effects (likely causal relationship)
    - respiratory-related hospital admissions

- asthma-related emergency department visits

Health effects associated with long-term $PM_{2.5}$ exposure:

- Mortality (causal relationship)
  - all-cause
  - ischemic heart disease (IHD)-related
  - cardiopulmonary-related
  - lung cancer

While we selected specific health effect endpoints that were all within broad health effect categories classified in the ISA as having a "causal" or "likely causal" association with $PM_{2.5}$ exposure, our selection is a based on applying the multi-factor approach described above.

The evidence available for these selected health effect endpoints generally focused on the entire population, although some information was available that allowed us to consider differences in estimated risk for the at-risk populations of older adults and people with pre-existing cardiovascular and respiratory diseases. While evidence of effects in other important at-risk populations, including children and people with lower socioeconomic status, was not judged to be sufficient to support quantitative risk assessment, this evidence will be part of the evidence-based considerations to be discussed in the policy assessment document currently being developed.

3.3.2 Selection and Delineation of Urban Study Areas

This section describes the approach used in selecting the 15 urban study areas included in this risk assessment (see Table 3-3 for a listing of the urban study areas). This approach builds upon and expands the approach for selecting urban study areas from the prior risk assessment (EPA, 2005, section 3.2, p. 37).

Criteria used in the prior risk assessment and updated in this analysis include:

- **Availability of sufficient air quality data**: Sufficient air quality data was identified as having at least 11 observations per quarter for a one year period and at least 122 observations per year. We assessed prospective study areas by insuring that there was at least one $PM_{2.5}$ monitor within the boundaries of the prospective study area that met these completeness criteria for the period 2005 to 2007 with additional preference given to locations with more than one $PM_{2.5}$ monitor meeting completeness criteria, since this provided a better characterization of ambient air levels for that urban location.

- **Inclusion in epidemiology study**: Coverage of the location within one of the key epidemiology studies included in the risk assessment (at or close to the location where at least one C-R function for one of the recommended health endpoints has been estimated by a study satisfying the selection criteria used in the risk assessment). In this review, because the current risk assessment primarily utilizes multi-city studies to evaluate risk for short-term and long-term $PM_{2.5}$ exposures (whereas the prior risk assessment used city-specific studies in modeling endpoints associated with short-term exposures), this criterion no longer applies for most prospective areas.

- **Availability of city-specific baseline incidence data:** Regarding sufficiency of baseline health effects incidence data, an ongoing effort by EPA to collect county-level hospital and emergency department admissions data from states to support this risk assessment (see section 3.5) has resulted in enhanced health effects baseline incidence data, largely addressing this criterion (i.e., most urban areas in the U.S. now have coverage with the updated baseline health effects incidence data).

Two additional factors considered in selecting locations to model in the current assessment included:

- **Potential for risk reductions using alternative standard levels**: Specifically, we focused on those urban areas with $PM_{2.5}$ monitoring levels suggesting the potential for risk reduction under alternative (24-hour or annual) standards under consideration, particularly focusing on urban locations with at least one monitor having an annual average above 12 $\mu g/m^3$ and/or a 24-hour value above 25 $\mu g/m^3$. Furthermore, locations with ambient $PM_{2.5}$ level significantly higher than these levels were favored (with several urban study areas selected having both annual and 24-hour design values exceeding the current standards – Table 3-4).

- **Regional representation:** The second criterion we added for study area selection focused on providing coverage for factors believed to play a role in influencing risk heterogeneity at the national-level (e.g., $PM_{2.5}$ source characteristics and composition, demographics, SES status, air conditioner use). Building on the 7 regions originally identified in the 1996 PM Criteria Document (EPA, 1996, section 6.4) (i.e., PM regions), we evaluated several urban locations from each of these PM regions with the goal to identify one or more candidate urban study areas in each region. Ultimately, consideration of the criteria described here resulted in an urban study area not being identified for one of the PM regions (the Upper Midwest), however, the remaining six PM regions each included at least one urban study areas evaluated in the risk assessment. While the PM regions were originally defined focusing primarily on differences in PM composition, size and seasonality, by selecting urban study areas from regions across the continental U.S., we recognize the potential for covering regional differences in other factors related to risk heterogeneity as well (e.g., demographics, SES). The representativeness analysis (section 4.4) specifically assesses the degree to which the 15 urban study areas provide coverage for national trends in key risk-related factors such as those listed here.

Based on consideration of the above criteria, 15 study areas were selected for inclusion in this risk assessment. Table 3-4 presents the 15 urban study areas including (a) whether the urban study area was included in the prior risk assessment, (b) which PM region the urban study area is located in, and (c) the 24-hour and annual design values using 2005-2007 air quality data. Figure 3-4 identifies each of the 15 urban study areas in relation to the 7 regions used to guide the selection of the urban study areas.

Table 3-4. Urban Study Areas Selected for the Risk Assessment.

Urban study area	State	Modeled in last NAAQS review	PM region*	Annual design value (μg/m^3)	24-hour design value (μg/m^3)
Atlanta	GA		SE	16.2	35
Baltimore	MD		NE	15.6	37
Birmingham	AL		SE	18.7	44
Dallas	TX		SE	12.8	26
Detroit	MI	X	IM	17.2	43
Fresno	CA		SCA	17.4	63
Houston	TX		SE	15.8	31
LA	CA	X	SCA	19.6	55
New York	NY		NE	15.9	42
Philadelphia	PA	X	NE	15.0	38
Phoenix	AZ	X	SW	12.6	32
Pittsburgh	PA	X	IM	19.8	60
Salt Lake City	UT		NW	11.6	55
St. Louis	MO	X	IM	16.5	39
Tacoma	WA	X	NW	10.2	43

* SE (Southeast), IM (industrial Midwest), SCA (Southern California), NE (Northeast), NW (Northwest), SW (Southwest) (See, EPA, 1996, section 6.4 for description of these regions).

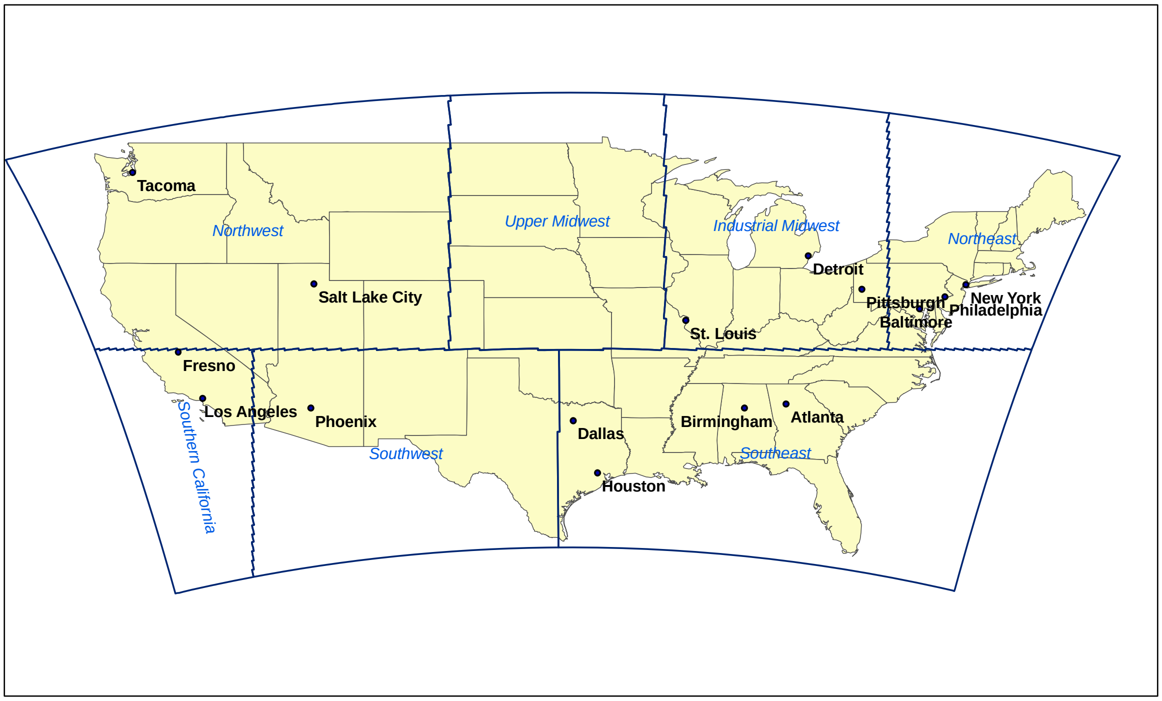


Figure 3-4 15 urban study areas included in the risk assessment (including seven PM regions used to guide selection of study areas).

Once the 15 urban study areas were selected, the next step was to identify the spatial template to use in defining each study area (i.e., the geographical area associated with each study area that would be used in identifying which counties and $PM_{2.5}$ monitors were associated with a particular study area). For 12 of the 15 urban study areas, we either used a combined statistical area (CSA) as the basis for the spatial template, or if that was not available, we used a core-based statistical area (CBSA). The three remaining urban study areas were special cases and were handled as follows:

- **Baltimore:** We used counties in the Baltimore CBSA only and did not consider the larger Baltimore-DC CSA since we felt it unlikely that the entire larger CSA would behave similarly with regard to $PM_{2.5}$ emissions reduction strategies;
- **Philadelphia**: We used the Philadelphia CSA, but excluded Berks County (Reading), and
- **Tacoma**: we only used Pierce County (since we felt it unlikely that efforts to reduce emissions at the "elevated" monitor in Pierce County, would significantly impact monitors in Seattle).

As noted above, in a few instances, two or more epidemiological studies used different geographic boundaries for determining which populations were included in their studies. For example, in one study conducted in Birmingham, AL populations from Blount, Jefferson, Shelby, St. Clair, and Walker Counties were included, while another study included the population residing in only Jefferson County. In such cases, we matched our delineation of the urban area to that of each study, resulting in two or more different delineations of the urban area.

As we discuss below, two of the studies on which we rely for our core analysis – Zanobetti and Schwartz (2009) and Bell et al. (2008) – are multi-location studies. Zanobetti and Schwartz (2009) specified the county or counties included in each of the urban areas they included in their analysis. Bell et al. (2008), however, did not focus on urban areas, but instead focused on counties with populations above a specified threshold number. To limit the number of different "versions" of a risk assessment location, wherever possible we specified the counties in a risk assessment location for Bell et al. (2008) to match the set specified for Zanobetti and Schwartz (2009). This was possible in those cases in which Zanobetti and Schwartz (2009) identified an urban area as a single county, and that county was also included in Bell et al. (2008). This was the case for several of the risk assessment locations. In some cases, however, Zanobetti and Schwartz (2009) used a multi-county delineation of an urban area where at least one of the counties was not among those included in Bell et al. (2008). In those cases, we had to delineate two definitions of the urban area – one corresponding to Zanobetti and Schwartz (2009) and the other corresponding to Bell et al. (2008). This was the case for Atlanta, Birmingham, and St. Louis. In both Atlanta and New York, other delineations by other studies forced additional delineation of these urban areas, as shown in Table 3-1 above.

Finally, we applied the studies of mortality associated with long-term exposure to $PM_{2.5}$ to the urban areas as defined by the short-term exposure mortality study, Zanobetti and Schwartz (2009), to enable meaningful comparisons between estimates of premature morality associated with short-term and long-term exposure to $PM_{2.5}$.

3.3.3 Selection of Epidemiological Studies and Concentration-response (C-R) Functions within those Studies

As discussed above, we included in the $PM_{2.5}$ risk assessment only those health effect endpoint categories (and specific health effects) that met the set of criteria reflected in the multi-factor approach we developed for selecting health effect endpoints (see section 3.3.1). One of these factors was the strength of evidence supporting a causal association between $PM_{2.5}$ exposure and the endpoint of interest. Thus, in cases where the majority of the available studies did not report a statistically significant relationship, the effect endpoint was not included. Once it had been determined that a health endpoint would be included in the analysis, however, inclusion of a study on that health endpoint was not based on statistical significance alone, but considered other factors (e.g., overall design of the study including degree of control for confounders, method used to characterize exposure to $PM_{2.5}$ within the risk assessment).

A significant change since the previous PM risk assessment is the addition to the relevant epidemiological literature of several multi-city studies. This type of study has several advantages over single-city studies. First, multi-city studies use the same study design in each of the cities included in the study, so that city-specific results are readily comparable. Second, when they are estimating a single C-R function based on several cities, multi-city studies also tend to have more statistical power and provide effect estimates with relatively greater precision than single city studies due to larger sample sizes, reducing the uncertainty around the estimated coefficient. Moreover, in a multi-city study the statistical power to detect an effect in any given city can be supplemented by drawing statistical power from data across all the cities included in the study (or all the cities in the same region) to adjust city-specific estimates towards the mean across all cities included in the analysis (or in the same region). This is particularly useful in those instances, where a city has relatively less data resulting in a larger standard error for the effect estimate. In this situation, the information on the C-R relationship in all the other cities included in a multi-city study can be used to help inform an assessment of the C-R relationship in the city in question. Finally, multi-city studies tend to avoid the often-noted problem of publication bias that single-city studies confront (in which studies with statistically insignificant or negative results are less likely to get published than those with positive and/or statistically significant results).

For this risk assessment, we selected what we considered to be the best study to assess the C-R relationship between $PM_{2.5}$ and a given health endpoint, and we included other studies for that health endpoint only if they were judged to contribute something above and beyond what we could learn from the primary study selected.

A primary study for a given health endpoint had to satisfy the study selection criteria that we have used in past PM (and other) risk assessments. In particular:

- It had to be a published, peer-reviewed study that has been evaluated in the PM ISA and judged adequate by EPA staff for purposes of inclusion in this risk assessment based on that evaluation.
- It had to directly measure, rather than estimate, $PM_{2.5}$ on a reasonable proportion of the days in the study.

It had to either not rely on Generalized Additive Models (GAMs) using the S-Plus software to estimate C-R functions or to appropriately have re-estimated these functions using revised methods.[20]

Because of the advantages noted above, we selected multi-city studies as our primary studies for assessing the risks of premature non-accidental, cardiovascular, and respiratory mortality (Zanobetti and Schwartz, 2009) and cardiovascular and respiratory hospital admissions (Bell et al., 2008) associated with short-term exposure to $PM_{2.5}$ in our core analysis. In each of these studies, the 15 urban areas selected for the PM risk assessment were among the locations included in their analysis. These two multi-city studies are based on more recent air quality and health effects incidence data for short-term exposure-related mortality and morbidity and therefore represent the best studies to use in deriving C-R functions for this risk assessment. Dominici et al. (2007) was considered as an alternative study in identifying C-R functions for modeling short-term exposure-related mortality, however its study period and the underlying air quality data and disease incidence data (1987-2000) are not as current as that of Zanobetti and Schwartz et al., 2009 (study period of 2001-2005), and therefore, we decided to focus on Zanobetti and Schwartz et al. (2009) as the source of C-R functions for modeling short-term exposure-related mortality.

Studies often report more than one estimated C-R function for the same location and health endpoint. Sometimes models including different sets of co-pollutants are estimated in a study; sometimes different lag structures are used. Sometimes different modeling approaches are used to fit weather and temporal variables in the model. Once a study has been selected, the next step is to select one or more C-R functions from among those reported in the study.

Zanobetti and Schwartz (2009) divided the United States into six regions, based on the Köppen climate classification (Kottek 2006; Kottek et al. 2006)(http://koeppen-eiger.vuwien.ac.at/).[21] They estimated the coefficient of $PM_{2.5}$ in single-pollutant log-linear models using Poisson regression for each of 112 cities, as well as in two-pollutant models with coarse PM. They estimated annual models (which assume that the relationship between mortality and $PM_{2.5}$ is the same through the year), as well as four seasonal models per location. They then used a random effects meta-analysis to combine the city-specific results (Berkey et al.

[20] The GAM S-Plus problem was discovered prior to the recent final PM risk assessment carried out as part of the PM NAAQS review completed in 2006. It is discussed in the 2004 PM Criteria Document (EPA, 2004), PM Staff Paper (EPA, 2005c), and PM Health Risk Assessment Technical Support Document (Abt Associates, 2005).

[21] Zanobetti and Schwartz delineate regions as follows: "region 1: humid subtropical climates and maritime temperate climates (Cfa, Cfb), which includes FL, LA TX, GA, AL, MS, AR, OK, KS, MO, TN, SC, NC, VA, WV, KY; region 2: warm summer continental climates (Dfb), including ND, MN, WI, MI, PA, NY, CT, RI, MA, VT, NH, ME; region 3: hot summer continental climates (Dfa) with SD, NE, IA, IL, IN, OH; region 4: dry climates (BSk) (NM, AZ, NV); region 5: dry climates together with continental climate (Dfc, BSk) with MT, ID, WY, UT, CO; region 6: Mediterranean climates which includes CA, OR, WA (Csa, Csb)" (p. 10).

1998). Pooling of city-specific results was done at the national level as well as at the regional level, and separately for each season as well as for the annual functions.

With respect to the multi-city study for short-term exposure mortality, at the request of EPA, the authors produced Empirical Bayes "shrunken" city-specific estimates, adjusted towards the appropriate regional mean, using the approach described in Le Tertre et al. (2005). This was done for the annual estimates as well as for each season-specific estimate.[22] The annual city-specific "shrunken" estimates were used in our core analysis.[23] The seasonal estimates were used in a sensitivity analysis. City-specific estimates have the advantage of relying on city-specific data; however, as noted above, such estimates can have large standard errors (and thus be unreliable); "shrinking" city-specific estimates towards the regional mean estimate is a more efficient use of the data.[24] Such "shrinking" can be thought of as combining the advantages of a single-city study (in which the estimation of a city-specific coefficient is not influenced by data from other locations) with the advantages of a multi-city study (in which there is much greater statistical power to detect small effects).

In Zanobetti and Schwartz (2009) all $PM_{2.5}$ models used the same lag structure (i.e., an average of same-day and the previous day's $PM_{2.5}$). The study did, however, examine both single-pollutant and two-pollutant models (with coarse PM). We selected the single-pollutant models, in part to avoid collinearity problems, and in part to be consistent with most of the other studies used in the risk assessment, which were single-pollutant studies.

Bell et al. (2008) estimated log-linear models relating short-term exposure to $PM_{2.5}$ and hospital admissions for cardiovascular and respiratory illnesses among people 65 and older, using a 2-stage Bayesian hierarchical model, for each of 202 counties in the United States. They reported both annual and season-specific results, nationally and regionally (for four regions: Northeast, Southeast, Northwest, and Southwest), but not at the local (city-specific) level. All cardiovascular hospital admissions models were single-pollutant, 0-day lag models; for respiratory hospital admissions, both single-pollutant 0-day models and single-pollutant 2-day models were estimated. We used the regional, annual C-R functions in our core analysis (identifying the appropriate region for each of our 15 risk assessment locations).[25] For

[22] These city-specific "shrunken" estimates were provided to EPA (see Zanobetti, 2009) .

[23] One reason we selected the annual functions over the season-specific functions for the core analysis is that, while we can sum the season-specific mortality estimates across the four seasons, we cannot do the same for the upper and lower bounds of 95% confidence intervals around those estimates. To produce correct confidence bounds around annual mortality estimates based on seasonal functions, we would need the covariance matrix of the season-specific estimates, separately for each location, which we do not have.

[24] The degree to which a city-specific estimate is "shrunken" towards the regional mean depends on the size of the standard error of the city-specific estimate relative to that of the regional mean estimate. The larger the city-specific estimate relative to the regional mean estimate, the less shrinkage toward the regional mean.

[25] The region into which each of the 202 counties in Bell et al. (2008) falls is given at: http://www.biostat.jhsph.edu/MCAPS/estimates-full.html.

respiratory hospital admissions (for the core analysis), we selected the 2-day lag models, based on evidence that for respiratory effects the strongest associations with PM exposure may be associated with longer lag periods (on the order of 2 days or more).[26] We used the regional season-specific functions in a sensitivity analysis.

We identified two studies that estimated C-R relationships between short-term exposure to $PM_{2.5}$ and emergency department (ED) visits for cardiovascular and/or respiratory illnesses. (There were no multi-city studies for this category of health endpoint.) Tolbert et al. (2007) examined both cardiovascular and respiratory ED visits in Atlanta, GA, using single-pollutant log-linear models with a 3-day moving average (0-day, 1-day, and 2-day lags) of $PM_{2.5}$. Ito et al. (2007) estimated the relationship between short-term exposure to $PM_{2.5}$ and ED visits for asthma in New York City (Manhattan). They estimated two single-pollutant models, one for the whole year and one for the period from April through August; in addition, they estimated several two-pollutant models for the period from April through August. We selected the single-pollutant model for the whole year for the core analysis, and we explored the impacts of using the annual versus the April-through-August model, as well as the single- versus multi-pollutant models in sensitivity analyses.

For the purpose of conducting a sensitivity analysis to show the impact of different lag structures, different modeling approaches, and single- versus two-pollutant models on estimates of the risks of premature mortality and hospital admissions associated with short-term exposure to $PM_{2.5}$, we selected Moolgavkar (2003). This study reported results for premature non-accidental, cardiovascular, and respiratory mortality and for cardiovascular and respiratory hospital admissions associated with short-term exposures to $PM_{2.5}$ in Los Angeles, using several different lag structures and several different approaches to modeling the effects of weather and temporal variables.

In modeling premature mortality associated with long-term exposure to $PM_{2.5}$ in our core analysis, we selected Krewski et al. (2009) as our primary study. This study is an extension of the ACS prospective cohort study (Pope et al., 2002), used in the previous PM risk assessment,. The Krewski et al., 2009 study (and the underlying ACS dataset) has a number of advantages which informed our selection of this study as the basis for C-R functions used in the core analysis, including: (a) extended air quality analysis incorporating data from 1989 to 2000 (extending the period of observation to eighteen years: 1982-2000), which increases the power of the study and allows the study authors to examine the important issue of exposure time windows,

[26] The ISA states that, "Generally, recent studies of respiratory HAs that evaluate multiple lags, have found effect sizes to be larger when using longer moving averages or distributed lag models. For example, when examining HAs for all respiratory diseases among older adults, the strongest associations where observed when using PM concentrations 2 days prior to the HA." (EPA, 2009d, section 2.4.2.2).

(b) rigorous examination of a range of model forms and effect estimates, including consideration for such factors as spatial autocorrelation in specifying response functions, (c) coverage for a range of ecological variables (social, economic and demographic) which allows for consideration for whether these confound or modify the relationship between $PM_{2.5}$ exposure and mortality, (d) inclusion of a related analysis (focusing on Los Angeles), which allowed for consideration of spatial gradients in $PM_{2.5}$ and whether they effect response models (by addressing effect modification, for example) and (e) large overall dataset with over 1.2 million individuals and 156 MSAs. To provide coverage for one of the other larger datasets used in prospective cohort analyses of long-term mortality (the six-cites dataset), we selected the Krewski et al. (2000) study to provide C-R functions that were used in the sensitivity analysis completed for this risk assessment.

A number of other studies were considered as candidates for use in modeling long-term exposure-related mortality in this analysis. For purposes of transparency, we have included a brief summary here of our rationale for not selecting a number of the more high-profile studies for use in the core analysis. The Laden et al. (2006) study (which focused on the six-cities dataset) was not selected because it used visibility data to estimate ambient $PM_{2.5}$ levels. The Goss et al. (2004) study (based on the cystic fibrosis data), while addressing an at-risk population of concern, was not selected because of a lack of baseline incidence data for this population which prevents quantitative modeling of mortality incidence. The Miller et al. (2007) study (focusing on the Women's Health Initiative dataset) while providing coverage for a population of particular interest, was not used, again due to an absence of baseline incidence data (which is particularly important for this population which is typically healthier than the general population). And finally, the Eftim et al. (2008) study (focusing on the Medicare population) was not included because this study did not include representative confounder control for smoking, which introduces uncertainty into C-R functions obtained from the study.

Krewski et al. (2009) (the study selected as the basis for C-R functions used in the core analysis) considered mortality from all causes, as well as cardiopulmonary mortality, mortality from ischemic heart disease, and lung cancer mortality. The study presents a variety of C-R functions, in an effort to show how the results vary with various changes to the method/model used. It was not readily apparent from review of the HEI report, that the authors of the study recommended any one of these as clearly superior to the others. Therefore, we corresponded with the authors of the Krewski et al. (2009) study to obtain additional clarification regarding specific aspects of the study and associated results as presented in the HEI report (Krewski et al., 2009). In response to the our question of whether the study authors had a preference for a particular model (in the context of using that model and its hazard ratio(s) in risk assessment), the authors stated that they had "refrained from expressing a preference among the results for their use in quantitative risk assessment," preferring to "explore several plausible statistical models that we have fit to the available data." However, the authors go on to state that "...if one had to choose a model for use in practical applications involved in air quality management, one could argue that a random effects model (which accounts for apparent spatial autocorrelation in the data) might be preferable. A model that included ecological covariates, which has the effect of reducing the residual variation in mortality, might also be of interest. If forced to pick a single model for risk assessment applications in air quality management, our random effects model with ecological covariates might be selected" (Krewski, 2009).

In addition to these statements from the study authors regarding the model form to use, EPA staff also considered the results of an analysis presented in the study examining the importance of exposure time windows in deriving C-R functions. This analysis suggested that models developed using both exposure time windows considered in the analysis (1979-1983 and 1999-2000) were equally effective at representing the relationship between $PM_{2.5}$ exposure and long-term exposure-related mortality. Therefore, we concluded that C-R functions used in the core analysis should include functions fitted to both exposure time windows. However, the study does not provide random effects models with ecological covariates for both exposure time windows (this form of model is only provided with a fit to the latter exposure window). Therefore, for the core analysis, we decided to use the Cox proportional hazard model with 44 individual and 7 ecological variables fitted to both exposure time windows (note, that if the Krewski et al. (2009) study had provided a random effects model with ecological covariates (for both PM monitoring periods – 1979-1983 and 1999-2000), then we would have used those models in our core analysis).

In specifying effect estimates for each set of models, the relative risks for a 10 $\mu g/m^3$ change in $PM_{2.5}$ were back-calculated from Table 33 of Krewski et al. (2009). We selected several additional C-R functions from Krewski et al. (2009) to use in sensitivity analyses carried out in two risk assessment locations (Los Angeles and Philadelphia), including the random effects form (section 3.5.4), as described below. In addition, as mentioned earlier, we used C-R functions obtained from Krewski et al. (2000) [reanalysis of the Six Cities Study] in the sensitivity analysis.

3.3.4 Summary of Selected Health Endpoints, Urban Areas, Studies, and C-R Functions

A summary of the selected health endpoints, urban areas, and epidemiological studies used in the risk assessment is given below in Tables 3-5 and 3-6 for short-term and long-term exposure studies, respectively. A more detailed overview of the locations, health endpoints, studies, and C-R functions included in the core analysis is given in Table 3-7. An overview of the locations, health endpoints, studies, and C-R functions included in sensitivity analyses is given in Table 3-8.

Table 3-5. Locations, Health Endpoints, and Short-Term Exposure Studies Included in the $PM_{2.5}$ Risk Assessment*

<table>
<tr><th rowspan="2">Urban Area</th><th colspan="3">Premature Mortality</th><th colspan="2">Hospital Admissions</th><th colspan="2">ED Visits</th></tr>
<tr><th>Non-Accidental</th><th>Cardiovascular</th><th>Respiratory</th><th>Cardiovascular</th><th>Respiratory</th><th>Cardiovascular</th><th>Respiratory</th></tr>
<tr><td>Atlanta, GA</td><td rowspan="8">Zanobetti and Schwartz (2009)</td><td rowspan="8">Zanobetti and Schwartz (2009)</td><td rowspan="8">Zanobetti and Schwartz (2009)</td><td rowspan="8">Bell et al. (2008)</td><td rowspan="8">Bell et al. (2008)</td><td>Tolbert et al. (2007)</td><td>Tolbert et al. (2007)</td></tr>
<tr><td>Baltimore, MD</td><td></td><td></td></tr>
<tr><td>Birmingham, AL</td><td></td><td></td></tr>
<tr><td>Dallas, TX</td><td></td><td></td></tr>
<tr><td>Detroit, MI</td><td></td><td></td></tr>
<tr><td>Fresno, CA</td><td></td><td></td></tr>
<tr><td>Houston, TX</td><td></td><td></td></tr>
<tr><td rowspan="2">Los Angeles, CA</td><td></td><td></td></tr>
<tr><td>Moolgavkar (2003)</td><td>Moolgavkar (2003)</td><td></td><td>Moolgavkar (2003)</td><td></td><td></td><td></td></tr>
<tr><td>New York, NY</td><td rowspan="7">Zanobetti and Schwartz (2009)</td><td rowspan="7">Zanobetti and Schwartz (2009)</td><td rowspan="7">Zanobetti and Schwartz (2009)</td><td rowspan="7">Bell et al. (2008)</td><td rowspan="7">Bell et al. (2008)</td><td></td><td>Ito et al. (2007)</td></tr>
<tr><td>Philadelphia, PA</td><td></td><td></td></tr>
<tr><td>Phoenix, AZ</td><td></td><td></td></tr>
<tr><td>Pittsburgh, PA</td><td></td><td></td></tr>
<tr><td>Salt Lake City, UT</td><td></td><td></td></tr>
<tr><td>St. Louis, MO</td><td></td><td></td></tr>
<tr><td>Tacoma, WA</td><td></td><td></td></tr>
</table>

*Studies in italics are used only in sensitivity analyses.

Table 3-6. Locations, Health Endpoints, and Long-Term Exposure Studies Included in the $PM_{2.5}$ Risk Assessment*

Urban Area	Premature Mortality			
	All-Cause	**Cardiopulmonary**	**Ischemic Heart Disease**	**Lung Cancer**
Atlanta, GA Baltimore, MD Birmingham, AL Dallas, TX Detroit, MI Fresno, CA Houston, TX New York, NY Phoenix, AZ Pittsburgh, PA Salt Lake City, UT St. Louis, MO Tacoma, WA	Krewski et al. (2009) [extension of the ACS study]	Krewski et al. (2009) [extension of the ACS study]	Krewski et al. (2009) [extension of the ACS study]	Krewski et al. (2009) [extension of the ACS study]
Los Angeles, CA Philadelphia, PA	Krewski et al. (2009) [extension of the ACS study] *Krewski et al. (2000) [reanalysis of the Six Cities Study]*	Krewski et al. (2009) [extension of the ACS study] *Krewski et al. (2000) [reanalysis of the Six Cities Study]*		Krewski et al. (2009) [extension of the ACS study] *Krewski et al. (2000) [reanalysis of the Six Cities Study]*

*Studies in italics are used only in sensitivity analyses.

Table 3-7. Summary of Locations, Health Endpoints, Studies and Concentration-Response Functions Included in the Core Analysis.*

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
Atlanta	Cobb, De Kalb, Fulton, Gwinnett	Zanobetti and Schwartz (2009)[1]	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)[1]	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)[1]	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)[2]	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)[2]	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)[2]	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)[2]	Long-term exposure lung cancer mortality	NA
	Cobb, DeKalb, Fulton,	Bell et al. (2008)[3]	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)[3]	Short-term exposure HA (unscheduled), respiratory	2-day lag
	Barrow, Bartow, Carroll, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinett, Henry, Newton, Paulding, Pickens, Rockdale, Spalding, Walton	Tolbert et al. (2007)	Short-term exposure Emergency room (ED) visits, cardiovascular	Avg. of 0-,1-day, and 2-day lags
		Tolbert et al. (2007)	Short-term exposure Emergency room (ED) visits, respiratory	Avg. of 0-,1-day, and 2-day lags
Baltimore	Baltimore city, Baltimore county	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Birmingham	Blount, Jefferson, Shelby, St. Clair, Walker	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
	Jefferson	Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Dallas	Dallas	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Detroit	Wayne	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Fresno	Fresno	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Houston	Harris	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Los Angeles	Los Angeles	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
New York	Kings, New York City (Manhattan), Queens, Richmond, Bronx	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
	New York City (Manhattan)	Ito et al. (2007)	Short-term exposure Emergency room (ED) visits, asthma	Avg. of 0-day and1-day lags
Philadelphia	Philadelphia	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Phoenix	Maricopa	Zanobetti and Schwartz (2009)	Short-term exposure non-accidental mortality	Avg. of 0-day and 1-day lags

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
		Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Pittsburgh	Allegheny	Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Salt Lake City	Salt Lake	Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA

Risk Assessment Location	Counties	Study/C-R Function	Health Endpoint	Lag Structure
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
St. Louis	Jeffferson, Madison (IL), St. Louis, St. Louis city, St. Clair (IL)	Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1-day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
	Madison (IL), St. Louis, St. Louis city, St. Clair (IL)	Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag
Tacoma	Pierce	Zanobetti and Schwartz (2009)	Short-term exposure cardiovascular mortality	Avg. of 0-day and 1 day lags
		Zanobetti and Schwartz (2009)	Short-term exposure respiratory mortality	Avg. of 0-day and 1-day lags
		Krewski et al. (2009)	Long-term exposure all-cause mortality	NA
		Krewski et al. (2009)	Long-term exposure cardiopulmonary mortality	NA
		Krewski et al. (2009)	Long-term exposure ischemic heart disease mortality	NA
		Krewski et al. (2009)	Long-term exposure lung cancer mortality	NA
		Bell et al. (2008)	Short-term exposure HA (unscheduled), cardiovascular	0-day lag
		Bell et al. (2008)	Short-term exposure HA (unscheduled), respiratory	2-day lag

*All C-R functions in the core analysis are single-pollutant, log-linear models; all are for a full year. The exposure metric for all short-term exposure C-R functions is the 24-hour average; the exposure metric for all long-term exposure C-R functions is the annual average.

[1] This is a multi-city study; city-specific estimates "shrunken" towards the mean across all cities in a region were supplied to EPA (Zanobetti, 2009).

[2] Two C-R functions were used for the core analysis – one corresponding to the earlier exposure period, from 1979 – 1983, and the other corresponding to the later exposure period, from 1999 – 2000. Both C-R functions were based on follow-up of the cohort through 2000. Both used the standard Cox proportional

hazards model, with 44 individual and 7 ecologic covariates. The relative risks for a 10 μg/m^3 change in $PM_{2.5}$ from which the $PM_{2.5}$ coefficients were back-calculated were taken from Table 33 of Krewski et al. (2009).

[3] This study estimated four regional C-R functions – for the Northeast, Southeast, Northwest, and Southwest – for each health endpoint. For each risk assessment location, we used the regional C-R function for the region containing the risk assessment location. The designation of counties to each of these four regions can be found at http://www.biostat.jhsph.edu/MCAPS/estimates-full.html .

Table 3-8. Summary of Locations, Health Endpoints, Studies and Concentration-Response Functions Included in Sensitivity Analyses.

Sensitivity Analysis	Study/C-R Function	Health Endpoint**	Risk Assessment Location(s)
Single-Factor Sensitivity Analyses:			
Impact of using different model choices – fixed effects log-linear vs. random effects log-linear vs. random effects log-log C-R function*	random effects log-linear: Krewski et al. (2009) [Table 9, "Autocorrelation at MSA and ZCA levels" group - "MSA & Diff" row] random effects log-log: Krewski et al. (2009) [Table 11, "MSA and DIFF" rows]	All-cause, cardiopulmonary, ischemic heart disease, and lung cancer mortality associated with long-term exposure	Los Angeles and Philadelphia
Impact of using copollutant models in modeling long-term exposure-related mortality	Krewski et al., 2000 (reanalysis of ACS) – provides 2-pollutant models combining $PM_{2.5}$ with CO, NO_2 , O_3 or SO_2.	All-cause mortality associated with long-term exposure	Los Angeles and Philadelphia
Impact of estimating risks down to PRB rather than down to LML	Krewski et al. (2009) – C-R functions for each of two exposure periods	Long-term exposure all-cause mortality	All 15 urban areas
Impact of C-R function from alternative long-term exposure study	Krewski et al. (2000) [reanalysis of the Harvard Six Cities study]	All-cause, cardiovascular, respiratory, lung cancer mortality associated with long-term exposure	Los Angeles and Philadelphia
Impact of using alternative hybrid rollback approach (note, that as discussed in section 3.2.3, in addition to the hybrid rollback approach, we have also included a peak-shaving rollback approach as an alternative to the proportional rollback approach).[27]	Krewski et al. (2009)	All-cause mortality associated with long-term exposure	Baltimore, Birmingham, Detroit, Los Angeles, New York, Pittsburgh, and St. Louis
Impact of using season-specific C-R functions (vs. an annual C-R function)	Zanobetti and Schwartz (2009) – seasonal functions vs. annual function	Non-accidental mortality, cardiovascular mortality, respiratory mortality associated with short-term	All 15 urban areas

[27] However, as noted in section 3.2.3 and in section 3.5.4, quantitative risk estimates were not generated using the peak-shaving approach and instead, composite monitor values (acting as surrogates for long-term exposure-related risk) were used as the basis for the sensitivity analysis involving the peak-shaving rollback approach.

Sensitivity Analysis	Study/C-R Function	Health Endpoint**	Risk Assessment Location(s)
		exposure	
Impact of using season-specific C-R functions (vs. an annual C-R function)	Bell et al. (2008) – seasonal functions vs. annual function	HA (unscheduled), cardiovascular and respiratory, associated with short-term exposure	All 15 urban areas
Impact of using an annual C-R function (applied to the whole year) vs. a seasonal function for April through August (applied only to that period) (using a single pollutant model).	Ito et al. (2007)	Asthma ED visits	New York
Impact of model selection (e.g., log-linear GAM with 30 df; log-linear GAM with 100 df; and log-linear GLM with 100 df)	Moolgavkar (2003)	Non-accidental and cardiovascular mortality; and cardiovascular and COPD+ HA associated with short-term exposure	Los Angeles
Impact of lag structure (0-day, 1-day, 2-day)	Moolgavkar (2003)	Non-accidental and cardiovascular and COPD+ HA associated with short-term exposure	Los Angeles
Impact of single- vs. multi-pollutant models ($PM_{2.5}$ with CO)	Moolgavkar (2003)	Non-accidental and cardiovascular mortality; and cardiovascular and COPD+ HA associated with short-term exposure	Los Angeles
Impact of using alternative hybrid rollback approach	Zanobetti and Schwartz (2009)	Non-accidental mortality associated with short-term exposure	Baltimore, Birmingham, Detroit, Los Angeles, New York, Pittsburgh, and St. Louis
Impact of lag structure (0-day, 1-day, 2-day)	Bell et al., 2008	Cardiovascular and respiratory hospital admissions associated with short-term exposure	Los Angeles and Philadelphia
Multi-Factor Sensitivity Analyses:			
Impact of using a fixed effects log-linear vs. a random effects log-log model, estimating incidence down to the lowest measured level (LML) in the study vs. down to PRB, and using a proportional vs. hybrid rollback to estimate incidence associated with long-term exposure to $PM_{2.5}$ concentrations that just meet the current standards		All-cause and ischemic heart disease mortality associated with long-term exposure	Los Angeles and Philadelphia
Impact of using season-specific vs. all-year C-R functions and proportional vs. hybrid rollbacks to estimate incidence associated with short-term exposure to $PM_{2.5}$ concentrations that just meet the current	Zanobetti and Schwartz (2009)	Non-accidental mortality associated with short-term exposure	Baltimore, Birmingham, Detroit, Los Angeles, New York, Pittsburgh, and St. Louis

Sensitivity Analysis	Study/C-R Function	Health Endpoint**	Risk Assessment Location(s)
standards			

*This “single-factor” sensitivity analysis is actually two factors – first the change from a fixed effects log-linear model to a random effects log linear model, and then the change from a random effects log-linear model to a random effects log-log model. These were combined into a single sensitivity analysis because Krewski et al. (2009) did not present the results of a fixed effects log-log model (to compare to the core analysis fixed effects log-linear model).

**”HA” = hospital admissions, “ED” = emergency department visits, “COPD+” = chronic obstructive pulmonary disease.

3.4 BASELINE HEALTH EFFECTS INCIDENCE DATA

As noted in section 3.2.1 above, the form of C-R function most commonly used in epidemiological studies on PM, shown in equation (1), is log-linear. To estimate the change in incidence of a health endpoint associated with a given change in $PM_{2.5}$ concentrations using this form of C-R function requires the baseline incidence (often calculated as the baseline incidence rate times the population) of the health endpoint, that is, the number of cases per unit time (e.g., per year) in the location before a change in $PM_{2.5}$ air quality (denoted y_0 in equations 3 and 4).

Incidence rates express the occurrence of a disease or event (e.g., asthma episode, death, hospital admission) in a specific period of time, usually per year. Rates are expressed either as a value per population group (e.g., the number of cases in Philadelphia County) or a value per number of people (e.g., the number of cases per 10,000 residents in Philadelphia County), and may be age- and sex-specific. Incidence rates vary among geographic areas due to differences in population characteristics (e.g., age distribution) and factors promoting illness (e.g., smoking, air pollution levels).

3.4.1 Data Sources

3.4.1.1 Mortality

We obtained individual-level mortality data for 2006 for the whole United States from the Centers for Disease Control (CDC), National Center for Health Statistics (NCHS). The data are compressed into a CD-ROM, which contains death information for each decedent, including residence county FIPS, age at death, month of death, and underlying causes (ICD-10 codes). The detailed mortality data allow us to generate cause-specific death counts at the county level for selected age groups. Below we describe how we generated the county-level death counts.

3.4.1.2 Hospital Admission and Emergency Department Visits

For hospital admissions (HA) and emergency department (ED) visits, there are multiple data sources:

- **Healthcare Cost and Utilization Project (HCUP) Central Distributor**. HCUP is a family of health care databases developed through a Federal-State-Industry partnership and sponsored by the Agency for Healthcare Research and Quality (AHRQ). The HCUP databases are based on the data collection efforts of data organizations in participating states. We used two HCUP databases: the State Inpatient Database (SID) and the State Emergency Department Database (SEDD) respectively. SID/SEDD include detailed HA/ED information for each discharge, including patient county FIPS, age, admission type (e.g., emergent, urgent), admission/discharge season, and principle diagnosis (ICD-9 codes). The HCUP databases can be purchased from the HCUP Central Distributor, although not all participant states release the data to the Central Distributor.

- **HCUP State Partners**. For those HCUP participating states that don't release their data to the Central Distributor, we contacted the HCUP state partners to obtain the HA and/or ED data.
- **Communication with the author(s) of selected epidemiological studies**. The ED data for Atlanta in 2004 were sent to EPA by one of the authors of Tolbert et al. (2007).

Table 3-9 shows the states for which we obtained data from the HCUP Central Distributor and the HCUP State Partners. The data are at the discharge level if not otherwise noted, and the data year is 2007 for all the states in the table. The column "PM RA Location" indicates the selected risk assessment location(s) where the incidence rate is applied.

The necessary baseline incidence data were not available for Atlanta, Birmingham, Philadelphia, Pittsburgh and St. Louis. Therefore, for each of these five risk assessment locations EPA instead used the baseline incidence rate for a designated surrogate location. Surrogate locations were chosen if they were deemed to be sufficiently similar to the urban area whose baseline incidence data were not available. Surrogate locations are noted in Table 3-9.

Table 3-9. Sources of Hospital Admissions (HA) and Emergency Department (ED) Visit Data.

States	HCUP Central Distributor	HCUP State Partner	PM RA Location	Notes
Arizona	HA data	--	Phoenix	
California	NA*	HA data	Fresno, Los Angeles	Due to privacy concerns, CA state agency provided county level data.
Illinois	NA	HA data	St. Louis	1. Due to privacy concerns, IL state agency provided county level data. 2. Two IL counties (Madison and St. Clair) serve as the surrogate for the St. Louis metropolitan region.
Maryland	HA data	--	Baltimore, Philadelphia	Baltimore serves as the surrogate for Philadelphia.
Michigan	HA data	--	Detroit	
New York	NA	HA and ED data	New York, Pittsburgh	Buffalo, NY serves as the surrogate for Pittsburgh.
North Carolina	HA data	--	Atlanta and Birmingham	Charlotte, NC serves as the surrogate for both Atlanta and Birmingham.
Texas	NA	HA data	Dallas, Houston	
Utah	HA data	--	Salt Lake City	
Washington	HA data	--	Tacoma	

*NA denotes "not available, or not available with all variables required for our analysis. If data were not available from the HCUP Central Distributor, we contacted the HCUP State Partner.

3.4.1.3 Populations

To calculate baseline incidence rate, in addition to the health baseline incidence data we also need the corresponding population. We obtained population data from the U.S. Census Bureau (http://www.census.gov/popest/counties/asrh/). These data, released on May 14, 2009, are the population estimates of the resident populations by selected age groups and sex for counties in each U.S. state from 2000 to 2008. We used 2007 populations for calculating most incidence rates except for the ED visit rate in Atlanta. Because the ED visit data obtained from the authors of Tolbert et al. (2007) are for 2004, we used 2004 population estimates for the 20-county Metropolitan area used in the Tolbert et al. study for the Atlanta area to calculate the ED incidence rates to be applied when using that study in the risk assessment; we then applied the 2004 rates to the 2007 population, assuming the ED incidence rates in Atlanta did not change significantly from 2004 to 2007. The sizes of the populations in the assessment locations that are relevant are shown below in Table 3-10.

Table 3-10. Relevant Population Sizes for PM Risk Assessment Locations.

City	Counties	Population (Year 2006 and 2007)*					
		All Ages		Ages ≥30		Ages ≥ 65	
		2006	2007	2006	2007	2006	2007
Atlanta, GA - 1	Cobb, De Kalb, Fulton, Gwinnett	3,126,000	3,198,000	1,817,000	1,865,000	236,000	245,000
Atlanta, GA - 2	Cobb, De Kalb, Fulton	2,376,000,	2,421,000	1,400,000	1,433,000	191,000	198,000
Atlanta, GA - 3	20-County MSA**	4,975,000	5,123,000	2,831,000	2,918,000	391,000	408,000
Baltimore, MD	Baltimore city, Baltimore county	1,429,000	1,426,000	849,000	848,000	190,000	189,000
Birmingham, AL - 1	Blount, Jefferson, Shelby, St. Clair, Walker	1,037,000	1,044,000	619,000	625,000	131,000	133,000
Birmingham, AL - 2	Jefferson	660,000	659,000	397,000	397,000	88,000	88,000
Dallas, TX	Dallas	2,338,000	2,367,000	1,285,000	1,308,000	195,000	199,000
Detroit, MI	Wayne	2,012,000	1,985,000	1,176,000	1,168,000	236,000	234,000
Fresno, CA	Fresno	886,000	899,000	444,000	452,000	86,000	87,000
Houston, TX	Harris	3,876,000	3,936,000	2,097,000	2,139,000	299,000	307,000
Los Angeles, CA	Los Angeles	9,881,000	9,879,000	5,544,000	5,579,000	1,011,000	1,030,000
New York, NY - 1	Kings, New York City (Manhattan), Queens, Richmond, Bronx	8,251,000	8,275,000	4,940,000	4,975,000	1,004,000	1,013,000
New York, NY - 2	New York city (Manhattan)	1,613,000	1,621,000	1,061,000	1,074,000	201,000	204,000
Philadelphia, PA	Philadelphia	833,000	1,450,000	833,000	833,000	189,000	187,000
Phoenix, AZ	Maricopa	3,779,000	3,880,000	2,103,000	2,167,000	417,000	432,000
Pittsburgh, PA	Allegheny	1,225,000	1,219,000	790,000	786,000	208,000	206,000
Salt Lake City, UT	Salt Lake	991,000	1,010,000	504,000	517,000	83,000	86,000
St. Louis, MO - 1	Jefferson, Madison (IL), St. Louis, St. Louis city, St. Clair (IL)	2,093,000	2,091,000	1,259,000	1,261,000	274,000	275,000

City	Counties	Population (Year 2006 and 2007)*					
		All Ages		Ages ≥30		Ages ≥ 65	
		2006	2007	2006	2007	2006	2007
St. Louis, MO - 2	Madison (IL), St. Louis, St. Louis city, St. Clair (IL)	1,879,000	1,875,000	1,134,000	1,134,000	253,000	252,000
Tacoma, WA	Pierce	764,000	773,000	437,000	444,000	79,000	81,000

* Not all populations listed in the table were used for calculating the incidence rates. As noted above, the population year needs to match the year of the health data and the population age group needs to match what is used in the epidemiological studies. In addition, 2004 population (all ages) is used for ED visits in Atlanta-3, which is 4,663,946. Populations in this table are rounded to the nearest 1,000.

** The 20 counties are Barrow, Bartow, Carroll, Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinett, Henry, Newton, Paulding, Pickens, Rockdale, Spalding, and Walton.

3.4.2 Calculation of Baseline Incidence Rates

To calculate a baseline incidence rate to be used with a C-R function from a given study, we matched the counties, age groupings, and ICD codes used in that study. For example, Bell et al. (2008) designated Dallas, TX as Dallas County and estimated a C-R function for ICD-9 codes 490–492, 464–466, and 480–487 (respiratory HA) among ages 65 and up; we therefore selected only those HA records that had corresponding ICD codes for ages 65 and up in Dallas County and also selected the population for the same age group in the same county. The incidence rate is simply the ratio of the selected HA count to the population. The same procedure was used to calculate baseline incidence rates for all of the risk assessment locations.[28]

If a C-R function was estimated for a specific season, we selected only those HA records within that season. The season definitions are: winter (December, January, and February), spring (March, April, and May), summer (June, July, and August) and fall (September, October, and November). Note that the HA data for some states didn't include information about admission season but only discharge season or discharge quarter. The admission season was then approximated using discharge season or discharge quarter.[29]

Some studies (e.g., Bell et al., 2008) look at the unscheduled HAs only, so we excluded scheduled admissions from the analyses to match the study. A HA is unscheduled if the admission type is emergency or urgent.

The baseline mortality rates are given in Table 3-11. The baseline HA and ED visit rates are given in Table 3-12.

[28] For Atlanta, Birmingham, Philadelphia, Pittsburgh and St. Louis, the HA data are not available. We calculated the hospital admission rates for the surrogate cities. These cities are listed in Table 3-7.

[29] Based on communication with the HCUP state partner in Texas, patients are normally admitted and discharged in the same season.

Table 3-11. Baseline Mortality Rates (Deaths per 100,000 Relevant Population per Year) for 2006 for PM Risk Assessment Locations.*

City	Age Group	Type of Mortality (ICD-10 or ICD-9 Codes)							
		All-Cause	Non-accidental (A00-R99)	Cardiovascular (I01-I59)	Respiratory (J00-J99)	Cardio-pulmonary (401-440, 460-519)	Ischemic Heart Disease (410-414)	Lung Cancer (162)	COPD (490-496)
Atlanta, GA - 1	All ages	---	480	120	41	---	---	---	---
Atlanta, GA - 1	≥ 30	860	---	---	---	330	89	51	---
Atlanta, GA - 2	---	---	---	---	---	---	---	---	---
Atlanta, GA - 3	---	---	---	---	---	---	---	---	---
Baltimore, MD	All ages	---	950	270	85	---	---	---	---
Baltimore, MD	≥ 30	1,700	---	---	---	690	300	110	---
Birmingham, AL - 1	All ages	---	920	260	85	---	---	---	---
Birmingham, AL - 1	≥ 30	1,600	---	---	---	680	190	104	---
Birmingham, AL - 2	---	---	---	---	---	---	---	---	---
Dallas, TX	All ages	---	540	150	48	---	---	---	---
Dallas, TX	≥ 30	1,020	---	---	---	420	170	66	---
Detroit, MI	All ages	---	850	300	67	---	---	---	---
Detroit, MI	≥ 30	1,500	---	---	---	700	360	107	---
Fresno, CA	All ages	---	620	190	67	---	---	---	---
Fresno, CA	≥ 30	1,300	---	---	---	590	260	66	---
Houston, TX	All ages	---	480	130	37	---	---	---	---
Houston, TX	≥ 30	920	---	---	---	370	150	57	---
Los Angeles, CA	All ages	---	560	190	57	---	---	---	29
Los Angeles, CA	≥ 30	1,030	---	---	---	510	250	55	---
New York, NY - 1	All ages	---	630	270	52	---	---	---	---

City	Age Group	Type of Mortality (ICD-10 or ICD-9 Codes)							
		All-Cause	Non-accidental (A00-R99)	Cardiovascular (I01-I59)	Respiratory (J00-J99)	Cardio-pulmonary (401-440, 460-519)	Ischemic Heart Disease (410-414)	Lung Cancer (162)	COPD (490-496)
New York, NY - 1	≥ 30	1,0800	---	---	---	580	380	56	---
New York, NY - 2	---	---	---	---	---	---	---	---	---
Philadelphia, PA	All ages	---	970	280	83	---	---	---	---
Philadelphia, PA	≥ 30	1,700	---	---	---	720	300	120	---
Phoenix, AZ	All ages	---	600	160	67	---	---	---	---
Phoenix, AZ	≥ 30	1,100	---	---	---	470	220	68	---
Pittsburgh, PA	All ages	---	1,090	330	96	---	---	---	---
Pittsburgh, PA	≥ 30	1,800	---	---	---	770	350	120	---
Salt Lake City, UT	All ages	---	480	110	45	---	---	---	---
Salt Lake City, UT	≥ 30	980	---	---	---	350	101	37	---
St. Louis, MO - 1	All ages	---	870	270	83	---	---	---	---
St. Louis, MO - 1	≥ 30	1,500	---	---	---	680	320	106	---
St. Louis, MO - 2	---	---	---	---	---	---	---	---	---
Tacoma, WA	All ages	---	660	190	66	---	---	---	---
Tacoma, WA	≥ 30	1,200	---	---	---	510	240	88	---
National	All ages	810	750	220	76	340	140	53	42
National	≥ 30	1,300	1,300	370	130	580	240	90	71

* Figures in this table are rounded to a two-integer level of precision.

Table 3-12. Baseline Hospital Admission (HA) and Emergency Department (ED) Rates (Admissions/Visits per 100,000 Relevant Population per Year) for 2007 for PM Risk Assessment Locations.*

City	Age Group	Health Endpoints (ICD-9 Codes)						
		HA, cardio-vascular (390-429)	HA (unscheduled), cardiovascular(426–429, 430–438, 410–414, 440–449)	HA, COPD (490-496)	HA (unscheduled), respiratory (490–492, 464–466, 480–487)	ED visits, cardiovascular (410–414, 427, 428, 433–437, 440, 443–445, 451–453)	ED visits, respiratory (460–465, 466.1, 466.11, 466.19, 477, 480–486, 491-493, 496, 786.07, 786.09)	ED visits, asthma (493)
Atlanta, GA - 1	---	---	---	---	---	---	---	---
Atlanta, GA - 2	≥ 65	---	5,700	---	2,020	---	---	---
Atlanta, GA - 3	All ages	---	---	---	---	690**	2600**	---
Baltimore, MD	≥ 65	---	8,600	---	2,600	---	---	---
Birmingham, AL - 1	---	---	---	---	---	---	---	---
Birmingham, AL - 2	≥ 65	---	5,700	---	2,020	---	---	---
Dallas, TX	≥ 65	---	5,000	---	2,000	---	---	---
Detroit, MI	≥ 65	---	8,800	---	3,000	---	---	---
Fresno, CA	≥ 65	---	5,600	---	2,100	---	---	---
Houston, TX	≥ 65	---	5,900	---	2,200	---	---	---
Los Angeles, CA	All ages	---	---	223	---	---	---	---
Los Angeles, CA	≥ 65	5,500	5,500	---	2,000	---	---	---
New York, NY - 1	≥ 65	---	6,400	---	2,030	---	---	---
New York, NY - 2	All ages	---	---	---	---	---	---	1,100
Philadelphia, PA	≥ 65	---	8,600	---	2,600	---	---	---
Phoenix, AZ	≥ 65	---	5,020	---	1,600	---	---	---
Pittsburgh, PA	≥ 65	---	6,100	---	1,900	---	---	---
Salt Lake City, UT	≥ 65	---	3,030	---	1,200	---	---	---
St. Louis, MO - 1	---	---	---	---	---	---	---	---
St. Louis, MO - 2	≥ 65	---	5,600	---	2,600	---	---	---
Tacoma, WA	≥ 65	---	4,500	---	1,600	---	---	---

* Figures in this table are rounded to a two-integer level of precision.
** These are 2004 incidence rates because Tolbert et al. (2007) provided 2004 ED visit data in a 20-county delineation of Atlanta. However, the 2004 rates were applied to the appropriate year population in the risk assessment.

3.5 ADDRESSING UNCERTAINTY AND VARIABILITY

3.5.1 Overview

An important component of a population health risk assessment is the characterization of both uncertainty and variability. *Variability* refers to the heterogeneity of a variable of interest within a population or across different populations. For example, populations in different regions of the country may have different behavior and activity patterns (e.g., air conditioning use, time spent indoors) that affect their exposure to ambient PM and thus the population health response. The composition of populations in different regions of the country may vary in ways that can affect the population response to exposure to PM – e.g., two populations exposed to the same levels of PM might respond differently if one population is older than the other. In addition, the composition of the PM to which different populations are exposed may differ, with different levels of toxicity and thus different population responses. Variability is inherent and cannot be reduced through further research. Refinements in the design of a population risk assessment are often focused on more completely characterizing variability in key factors affecting population risk – e.g., factors affecting population exposure or response – in order to produce risk estimates whose distribution adequately characterizes the distribution in the underlying population(s).

Uncertainty refers to the lack of knowledge regarding the actual values of inputs to an analysis. Models are typically used in analyses, and there is uncertainty about the true values of the parameters of the model (parameter uncertainty) – e.g., the value of the coefficient for $PM_{2.5}$ in a C-R function. There is also uncertainty about the extent to which the model is an accurate representation of the underlying physical systems or relationships being modeled (model uncertainty) – e.g., the shapes of C-R functions. In addition, there may be some uncertainty surrounding other inputs to an analysis due to possible measurement error—e.g., the values of daily $PM_{2.5}$ concentrations in a risk assessment location, or the value of the baseline incidence rate for a health effect in a population. In any risk assessment, uncertainty is, ideally, reduced to the maximum extent possible through improved measurement of key variables and ongoing model refinement. However, significant uncertainty often remains, and emphasis is then placed on characterizing the nature of that uncertainty and its impact on risk estimates. The characterization of uncertainty can be both qualitative and, if a sufficient knowledgebase is available, quantitative.

The selection of urban study areas for the $PM_{2.5}$ risk assessment was designed to cover the range of $PM_{2.5}$-related risk experienced by the U.S. population and, in general, to adequately reflect the inherent variability in those factors affecting the public health impact of $PM_{2.5}$ exposure. Sources of variability reflected in the risk assessment design are discussed in section

3.5.2, along with a discussion of those sources of variability which are not fully reflected in the risk assessment and consequently introduce uncertainty into the analysis.

The characterization of uncertainty associated with risk assessment is often addressed in the regulatory context using a tiered approach in which progressively more sophisticated methods are used to evaluate and characterize sources of uncertainty depending on the overall complexity of the risk assessment (WHO, 2008). Guidance documents developed by EPA for assessing air toxics-related risk and Superfund Site risks (USEPA, 2004b and 2001, respectively) as well as recent guidance from the World Health Organization (WHO, 2008) specify multi-tiered approaches for addressing uncertainty.

The WHO guidance presents a four-tiered approach, where the decision to proceed to the next tier is based on the outcome of the previous tier's assessment. The four tiers described in the WHO guidance include:

- **Tier 0** – recommended for routine screening assessments, uses default uncertainty factors (rather than developing site-specific uncertainty characterizations);
- **Tier 1** – the lowest level of site-specific uncertainty characterization, involves qualitative characterization of sources of uncertainty (e.g., a qualitative assessment of the general magnitude and direction of the effect on risk results);
- **Tier 2** – site-specific deterministic quantitative analysis involving sensitivity analysis, interval-based assessment, and possibly probability bound (high- and low-end) assessment; and
- **Tier 3** – uses probabilistic methods to characterize the effects on risk estimates of sources of uncertainty, individually and combined.

With this four-tiered approach, the WHO framework provides a means for systematically linking the characterization of uncertainty to the sophistication of the underlying risk assessment. Ultimately, the decision as to which tier of uncertainty characterization to include in a risk assessment will depend both on the overall sophistication of the risk assessment and the availability of information for characterizing the various sources of uncertainty. EPA staff has used the WHO guidance as a framework for developing the approach used for characterizing uncertainty in this risk assessment.

The overall analysis in the PM NAAQS risk assessment is relatively complex, thereby warranting consideration of a full probabilistic (WHO Tier 3) uncertainty analysis. However, limitations in available information prevent this level of analysis from being completed at this time. In particular, the incorporation of uncertainty related to key elements of C-R functions (e.g., competing lag structures, alternative functional forms, etc.) into a full probabilistic WHO Tier 3 analysis would require that probabilities be assigned to each competing specification of a given model element (with each probability reflecting a subjective assessment of the probability that the given specification is the "correct" description of reality). However, for many model elements there is insufficient information on which to base these probabilities. One approach that has been taken in such cases is expert elicitation; however, this approach is resource- and time-intensive and consequently, it was not feasible to use this technique in the current PM NAAQS review to support a WHO Tier 3 analysis.[30]

For most elements of this risk assessment, rather than conducting a full probabilistic uncertainty analysis, we have included qualitative discussions of the potential impact of uncertainty on risk results (WHO Tier1) and/or completed sensitivity analyses assessing the potential impact of sources of uncertainty on risk results (WHO Tier 2). Note, however, that in conducting sensitivity analyses, we have used both single- and multi-factor approaches (to look at the individual and combined impacts of sources of uncertainty on risk estimates). Also, as discussed below in section 3.5.4, in conducting sensitivity analyses, we used only those alternative specifications for input parameters or modeling approaches that were deemed to have scientific support in the literature (and so represent alternative reasonable input parameter values or modeling options). This means that the alternative risk results generated in the sensitivity analyses represent reasonable risk estimates that can be used to provide a context, with regard to uncertainty, within which to assess the set of core (base case) risk results (see section 4.5.3).

The sensitivity analysis also includes coverage for potential variability in the pattern of reductions in ambient $PM_{2.5}$ concentrations associated with simulations of just meeting the current and alternative suites of standards. Specifically, as discussed above in section 3.2.3, we have included three alternative rollback methods (proportional, hybrid and peak shaving) to provide coverage for variability in this potentially important factor influencing risk estimates.

In addition to the qualitative and quantitative treatment of uncertainty and variability which are described here, we have also completed two additional analyses intended to place the risk results generated for the 15 urban study areas in a broader national context. The first is a representativeness analysis (described in section 4.4) which evaluates the set of urban study areas against national-distributions of key PM risk-related attributes (with the goal of determining the degree to which the study areas are representative of national trends in these parameters). The second is a national-scale assessment of long-term mortality related to $PM_{2.5}$ exposures (discussed in chapter 5). In addition to providing an estimate of the national impact of $PM_{2.5}$ on long-term mortality, this analysis also evaluates whether the set of 15 urban study areas generally represents the broader distribution of risk across the U.S., or a more focused portion of the national risk distribution (e.g., the higher-end).

[30] Note, that while a full probabilistic uncertainty analysis was not completed for this risk assessment, we were able to use confidence intervals associated with effects estimates (obtained from epidemiological studies) to incorporate statistical uncertainty associated with sample size considerations in the presentation of risk estimates.

The remainder of this section is organized as follows. Key sources of variability which are reflected in the design of the risk assessment, along with sources excluded from the design, are discussed in section 3.5.2. A qualitative discussion of key sources of uncertainty associated with the risk assessment (including the potential direction, magnitude and degree of confidence associated with our understanding of the source of uncertainty – the knowledge base) is presented in section 3.5.3. The methods and results of the single- and multi-factor sensitivity analyses completed for the risk assessment are presented in section 3.5.4. An overall summary of the methods used to address uncertainty and variability for the 15 urban study areas (including the two assessments intended to place the urban study areas in a broader national context) is presented in section 3.5.5.

3.5.2 Treatment of Key Sources Of Variability

The risk assessment was designed to cover the key sources of variability related to population exposure and exposure response, to the extent supported by available data.[31] However, as with all risk assessments, there are sources of variability which have not been fully reflected in the design of the risk assessment and consequently introduce a degree of uncertainty into the risk estimates. While different sources of variability were captured in the risk assessment, it was generally not possible to separate out the impact of each factor on population risk estimates, since many of the sources of variability are reflected collectively in a specific aspect of the risk model. For example, inclusion of urban study areas from different PM regions likely provides some degree of coverage for a variety of factors associated with $PM_{2.5}$ risk (e.g., air conditioner use, $PM_{2.5}$ composition, differences in population commuting and exercise patterns, weather). However, the model is not sufficiently precise or disaggregated to allow the individual impacts of any one of these sources of variability on the risk estimates to be characterized.

Key sources of potential variability that are likely to affect population risks are discussed below, including the degree to which they are (or are not) fully captured in the design of the risk assessment:

[31] The term "key sources of variability" refers to those sources that the EPA staff believes have the potential to play an important role in impacting population incidence estimates generated for this risk assessment. Specifically, EPA staff has concluded that these sources of uncertainty, if fully addressed and integrated into the analysis, could result in adjustments to the core risk estimates which might be relevant from the standpoint of interpreting the risk estimates in the context of the PM NAAQS review. The identification of sources of variability as "key" reflects consideration for sensitivity analyses conducted for previous PM NAAQS risk assessments, which have provided insights into which sources of variability (reflected in different elements of those earlier sensitivity analyses) can influence risk estimates, as well as information presented in the final PM ISA. For example, chapter 2 of the final PM ISA addresses such issues as: ambient PM variability and correlations (section 2.1.1), trends and temporal variability (section 2.1.2), correlations between pollutants (section 2.1.4), and source contributions to PM (section 2.1.6). These discussions were carefully considered by staff in identifying key sources of variability to address both in the risk assessment and in the qualitative discussion of variability presented in this section.

- **$PM_{2.5}$ composition**: While information was not available to support modeling risk associated with different components of $PM_{2.5}$, the assessment did use effect estimates (for a number of the short-term exposure-related health endpoints) differentiated by region of the country, or differentiated for specific urban locations (sections 3.3.3 and 3.3.4). While many factors may contribute to differences in effect estimates (for the same health endpoint) across different locations, compositional differences in $PM_{2.5}$ may be partially responsible. Therefore, while the analysis did not explicitly address compositional differences in generating risk estimates, potential differences in $PM_{2.5}$ composition may be reflected in those effect estimates that are differentiated by region and/or urban study area. The effect estimates for mortality associated with long-term exposure to $PM_{2.5}$ are not regionally differentiated and instead, a single national-scale estimate is used. This means that any differences in risks of mortality associated with long-term exposure to $PM_{2.5}$ that are linked to differences in $PM_{2.5}$ composition (or to any other differences across regions or locations) would not be discernable, since a single national-scale risk estimate is generated for each mortality category. In addition to using region- or location-specific effect estimates for health effects associated with short-term exposures, the selection of urban areas to include in the risk assessment was designed in part to ensure that areas in different regions of the country, with different $PM_{2.5}$ composition, were included.

- **Intra-urban variability in ambient $PM_{2.5}$ levels**: Several recent studies (e.g., Jerrett et al., 2005) have addressed the issue of heterogeneity of PM concentrations within urban areas and its potential impact on the estimation of premature mortality associated with long-term exposure to $PM_{2.5}$. Most recently, the HEI Reanalysis II (Krewski et al., 2009), focusing on the ACS dataset, discusses epidemiological analyses completed for Los Angeles and New York City which included more highly-refined (zip code level) characterizations of spatial gradients in population exposure within each urban area based on land-use regression methods and/or kriging. While both analyses provide insights into the issue of intra-urban heterogeneity in $PM_{2.5}$ concentrations and its potential implications for epidemiology-based health assessments, due to the time and resource necessary to integrate them into the risk assessment, we were not able to incorporate these studies quantitatively. The implications of these studies for interpretation of long-term mortality C-R functions and potential exposure error associated with those functions is discussed below in section 3.5.3.

- **Variability in the patterns of ambient $PM_{2.5}$ reduction as urban areas:** In simulating just meeting the current or alternative suites of standards, there can be considerable variability in the patterns of ambient $PM_{2.5}$ reductions that result from different simulation approaches (i.e., they can be more localized, more regional, or some combination thereof). To address this issue in the risk assessment, we have included three rollback approaches as part of the sensitivity analysis including: proportional (reflecting regional patterns of reduction), hybrid (reflecting a combination of localized and regional patterns of reduction), and peak shaving (reflecting localized patterns of reduction) (see section 3.2.3 for additional detail on these rollback methods and section 3.5.4 for a description of how this factor is addressed in the sensitivity analysis).

- **Copollutant concentrations**: Inclusion of copollutant models in short-term exposure-related time series studies has produced mixed results in terms of the degree of attenuation of the $PM_{2.5}$ signal that results from inclusion of other pollutants (see final PM ISA, sections 6.2.10.9 and 6.3.8.5). The PM ISA (section 6.2.10.9) suggests that these inconsistent findings associated with controlling for gaseous pollutants are likely due to differences in the correlation structure among pollutants as well as differing degrees of exposure measurement error related to the copollutants. Further, the PM ISA (section 2.1.3) notes that correlations between PM and copollutants (including CO, O_3, SO_2 and NO_2) can vary both seasonally and spatially. Therefore, it is possible that the degree of attenuation of $PM_{2.5}$-related risk by copollutants may differ across study areas. However, because the multi-city studies used in the core risk assessment (Zanobetti and Schwartz., 2009; Bell et al., 2008; and Krewski et al., 2009) provide single pollutant models, our analysis does not directly address the issue of copollutant confounding (see section 3.5.3 for additional discussion of uncertainty introduced into the analysis as a result of not including copollutant models in the core risk assessment). We did explore the issue of copollutant modeling in the context of modeling long-term exposure-related mortality as part of the sensitivity analysis (section 3.5.4). In addition, the potential impact of copollutant confounding on short-term exposure-related mortality and morbidity was explored in the Moolgavkar et al., 2003 study, as discussed below in section 4.3.1.1 (although they have limited applicability to the core risk estimates generated in this RA).
- **Demographics and socioeconomic-status (SES)-related factors:** Variability in population density particularly in relation to elevated levels of $PM_{2.5}$ has the potential to influence population risk. In addition, other aspects of demographics such as age of housing stock (which can influence rates of air conditioner use thereby impacting rates of infiltration of PM indoors) can impact exposure and therefore risk (discussed in PM ISA – sections 2.2.1 and 2.3.2). While risk modeling completed for this analysis is based on concentrations measured at central-site monitors used as surrogates for population exposure and does not explicitly consider more detailed patterns of PM exposure by different subpopulations, potential differences in exposure to $PM_{2.5}$ reflecting demographic and SES-related factors is covered to some degree by the use of urban study area-differentiated effects estimates (for short-term exposure-related mortality) and regionally-differentiated effects estimates (in the case of short-term exposure-related morbidity). In the case of long-term exposure-related mortality, while the modeling for this group of endpoints does not utilize location-specific or regionally-differentiated effects estimates, the national-scale effects estimates that are used do reflect differences in exposure and health response across urban study areas (which will reflect, to some extent, differences in demographics and SES-related factors to the extent that these factors influence the relationship between $PM_{2.5}$ exposure and mortality response, as detected by the underling cohort studies).
- **Behavior affecting exposure to $PM_{2.5}$**: We have incorporated, where available, region- and/or city-specific effect estimates in order to capture behavioral differences across locations that could affect population exposures to $PM_{2.5}$ (e.g., time spent outdoors, air conditioning use). However, while these location-specific effect estimates may be capturing differences in behavior, they may also be capturing other

differences (e.g., differences in the composition of $PM_{2.5}$ to which populations are exposed). As noted above, it was not possible to separate out the impact of these different factors, which may vary across locations and populations, on effect estimates.

- **Baseline incidence of disease**: We collected baseline health effects incidence data (for mortality and morbidity endpoints) from a number of different sources (see section 3.4). Often the data were available at the county-level, providing a relatively high degree of spatial refinement in characterizing baseline incidence given the overall level of spatial refinement reflected in the risk assessment as a whole. Otherwise, for urban study areas without county-level data, either (a) a surrogate urban study area (with its baseline incidence rates) was used, or (b) less refined state-level incidence rate data were used.
- **Longer-term temporal variability in ambient $PM_{2.5}$ levels** (reflecting meteorological trends, as well as future changes in the mix of $PM_{2.5}$ sources and regulations impacting $PM_{2.5}$): Risk estimates for the $PM_{2.5}$ NAAQS review have been generated using recent years of air quality data. In other words, efforts have not been made to simulate potential future changes in either the concentrations or composition of ambient $PM_{2.5}$ in the risk assessment locations based on possible changes in economic activity, demographics or meteorology. Actual risk levels potentially experienced in the future as a result of implementing alternative standard levels may differ from those presented in this report due, in part, to potential changes in these factors related to ambient $PM_{2.5}$.

3.5.3 Qualitative Assessment of Uncertainty

As noted in section 3.5.1, we have based the design of the uncertainty analysis carried out for this risk assessment on the framework outlined in the WHO guidance document (WHO, 2008). That guidance calls for the completion of a Tier 1 qualitative uncertainty analysis, provided the initial Tier 0 screening analysis suggests there is concern that uncertainty associated with the analysis is sufficient to significantly impact risk results (i.e., to potentially affect decision making based on those risk results). Given previous sensitivity analyses completed for prior PM NAAQS reviews, which have shown various sources of uncertainty to have a potentially significant impact on risk results, we believe that there is justification for conducting a Tier 1 analysis. In fact, as argued earlier, given the complexity of the overall risk assessment, a full Tier 3 uncertainty analysis is warranted for consideration under the WHO guidelines (although as discussed later, limitations in available data preclude completion of this level of more-refined uncertainty analysis at this time).

For the qualitative uncertainty analysis, we have described each source of uncertainty and qualitatively assessed its potential impact (including both the magnitude and direction of the impact) on risk results, as specified in the WHO guidance. As shown in Table 3-13, for each source of uncertainty, we have (a) provided a description, (b) estimated the direction of influence (*over, under, both, or unknown*) and magnitude (*low, medium, high)* of the potential impact of each source of uncertainty on the risk estimates, (c) assessed the degree of uncertainty (*low,* *medium, or high*) associated with the knowledge-base (i.e., assessed how well we understand each source of uncertainty), and (d) provided comments further clarifying the qualitative assessment presented. Table 3-13 includes all key sources of uncertainty identified for the $PM_{2.5}$ NAAQS risk assessment. A subset of these sources has been included in the Tier 2 quantitative assessment discussed in section 3.5.4.

The categories used in describing the potential magnitude of impact for specific sources of uncertainty on risk estimates (i.e., low, medium, or high) reflect EPA staff consensus on the degree to which a particular source could produce a sufficient impact on risk estimates to influence the interpretation of those estimates in the context of the PM NAAQS review.[32] Sources classified as having a "low" impact would not be expected to impact the interpretation of risk estimates in the context of the PM NAAQS review; sources classified as having a "medium" impact have the potential to change the interpretation; and sources classified as "high" are likely to influence the interpretation of risk in the context of the PM NAAQS review (if those sources of uncertainty are reduced or more fully characterized). Because this classification of the potential magnitude of impact of sources of uncertainty is qualitative and not informed directly by any type of analytical results, it is not possible to place a quantitative level of impact on each of the categories. [33] Therefore, the results of the qualitative analysis of uncertainty have limited utility in informing consideration of overall confidence in the core risk estimates and, instead, serve primarily as a means for guiding future research to reduce uncertainty related to $PM_{2.5}$ risk assessment.

As with the qualitative discussion of sources of variability included in the last section, the characterization and relative ranking of sources of uncertainty addressed here is based on consideration by EPA staff of information provided in previous PM NAAQS risk assessments (particularly sensitivity analyses), the results of the sensitivity analyses completed for the current PM NAAQS risk assessment and information provided in the final PM ISA as well as earlier PM Criteria Documents. Where appropriate, in Table 3-13, we have included references to specific sources of information considered in arriving at a ranking and classification for a particular source of uncertainty.

---

[32] For example, if a particular source of uncertainty were more fully characterized (or if that source was reduced, potentially reducing bias in a core risk estimate), would the estimate of incremental risk reduction in going from the current to an alternative standard level change sufficiently to produce a different conclusion regarding the magnitude of that risk reduction in the context of the PM NAAQS review?

[33] Thematically, the categories used in the qualitative uncertainty analysis are similar to the categories used in categorizing the results of the single- and multi-factor sensitivity analyses completed for this analysis (section 4.3). However, in the context of the sensitivity analysis results, because we do have quantitative estimates of the impact of individual modeling elements, it is possible to categorize the modeling elements included in the sensitivity analysis based on magnitude of impact on risk estimates. This is not possible for the qualitative uncertainty analysis described in this section.

Table 3-13. Summary of Qualitative Uncertainty Analysis of Key Modeling Elements in the PM NAAQS Risk Assessment.

Source	Description	Potential influence of uncertainty on risk estimates		Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
		Direction	Magnitude		
A. Characterizing ambient $PM_{2.5}$ levels for study populations using the existing ambient monitoring network	If the set of monitors used in a particular urban study area to characterize population exposure as part of an ongoing risk assessment do not match the ambient monitoring data used in the original epidemiological study, then uncertainty can be introduced into the risk estimates.	Both	Low-medium	Low-medium	KB and INF: In modeling risk, we focus on those counties that were included in the epidemiological studies supplying the underlying C-R functions. This means that, particularly for those endpoints modeled using C-R functions obtained from more recent studies, there is likely a close association between the monitoring network used in the risk assessment and the network used in the study supplying the C-R function(s). Note, however, that in those instances where the networks are different (e.g., when older studies are used, resulting in an increased potential for networks to have changed), uncertainty may be introduced into the risk assessment and it is challenging to evaluate the nature and magnitude of the impact that that uncertainty would have on risk estimates, given the complex interplay of factors associated with mismatched monitoring networks (i.e., differences in the set of monitors used in modeling risk and those used in the underlying epidemiological study).
B. Characterizing policy-relevant background (PRB)	For this analysis, we have used modeling to estimate PRB levels for each urban study area. Depending on the nature of errors reflected in that modeling, uncertainty (in both directions) may be introduced into the analysis.	Both	Low	Low	INF: Given that the risk assessment focuses primarily on the reduction in risk associated with moving from the current NAAQS to alternative standard levels, the impact of uncertainty in PRB levels on the risk estimates is expected to be low. In addition, for long-term exposure related mortality, we have based the core analysis on modeling risk down to LML rather than PRB, which reduces the significance of the PRB issue in the context of modeling long-term exposure-related mortality.
C. Characterizing intra-urban population exposure in the context of epidemiology studies linking	Exposure misclassification within communities that is associated with the use of generalized population monitors (which may miss important patterns of exposure within urban study areas) introduces uncertainty into the	Under (generally)	Medium-high	High	KB and INF: Recent analyses in Los Angeles and New York City based on ACS data (as reported in Krewski et al., 2009) demonstrate the relatively significant effect that this source of uncertainty can have on effect estimates (and therefore on risk results). These analyses also illustrate the complexity and site-specific nature of this source of uncertainty. The results of the Los Angeles analysis suggest that exposure error may result in effects estimates that are biased low and therefore result in the

Source	Description	Potential influence of uncertainty on risk estimates		Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
		Direction	Magnitude		
$PM_{2.5}$ to specific health effects	effect estimates obtained from epidemiology studies.				underestimation of risk. Specifically in relation to the zip-code level analysis based on ACS data conducted in Los Angeles (Jerrett et al., 2005), the final ISA states that, "This [the refined exposure analysis reported in the Jerrett study] resulted in both improved exposure assessment and an increased focus on local sources of fine particle pollution. Significant associations between $PM_{2.5}$ and mortality from all causes and cardiopulmonary diseases were reported with the magnitude of the relative risks being greater than those reported in previous assessments. In general, the associations for $PM_{2.5}$ and mortality using these two methods [kriging and land-use regression] for exposure assessment were similar, though the use of land use regression resulted in somewhat smaller hazard ratios and tighter confidence intervals (see Table 7-9). This indicates that city-to-city confounding was not the cause of the associations found in the earlier ACS Cohort studies. This provides evidence that reducing exposure error can result in stronger associations between $PM_{2.5}$ and mortality than generally observed in broader studies having less exposure detail" (final ISA, section 7.6.3, p. 7-90).
D. Statistical fit of the C-R functions	Exposure measurement error combined with other factors (e.g., size of the effect itself, sample size, control for confounders) can effect the overall level of confidence associated with the fitting of statistical effect-response models in epidemiological studies.	Both	• Low-medium (long-term health endpoints) • Medium (short-term health endpoints)	Medium	INF: Long-term mortality studies benefit from (a) having larger sample sizes (given that large national datasets are typically used in deriving national-scale models), (b) the fact that the form of the models used appears to be subject to relatively low uncertainty (see next row below) and (c) our not attempting to derive location-specific effects estimates (but instead, relying on national-scale estimates). These factors combine to produce effects estimates that tend to be statistically robust (as reflected in results presented in Krewski et al., 2009). In addition, while concerns remain regarding exposure misclassification and potential confounding, generally we do not believe that the effects estimates are consistently biased in a particular direction. In the case of short-term mortality and morbidity health endpoints, there is greater uncertainty associated with the fit of models given the smaller sample sizes often involved, difficulty in identifying the etiologically relevant time period for short-term PM exposure, and the fact that models tend to be fitted to individual counties or

Source	Description	Potential influence of uncertainty on risk estimates		Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
		Direction	Magnitude		
					urban areas (which introduces the potential for varying degrees of confounding and effects modification across the locations). In contrast to the long-term mortality studies, the short-term mortality and morbidity endpoints occasionally have effects estimates that are not statistically significant. Note, however that for this risk assessment, in modeling both short-term mortality and morbidity endpoints, we are not relying on location-specific models. In the case of short-term mortality, we are using city-specific effects estimates derived using Bayesian techniques (these combine national-scale models with local-scale models) (personal communication with Zanobetti, 2009). For short-term morbidity, we are using regional effects estimates (Bell et al., 2008). In both cases, while effects estimates are at times non-statistically significant, these models do benefit from larger sample sizes compared to city-specific models.
E. Shape of the C-R functions	Uncertainty in predicting the shape of the C-R function, particularly in the lower exposure regions which are often the focus in PM NAAQS regulatory reviews.	Both	Medium	Low-medium	INF: Regarding long-term mortality, the ISA suggests that a log-linear non-threshold model is best supported in the literature for modeling both short-term and long-term health endpoints. Although consideration for alternative model forms (Krewski et al., 2009) does suggest that different models can impact risk estimates to a certain extent, generally this appears to be a moderate source of overall uncertainty. Particularly if, as is the case in this risk assessment, we are not extrapolating below the lowest measured levels found in the underlying epidemiological studies. With regard to long-term mortality, the final ISA concludes that, "In addition to examining the concentration-response relationship between short-term exposure to PM and mortality, Schwartz et al. (2008, 156963) conducted an analysis of the shape of the concentration-response relationship associated with long-term exposure to PM. Using a variety of statistical methods, the concentration-response curve was found to be indistinguishable from linear, and, therefore, little evidence was observed to suggest that a threshold exists in the association between long-term exposure to $PM_{2.5}$ and the risk of death (Section 7.6)." (section 2.4.3, p. 2-26). Regarding short-term morbidity, the final ISA states that, "Overall, the studies evaluated

Source	Description	Potential influence of uncertainty on risk estimates: Direction	Potential influence of uncertainty on risk estimates: Magnitude	Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
					further support the use of a no-threshold log-linear model, but additional issues such as the influence of heterogeneity in estimates between cities, and the effect of seasonal and regional differences in PM on the concentration-response relationship still require further investigation." (section 2.4.3, p. 2-25).
F. Addressing co-pollutants	The inclusion or exclusion of co-pollutants which may confound, or in other ways, affect the PM effect, introduces uncertainty into the analysis.	Both	Low-medium	Medium	INF: With regard to long-term health endpoints, the final ISA states that, "Given similar sources for multiple pollutants (e.g., traffic), disentangling the health responses of co-pollutants is a challenge in the study of ambient air pollution." (ISA, section 7.5.1, p. 7-57). The final ISA also notes that in some instances, consideration of copollutants can have a significant impact on risk estimates. For example, the more refined study of mortality in LA as reported in Krewski et al., 2009 suggested that inclusion of ozone in the model along with $PM_{2.5}$ results in statistically non-significant results for long-cancer mortality, while IHD-associated mortality remained statistically significant (Krewski et al., 2009 – Table 23). With regard to short-term mortality and morbidity, the final ISA generally concludes that observed associations are fairly robust to the inclusion of copollutants in the predictive models (see ISA, sections 6.3.8, 6.3.9, and 6.3.10). The mixed impact of considering multi-pollutant models in assessing $PM_{2.5}$-associated risk for short-term and long-term exposure related endpoints, leads us to conclude that the potential impact of this source of uncertainty is low-medium (depending on the specific endpoints under consideration). The epidemiological studies used as the basis for selecting C-R functions for the core risk assessment did not include multi-pollutant models (with the exception of $PM_{10-2.5}$ and $PM_{2.5}$ combined models in Zanobetti and Schwartz, 2009). However, we have included copollutant models in the sensitivity analysis (see Section 4.3).
G. Potential variation in effects estimates reflecting compositional	The composition of PM can differ across study areas reflecting underlying differences in primary and secondary $PM_{2.5}$ sources (both natural and anthropogenic). If	Both	Medium-High	Medium-High	KB and INF: Epidemiology studies examining regional differences in $PM_{2.5}$-related health effects have found differences in the magnitude of those effects (see sections 2.3.1.1 and 2.3.2 in the draft ISA). While these may be the result of factors other than composition (e.g., different degrees of exposure misclassification), composition remains one potential explanatory factor. For short-

Source	Description	Potential influence of uncertainty on risk estimates		Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
		Direction	Magnitude		
differences for PM	these compositional differences in fact translate into significant differences in public health impact (per unit concentration in ambient air) for $PM_{2.5}$ then significant uncertainty may be introduced into risk assessments if these compositional differences are not explicitly addressed.				term exposure morbidity and mortality effects, the inclusion of city-specific and/or regional-specific effect estimates in the risk assessment may well reflect differences in PM composition and, thus consideration of differences in risk due to city-specific differences in composition may already be incorporated in the risk estimates for these endpoints to some extent.
H. Specifying lag structure (short-term exposure studies)	Different lags may have varying degrees of association with a particular health endpoint and it may be difficult to clearly identify a specific lag as producing the majority of a PM-related effect (recently, distributed lags have been recommended since they allow for a distribution of the impact across multiple days of PM exposure prior to the health outcome). A lack of clarity regarding the specific lag(s) associated with a particular health endpoint adds uncertainty into risk estimates generated for that endpoint.	Both	Medium	Medium	KB and INF: With regard to lag periods, the ISA states, "An attempt has been made to identify whether certain lag periods are more strongly associated with specific health outcomes. The epidemiologic evidence evaluated in the 2004 PM AQCD supported the use of lags of 0-1 days for cardiovascular effects and longer moving averages or distributed lags for respiratory diseases (U.S. EPA, 2004a). However, currently, little consensus exists as to the most appropriate a priori lag times to use when examining morbidity and mortality outcomes." (final ISA, section 2.4.2, p. 2-24). This suggests that uncertainty remains concerning the identification of appropriate lags, and thus the etiologically relevant time period for exposure to PM for specific health endpoints.
I. Transferability of C-R functions from study locations to urban study area locations	The use of effects estimates based on data collected in a particular location(s) as part of the underlying epidemiological study in different locations (the focus of the risk assessment) introduces uncertainty into the analysis.	Both	Medium (for long-term exposure mortality) Not applicable (for short-	Medium (for long-term exposure mortality) Low (for short-term exposure mortality)	INF: This issue has been ameliorated to a great extent in this risk assessment since we are now using multi-city studies for key short-term endpoints with effects estimates generally being applied only to urban study areas matching locations used in the underlying epidemiological study. In the case of long-term exposure mortality studies, these are designed to capture a more generalized national signal and therefore, concerns over the transferability of functions between locations is of greater concern.

Source	Description	Potential influence of uncertainty on risk estimates		Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
		Direction	Magnitude		
			term exposure health effect risk estimates)		
J. Use of single-city versus multi-city studies in the derivation of C-R functions	Often both single-city and multi-city studies are available (for a given health effect endpoint) for the derivation of C-R functions. Each of these study designs has advantages and disadvantages which should be considered in the context of assessing uncertainty in a risk assessment (Note, that generally this issue applies more to the modeling of short-term exposure-related endpoints then to the modeling of long-term exposure related endpoints, since the latter is typically based on multi-city prospective cohort studies).	Both	Medium	High	KB: Because many health endpoints have been evaluated using both single-city and multi-city studies, we have a relative large selection of single city studies and a few large multi-city studies to consider in examining this issue. INF: For reasons presented in section 3.3.3, we have decided to focus on multi-city studies as a source of C-R functions for the core risk assessment, reflecting advantages that these studies offer (e.g., they tend to have more statistical power and provide effect estimates with relatively greater precision than single city studies due to larger sample sizes, reducing the uncertainty around the estimated coefficient, and reducing publication bias). While the choice of multi-city studies is well-supported, this decision does introduce uncertainty since single city studies can provide a wider range of C-R functions (and associated effects estimates) reflecting greater variation in study design, differences in composition, human behavior, and copollutants, and differences in the input datasets used (e.g., ambient air monitors and disease baseline incidence data). Even if there is greater confidence in C-R functions obtained from multi-city studies, overall uncertainty in those C-R functions may be reflected to some extent in the range of C-R functions seen across single-city studies.
K. Impact of historical air quality on estimates of health risk from long-term $PM_{2.5}$ exposures	Long-term studies of mortality suggest that different time periods of PM exposure can produce significantly different effects estimates, raising the issue of uncertainty in relation to determining which exposure window is most strongly associated with mortality.	Both	Medium	Medium	INF: The latest HEI Reanalysis II study (HEI, 2009) which looked at exposure windows (1979-1983 and 1999-2000) for long-term exposure in relation to mortality, did not draw any conclusions as to which window was more strongly associated with mortality. However, the study did suggest that moderately different effects estimates are associated with the different exposure periods (with the more recent period having larger estimates). Overall, the evidence for determining the window over which the mortality effects of long-term pollution exposures occur suggests a latency

Source	Description	Potential influence of uncertainty on risk estimates		Knowledge-Base uncertainty*	Comments (KB: knowledge base, INF: influence of uncertainty on risk estimates)
		Direction	Magnitude		
					period of up to five years, with the strongest results observed in the first few years after intervention (final ISA, section 7.6.4. p. 7-95).
L. Characterizing baseline incidence rates	Uncertainty can be introduced into the characterization of baseline incidence in a number of different ways (e.g., error in reporting incidence for specific endpoints, mismatch between the spatial scale in which the baseline data were captured and the level of the risk assessment).	Both	Low-medium	Low	INF: The degree of influence of this source of uncertainty on the risk estimates likely varies with the health endpoint category under consideration. There is no reason to believe that there are any systematic biases in estimates of the baseline incidence data. The influence on risk estimates that are expressed as incremental risk reductions between alternative standards should be relatively unaffected by this source of uncertainty. KB: The county level baseline incidence and population estimates at the county level were obtained from data bases where the relative degree of uncertainty is low.

* Refers to the degree of uncertainty associated with our understanding of the phenomenon, in the context of assessing and characterizing its uncertainty (specifically in the context of modeling PM risk)

The results presented in Table 3-13 consider only the potential impact of each source of uncertainty when acting in isolation to impact core risk estimates. However, it is likely that a number of these sources of uncertainty could act in concert to impact risk estimates and furthermore, that these combined effects could be more than additive in certain circumstances. EPA staff has identified several combinations of sources of uncertainty addressed in Table 3-13 that should be highlighted due to their potential to produce significant impacts on core risk estimates when acting in concert. These are briefly described below:

- **Uncertainty source D (statistical fit of the C-R functions), Source E (shape of the C-R functions), Source F (addressing copollutants), and Source J (use of single-city versus multi-city studies in the derivation of C-R functions):** Consideration of uncertainty associated with the shape of C-R functions needs to be considered in light of overall confidence (uncertainty) associated with a particular model. A number of factors contribute to an interpretation of confidence in a model including: statistical fit of the model, degree to which potential confounding by copollutants is considered, and other aspects of study design including single- versus multi-city study design. While choice of a particular model (e.g., threshold model, or log-log model) may produce a significant impact on risk estimates relative to alternative model forms, the overall scientific support for that particular model form (informed by consideration of the factors listed above) is an important consideration in assessing overall uncertainty both from a qualitative and quantitative standpoint.

In addition, there is the potential for sources of uncertainty discussed in Table 3-13 to interact with sources of variability covered in section 3.5.2 in impacting core risk estimates. One such interaction is discussed below:

- **Uncertainty source A (characterizing ambient $PM_{2.5}$ levels for study populations using the existing ambient monitoring network) and variability related to the pattern of ambient $PM_{2.5}$ reductions at urban study areas (see section 3.5.2):** The estimation of a composite monitor value to use in modeling risk for a study area under an alternative suite of standards is dependent both on the specification of the monitoring network and the approach used in adjusting the concentrations for the monitors in that network (i.e., the rollback approach used to simulate the pattern of ambient $PM_{2.5}$ reductions associated with just meeting the current or alternative suites of standards). As we have seen in modeling risk for Pittsburgh, refinements in the approach used to simulate air quality just meeting alternative suites of standards (in the case of Pittsburgh transitioning from a single study area to two distinct study areas each with different design values and separate assessments of rollback) produced significant differences in composite monitor values for the study area. Therefore, both of these factors (the definition of the monitoring network and rollback approach) can work in concert to impact ambient $PM_{2.5}$ levels and hence risk estimates.

3.5.4 Single and Multi-Factor Sensitivity Analyses

We quantitatively examined the impact of several inputs to the risk assessment in a series of single-factor sensitivity analyses summarized above in Table 3-8. A number of these sources of uncertainty were also examined in-concert to assess their combined impact on core risk estimates through the multi-factor sensitivity analysis. In addition, the sensitivity analysis considered variability in the pattern of reductions in ambient $PM_{2.5}$ associated with just meeting the current and alternative suites of standards (i.e., consideration of variability in the simulation of rollback). This section focuses on providing additional detail on the sources of alternative model specifications and input datasets used in the sensitivity analysis (as alternative to the core modeling approach).

Rather than present results for each sensitivity analysis for all of the air quality scenarios considered in the core analysis, we selected a single air quality scenario – $PM_{2.5}$ concentrations that just meet the current standards – to use for the sensitivity analyses. The one exception to this was the sensitivity analyses examining the impact of alternative approaches to simulating just meeting alternative standards (the hybrid and peak-shaving rollback methods).[34]

In discussing the approach used in conducting the sensitivity analysis, we focus first on methods used in assessing long-term exposure related health endpoints followed by the methods used in assessing short-term exposure related health endpoints. We then discuss multi-factor sensitivity analyses completed for both short-term and long-term exposure-related health endpoints. Note, that the results of the sensitivity analyses (including both single- and multi-factor analyses) are presented and discussed in section 4.3.

3.5.4.1 Sensitivity Analyses for Long-Term Exposure-Related Mortality

Because Krewski et al. (2009) presented results based on alternative model specifications only for the later exposure period (1999 – 2000), our sensitivity analyses focusing on the estimates of health effects incidence associated with long-term exposure to $PM_{2.5}$ similarly used the C-R functions based on this later exposure period. Krewski et al. (2009) considered several alternative modeling approaches to estimate the relationship between mortality (both all cause and cause-specific) and long-term exposure to $PM_{2.5}$, providing us the opportunity to examine the impact of alternative modeling approaches on the estimate of mortality risk associated with long-term exposure. In particular, we examined the impact of using a random effects log-linear model and of using a random effects log-log model[35] (rather than the standard fixed effects log-linear model used in the core analysis) to estimate the risks of all cause mortality,

---

[34] Sensitivity analyses focusing on the hybrid and peak-shaving rollback approach (relative to the proportional rollback approach used in the core analysis) involved the full set of alternative standard levels, in order to assess potential differences in risk across the range of standard levels.

[35] In the log-log model, the natural logarithm of mortality is a linear function of the natural logarithm of $PM_{2.5}$.

cardiopulmonary mortality, ischemic heart disease mortality, and lung cancer mortality associated with long-term exposure in Los Angeles and Philadelphia.[36] The coefficient of $PM_{2.5}$ in the random effects log-linear model was back-calculated from the relative risk reported in Table 9 ("Autocorrelation at MSA and ZCA levels" group – "MSA & DIFF" row) of Krewski et al. (2009). The coefficient of $PM_{2.5}$ in the random effects log-log model was back-calculated from the relative risks reported in Table 11 ("MSA and DIFF" rows) of Krewski et al. (2009).

As noted above, for all health endpoints associated with long-term exposure to $PM_{2.5}$ we estimated risk associated with $PM_{2.5}$ concentrations above 5.8 $\mu g/m^3$ (the LML for the later exposure period used in Krewski et al., 2009). In a sensitivity analysis we examined the impact of that limitation by comparing those mortality risk estimates to the mortality risk estimates obtained when we estimated risk associated with $PM_{2.5}$ concentrations above estimated PRB levels. This sensitivity analysis was carried out for all cause mortality in all 15 risk assessment urban areas.

In addition, we compared the impact of using the primary C-R functions used in the risk assessment, taken from Table 33 of Krewski et al. (2009), versus C-R functions for mortality associated with long-term exposure reported in another study, Krewski et al. (2000), which was based on a reanalysis of the Harvard Six Cities Study. The C-R functions estimated in Krewski et al. (2000) from the Harvard Six Cities cohort were estimated for ages 25 and up, while the C-R functions estimated in Krewski et al. (2009) from the ACS cohort were for ages 30 and up. For purposes of consistency in the comparison, however, we applied the C-R functions from Krewski et al. (2000) to ages 30 and up (and used the baseline incidence rates for that age group as well).[37] This sensitivity analysis was carried out for all cause mortality, cardiopulmonary mortality, and lung cancer mortality in Los Angeles and Philadelphia.

We also considered the impact of using multi-pollutant models in estimating long-term exposure-related mortality. Specifically, we obtained 2-pollutant models (considering CO, NO_2, O_3 or SO_2 together with $PM_{2.5}$) from Krewski et al., 2000, which is an earlier reanalysis of the ACS dataset and used them in generating alternative estimates of all-cause mortality to contrast with the core estimates generated using Krewski et al., 2009.

For all of the sensitivity analyses involving alternative C-R functions, in addition to calculating the incidence of the health effect when an alternative approach is taken, we

[36]As noted in Table 3-8, we combined both of these alternative modeling approaches in a single sensitivity analysis. In changing from a fixed effects log-linear model to a random effects log-log model, two changes are actually being made – the change from a fixed effects log-linear model to a random effects log-linear model, and the change from a random effects log-linear model to a random effects log-log model. However, because Krewski et al. (2009) did not present results for a fixed effects log-log model, it was not possible to compare the impact of making the single change from a fixed effects log-linear model (our core analysis selection) to a fixed effects log-log model. We thus instead present a two-stage sensitivity analysis incorporating both of the changes.

[37] The baseline incidence rates for ages 25 and up and ages 30 and up are likely to be very similar.

calculated the percent difference in estimates from the core analysis resulting from the change in analysis input. So for example, when we calculated the incidence of all cause mortality associated with long-term exposure to $PM_{2.5}$ using a random effects log-log model (instead of the fixed effects log-linear model used in the core analysis), we calculated the percent difference in the result as (incidence estimated using a random effects log-log model - incidence estimated using a fixed effects log-linear model)/(incidence estimated using a fixed effects log-linear model).

Finally, we also examined the issue of variability in estimating the pattern of reductions in ambient $PM_{2.5}$ levels under the current and alternative standard levels (i.e., conducting rollback). For the first draft RA, we considered the impact of using a hybrid rollback approach in addition to the proportional rollback approach which has been more traditionally used in PM NAAQS risk assessment (this sensitivity analysis was implemented including the generation of quantitative risk estimates for a full suite of long-term exposure-related mortality categories). For this second draft, as discussed above in sections 2.6, and 3.2.3, we have included consideration of a peak shaving rollback approach in addition to the hybrid as non-proportional methods to contrast with proportional rollback. As discussed in Section 3.2.3, for the second draft risk assessment, rather than generating quantitative risk estimates, we have calculated composite monitor estimates using the different rollback methods (proportional, hybrid and peak shaving). The composite monitor values are surrogates for long-term exposure-related mortality. Therefore, by comparing composite monitor values generated for the same study area/standard level combination (using different rollback methods), we can obtain insights into the potential impact of the rollback method used on long-term exposure-related mortality. Specifically, for this sensitivity analysis, we compared composite monitor values in two ways:

- *Potential difference in composite monitor values at the current or alternative standard level (for the same study area) given application of alternative rollback methods:* We compared the absolute magnitude of composite monitors values produced using different rollback methods for the same study area/standard level combination to provide insights into differences in the magnitude of <u>residual risk</u> for a given suite of standards in a study area using different rollback methods (Appendix F, Table F-50).[38] For example, in Table F-50, for Los Angeles, we see that for the current standard suite of standards, use of proportional rollback and peak shaving rollback methods results in composite monitor values of 9.5 $\mu g/m^3$ and 12.0 $\mu g/m^3$, respectively, with the peak shaving value being 40% higher than the value derived using proportional rollback. Given that the composite monitor values are surrogates for long-term exposure-related mortality, we conclude that for this combination of urban study area and suite of standards, use of the peak shaving rollback method could produce $PM_{2.5}$-attributable long-term mortality risk estimates that are approximately 40% higher than use of the proportional rollback method.

[38] This calculation reflects the fact that we model long-term exposure-related mortality down to LML.

- *Potential difference in the pattern of reduction in composite monitor values across alternative standards:* We compared differences in the percent reduction in composite monitor values across alternative suites of standards for the same study area using different rollback methods to provide insights into differences in <u>incremental risk reduction</u> resulting from the use of different rollback approaches (Appendix F, Table F-49).[39] For example, in Table F-49, for Baltimore, we see that the proportional rollback and hybrid rollback approaches resulted in composite monitor values for the 13/35 alternative suite of standards of 11.6 µg/m^3 and 11.8 µg/m^3, respectively, with these translating into a percent reduction (compared with their respective values under the current suite of standards) of 21% and 16%, respectively. Given that the composite monitor values are surrogates for long-term exposure-related mortality, we conclude that use of the two rollback methods (in the case of Baltimore for these two suites of standards) does not appear to produce notably different patterns of risk reduction (in terms of percent reduction), although residual risk could differ using the two approaches.

The peak-shaving and hybrid rollback approaches were not applied to all study areas, since they are primarily applicable in certain situations.[40] The sensitivity analysis results described above (presented in Appendix F, Tables F-49 and F-50) form the basis for summary information related to rollback approaches presented in Table 4-3.

In addition to the above insights regarding potential impacts on residual risk and the degree of risk reduction across standard levels, inclusion of multiple rollback approaches also allowed us to more fully examine the degree to which alternative 24-hour standards can produce reductions in annual-average $PM_{2.5}$ concentrations, thereby producing reductions in long-term exposure-related mortality. As discussed below in section 6.2, alternative 24-hour standards, when controlling, can result in reductions in annual average $PM_{2.5}$ concentrations, particularly if proportional rollback is used. In this case, the assumption of more regional patterns of $PM_{2.5}$ reduction in reducing $PM_{2.5}$ concentrations to just meet alternative 24-hour standards results in an equivalent magnitude of reduction in the annual average. However, in simulating more localized patterns of $PM_{2.5}$ reductions to just meet alternative 24-hour standards, the $PM_{2.5}$ reductions can be more limited to the monitor(s) (and areas) exceeding the 24-hour standard, and other monitors may not be effected, resulting in a smaller impact on the annual average. Inclusion of rollback approaches reflecting more localized patterns of ambient $PM_{2.5}$ reduction (i.e., the hybrid and particularly the peak shaving methods) allows us to assess the degree to which alternative 24-hour standards (when controlling) produce appreciable reductions in

[39] We note that this analysis also reflects calculation of long-term exposure-related mortality down to LML.

[40] For the hybrid rollback approach, only select study areas had the mix of local sources in proximity to monitor with elevated levels necessary to support consideration of a hybrid local/regional attainment strategy (i.e., application of the hybrid rollback) (i.e., Baltimore, Birmingham, Detroit, Los Angeles, New York, St. Louis). In the case of the peak sharing approach, only those locations where the 24-hour standard was controlling were considered for this sensitivity analysis (i.e., Atlanta, Baltimore, Birmingham, Detroit, Fresno, Los Angeles, New York, Philadelphia, Phoenix, Pittsburgh, St. Louis, Tacoma).

annual-average $PM_{2.5}$ concentrations and consequently in long-term exposure-related mortality. This issue is revisited in discussing the results of the sensitivity analysis (section 4.3.1.1) and in the integrative discussion of the core risk estimates (section 6.2).

3.5.4.2 Sensitivity Analyses for Short-Term Exposure-Related Mortality and Morbidity

The scope of the sensitivity analysis completed for short-term exposure-related mortality and morbidity is more limited than that completed for long-term exposure-related mortality. This reflects, in part, the much greater magnitude of long-term exposure-related mortality. An additional factor is that while there has been considerable research in the area of short-term exposure-related mortality and morbidity which sheds light on uncertainty in such factors as C-R function specification, this information is not directly applicable in a sensitivity analysis. In order to complete a quantitative sensitivity analysis, we need alternative C-R function specifications that produce risk estimates that can be directly compared to the core risk estimates. Ideally, this is done by identifying alternative model forms in the epidemiological study used in the core risk model. However, in the case of short-term exposure-related mortality, the studies providing our core risk models (Zanobetti and Schwartz et al., 2009 and Bell et al., 2008), only provide limited alternative model specifications, as described below. Further, alternative epidemiological studies, such as Moolgavkar et al., 2003, while providing useful insights into which factors can impact risk estimates (e.g., lag, multipollutant forms), cannot generate alternative risk estimates that can be readily compared with the core risk estimates given differences in the underlying study designs and datasets employed.

The primary studies selected to assess mortality risk and risk of hospitalization associated with short-term exposure to $PM_{2.5}$ (Zanobetti and Schwartz, 2009, and Bell et al., 2008, respectively) both provided all-year C-R functions as well as season-specific C-R functions. We examined the impact of using season-specific functions by applying these functions to each season, as defined by the study authors,[41] and summing the estimated season-specific incidences of mortality and hospitalizations. We compared these estimates to the estimates obtained by applying the corresponding all-year C-R functions to a year of air quality data.[42] This sensitivity analysis was carried out for all 15 of the risk assessment urban areas.

---

[41] Both studies defined each season as three months, beginning with winter defined as December, January, and February. In applying a season-specific function to a year of air quality data, we chose to keep a calendar year together, so that, for example, winter 2005 was defined as December 2005, January 2005, and February 2005.

[42] The mean season-specific incidence estimates can be summed to produce an all-year estimate of incidence. However, the 2.5th and 97.5th percentile season-specific estimates cannot be summed. To calculate the 2.5th and 97.5th percentile estimates of all-year incidence from the season-specific estimates would require the variance-covariance matrix of the season-specific coefficient estimators, which was not available. Therefore our comparison of all-year estimates based on summed season-specific estimates versus estimates based on an all-year C-R function was carried out only using the mean estimates.

In addition, Ito et al. (2007) estimated an annual C-R function as well as a seasonal function for April through August for asthma ED visits in New York City. We compared the results of applying the annual C-R function to a whole year of air quality data to the results of applying the seasonal function to only those months (April through August) for which it was estimated.

Moolgavkar (2003) estimated C-R functions for several health endpoints – non-accidental and cardiovascular mortality; and cardiovascular and respiratory HAs – associated with short-term exposures to $PM_{2.5}$ in Los Angeles using different lag structures, different modeling approaches to incorporating weather and temporal variables, and single-pollutant versus multi-pollutant models. This study thus provided an opportunity to show the impact of lag structure, modeling approach, and single- vs. multi-pollutant models, individually, for several health endpoints associated with short-term exposures, although it is difficult to generalize to other locations since the study was only conducted in a single urban area. As noted earlier, differences in study design and the underlying datasets used prevent the results based on application of models from Moolgavkar et al., 2003 from being compared directly to the core risk estimates.

Finally, as with estimates of long-term exposure-related mortality, we also considered the impact of variability related to simulating ambient $PM_{2.5}$ levels under the suite of current standard levels (i.e., variability in conducting rollback) on estimates of non-accidental mortality associated with short-term exposures to $PM_{2.5}$ (using Zanobetti and Schwartz, 2009). However, in this case, we only considered the hybrid model (consideration of peak shaving focused on the impact on long-term exposure-related mortality). We note however, that sensitivity analysis findings based on consideration for peak shaving generally will hold for short-term exposure-related mortality and morbidity since both categories of health endpoints are also driven primary by annual-average $PM_{2.5}$ levels (see section 6.2). .

In all cases except the ED visits sensitivity analysis, in addition to calculating the incidence of the health effect when an alternative approach is taken, we calculated the percent difference in estimates from the core analysis resulting from the change in analysis input.[43]

3.5.4.3 Multi-factor Sensitivity Analyses

Each single-element sensitivity analysis shows how the estimates of $PM_{2.5}$–related health effects incidence change as we change a single element of the analysis (such as the form of the C-R function or the way we simulate just meeting a set of standards). Because each of the alternative modeling choices is considered to be a reasonable choice, the results of these single-

[43] We did not calculate percent different for the ED visits sensitivity analysis because the two different C-R functions (all-year in the core analysis vs. April through August in the sensitivity analysis) are also being applied to different portions of the year (all year vs. April through August), so it is something of an "apple to oranges" comparison.

element sensitivity analyses provide a set of reasonable alternative estimates that may similarly be considered plausible (see section 4.3). The results of the single-element sensitivity analysis are presented and discussed in section 4.3.1.

The single-element sensitivity analyses provide insight into which sources of uncertainty may have the greatest impact on risk estimates when acting alone. However, there are several sources of uncertainty in estimating $PM_{2.5}$–related health effects. To provide a more complete picture of the uncertainty surrounding estimates of $PM_{2.5}$–related health effects incidence – and to expand the set of reasonable alternative estimates – we next carried out multi-element sensitivity analyses. The results of the multi-factor sensitivity analysis are presented and discussed in section 4.3.1.2.

The choice of uncertain analysis elements to include in the multi-element sensitivity analyses was guided by the single-element sensitivity analyses. In particular, we selected those modeling choices that had the greatest impacts on the estimates of health effects incidence in the single-element sensitivity analyses to provide insight into the scope of possible estimates that, while perhaps not based on our first choice of analysis elements, are nevertheless plausible alternative estimates.

We identified three analysis elements that substantially affected the estimates of mortality associated with long-term exposure to $PM_{2.5}$ -- the model choice (fixed effects log linear vs. random effects log-log), whether effects are estimated associated with $PM_{2.5}$ concentrations down to the LML in the study (5.8 $\mu g/m^3$) or down to PRB, and whether a proportional or a hybrid rollback is used to simulate $PM_{2.5}$ concentrations that just meet a given set of standards. This resulted in 2 x 2 x 2 = 8 different estimates of mortality, all of which could be considered plausible, based on the fact that the underlying model choices are all considered reasonable.

We identified two analysis elements that substantially affected the estimates of mortality associated with short-term exposure to $PM_{2.5}$ – whether season-specific or all-year C-R functions were used and whether a proportional or a hybrid rollback approach was used to simulate just meeting the current and alternative standards.

3.5.5 Summary of Approach to Addressing Variability and Uncertainty

The characterization of uncertainty and variability associated with the risk assessment includes a number of elements, which have been discussed in detail above. These include:

- Identification of key sources of variability associated with $PM_{2.5}$-related population exposure and hazard response and the degree to which they are captured in the risk assessment (see section 3.5.2). When important sources of variability in exposure and/or hazard response are not reflected in a risk assessment, significant uncertainty can be introduced into the risk estimates that are generated. While not explicitly referenced in the WHO guidance, this assessment (focused on coverage for key sources of variability) could be considered part of a Tier 1 analysis (i.e., the qualitative characterization of sources of uncertainty).

- Qualitative assessment of uncertainty, including both an assessment of the magnitude of potential impact of each source on risk estimates (along with the potential direction of that impact) as well as an assessment of overall confidence associated with our understanding of that source of uncertainty (see section 3.5.3). This represents a WHO Tier 1 analysis.
- Single-factor sensitivity analysis intended to evaluate the impact of individual sources of uncertainty and variability on risk estimates (see section 3.5.4). The goal of this assessment is to evaluate the relative importance of these sources of uncertainty and variability in impacting core risk estimates. The single-factor sensitivity analysis represents a WHO Tier 2 analysis. In conducting these assessments, we have used alternative representations of modeling elements that have support in the literature to ensure that the risk estimates that are generated represent reasonable alternate estimates that can supplement the core risk estimates generated in the analysis (see section 4.5.3).
- Multi-factor sensitivity analysis intended to assess the combined impact of multiple sources of uncertainty and variability on risk estimates (see section 3.5.4). By considering the combined effect of multiple sources of uncertainty and variability, this analysis has the potential to identify any non-linearities which can magnify the impact of uncertainty and variability on risk estimates, especially if several non-linear factors act in concert. This also represents a WHO Tier 2 analysis. As with the single-factor sensitivity analysis results, these risk estimates are also generated using modeling inputs which have support in the literature and consequently, they also represent reasonable alternate estimates that supplement the core risk estimates (see section 4.5.2).

As noted above, since information was not available to characterize overall levels of confidence in alternative model inputs, the uncertainty characterization completed for this risk assessment did not include a full probabilistic assessment of uncertainty and its impact on core risk estimates (i.e., a WHO Tier 3 analysis was not completed). Further, the risk estimates generated using the single- and multi-factor sensitivity analyses do not represent uncertainty distributions, but rather additional plausible point estimates of risk (i.e., we do not know whether they represent risk estimates near the upper or lower bounds of a true but undefined uncertainty distribution and we do not know the actual population percentiles that they represent). The appropriate use for these reasonable alternate risk estimates in informing consideration of uncertainty in the core risk estimates is discussed in section 4.5.3.

In addition to the specific analyses discussed above, we have also completed two additional analyses intended to place the 15 urban study areas in a broader national context with regard to risk. These include a representativeness analysis which evaluates the way the 15 urban study areas compare to national distributions for key PM-related risk attributes (discussed in section 4.4). We have also completed a national-scale assessment of long-term mortality related to $PM_{2.5}$ exposures (chapter 5), which, in addition to providing an estimate of the national impact of $PM_{2.5}$ on long-term mortality, also evaluates whether the set of 15 urban study areas generally represents the broader distribution of risk across the U.S., or a more focused portion of the national risk distribution (e.g., the higher-end).

A third set of analyses that has been added to this second draft RA focuses on evaluating patterns in the design values (including both 24-hour and annual) and underlying $PM_{2.5}$ monitoring data for the 15 urban study areas (see Section 4.5). The goal of this analysis is to use this information to enhance our understanding of patterns in risk reduction seen under both the current and alternative suites of standards across the urban study areas. The interplay of design values and underlying $PM_{2.5}$ monitoring data play a key role in determining whether a location will experience risk reductions when just meeting any given suite of standards is simulated and, if so, the magnitude of those reduction. As part of this analysis, we contrast patterns in design values for the 15 urban study areas with patterns seen more broadly across urban areas in the U.S. with the goal of placing the urban study areas in a national context with regard to this key factor influencing risk.

4 URBAN CASE STUDY RESULTS

For this risk assessment, we have developed a core set of risk estimates supplemented by an alternative set of risk results generated using single-factor and multi-factor sensitivity analysis. The core set of risk estimates was developed using model inputs that staff judge to have a greater degree of support in the literature relative to inputs used in the sensitivity analyses (the rationale for selection of specific epidemiological studies and associated C-R functions for the core analysis is discussed above in section 3.3.3). This chapter presents and discusses the core set of risk estimates generated for the urban case study area, and also discusses the results of the sensitivity analyses which serve to augment the core risk estimates. The results of the sensitivity analyses allow us to evaluate and rank the potential impact of key sources of uncertainty on the core risk estimates. In addition, because the sensitivity analyses were conducted using alternative modeling inputs having some degree of support in the literature, the results of the sensitivity analysis also represent a set of reasonable alternatives to the core set of risk estimates that can be used to inform characterization of uncertainty in the core results (see section 4.3 below).

As discussed above in section 2.2 and 3.2, this risk assessment includes consideration of the following air quality scenarios:

- Recent conditions: based on $PM_{2.5}$ concentrations characterized through monitoring for the period 2005-2007 at each urban case study location;
- Current NAAQS: based on rolling back $PM_{2.5}$ concentrations to just meet the current suite of standards in each urban study area (annual standard of 15 $\mu g/m^3$ and a 24-hour standard of 35 $\mu g/m^3$, denoted 15/35);
- Alternative NAAQS: based on rolling back $PM_{2.5}$ concentrations to just meet alternative suites of standards in each urban study area:
    - annual standard of 14 $\mu g/m^3$ and a 24-hour standard of 35 $\mu g/m^3$ (denoted 13/35);
    - annual standard of 13 $\mu g/m^3$ and a 24-hour standard of 35 $\mu g/m^3$ (denoted 13/35);
    - annual standard of 12 $\mu g/m^3$ and a 24-hour standard of 35 $\mu g/m^3$ (denoted 12/35);
    - annual standard of 13 $\mu g/m^3$ and a 24-hour standard of 30 $\mu g/m^3$ (denoted 13/30);
    - annual standard of 12 $\mu g/m^3$ and a 24-hour standard of 25 $\mu g/m^3$ (denoted 12/25).

In simulating both current and alternative suites of standards, for the core analysis, we used a proportional roll-back approach (see section 3.2.3), while a hybrid roll-back approach reflecting the potential for local source control was used for a subset of urban study areas as part of the sensitivity analysis conducted for this assessment (see section 3.2.3). In addition, we have considered the peak-shaving approach as a further alternative to proportional rollback in simulating just meeting the current and alternative suites of standards. While we did not generate risk estimates based on application of the peak-shaving approach, we did generate composite monitor-based annual average $PM_{2.5}$ levels which allow us to assess how long-term exposure-related risk could vary if this alternative roll-back method was used (see Section 4.3).

As described in section 2.1 and 3.3.2, we assessed risk for 15 urban study areas chosen to provide coverage for the diversity of urban settings across the U.S. that reflect areas with elevated annual and/or daily $PM_{2.5}$ concentrations. At a minimum, all areas selected had recent air quality levels at or above the lowest annual and/or 24-hour standards analyzed. In addition, our goal was to select areas reflecting the heterogeneity in PM risk-related attributes such as sources, composition, demographics, and population behavior.

Risk estimates were generated for the following health effects endpoints: (a) long-term exposure-related mortality (all-cause, cardiopulmonary disease-related (CPD), ischemic heart disease-related (IHD) and lung cancer-related), (b) short-term exposure-related mortality (non-accidental, cardiovascular disease-related (CVD), respiratory), and (c) short-term exposure-related morbidity (hospital admissions (HA) for CVD and respiratory illness and emergency department (ED) visits). Risk estimates are presented separately for each of these 15 study areas, although in certain circumstances, risk estimates may be restricted to a subset of these locations if, for example, an endpoint is modeled using a C-R function derived from an epidemiological study that was conducted only in a subset of the urban areas. For the core analysis, long-term exposure mortality risk was modeled down to lowest measured level (LML), because the LML was higher than estimated PRB and because there is substantial uncertainty as to the shape of the concentration-response (C-R) function at concentrations below the LML. For long-term exposure mortality a sensitivity analysis was conducted that estimated risk down to policy-relevant background (PRB). In contrast, all short-term exposure health effects endpoints were modeled down to PRB, since this was higher than the LML across all studies and for purposes of NAAQS decision making, EPA is focused on risks associated with $PM_{2.5}$ levels that are due to anthropogenic sources that can be controlled by U.S. regulations (or through international agreements with neighboring countries).

In modeling long-term exposure mortality, for the core analysis, we have based estimates on the latest reanalysis of the American Cancer Society (ACS) dataset, with two sets of risk estimates being generated; one using a C-R function derived by fitting $PM_{2.5}$ monitoring data from 1979-1983 and a second set based on fitting $PM_{2.5}$ monitoring data from 1999-2000 (Krewski et al., 2009) (see section 3.3.3). In presenting core risk estimates for long-term mortality, both sets of estimates are given equal weight.

In modeling short-term exposure mortality and morbidity for the core analysis, we have used the latest multi-city studies (Zanobetti and Schwartz, 2009; Bell et al., 2008) (see section

3.3.3). In the case of short-term exposure mortality, we obtained and used city-specific effects estimates derived using empirical Bayes methods from the study authors (Zanobetti, 2009). Multi-city studies were favored for the core analysis, since these studies are not subject to publication bias and because they reflect a diverse set of locations with regard to the observed relationship between short-term $PM_{2.5}$ exposure and health affect response in the population. Additional detail on the specific C-R functions and related modeling elements such as effects estimates and lag periods used in the core analysis relative to the sensitivity analysis are presented above in sections 3.3 and 3.4 and called out where appropriate below as specific risk estimates are discussed.

The pattern of mortality incidence across the urban study areas is markedly different for short-term exposure-related mortality compared with long-term exposure-related mortality reflecting a number of factors including: (a) differences in patterns of daily $PM_{2.5}$ levels versus annual average values across the urban study areas and (b) the fact that urban study area-specific effect estimates are used in modeling short-term exposure-related mortality, while a single effect estimate is used for all study areas for long-term exposure-related mortality (for a particular mortality category). Further, effect estimates for short-term exposure-related mortality can be notably small for some study areas (e.g., the effect estimates for non-accidental mortality for Los Angeles is significantly smaller than effect estimates for the other study areas, thereby accounting for the relatively small total incidence estimate for this study area – see Appendix C, Table C-1).

Because the recent conditions air quality scenario spans three years (2005-2007), risk estimates are generated for each of these years, reflecting the underlying air quality data for a particular year. Risk metrics generated for the above health effects endpoints include:

- **Annual incidence of the endpoint due to $PM_{2.5}$ exposure (*annual incidence*)**: Generated for the population associated with a given urban study area (for a given simulation year), in most cases, these risk estimates include both a point estimate as well as a 95th percentile confidence interval, the latter reflecting sampling error as characterized in the underlying epidemiological study.
- **Percent of total annual incidence for the health endpoint due to $PM_{2.5}$ exposure (*percent of total incidence attributable to $PM_{2.5}$*):** Again, generated for the population associated with a given urban study area (and simulation year), this metric characterizes the fraction of total incidence that is associated with $PM_{2.5}$ exposure. As with the underlying PM-related incidence estimates, this risk metric also typically includes a 95th percentile confidence interval reflecting sampling error associated with the effects estimate. Compared with the annual incidence metric which reflects underlying population size for each study area, this risk metric has the advantage of not being dependent on the size of the underlying population, thereby allowing direct comparison of the potential impact of $PM_{2.5}$ for the health effect endpoint of interest across urban study area locations. For this reason, in discussing risk estimates in this section, the

percent of total incidence attributable to $PM_{2.5}$ risk metric is given greater emphasis than the absolute measure of *annual incidence attributable to $PM_{2.5}$*.

- **Percent reduction in $PM_{2.5}$-related health effect incidence for an alternative set of standards or the recent conditions scenario, relative to the current standards (*percent change from the current set of standards*)**: Also estimated separately for each urban study area and simulation year, this metric characterizes the degree of risk reduction (for alternative standard levels) or increased risk (for the recent conditions scenario) relative to the current NAAQS. For this metric, a negative value represents an increase in risk (this is the case for the recent conditions scenario, where risks are higher than those associated with just meeting the current suite of standards). This metric is positive, or zero, for alternative suites of standards since they either produce no risk reduction (if ambient air levels under recent conditions are already at or below that alternative standard levels), or a positive risk reduction for alternative standards resulting in a reductions in ambient $PM_{2.5}$ concentrations. Because this metric is incremental, it was not possible to generate the 95th percentile confidence intervals included with the other two "absolute" risk metrics described above. As with the previous risk metric, this metric is not dependent on the underlying population size and therefore, allows direct comparison across urban study areas.

In addition to presenting the central-tendency (highest confidence) estimates for each of these metrics, we also include 95th percentile confidence intervals, reflecting statistical uncertainty surrounding the estimated coefficients in the reported C-R functions used in deriving the risk estimates (note, that these confidence intervals only capture this statistical fit uncertainty – other sources of uncertainty including shape and form of the function, are addressed separately as part of the sensitivity analysis – see Section 4.3.1.1 and the qualitative analysis of uncertainty – see Section 3.5.3).

Detailed tables presenting estimates for these risk metrics for the complete set of air quality scenarios (for all 15 urban study areas) are included in Appendix E and referenced as needed in the discussion of risk estimates presented in the following sections. To support the discussion of risk estimates presented in this chapter, we have included a subset of tables and summary figures including:

- **Tables summarizing risk for the current standard levels**: Two tables are included which summarize both long-term and short-term exposure-related risk for the 15 urban study areas associated with just meeting the current suite of standards. Both tables include a subset of the health endpoints believed to have the greatest support in the literature including IHD mortality for long-term exposure, cardiovascular mortality and hospital admissions for short-term exposure. Table 4-1 presents total incidence attributable to $PM_{2.5}$ exposure for the endpoints and Table 4-2 presents percent of total incidence attributable to $PM_{2.5}$ exposure for these endpoints. Together, these tables inform consideration for the magnitude of public health impact (related to both long-term and short-term exposure to $PM_{2.5}$) associated with just meeting the current suite of standards in the 15 urban study areas.

- **Figures illustrating the percent reduction in long-term and short-term exposure-related risk for the alternative standard levels relative to the current standard (as well as increases in risk under recent conditions relative to the current standard)**: Figures 4-1 and 4-4 provide a snapshot of trends in risk reduction for long-term exposure-related risk (Figure 4-1) and short-term exposure-related risk (Figure 4-4) across alternative standard levels relative to the risk under the current standard. These figures include plots for each of the 15 urban study areas, thereby allowing trends in risk reduction across standard levels (and urban study areas) to be assessed simultaneously.[44] Each of these figures is presented in additional detail by splitting each into (a) comparison of the recent conditions risk against the current standard level and (b) comparison of risk under alternative standard level against the current standard, in order to allow a more detailed look at patterns in risk reduction for individual urban study areas (splitting Figures 4-1 and 4-4 in this fashion allows greater resolution in tracing the linear risk plots for each study area). Specifically, Figures 4-2 and 4-3 provide these higher-resolution plots for long-term exposure-related risk and Figures 4-5 and 4-6 provide higher-resolution plots for short-term exposure related risk.

Although risk estimates were generated for all three simulation years, in this chapter core risk estimates primarily from 2007 are presented and discussed for both the recent conditions air quality scenario and just meeting current and alternative suites of standards. This reflects the observation that in generally 2007 represents a reasonable central year (in terms of the magnitude of risk generated for the three simulated years), when considering results for all modeled health effect endpoints across the 15 study areas. In addition, 2007 is the most recent year of the three simulated. We note, however, that while we do focus on 2007 in presenting and discussing risk estimates, we include an assessment of general trends across the three simulation years to gain perspective on year-to-year variation in $PM_{2.5}$-related risk estimates as assessed here.

[44] Note, that importantly, patterns of risk reduction across standard levels (in terms of percent change relative to risk for the current standard level) are similar for all health endpoints modeled for a particular exposure duration (i.e., patterns of percent risk reduction will be similar for long-term exposure related all-cause, IHD and cardiopulmonary mortality). This reflects the fact that the C-R functions used in this risk assessment are close to linear across the range of ambient air levels evaluated. This allows us to present these figures plotting changes in risk more generally for short-term exposure-related endpoints and long-term exposure related endpoints without having to provide figures for each specific endpoint category.

Table 4-1. Estimated Annual Incidence of Selected Mortality and Morbidity Endpoints Associated with Long- and Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations. [1,2]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-term Exposure to PM2.5[3]		Incidence of Cardiovascular Mortality Associated with Short-term Exposure to PM2.5[4]	Incidence of Cardiovascular Hospitalizations Associated with Short term Exposure to PM2.5[5]
	Exposure Period: 1979-1983	Exposure Period: 1999-2000		
Atlanta, GA	220 (180 - 258)	277 (227 - 324)	32 (-33 - 95)	41 (-27 - 109)
Baltimore, MD	297 (243 - 349)	374 (307 - 440)	62 (-4 - 126)	216 (159 - 273)
Birmingham, AL	131 (107 - 154)	165 (135 - 194)	-1 (-42 - 40)	16 (-11 - 43)
Dallas, TX	195 (159 - 230)	247 (202 - 291)	29 (-19 - 76)	28 (-18 - 73)
Detroit, MI	377 (308 - 445)	478 (390 - 563)	60 (-8 - 127)	233 (171 - 295)
Fresno, CA	77 (63 - 92)	98 (80 - 116)	12 (-9 - 33)	23 (0 - 46)
Houston, TX	344 (281 - 405)	434 (355 - 511)	46 (-31 - 122)	56 (-37 - 149)
Los Angeles, CA	860 (701 - 1018)	1094 (890 - 1296)	-30 (-132 - 72)	258 (3 - 511)
New York, NY	1755 (1435 - 2070)	2222 (1814 - 2620)	473 (276 - 668)	752 (552 - 951)
Philadelphia, PA	261 (214 - 308)	330 (270 - 389)	84 (22 - 145)	203 (149 - 257)
Phoenix, AZ	317 (258 - 374)	402 (327 - 476)	84 (-4 - 170)	108 (1 - 215)
Pittsburgh, PA	256 (209 - 302)	324 (264 - 382)	43 (-9 - 93)	140 (103 - 177)
Salt Lake City, UT	15 (12 - 18)	19 (16 - 23)	9 (-2 - 20)	9 (0 - 18)
St. Louis, MO	446 (365 - 525)	563 (461 - 662)	106 (24 - 187)	178 (131 - 225)
Tacoma, WA	38 (31 - 46)	49 (40 - 58)	11 (-6 - 27)	19 (-46 - 82)

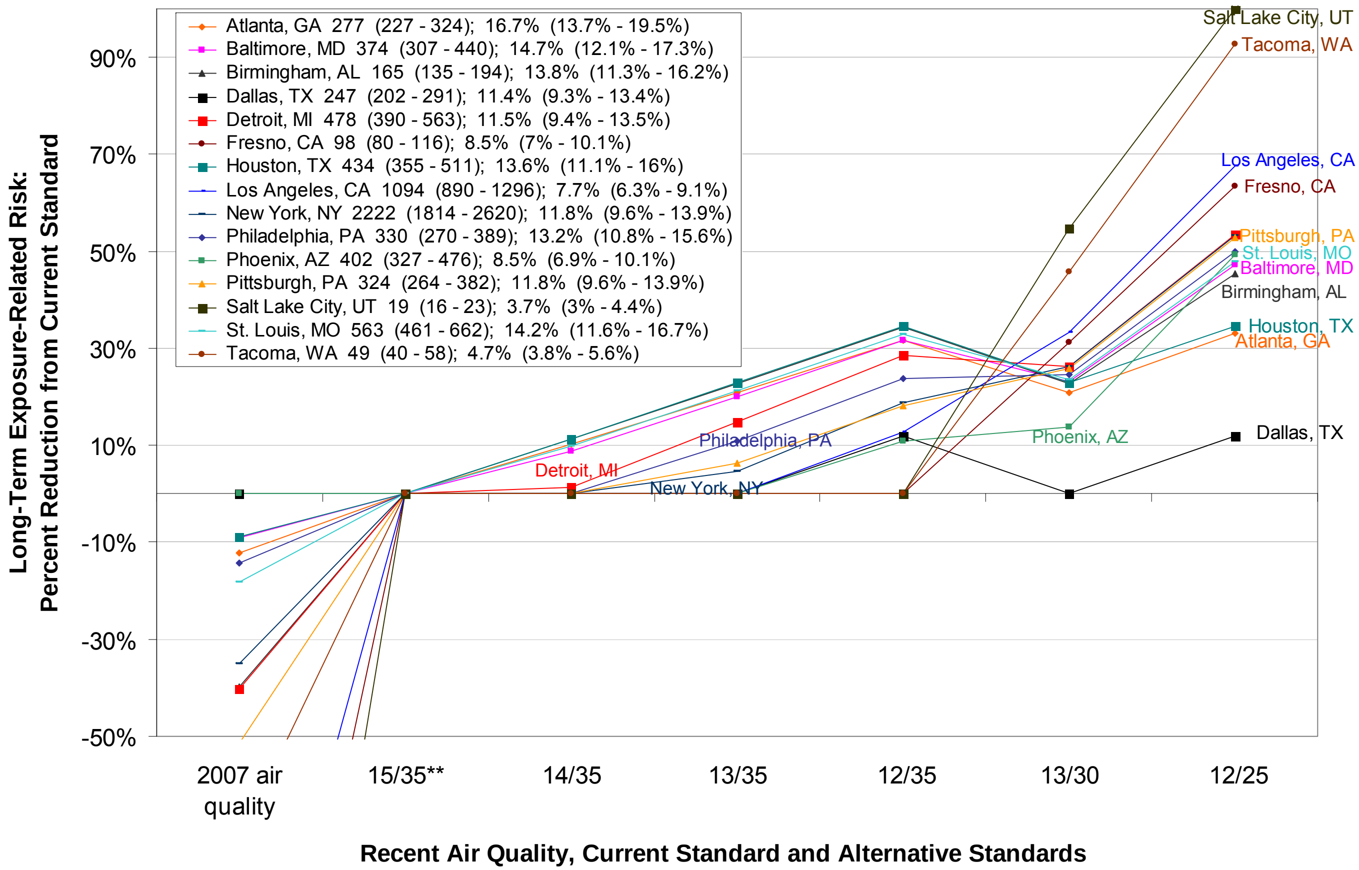
1The current primary PM2.5 standards include an annual standard set at 15 ug/m3 and a daily standard set at 35 ug/m3.
2Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
3Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1979 - 1983 and from 1999-2000 respectively.
4Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.
5Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

Table 4-2 Estimated Percent of Total Annual Incidence of Selected Mortality and Morbidity Endpoints Associated with Long- and Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations. 1,2

Risk Assessment Location	Percent of Incidence of Ischemic Heart Disease Mortality Associated with Long-term Exposure to PM2.5[3]		Percent of Incidence of Cardiovascular Mortality Associated with Short-term Exposure to PM2.5[4]	Percent of Incidence of Cardiovascular Hospital Admissions Associated with Short term Exposure to PM2.5[5]
	Exposure Period: 1979-1983	Exposure Period: 1999-2000		
Atlanta, GA	13.2% (10.9% - 15.5%)	16.7% (13.7% - 19.5%)	0.8% (-0.8% - 2.4%)	0.4% (-0.2% - 1%)
Baltimore, MD	11.7% (9.6% - 13.7%)	14.7% (12.1% - 17.3%)	1.6% (-0.1% - 3.2%)	1.3% (1% - 1.7%)
Birmingham, AL	10.9% (8.9% - 12.9%)	13.8% (11.3% - 16.2%)	0% (-1.5% - 1.5%)	0.3% (-0.2% - 0.9%)
Dallas, TX	9% (7.3% - 10.6%)	11.4% (9.3% - 13.4%)	0.8% (-0.5% - 2.2%)	0.3% (-0.2% - 0.7%)
Detroit, MI	9.1% (7.4% - 10.7%)	11.5% (9.4% - 13.5%)	1% (-0.1% - 2.2%)	1.1% (0.8% - 1.4%)
Fresno, CA	6.7% (5.5% - 8%)	8.5% (7% - 10.1%)	0.7% (-0.5% - 2%)	0.5% (0% - 0.9%)
Houston, TX	10.7% (8.8% - 12.6%)	13.6% (11.1% - 16%)	0.9% (-0.6% - 2.4%)	0.3% (-0.2% - 0.8%)
Los Angeles, CA	6.1% (4.9% - 7.2%)	7.7% (6.3% - 9.1%)	-0.2% (-0.7% - 0.4%)	0.5% (0% - 0.9%)
New York, NY	9.3% (7.6% - 11%)	11.8% (9.6% - 13.9%)	2.1% (1.2% - 3%)	1.2% (0.8% - 1.5%)
Philadelphia, PA	10.5% (8.6% - 12.3%)	13.2% (10.8% - 15.6%)	2.1% (0.5% - 3.6%)	1.3% (0.9% - 1.6%)
Phoenix, AZ	6.7% (5.5% - 7.9%)	8.5% (6.9% - 10.1%)	1.3% (-0.1% - 2.7%)	0.5% (0% - 1%)
Pittsburgh, PA	9.3% (7.6% - 11%)	11.8% (9.6% - 13.9%)	1.1% (-0.2% - 2.3%)	1.1% (0.8% - 1.4%)
Salt Lake City, UT	2.9% (2.4% - 3.4%)	3.7% (3% - 4.4%)	0.8% (-0.2% - 1.7%)	0.4% (0% - 0.7%)
St. Louis, MO	11.2% (9.2% - 13.2%)	14.2% (11.6% - 16.7%)	1.9% (0.4% - 3.3%)	1.3% (0.9% - 1.6%)
Tacoma, WA	3.7% (3% - 4.4%)	4.7% (3.8% - 5.6%)	0.7% (-0.4% - 1.8%)	0.5% (-1.3% - 2.3%)

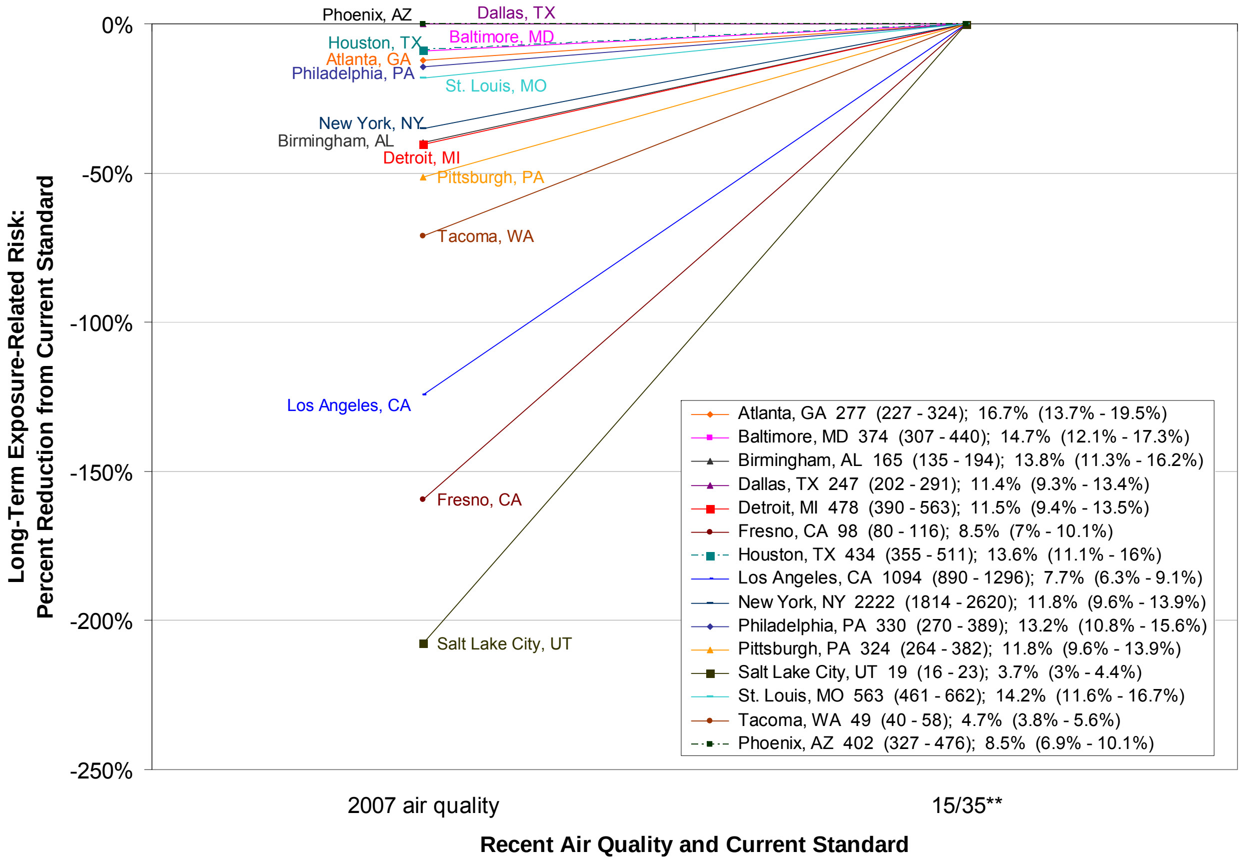
1The current primary PM2.5 standards include an annual standard set at 15 ug/m3 and a daily standard set at 35 ug/m3.
2Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
3Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1979 - 1983 and from 1999-2000 respectively
4Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.
5Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

Figure 4-1 **Percent reduction in long-term exposure-related mortality risk (**alternative standards and recent conditions relative to the current standards) (Note: inset shows $PM_{2.5}$ related incidence and percent of total incidence for IHD mortality under the current suite of standards**)**



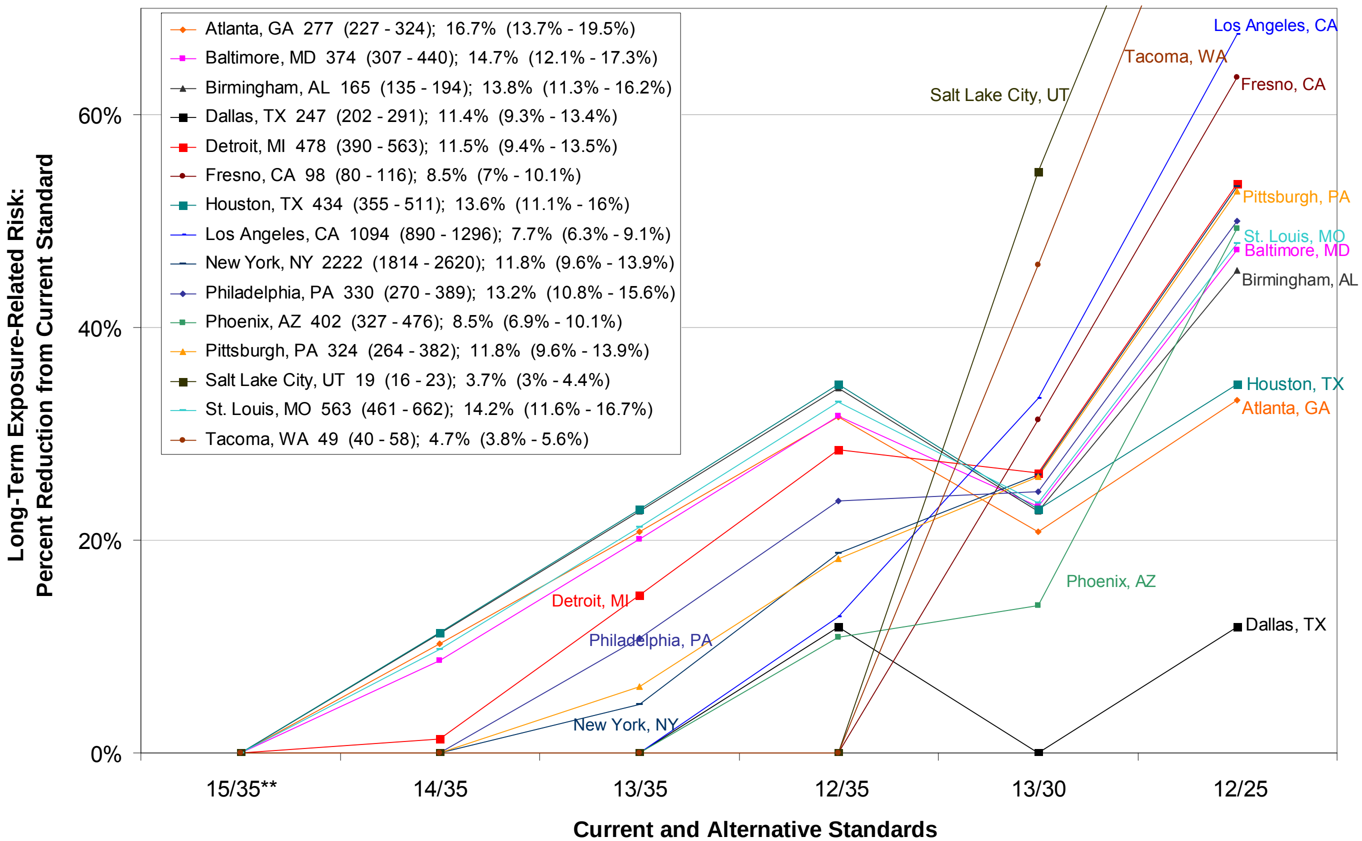
*Based on Krewski et al. (2009), exposure period from 1999 – 2000. The legend contains, for each urban area, the incidence estimate (and 95% CI) and the estimate of percent of total incidence (and 95% CI) under the current standards.
**The current standards consist of an annual standard of 15 µg/m^3 and a daily standard of 35 µg/m^3. Combinations of an annual standard (n) and a daily standard (m) are denoted n/m in this figure.

Figure 4-2 **Percent reduction in long-term exposure-related mortality risk** (recent conditions relative to the current standards) (Note: inset shows $PM_{2.5}$ related incidence and percent of total incidence for IHD mortality under the current suite of standards)



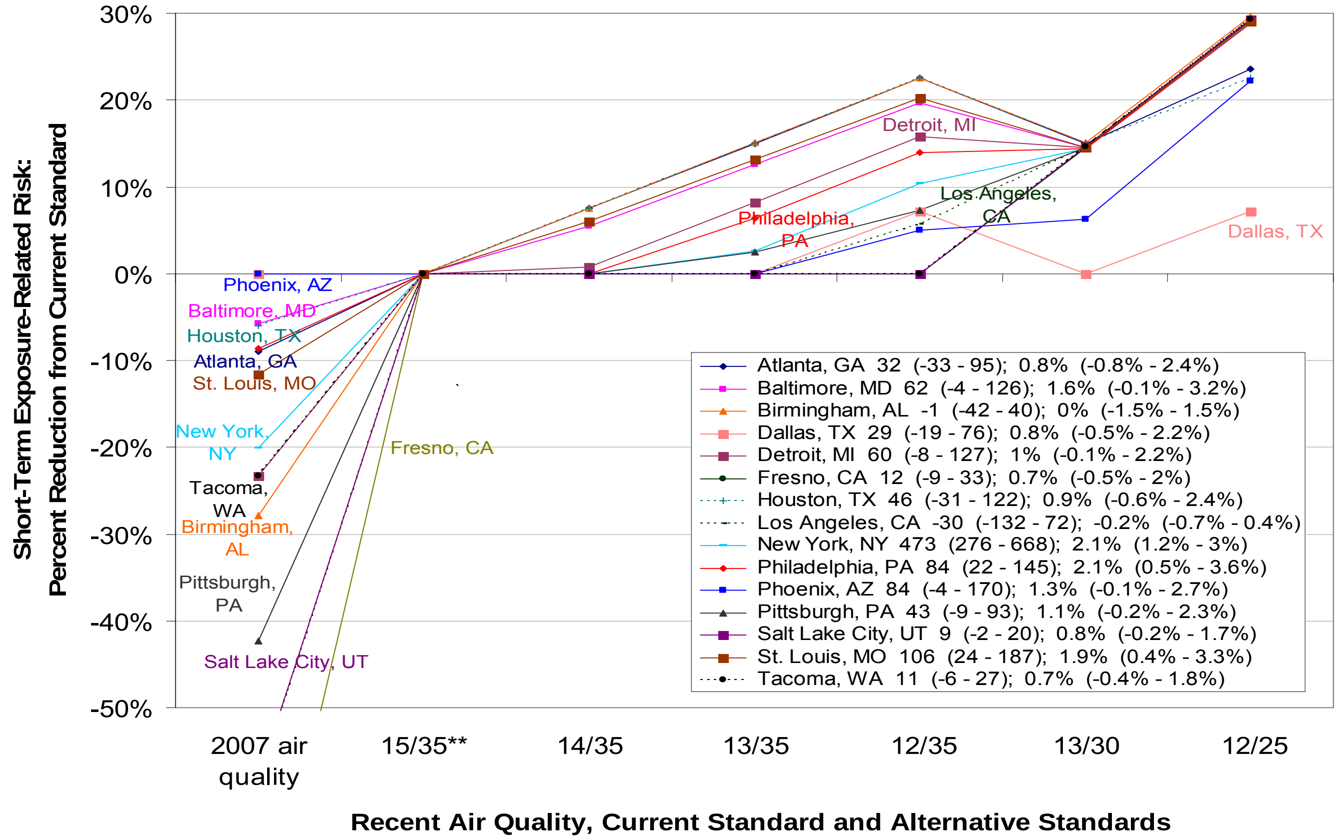
*Based on Krewski et al. (2009), exposure period from 1999 – 2000. The legend contains, for each urban area, the incidence estimate (and 95% CI) and the estimate of percent of total incidence (and 95% CI) under the current standards.
**The current standards consist of an annual standard of 15 μg/m^3 and a daily standard of 35 μg/m^3. Combinations of an annual standard (n) and a daily standard (m) are denoted n/m in this figure.

Figure 4-3 Percent reduction in long-term exposure-related mortality risk (alternative standards relative to the current standards) (Note: inset shows $PM_{2.5}$ related incidence and percent of total incidence for IHD mortality under the current suite of standards)



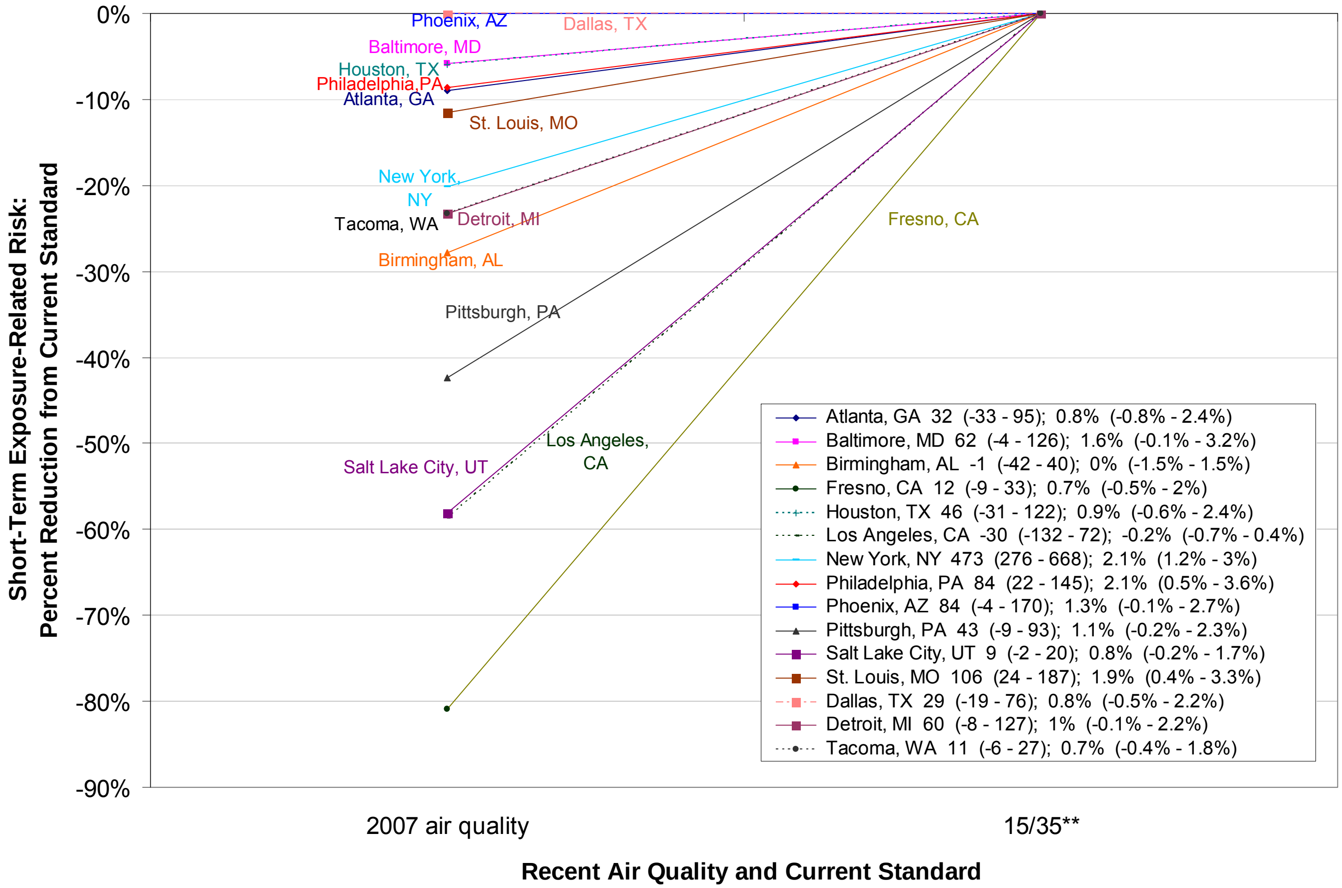
*Based on Krewski et al. (2009), exposure period from 1999 – 2000. The legend contains, for each urban area, the incidence estimate (and 95% CI) and the estimate of percent of total incidence (and 95% CI) under the current standards.
**The current standards consist of an annual standard of 15 µg/m^3 and a daily standard of 35 µg/m^3. Combinations of an annual standard (n) and a daily standard (m) are denoted n/m in this figure.
***The percent reductions for Salt Lake City and Tacoma at the 12/25 standard are 100% and 93%, respectively.

Figure 4-4 **Percent reduction in short-term exposure-related mortality and morbidity risk** (alternative standards and recent conditions relative to the current standards) (Note: inset shows $PM_{2.5}$ related incidence and percent of total incidence for CV under the current suite of standards)



*Based on Zanobetti and Schwartz (2009). The legend contains, for each urban area, the incidence estimate (and 95% CI) and the estimate of percent of total incidence (and 95% CI) under the current standards.
**The current standards consist of an annual standard of 15 µg/m^3 and a daily standard of 35 µg/m^3. Combinations of an annual standard (n) and a daily standard (m) are denoted n/m in this figure.
*** The percent reductions from 2007 air quality to the current standard for Salt Lake City and Fresno are -58% and -81%, respectively.

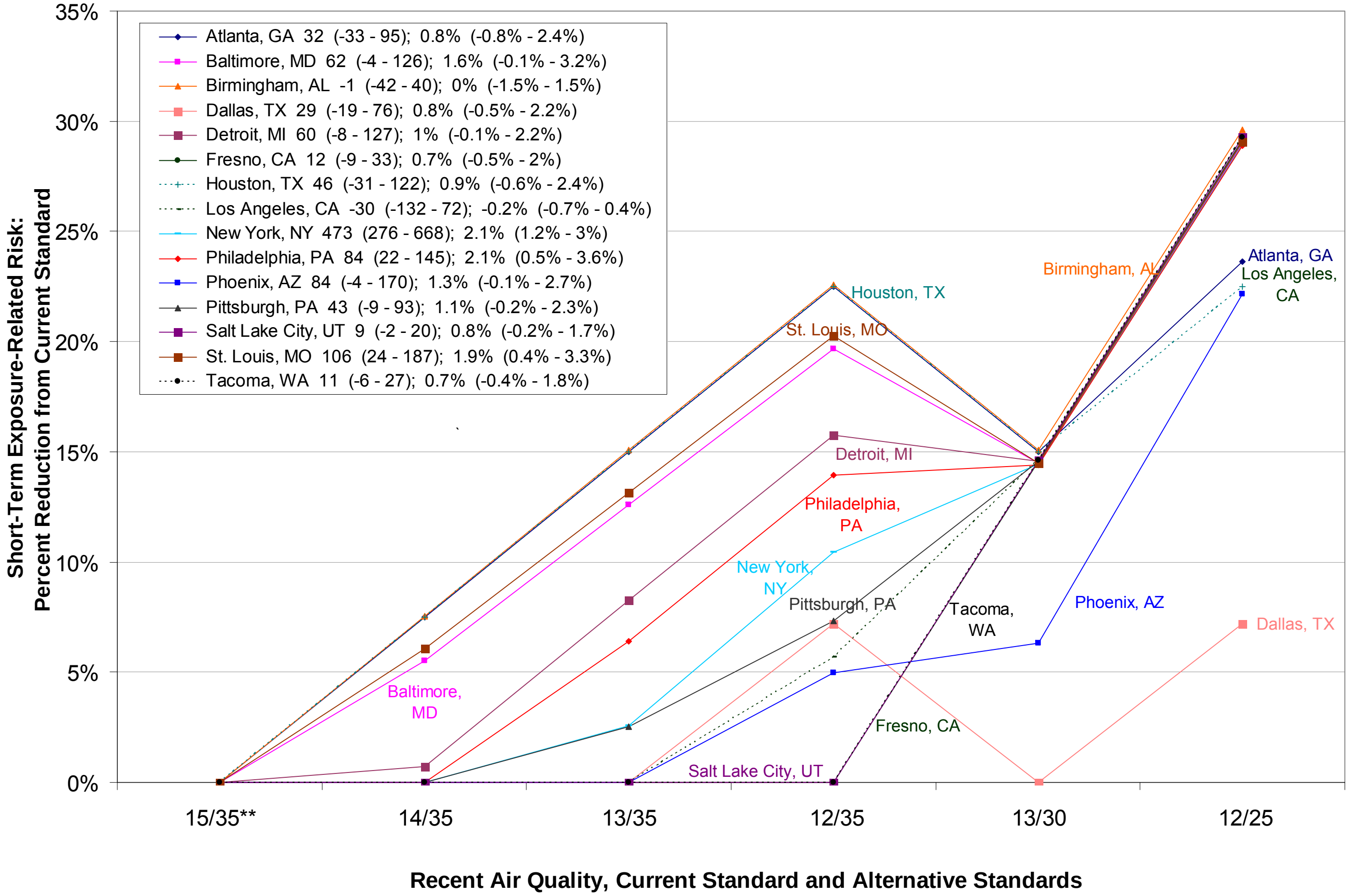
Figure 4-5 **Percent reduction in short-term exposure-related mortality and morbidity risk** (recent conditions relative to the current standards) (Note: inset shows $PM_{2.5}$ related incidence and percent of total incidence for CV under the current suite of standards)



*Based on Zanobetti and Schwartz (2009). The legend contains, for each urban area, the incidence estimate (and 95% CI) and the estimate of percent of total incidence (and 95% CI) under the current standards.

**The current standards consist of an annual standard of 15 μg/m^3 and a daily standard of 35 μg/m^3. Combinations of an annual standard (n) and a daily standard (m) are denoted n/m in this figure.

Figure 4-6 **Percent reduction in short-term exposure-related mortality and morbidity risk** (alternative standards relative to the current standards) (Note: inset shows $PM_{2.5}$ related incidence and percent of total incidence for CV under the current suite of standards)



*Based on Zanobetti and Schwartz (2009). The legend contains, for each urban area, the incidence estimate (and 95% CI) and the estimate of percent of total incidence (and 95% CI) under the current standards.
**The current standards consist of an annual standard of 15 $\mu g/m^3$ and a daily standard of 35 $\mu g/m^3$. Combinations of an annual standard (n) and a daily standard (m) are denoted n/m in this figure.

As noted above, the risk assessment includes risk estimates for a range of short-term and long-term exposure-related health effect endpoints. To focus the discussion of these risk estimates, we have selected a subset of the health endpoints as examples to help illustrate patterns in the risk estimates that might be of interest from a policy standpoint. Specifically, we have focused on those endpoints that the ISA identifies as having the greatest support in the literature (i.e., endpoints related to cardiovascular effects, including both mortality and morbidity). The subset of health effect endpoints selected as illustrative examples for this overview include: IHD-related mortality (for long-term exposure) and CV-related mortality and HA (for short-term exposure). While the discussion does focus on these cardiovascular-related endpoints, we do address other endpoints modeled in the risk assessment to a limited extent. The full set of risk estimates generated is presented in the detailed tables in Appendix E.

For a subset of the urban case studies (e.g., Dallas and Phoenix), incremental reductions across alternative standards are initially very low (or even zero) reflecting the fact that recent ambient $PM_{2.5}$ concentrations for these study areas are well below the current annual standard levels. For these study areas, meaningful reductions in risk may not be seen until relatively lower alternative standards are assessed (and results in the percent reduction from the current set of standards tables and figures may be zero for several of the less stringent, alternative sets of standards). The pattern of risk reductions across alternative standard levels for a given urban study area is an important factor that is discussed in the integrative discussion in Chapter 6. To set up that later discussion, in summarizing risk estimates below, we provide observations regarding trends in risk estimates across alternative suites of standards (for a given urban study area).

For a number of the urban study areas, confidence intervals (and in some instances, point estimates) for short-term mortality and morbidity incidence and related risk metrics include values that fall below zero. Population incidence estimates with negative lower-confidence bounds (or point estimates) do not imply that additional exposure to $PM_{2.5}$ has a beneficial effect, but only that the estimated $PM_{2.5}$ effect estimate in the C-R function was not statistically significantly different from zero. In the case of short-term exposure mortality, where study area-specific effects estimates were used (see section 3.4), several of the urban locations have non-statistically significant effects estimates; these result in incidence estimates with non-positive lower bounds and/or best estimates (e.g., Birmingham, Detroit, and Los Angeles for non-accidental mortality). In the case of short-term morbidity (e.g., HAs), where regional effects estimates were used, one of the regional coefficients (for the southeast) is not statistically significant, producing incidence estimates including negative values in the confidence interval for urban study areas falling within that region (e.g., Atlanta, Dallas, and Houston, for CV-related HAs). Lack of statistical significance could mean that there is no relationship between

$PM_{2.5}$ and the health endpoint or it could mean that there was not sufficient statistical power to detect a relationship that actually exists. In the case of $PM_{2.5}$ and both short-term exposure mortality and morbidity, recognizing that the ISA has concluded that there is either a causal or likely causal relationship between short-term $PM_{2.5}$ exposure and these health effects (see section 3.3.1), we believe it is reasonable to assume that instances where effects estimates are not-statistically significant are likely to reflect insufficient sample size, rather than the absence of an actual association. We note, however, that (as discussed in section 3.6.3) many factors can potentially result in variations in the magnitude of effect estimates. In addition to sample size, these include: source and compositional differences for $PM_{2.5}$, exposure error associated with the use of ambient monitors as a surrogate for actual exposure, and differences in population susceptibility and vulnerability.

An important theme in discussing risk associated with both current and alternative standard levels is the linkage between the nature and magnitude of risk reductions seen for a particular study area (for a particular suite of 24-hour and annual standards) and the specific mix of 24-hour and annual design values associated with that study area. Because design values determine the degree to which the $PM_{2.5}$ monitors in a study area are adjusted in simulating attainment of both current and alternative standard levels, they play a central role in determining the degree of risk reduction associated with a particular suite of standard levels. Given the importance of design values in determining risk reduction under both current and alternative standard levels, we have examined patterns in design values (specifically the relationship between 24-hour and annual design values) across the 15 urban study areas, as a means for enhancing our interpretation of patterns in risk reductions for the standard levels modeled. In addition, we have contrasted the patterns of design values for the 15 urban study areas with patterns of design values for the broader set of urban areas in the U.S.; this supporting efforts to place risk estimates for the urban study areas in a broader national context. This exploration of design values is discussed in section 4.5.

An additional factor to consider in examining patterns in risk estimates is the overall spread in $PM_{2.5}$ measurements across monitors at a particular urban study area, including distributions of both 24-hour distributions and annual averages. This factor works in concert with the patterns in design values mentioned earlier in determining the degree of risk reduction associated with a particular suite of standard levels. In addition, the spread in monitor values for a particular urban study area can also determine the degree to which alternative rollback methods (proportional, hybrid and peak shaving) produce differences in risk estimates for a given study area. Consequently, in concert with examining patterns in design values (see above) we have also explored patterns in $PM_{2.5}$ monitoring data for the 15 urban study areas in an effort to better understand how application of different rollback methods results in differing impacts on core risk estimates. This topic is discussed in section 4.5.

The remainder of this section is organized as follows. Core modeling results for the recent conditions air quality scenario are presented in section 4.1. Core modeling results for just meeting the current NAAQS and just meeting alternative NAAQS are presented in section 4.2. The results of the sensitivity analysis (including single-factor and multi-factor results) are presented in section 4.3. The results of a representativeness analysis involving comparison of counties associated with the 15 urban study area locations against the national distribution of counties with regard to a set of PM-risk related attributes are presented in section 4.4. Section 4.5 discusses the consideration of design values in interpreting risk estimates generated for the 15 urban study areas and helping to place them in a broader national context (section 5.4.1), as well as consideration for the patterns in ambient $PM_{2.5}$ data within study areas as a factor influencing patterns of risk estimates (section 4.5.2). Chapter 6 provides an integrative discussion of the results of the core risk assessment for the 15 urban study areas informed by consideration of: (a) the single- and multi-factors sensitivity analysis, (b) the qualitative analysis of sources of variability and uncertainty, (c) the representativeness analysis (d) the national-scale mortality analysis (presented in chapter 5), and (e) the role of design values (and patterns in ambient $PM_{2.5}$ monitoring data) in influencing overall patterns of risk estimates across alternative suites of standards.

4.1 ASSESSMENT OF HEALTH RISK ASSOCIATED WITH RECENT CONDITIONS (CORE ANALYSIS)

This section discusses core risk estimates generated for the recent conditions air quality scenario, focusing on the 2007 simulation year. Specifically, it provides a set of key observations regarding core risk estimates generated for the recent conditions air quality scenario. Note, that while the focus of this section is on identifying key risk-related observations potentially relevant to the current review of the PM NAAQS, additional review of the risk estimates provided in Appendix E is likely to result in additional observations that might be relevant to the PM NAQQS review (EPA staff will continue to review those results as they work on completing the summary of the RA presented in the first draft PA).

In discussing results for the recent conditions air quality scenario, we have focused on absolute risk (either above PRB or LML, depending on the health effect endpoint). This reflects the fact that this air quality scenario represents recent conditions within the urban study areas and therefore, does not lend itself to an incremental assessment. The section is organized by health endpoint category, with results discussed in the following order: long-term exposure mortality, short-term exposure mortality and short-term exposure morbidity.[45] In summarizing estimates for each endpoint category, we fist focus on the central-tendency risk estimates (these are what is discussed in each of the bullets focusing on a particular endpoint category). A discussion of the broader risk range reflecting consideration for 95th% confidence interval risk estimates is presented as a separate bullet towards the end of the discussion. Key observations include:

- **Long-term exposure-related mortality:** Total incidence of $PM_{2.5}$-related all-cause mortality ranges from 50-60 (Salt Lake City) to 2,380-3,000 (New York) (Appendix E, Table E-21 and E-30), with this range reflecting not only differences in baseline incidence across urban study areas, but also the size of study populations which vary considerably across the study areas. The percent of total incidence of IHD-related mortality attributable to $PM_{2.5}$ ranges from 6.3-8.0% (Tacoma) to 17.7-22.2% (Fresno) (Appendix E, Table E-24 and E-33). Total $PM_{2.5}$-attriutable incidence for all-cause mortality and cardiopulmonary mortality is larger than IHD (for a given study area under recent conditions), while total $PM_{2.5}$-attributable incidence for lung-cancer mortality is lower than for IHD. However, the percent of total incidence attributable to $PM_{2.5}$ exposure is larger for IHD-related mortality than for any of the other mortality categories modeled (Appendix E, Tables E-24 and E-33).
- **Short-term exposure-related mortality:** Total incidence of $PM_{2.5}$-related mortality for short-term exposure (for all categories modeled) is substantially smaller than estimates for long-term exposure-related mortality. Estimates for CV mortality for short-term exposure ranges from 14 (Salt Lake City) to 570 (New York) (Appendix E, Table E-84). The percent of total non-accidental mortality attributable to $PM_{2.5}$ ranges from 0.9% (Tacoma) to 2.5% (New York). (Appendix E, Table E-87). Percent <u>of total incidence</u> attributable to $PM_{2.5}$ exposure is generally lower for total non-accidental mortality (compared with CV), ranging from 0.2% (Los Angeles) to 1.8% (Baltimore) (Appendix E, Table E-78). Estimates for respiratory mortality are usually higher than for CV mortality, ranging from 0.9% (Dallas) to 2.8% (Fresno and New York) (Appendix E, Table E-96). Of the 15 urban study areas modeled for CV mortality, 12 locations had negative lower bound estimates of incidence (and two of these head negative point estimates), reflecting use of non-statistically significant effects estimates (see section 4.0 for additional discussion). The number of study areas modeled with non-statistically significant effects estimates was lower for the other two short-term exposure-related mortality endpoints.
- **Short-term exposure-related morbidity (hospital admissions for respiratory and cardiovascular illness):** Total incidence of $PM_{2.5}$-related cardiovascular HA range from 15 (Salt Lake City) to 910 (New York City) and are significantly larger than estimates of respiratory HA attributable to $PM_{2.5}$ exposure (Appendix E, Tables E102 and E-111). Similarly, the percent of total cardiovascular HA attributable to $PM_{2.5}$ is larger than estimates for respiratory HA and ranges from 0.28% (Dallas) to 1.6% (Pittsburgh) (Appendix E, Table E-105). In this case, the pattern of risk across urban study areas reflects both differences in

[45] Note, that as discussed earlier, for long-term exposure-related mortality, two risk estimates are provided for each urban study area, reflecting application of the two C-R functions used in modeling each mortality endpoint in the core analysis - i.e., C-R function derived using 1979-1983 $PM_{2.5}$ monitoring data and the C-R function derived using 1999-2000 data, with the latter function having the larger effect estimates and therefore, producing higher risk estimates.

underlying baseline incidence for these endpoints as well as the use of regionally-differentiated effect estimates obtained from Bell et al., 2008 (see Appendix C, Table C-1). Of the 15 urban study areas modeled for cardiovascular-related HAs, five locations had negative lower bound estimates of incidence, reflecting use of non-statistically significant effects estimates (see section 4.0 for additional discussion).

- **Patterns of recent conditions risk across the three simulation years:** A comparison of IHD mortality incidence estimates (based on the C-R function derived using 1979-1982 monitoring data) across the three years (see Appendix E, Tables E-22 through E-24) shows that, while 2007 does produce incidence estimates that fall between those estimated for 2005 and 2006 for some urban areas (e.g., Tacoma, St. Louis, LA), results for 2007 can be the highest of the three years (e.g., Fresno) or the lowest (e.g., Baltimore) for some locations. Generally, results for the same urban study area across the three years are fairly similar (results for Birmingham vary by less than 7% across the years), although they can vary by as much as 30% or more in some locations (see results for Tacoma in 2005 and 2006). All of this temporal variation results from year-to-year variation in the annual average $PM_{2.5}$ levels for the study areas (see Appendix A). This is because other candidate input parameters, which could also involve temporal variability (e.g., demographics and baseline incidence rates) were not modeled with year-specific values, but rather using one representative year (see section 3.4.1.3 and 3.5 for demographics and baseline health effects incidence rates, respectively). In terms of short-term exposure-related morbidity and mortality endpoints, the pattern is similar to that described above for long-term mortality, with risk estimates for 2007 generally falling between those generated for 2005 and 2006 (in terms of magnitude), although the magnitude of variations across the three simulation years for a given health endpoint/case study combination was notably lower for the short-term exposure-related endpoints than for the long-term endpoints. For example, with CV mortality, one of the urban study area with the greatest variation across the three years (New York) had a 15% difference in $PM_{2.5}$ –related risk across the three years (see Appendix E, Tables E-82 through E-84). This compares with a spread of 30% for some of the urban study areas modeled for long-term exposure-related IHD mortality – see above. As with the long-term mortality risk metrics, all of this temporal variation results from year-to-year variation in the daily $PM_{2.5}$ levels for the study areas (see Appendix A), given that other candidate input parameters, which could have temporal variability (e.g., demographics and baseline incidence rates) were not modeled with year-specific values, but rather using one representative year.

- **Consideration for the 95th percentile confidence interval risk estimates in assessing uncertainty related to the statistic fit of effect estimates:** As noted above, all of the risk metrics generated for this analysis include 95th percentiles, reflecting uncertainty in the statistical fit of the underlying effect estimates in the C-R functions. These results suggest that this source of uncertainty can be notable. In the case of recent conditions risk estimates, for long-term mortality, while the central tendency risk estimate for all-cause (long term exposure-related) mortality incidence in New York range from 2,380-3,000, the 95th percentile confidence interval for this estimates is 1,960 to 3,500 (Appendix E, Table E-21 and E-30). In this case, this source of uncertainty results in estimates that are ~18% lower to ~17% higher than the central tendency estimate range. Using the criteria we applied in assessing the results of the sensitivity analysis, these would translate as having a "small" impact on the core risk estimate (see Section 4.3.1). The impact of statistical fit uncertainty on the IHD-related long-term exposure-related mortality results (see Appendix E, Tables E-24 and E-33) are similar in magnitude to those seen for all-cause mortality and also results in a classification of this uncertainty having a "small" impact on core risk estimates. For short-term exposure-related mortality and morbidity, the impact of statistical fit (as reflected in the 95th percentile CI risk estimate ranges) is greater than for long-term mortality. For example with CV-related mortality, the central tendency estimate for New York is 570 cases, while the 95th percentile CI is 332 to 902 (i.e., ~40% lower and ~40% higher than the core central-tendency estimates). This translates into a "moderate" impact by this source of uncertainty on core risk estimates using the classification scheme developed for the sensitivity analysis. This suggests that uncertainty related to the statistical fig of effect estimates used in risk characterization has twice as greater an impact on short-term mortality as long-term mortality risk estimates.

4.2 ASSESSMENT OF HEALTH RISK ASSOCIATED WITH JUST MEETING THE CURRENT AND ALTERNATIVE SUITES OF STANDARDS (CORE ANALYSIS)

This section discusses core risk estimates generated for just meeting the current suite of standards and alternative suites of standards, focusing on the 2007 simulation year (although general trends in observations across the three simulated years are discussed to a limited extent).

In discussing risk estimates for the current and alternative suites of standards, we include discussion of risk metric which characterize both incremental reductions in risk (across standard levels) as well as absolute risk for a particular standard level. In presenting these two categories of risk metric, we recognize that there is greater uncertainty in estimates of absolute risk relative to estimates of incremental risk. This reflects the fact that we have greater confidence in the ability of the risk models to differentiate risk between sets of standards, since this requires the models to estimate risk for ambient air $PM_{2.5}$ levels likely near or within the range of ambient air quality data used in the underlying epidemiology studies. By contrast, estimates of absolute risk (for a given air quality scenario) require the models to perform at the lower boundary of ambient air $PM_{2.5}$ levels reflected in the studies (i.e., down to the LML reflected in the long-term exposure mortality epidemiology studies or down to PRB levels in the short-term exposure morbidity and mortality studies). There is greater overall uncertainty in risk estimates generated based on the contribution to risk of exposures at these lower ambient air $PM_{2.5}$ levels. While there is greater uncertainty associated with estimates of absolute risk, these estimates are of potential use in informing consideration of the magnitude of risk (and therefore public health impact) for a particular standard level. The overall level of confidence associated with different risk metrics (and implications for informing their use in the context of the PM NAAQS review) is discussed in Chapter 6.

This section discusses risk estimates generated for the current standard level first, followed by discussion of risk estimates associated the set of alternative standard levels assessed. Each of these discussions is further organized by health endpoint category, with results discussed in the following order: long-term exposure mortality, short-term exposure mortality and short-term exposure morbidity. Observations presented in the previous section regarding the statistical significance of effects estimates used in generating risk estimates and their implications for interpretation of those risk estimates also hold for estimates presented in this section. Consequently, observations regarding risk results with confidence intervals including negative estimates are not presented here and the reader is referred back to the earlier discussion in section 4.1.

We note that the lower magnitude of risk reductions (in terms of percent change in $PM_{2.5}$-attributable risk) generally seen for short-term exposure-related endpoints relative to long-term exposure-related endpoints primarily reflects the fact that $PM_{2.5}$-attributable risk is modeled down to PRB for short-term, but only down to LML for long-term. This means that an incremental change (reduction) in long-term risk will be a larger fraction of overall risk compared with short-term risk and hence, the magnitude of risk reductions for long-term exposure-related risk is notably larger compared with short-term risk

An important factor to consider in interpreting the risk estimates for both the current set of standards and sets of alternative standards is whether the annual or 24-hour standard for a given pairing of standards is controlling for a particular area.[46] This factor can have a significant impact on the pattern of risk reductions predicted for a given location under the simulation of just meeting a specific set of standards. In addition, the approach used to simulate ambient $PM_{2.5}$ levels under current and alternative standard levels (i.e., use of proportional, hybrid, or peak shaving) can significantly impact the magnitude risk reduction seen across standard levels (particularly the degree to which a particular standard produces notable reductions in long-term exposure-related mortality).[47] The potential for different rollback strategies (reflecting potentially different combinations of local and/or regional controls) to impact patterns of risk reduction is not discussed here, but rather reserved for discussion as part of the sensitivity analysis (section 4.3) and the integrative chapter (chapter 6).

An overview of which urban study areas are predicted to have risk reductions under the current and alternative suites of standards included in the risk assessment is presented below

[46] For a given pairing of standard levels (e.g., 13/35), the controlling standard can be identified by comparing these levels to the design values for a given study area (see section 4.5.1). The controlling standard is the standard (annual or 24 hr) that requires the greatest percent reduction in the matching design value to meet that standard.
[47] Approaches such as hybrid rollback or peak-shaving which simulate more localized control strategies have the potential to reduce $PM_{2.5}$ levels at monitors exceeding the daily standard, while leaving other monitors (which may have elevated annual-average $PM_{2.5}$ levels) relatively or totally unadjusted. This can result in the 24-hour standard not providing coverage for the annual standard, even when the 24-hour standard is controlling (i.e., additional reduction focused on monitors with high annual design values may be required to attain the annual) - see discussion in Section 4.3 and Chapter 6.

(Appendix E contains tables presenting the full set of detailed core risk estimates generated for the current and alternative suites of standards).

4.2.1 Core Risk Estimates for Just Meeting the Current Suite of Standards

This section summarizes risk estimates generated for the 15 urban study areas based on simulating just meeting the current suite of standards (including the magnitude of risk reductions relative to recent conditions, where applicable).

- **Long-term exposure-related mortality:** Total incidence of $PM_{2.5}$-related IHD mortality ranges from 15-20 (Salt Lake City) to 1,760-2,220 (New York) (Table 4-1). The percent of total incidence of IHD mortality attributable to $PM_{2.5}$ ranges from 3.7-4.7% (Tacoma) to 13.2-16.7% (Atlanta) (Table 4-2). These levels of IHD mortality risk attributable to $PM_{2.5}$ exposure reflect reductions in risk relative to recent condition ranging from 8.7% (Houston) to 68.6% (Salt Lake City). Two of the urban study areas (Dallas and Phoenix) do not exhibit reductions in risk in simulating just meeting the current suite of standards since these two locations meet the current suite of standards based on recent air quality data. As referenced above for the recent conditions scenario, total $PM_{2.5}$-attriutable incidence for all-cause mortality and cardiopulmonary mortality is larger than IHD (for a given study area under recent conditions), while total $PM_{2.5}$-attributable incidence for lung-cancer mortality is lower than for IHD. However, the percent of total incidence attributable to $PM_{2.5}$ exposure is larger for IHD-related mortality than for any of the other mortality categories modeled (Appendix E, Tables E-24 and E-33).
- **Short-term exposure-related mortality:** As with the recent conditions analysis, total incidence of $PM_{2.5}$-related mortality for short-term exposure is substantially smaller than estimates for long-term exposure-related mortality. Estimates for CV mortality for short-term exposure ranges from 9 (Salt Lake City) to 470 (New York) (Table 4-1). The percent of CV mortality attributable to $PM_{2.5}$ ranges from 0.7% (Fresno) to 2.1% (Philadelphia and New York). (Table 4-2). The level of risk reduction (comparing risk under the current standard with risk under recent conditions) is generally lower for short-term exposure-related CV mortality compared with long-term exposure-related all-cause mortality and ranges from 5.5% (Baltimore) to 36.9% (Los Angeles). As mentioned for long-term exposure-related risk, both Phoenix and Dallas did not exhibit any risk reduction since these two locations meet the current suite of standards based on recent air quality data. Percent of total incidence attributable to $PM_{2.5}$ exposure is generally lower for total non-accidental mortality (compared with CV), ranging from 0.1% (Los Angeles) to 1.7% (Baltimore) (Appendix E, Table E-78). Estimates for respiratory mortality are usually higher than for CV, ranging from 0.9% (Dallas) to 2.6% (Baltimore) (Appendix E, Table E-96). As noted above, of the 15 urban study areas modeled for CV mortality, 12 locations had negative lower bound estimates of incidence (and two of these had negative point estimates), reflecting use of non-statistically significant effects estimates (see section 4.0 for additional discussion).
- **Short-term exposure-related morbidity (hospital admissions for respiratory and cardiovascular illness):** Total incidence of $PM_{2.5}$-related cardiovascular HA range from 9 (Salt Lake City) to 750 (New York City) and are significantly larger than estimates of respiratory HA attributable to $PM_{2.5}$ exposure (Appendix E, Tables E102 and E-111). Similarly, the percent of total cardiovascular HA attributable to $PM_{2.5}$ is larger than estimates

for respiratory HA and ranges from 0.28% (Dallas) to 1.33% (Baltimore). As noted above, the pattern of risk across urban study areas reflects both differences in underlying baseline incidence for these endpoints as well as the use of regionally-differentiated effect estimates obtained from Bell et al., 2008 (see Appendix C, Table C-1). The level of risk reduction (comparing risk under the current standard with risk under recent conditions) for both respiratory and cardiovascular hospital admissions ranges from 5.5% (Baltimore) to 44.8% (Fresno), again with Phoenix and Dallas not exhibiting any risk reduction since these two locations meet the current suite of standards based on recent air quality data. As noted above, of the 15 urban study areas modeled for cardiovascular-related HAs, five locations had negative lower bound estimates of incidence, reflecting use of non-statistically significant effects estimates (see section 4.0 for additional discussion).

- **Patterns of recent conditions risk across the three simulation years:** Observations made earlier regarding patterns of risk across the three simulation years for the recent conditions simulations generally hold for the current standard level analysis. In other words, (a) 2007 generally represents risks in between the other two years in terms of magnitude, (b) there are exceptions where 2007 had the highest risks and lowest risk (depending on study area and endpoint), and (c) generally, long-term exposure-related mortality endpoints showed greater cross year variation then the short-term exposure-related endpoints (with the magnitude of this variation similar to what is reported above for the recent conditions simulation).
- **Consideration for the 95th percentile confidence interval risk estimates in assessing uncertainty related to the statistic fit of effect estimates:** Uncertainty related to the statistical fit of effect estimates has the same magnitude of effect in modeling risk under the current standard as it did under recent conditions (i.e., an impact of about +/-18% on the core risk estimates, translating into a "small" impact based on classification used in the sensitivity analysis) (see (Appendix E, Table E-21 and E-30 for risk estimates used to reach this conclusion). The impact of this source of uncertainty on short-term exposure-related CV morality was similar (although slightly larger) compared with what was seen with risk estimates generated for the recent conditions air quality scenarios (i.e., 48% lower to 42% higher than the core risk estimate – see estimates in Appendix E, Table E-84). This results in a classification of "moderate" for this source of uncertainty and its impact on short-term exposure-related mortality, based on the classification scheme developed for the sensitivity analysis.

4.2.2 Core Risk Estimates for Just Meeting Alternative Suites of Standards

This section summarizes risk estimates generated for the 15 urban study areas when ambient $PM_{2.5}$ levels under the alternative standard levels are simulated. As noted in section 4.2, this discussion focuses on the magnitude of incremental risk reductions for individual standard levels relative to the current standard, given that overall confidence in incremental risk metrics is considered higher than estimates of absolute risk for a given standard level. Note, however, that we do provide limited discussion of absolute risk levels attributable to $PM_{2.5}$ exposure for alternative standard levels, with the provision that these be interpreted in the context of their greater levels of uncertainty. In discussing risk estimates for the alternative standard levels, we focus first on patterns of risk reduction across *alternative annual levels* (i.e., 14/35, 13/35 and

12/35) and then discuss patterns across a *combination of alternative 24 hour and annual standards* (i.e., 13/30 and 12/25).

As noted in Section 4.1, although reductions in absolute incidence will differ for health effect endpoints associated with a particular averaging period across alternative suites of standards for a given urban study area, the patterns of reduction in terms of percent change in $PM_{2.5}$-attributable risk are very similar for a given urban study area across health endpoints. This reflects the fact that the C-R functions used in the core analysis are close to linear across the range of ambient $PM_{2.5}$ levels considered in this analysis, and consequently the main factor producing percent reductions in risk across alternative standards is the reduction in the air quality metric for a given study area (i.e., reductions in annual average $PM_{2.5}$ concentrations or reductions in the distribution of 24-hour estimates for a year). Consequently, in discussing incremental risk reduction in terms of percent change relative to the current suite of standards, we speak more generally in terms of the category of *annual-average risk* or *2-4hour average risk*, with the assumption that these observations hold for individual health effects endpoints assessed for each averaging period. These observations regarding patterns of percent risk reduction for the two averaging periods are reflected in Figures 4-1 through 4-6 which are referenced in the discussion below.

Alternative annual standard levels (14/35, 13/35, and 12/35) [48]

- **Percent reductions in long-term exposure-related mortality:** Reductions in all long-term exposure-related mortality categories were more limited under the 14/35 alternative standard, with only 5 of the 15 urban study areas demonstrating notable reductions ranging from 9% (Baltimore) to 12% (Houston and Birmingham) (see Figure 4-3 and Appendix E, Table E-9). Reducing the annual standard level to 13 μg/m^3 (i.e., the 13/35 alternative suite of standards) produced a notable increase in the number of locations (9 of the 15) with risk reductions relative to the current standard ranging from 5% (New York) to 24% (Houston and Birmingham). The lowest annual standard evaluated (12 μg/m^3 as reflected in the 12/35 alternative suite of standards) resulted in additional study areas (now 12 of the 15 study areas) experiencing risk reductions with percentage risk reductions now ranging from 11% (Phoenix) to 26% (Houston and Baltimore). Note, that even in the 12/35 case, three of the urban study areas (Tacoma, Fresno and Salt Lake City) did not experience any decreases in risk, although risk reductions were seen for these three study areas when alternative 24-hour standards were considered – see below. The specific pattern of risk reduction (including importantly, the magnitude of risk reduction as well as residual risk associated with a

[48] The three alternative annual standards considered in the risk assessment (12, 13 and 14 μg/m^3) were each paired with the current 24-hour standard of 35 μg/m^3 for purposes of generating risk estimates. A separate set of alternative suites of standards (i.e., 13/30 and 12/25) were also considered – see next section below. In discussing risk estimates associated with the *alternative annual standards*, each alternative annual standard level was paired with the current 24-hour standard of 35 μg/m^3 in determining which standard level was controlling and, consequently, whether the alternative annual standard would produce any notable reductions in risk.

particular standard level) reflects whether daily or annual standard levels were controlling – see discussion below regarding patterns of risk reduction.

- **Percent reduction in short-term exposure-related mortality and morbidity:** The pattern of reductions in the percent of risk attributable to $PM_{2.5}$ for mortality and morbidity associated with short-term exposure is similar to that described above for long-term mortality (see Figures 4-4 through 4-6). Specifically, the same five urban study areas (Atlanta, Baltimore, Birmingham, Houston and St. Louis) had notable risk reductions under the full set of alternative annual standards, with the degree of risk reduction for $PM_{2.5}$-related cardiovascular mortality for the lowest alternative annual standard level (12/35) compared to the current standard level, ranging from 20% (St. Louis) to 23% (Birmingham) (see Figure 4-4 and 4-6 and Appendix E, Table E-90). A number of the other study areas did not exhibit notable risk reductions until the lowest alternative annual standard was considered (i.e., Detroit, Los Angeles, New York, Philadelphia, Pittsburgh), with the degree of reduction in risk for the lowest alternative suite of standards (12/35) compared with the current standards ranging from 5% (Phoenix) to 16% (Detroit) (see Figure 4-4 and 4-6 and Appendix E, Table E-90). As with long-term exposure-related mortality, a number of additional study areas (Fresno, Salt Lake City, Tacoma) did not exhibit any notable risk reduction under the set of alternative annual standards considered and only experienced risk reductions when the 24-hour standard level was reduced. Because the same air quality metric (annual distributions of 24-hour $PM_{2.5}$ concentrations) is used in generating short-term exposure-related mortality and morbidity endpoints, patterns of risk reduction are similar for both sets of endpoints (see Figures 4-4 through 4-6. Specifically, the same groups of urban study areas experience the same magnitude of risk reductions (in terms of percent changes in $PM_{2.5}$-related risk relative to the current standard level) across the alternative standard levels for short-term exposure-related morbidity (HAs). The specific pattern of risk reduction reflects whether daily or annual standard levels are controlling – see discussion below regarding patterns of risk reduction.

- **Pattern of risk reduction linked to design values**: The patterns of risk reduction across the 15 urban study areas for the set of alternative annual standard levels considered here depends on whether the alternative annual (12, 13 or 14 $\mu g/m^3$) or the current 24-hour standard of 35 $\mu g/m^3$ is controlling. The approach used to simulate just meeting alternative 24-hour standards (i.e., proportional, hybrid, or peak shaving) can have an impact on the magnitude of risk reduction, although it does not influence whether the annual or 24-hour design value was controlling for a given alternative suite of standards (see sensitivity analysis discussion in 4.3 and the integrative discussion in Chapter 6). The pattern in risk reduction seen across the 15 urban study areas (given the set of alternative annual standards considered) can be divided into three categories: (a) all of the alternative annual standard levels are controlling, resulting in notable risk reductions for all of the annual standard levels considered (Birmingham, Atlanta, Houston), (b) alternative annual standards only control at lower levels (i.e., 13/35 and/or 12/35) and consequently notable risk reductions are only seen at the lower or lowest annual standard level(s) considered (Dallas, Los Angeles, New York, Philadelphia, Phoenix, Pittsburgh), and (c) none of the alternative annual standard levels is controlling and therefore there is no estimated risk reduction for the alternative annual standard levels considered (Salt Lake City, Tacoma, Fresno).

- **Absolute levels of $PM_{2.5}$-attributable risk under alternative annual standards:** As discussed above, we have greater confidence in estimating incremental reductions in risk between the current and alternative suites of standards, then the estimation of absolute incidence under a given suite of standards. Nonetheless, we provide a summary of that risk metric here for long-term and short-term exposure-related mortality and short-term exposure-related morbidity endpoints:
  - *Long-term exposure-related mortality*: The four study areas displaying the greatest degree of reduction across the alternative annual standards (Atlanta, Baltimore, Birmingham and Houston) have $PM_{2.5}$-related IHD mortality estimates (under the lowest alternative annual standard of 12/35) ranging from 85-110 (Birmingham) to 220-280 (Houston) (see Appendix E, Table E-21 and E-30). The two urban study areas with the greatest degree of $PM_{2.5}$-related risk in absolute terms (Los Angeles and New York) do not exhibit significant reductions in risk until the lowest annual standard level of 12/35 is considered, with $PM_{2.5}$-related IHD mortality estimated at 750-950 and 1,420-1,800, respectively under that alternative standard (see Appendix E, Table E-21 and E-30).
  - *Short-term exposure-related mortality*: The four study areas displaying the greatest degree of reduction across the alternative annual standards (Atlanta, Baltimore, Birmingham and Houston), have $PM_{2.5}$-related CV mortality estimates (under the lowest alternative standard of 12/35) ranging from 25 (Atlanta) to 50 (Baltimore) (see Appendix E, Table E-84). We note that Birmingham has an incidence estimate of -1, reflecting application of a non-statistically significant effect estimate in modeling this endpoint (see section 4.1). The urban study area with the greatest degree of $PM_{2.5}$-related risk in absolute terms (New York) does not exhibit significant reductions in risk until the lowest annual standard level of 12/35 is considered with $PM_{2.5}$-related CV mortality estimated at 420 under that alternative standard level (see Appendix E, Table E-84).
  - *Short-term exposure-related morbidity*: The four study areas displaying the greatest degree of reduction across the alternative annual standard levels (Atlanta, Baltimore, Birmingham and Houston), have $PM_{2.5}$-related cardiovascular HA (under the lowest alternative standard of 12/35) ranging from 12 (Birmingham) to 170 (Baltimore) (see Appendix E, Table E-102). The two urban study areas with the greatest degree of $PM_{2.5}$-related risk in absolute terms (Los Angeles and New York) do not exhibit significant reductions in risk until the lowest annual standard level of 12/35 is considered with $PM_{2.5}$-related all-cause mortality estimated at 240 and 670, respectively under that alternative standard level (see Appendix E, Table E-102).
- **Patterns of recent conditions risk across the three simulation years:** Observations made above regarding patterns of risk across the three simulation years for the recent conditions and current standards simulations generally hold for the alternative standards analysis. In other words, (a) 2007 generally represents risks between the other two years in terms of magnitude, (b) there are exceptions where 2007 had the highest risks and lowest risk (depending on study area and endpoint), and (c) generally, long-term exposure-related mortality endpoints showed greater cross-year variation then the short-term exposure-related endpoints in terms of both absolute $PM_{2.5}$ risk for a particular alternative suite of standards, as well as incremental risk reductions relative to the current suite of standards.

- **Consideration of the 95th percentile confidence interval risk estimates in assessing uncertainty related to the statistic fit of effect estimates:** Continuing the pattern seen with the current standard level, uncertainty related to the statistical fit of effect estimates has the same magnitude of effect in modeling risk under alternative standards involving reduction of the annual level as it did under recent conditions (i.e., an impact of about +/-18% on the core risk estimates, translating into a "small" impact based on classification used in the sensitivity analysis) (see Appendix E, Table E-21 and E-30 for risk estimates used to reach this conclusion). Similarly, the pattern of impact this source of uncertainty on short-term exposure-related CV morality continues to be similar compared with what was seen for risk estimates generated for the recent conditions air quality scenarios (i.e., 42% lower to 42%higher than the core risk estimate – see estimates in Appendix E, Table E-84). This continues to result in a classification of "moderate" for this source of uncertainty based on the classification scheme developed for the sensitivity analysis.

Combinations of alternative 24-hour and annual standard levels (13/30, 12/25)

- **Percent reductions in long-term exposure-related mortality:** The combination of suites of alternative 2-hour and annual standards produced notable reductions in long-term exposure-related mortality for 14 of the 15 urban study areas, with the lower combination (12/25) producing a notable reduction in risk relative to the first combination of 13/30. The only study area that did not exhibit a reduction in risk under the first combination (13/30) was Dallas, reflecting the fact that its 24-hour and annual design values are below 30 $\mu g/m^3$ and 13 $\mu g/m^3$, respectively (and consequently, the 13/30 did not produce a reduction in ambient air $PM_{2.5}$, or a resulting reduction in risk). Reductions in long-term exposure-related mortality (across all endpoints) under the 13/30 combination ranged from 14% (Phoenix) to 55% (Salt Lake City), while reductions for the 12/25 combination ranged from 12% (Dallas) to ~100% (Salt Lake City) (see Figure 4-1 and 4-3 and Appendix E, Table E-27). The reduction for Salt Lake City reflects a very high 24-hour design value which, when reduced to meet the 24-hour standard of 25 $\mu g/m^3$ produced a very large reduction in the annual design value (given application of the proportional adjustment to simulate rollback), such that the value was very close to 5.8 $\mu g/m^3$ (the LML below which long-term exposure-related mortality is not estimated). The specific pattern of risk reduction reflects whether the 24-hour or annual standard was controlling – see discussion below regarding patterns of risk reduction.

- **Percent reduction in short-term exposure-related mortality and morbidity:** The pattern of reductions in the percent of risk attributable to $PM_{2.5}$ for mortality and morbidity associated with short-term exposure is similar to that described above for long-term mortality in terms of the ordering of sites, however the magnitude of risk reduction (in terms of percent change in $PM_{2.5}$-related risk) is lower for short-term exposure-related health endpoints compared with long-term exposure-related mortality (see Figures 4-4 through 4-6). Specifically, 14 of the 15 urban study areas (Dallas being the exception), had notable risk reductions under both the 13/30 and 12/35 alternative suites of standards (Dallas only was estimated to have reductions in risk under the lower 12/25 combination - see Figure 4-4 and 4-6 and Appendix E, Table E-108). Reductions in short-term exposure-related mortality and morbidity (across all endpoints) under the 13/30 combination ranged from 6% (Phoenix) to 15% (Salt Lake City), while reductions for the 12/25 combination ranged from 7% (Dallas) to 30% (Birmingham).

- **Pattern of risk reduction linked to design values**: As with the set of alternative annual standards discussed in the previous section, the pattern of risk reduction seen for the two combinations of alternative 24-hour and annual standards described here depends on which standard is controlling. In addition, the magnitude of the reduction in risk reflects (a) the magnitude of the difference between the controlling design value and the standard level (which determines the degree of reduction in ambient air $PM_{2.5}$ levels) and (b) the method used to simulate ambient $PM_{2.5}$ levels under alternative suites of standards (i.e., proportional, hybrid or peak shaving). For this set of alternative suites of standards, 10 of the 15 study areas had the alternative 24-hour standard controlling under the 13/30 case and that number was increased to 12 out of the 15 study areas with the 12/25 case (Table 3-5). As expected, those study areas with the greatest reduction in risk (in terms of percent reduction compared with the current suite of standards) under the 12/25 case had a controlling 24-hour standard (e.g., Tacoma, Salt Lake City, Los Angeles and Fresno - see Figure 4-4 and 4-6 and Appendix E, Table E-90).
- **Absolute levels of $PM_{2.5}$-attributable risk under alternative suites of annual and 24-hour standards:** As with the alternative annual standards, below we provide a brief overview of the magnitude of $PM_{2.5}$-attributable risk (i.e., absolute risk) associated with the two alternative suites of annual and 24-hour standards:
    - *Long-term exposure-related mortality*: The four study areas displaying the greatest degree of reduction across these two alternative suites of standards (Tacoma, St. Louis, Los Angeles and Fresno), have $PM_{2.5}$-related IHD mortality estimates (under the 12/25 case) ranging from 3-4 (Tacoma) to 290-360 (Los Angeles) (see Appendix E, Table E-21 and E-30). The other urban study area with the greatest degree of $PM_{2.5}$-related risk in absolute terms besides New York (New York) has $PM_{2.5}$-related all-cause mortality estimated at 820-1,040 under the 12/25 case.
    - *Short-term exposure-related mortality*: eleven of the 15 study areas had percent reductions in risk for the 12/25 case (relative to the current standards) of approximately 29% (the other study areas had lower percent reductions). Of the locations with ~29% reductions in risk, $PM_{2.5}$-attributable CV mortality for the 12/25 case ranged from 6 (Salt Lake City) to 340 (New York) (see Appendix E, Table E-84). New York City also represents the study area with the greatest residual risk for short-term exposure-related mortality under the 12/25 case.
    - *Short-term exposure-related morbidity* Of the 11 urban study areas with ~29% reduction in risk (for the 12/25 case relative to the current standards), the incidence of $PM_{2.5}$-attributable cardiovascular HA emissions ranges from 7 (Salt Lake City) to 530 (New York) (see Appendix E, Table E-102). New York City also represents the study area with the greatest residual risk for short-term exposure-related morbidity under the 12/25 case.
- **Consideration for the 95th percentile confidence interval risk estimates in assessing uncertainty related to the statistic fit of effect estimates:** As with the alternative standards considering lower annual levels, risk estimates generated for the two standards considering lower annual and 24-hour levels also suggest that uncertainty related to the statistical fit of effect estimates will have a greater impact on short-term exposure-related mortality (+/- ~40%) compared with long-term exposure-related mortality (+/- ~18%) (see Appendix E,

Tables E-84 and E-21 plus Table E-30, respectively). Again, this results in a classification of this source of uncertainty as having a “lower” impact for long-term exposure-related mortality and a “moderate” impact on short-term exposure-related mortality.

4.3 SENSITIVITY ANALYSIS RESULTS

As noted in section 3.6.4 and section 4.1, the sensitivity analysis was conducted in order to gain insights into which of the identified sources of uncertainty and variability in the risk assessment model may have significant impacts on risk estimates. A second goal of the sensitivity analysis was to generate an additional set of reasonable risk estimates to supplement the core set of risk estimates to inform staff's characterization of uncertainty and variability associated with those core estimates.

The first goal can be achieved by considering the magnitude of the impact of individual modeling elements based on results from the sensitivity analysis and identifying those elements which have the greatest impact on the core risk estimates. Use of the sensitivity analysis results in this context is addressed in section 4.3.1. Use of the results of the sensitivity analysis as an additional set of reasonable risk estimates to augment the core risk estimates in considering the impact of uncertainty and variability in the core risk model is discussed in section 4.3.2.

In conducting the sensitivity analysis we modeled 2 of the 15 urban study areas (Philadelphia and Los Angeles - representing east and west coast urban areas, respectively) for most simulations. For some modeling elements (e.g., the hybrid and peak shaving alternative rollback approaches) we included a larger number of urban study areas that were applicable to the topic being assessed. In conducting the sensitivity analysis, we have also focused on long-term exposure mortality and to a lesser extent on short-term exposure mortality and morbidity.

Although the sensitivity analysis simulations were completed for all three simulation years (as reported in Appendix F), we have focused on results for 2007 in this presentation for comparability with the core results discussed in sections 4.1 and 4.2.

4.3.1 Sensitivity Analysis Results to Identify Potentially Important Sources of Uncertainty and Variability

The results of the sensitivity analysis are summarized in Table 4-3 (detailed results tables are presented in Appendix F). In presenting the results of the sensitivity analysis, we have compared the risk estimates for the particular simulation to the core set of risk estimates generated for the same health effect endpoint/urban study area combination. Specifically, we have calculated a percent difference between the sensitivity analysis result and the associated core risk estimate to compare the results of the sensitivity analysis across the different modeling elements that were considered. These *percent difference* results are emphasized in Table 4-1 and in the discussion presented below.

In discussing the results of the sensitivity analysis, we have developed four descriptive categories, based on the general magnitude of the percent difference estimate generated for a particular modeling element:

- Modeling elements estimated to have percent differences of 20% or smaller (i.e., they produced risk estimates that differed from the core risk estimates by no more than 20%) are classified as having a **small** contribution to uncertainty in the core risk estimates.
- Modeling elements estimated to have percent difference estimates in the range of 20 to 50% are classified as having a **moderate** contribution to uncertainty in the core risk estimates.
- Modeling elements estimated to have percent difference estimates in the range of 50 to 100% are classified as having a **moderate-large** contribution to uncertainty in the core risk estimates.
- Modeling elements estimated to have percent difference results >100% are classified as having a **large** contribution to uncertainty in the core risk estimates.

The sensitivity analysis based on Moolgavkar's (2003) study in Los Angeles addressing model specifications for both short-term mortality and morbidity (e.g., model selection, lag structure and co-pollutant models) are discussed together as a group. This reflects the fact that the Moolgavkar-based simulations were based on the same underlying dataset and focused on Los Angeles. Furthermore, the discussion of the Moolgavkar-based sensitivity analysis results presented below, as well as the summary of results presented in Table 4-1, focus on the difference in the spread of risk results across the Moolgavkar-based model specifications (for a particular endpoint), rather than the *percent difference* results based on comparison against the core result that are emphasized with the other sensitivity analyses.[49]

The sensitivity analysis examining the impact of alternative rollback approaches for simulating ambient $PM_{2.5}$ concentrations in urban study areas under both the current and alternative suites of standards also deserves additional discussion before presenting the results. For the first draft RA, we considered the impact of using a hybrid rollback approach in addition to the proportional rollback approach which has been traditionally used in PM NAAQS risk

[49] Comparison of the Moolgavkar-based risk estimates with the core risk estimates consistently produce percent difference estimates that range to levels well above +100%, resulting in a general conclusion, based on this metric, that all of the factors considered in the Moolgavkar-based sensitivity analysis are large contributors to uncertainty in the core risk estimates. However, there is significant uncertainty in assuming that the behavior of the Moolgavkar-based risk models (reflecting consideration for alternate design elements) would be representative of how models derived from either of the key short-term studies considered in this risk assessment (Zanobetti and Schwartz., 2009 and Bell et al., 2008) would respond to variations in design. Therefore, while sensitivity analysis results based on comparing Moolgavkar-based risk estimates against the core risk estimates are included in the detailed sensitivity analysis results tables presented in Appendix F (see Tables F-31 through F-33), we do not discuss these results here due to the degree of uncertainty associated with them.

assessments. For this second draft, as discussed in sections 2.6, 3.2.3 and 3.5.4, we have included consideration of a peak shaving rollback approach in addition to the hybrid as non-proportional methods to contrast with proportional rollback.[50]

As discussed in Section 3.2.3, for the second draft risk assessment, we have calculated composite monitor estimates based on proportional rollback and hybrid and/or peak shaving, where appropriate. The composite monitor values are surrogates for long-term exposure-related mortality.[51] Therefore, by comparing composite monitor values generated for the same study area/suite of standards (using different rollback methods), we can obtain insights into the potential impact of the rollback method used on long-term exposure-related mortality (see Section 3.5.4 for additional discussion of how the composite monitor values generated using the different rollback methods are used in the sensitivity analysis). These sensitivity analysis results based on consideration for composite monitor values generated using the different rollback methods (which are presented in detail in Appendix F, Tables F-49 and F-50) form the basis for summary information related to rollback presented in Table 4-3. Due to the complexity of the sensitivity analysis conducted examining the issue of rollback, the discussion of results from that particular analysis presented in section 4.3.1.1 is more detailed than for the other factors considered as part of the sensitivity analysis.

In discussing the results of the sensitivity analysis, results of the single-factor simulations are presented first (section 4.3.1.1), followed by the results of the multi-factor simulations (section 4.3.1.2). Within these categories, results are further organized by health effect endpoint with results for long-term exposure mortality discussed first and then short-term exposure mortality, followed by short-term exposure morbidity. An overall conclusion regarding which of the factors included in the sensitivity analysis represent potentially significant sources of uncertainty and variability impacting the core risk estimates is presented at the end of each sub-section.

---

[50] The peak shaving approach involves proportional reduction in 24-hour $PM_{2.5}$ levels only at those urban study areas where the 24-hour standard is controlling (and only at those specific monitors with design values exceeding that 24-hour standard level) – see Section 3.2.3 for additional detail.

[51] The composite monitor is essentially the mean of the annual averages across the $PM_{2.5}$ monitors in a study area. It is this air quality metric that is used in calculating long-term exposure-related mortality. Given that the same C-R function is used across all study areas, differences in long-term mortality across study areas (and/or across standard levels) reflect to a great extent underlying differences in the composite monitor values. Therefore, comparison of composite monitors (in terms of percent difference for example) can provide insights into potential percent differences in long-term mortality related to $PM_{2.5}$ exposure across study areas and/or standard levels (see Section 3.5.4).

1 **Table 4-3 Overview of Sensitivity Analysis Results**

Sensitivity Analysis[1]	Health Endpoint and Risk Assessment Location	Summary of Results (percent difference in risk estimate relative to the core estimate)	Appendix F Tables with Detailed Results (for 2007)
Single-Factor Sensitivity Analyses (long-term exposure mortality):			
Impact of using different model choices: fixed effects log-linear (the core) vs. random effects <u>log-linear</u> C-R function	• All-cause, CPD, IHD • Los Angeles and Philadelphia	Random effects log-linear C-R model: • all-cause: +23% • IHD: +12%	Table F-3
Impact of using different model choices: fixed effects log-linear (the core) vs. random effects <u>log-log</u> C-R function	• All-cause, CPD, IHD • Los Angeles and Philadelphia	Random effects log-log C-R model: • All-cause: +123 to +159% • CPD: +50 to +74% • IHD: +80 to +111% • Lung Cancer: +67 to +94%	Table F-3
Impact of using different model choices: Single vs. multi-pollutant models	• All-cause • Los Angeles and Philadelphia	• Model with CO: +45% • Model with NO_2: +73% • Model with O_3: +45% • Model with SO_2: -74%	F-43
Impact of estimating risks down to PRB rather than down to LML (the core)	• All cause • All 15 urban study areas	• All-cause: +47 to +273%	Table F-6
Impact of using alternative C-R function from another long-term exposure mortality study	• All-cause, CPD, lung cancer • Los Angeles, Philadelphia	• All-cause: +119 to +121% • CPD: +29 to +30% • Lung cancer: +29 to +30%	Table F-9
Impact of using alternative hybrid rollback approach reflecting more localized patterns of ambient $PM_{2.5}$ reduction (evaluated across current and alternative standard levels) – based on the composite monitor analysis described in Section 3.5.4 considering both hybrid and peak shaving approaches as alternatives to proportional rollback	• Surrogate for long-term mortality (composite monitor-based analysis) • All study areas except Dallas had either hybrid and/or peak shaving applied as an alternative	• Trend in incremental risk reduction (alternative standard level compared to current standard): rollback method did not appear to have a significant impact on this metric (those urban study areas with different trends in reduction did not demonstrate a consistent pattern related to	Tables F-49 and F-50

Sensitivity Analysis[1]	Health Endpoint and Risk Assessment Location	Summary of Results (percent difference in risk estimate relative to the core estimate)	Appendix F Tables with Detailed Results (for 2007)
	rollback method to the proportional	the type of hybrid method used) • Absolute risk for a given standard level: use of alternative rollback methods did appear to impact estimation of $PM_{2.5}$ risk remaining for a given standard level: <1% to >+50% • Has implications for degree to which 24-hour standard levels produce reductions in annual-average $PM_{2.5}$ levels (and consequently on long-term and short-term exposure-related risk). Results suggest that use of peek shaving rollback method can result in smaller degree of reduction in annual-average values compared with proportional rollback, (see discussion in text – section 4.3.1.1)	
Single-Factor Sensitivity Analyses (short--term exposure mortality):			
Impact of using season-specific C-R functions (vs. an annual C-R function)	• Non-accidental mortality, CV, respiratory • All 15 urban study areas	• Non-accidental: -116 to +179% • CV: -82 to +500% • Respiratory: -48 to +162% (Note, overall incidence estimates, particularly for the locations with higher percent change estimates, is very low, raising concerns over the stability of these sensitivity analysis results)	Table F-15 Table F-18 Table F-21
Impact of using alternative hybrid rollback approach reflecting a combination of more localized and regional patterns of ambient $PM_{2.5}$ reduction (note, this analysis is based exclusively on the hybrid rollback – the composite monitor analysis described	• Non-accidental mortality • Baltimore, Birmingham, Detroit, Los Angeles, New York and St. Louis	• Results for all seven urban study areas (across the current and alternative standard levels) do not exceed +17%, with most <+10%.	Table F-36

Sensitivity Analysis[1]	Health Endpoint and Risk Assessment Location	Summary of Results (percent difference in risk estimate relative to the core estimate)	Appendix F Tables with Detailed Results (for 2007)
above pertains only to long-term mortality-related risk)			
Single-Factor Sensitivity Analyses (short-term morbidity: hospital admissions (HA) and ED visits):			
Impact of using season-specific C-R functions (vs. an annual C-R function)	• HA (unscheduled), CV and respiratory • All 15 urban study areas	• HA (CV): -105 to +9% • HA (respiratory): -54 to +74% (Note, overall incidence estimates, particularly for the locations with higher percent change estimates, is very low, raising concerns over the stability of these sensitivity analysis results)	Table F-24 Table F-27
Impact of using an annual C-R function (applied to the whole year) vs. a seasonal function for April through August (applied only to that period) (using a single pollutant model)	• Asthma ED visits • New York	NA (although incidence estimates were generated for this simulation, "percent difference from the core" were not generated since the alternate simulation focused on a subset of the year).	Table F-30
Impact of considering models with different lags	• HA (CV and respiratory • LA and New York	NA (although incidence estimates were generated for this simulation, "percent difference from the core" were not generated since the lag-differentiated C-R functions used are not regionally-differentiated, and therefore, do not allow a focused consideration of the lag factor alone in impacting risk estimates)	Table F-48
Single-Factor Sensitivity Analysis (short-term exposure mortality and morbidity in LA based on Moolgavkar, 2003 study model options) (Note, results presented here reflect spread in risk estimates across Moolgavkar-based model specifications and not percent difference from core risk estimates, unless so stated – see text)			
Impact of model selection (e.g., log-linear GAM with 30 df; log-linear GAM with 100 df; and log-linear GLM with 100 df)	• Mortality (non-accidental, CV); HA (CV) • Los Angeles	• Non-accidental mortality: +80% • CV mortality: +49 • CV HA: +36%	Table F-33

Sensitivity Analysis[1]	Health Endpoint and Risk Assessment Location	Summary of Results (percent difference in risk estimate relative to the core estimate)	Appendix F Tables with Detailed Results (for 2007)
Impact of lag structure (0-day, 1-day, 2-day, 3-day, 4-day, 5-day)	• Mortality (non-accidental) • Los Angeles	• Non-accidental mortality: +55%	Table F-33
Impact of single- vs. multi-pollutant models ($PM_{2.5}$ with CO)	• Mortality (CV); HA (CV) • Los Angeles	• CV mortality: +106% • CV HA: +140%	Table F-33
Multi-Factor Sensitivity Analyses (long-term mortality):			
Impact of using a fixed effects log-linear vs. a random effects log-log model, estimating incidence down to the lowest measured level (LML) in the study vs. down to PRB, and using a proportional vs. hybrid rollback to estimate incidence associated with long-term exposure to $PM_{2.5}$ concentrations that just meet the current standards (note consideration of rollback in the multi-factor analysis did not incorporate the hybrid-based rollback approach)	• All-cause, IHD long-term mortality • Los Angeles and Philadelphia	• All-cause: +27 to +1,089% • IHD: +256to +673%	F-39
Multi-Factor Sensitivity Analyses (short--term mortality):			
Impact of using season-specific vs. all-year C-R functions and proportional vs. hybrid rollbacks to estimate incidence associated with short-term exposure to $PM_{2.5}$ concentrations that just meet the current standards	• Non-accidental • Baltimore, Birmingham, Detroit, Los Angeles, New York and St. Louis	• Non-accidental (four seasons + hybrid): -116 to +179%	F-42

[1] Unless otherwise noted, sensitivity analysis results are based on the scenario reflecting just meeting the current suite of $PM_{2.5}$ standards.
[2] This metric is the percent spread in risk estimates across the Moolgavkar-based model specifications (not the percent difference estimates – see text discussion above).

4.3.1.1 Single-factor Sensitivity Analysis

This section presents the results of the single-factor sensitivity analysis, which involved consideration of alternate model inputs on the core risk estimates, when those alternate inputs are considered one at a time (consideration of the combined effect of several model inputs being varied is covered by the multi-factor sensitivity analysis discussed in section 4.3.1.2). The results of the single-factor sensitivity analysis are characterized qualitatively using the four-category approach described above (i.e., low, moderate, moderate-large and large, with each of these representing a defined range of percent difference from the core risk estimates).

<u>Long-term exposure mortality</u>

This section summarizes the results of the sensitivity analysis focused on long-term exposure-related mortality endpoints (see Table 4-1 for the specific modeling elements considered in the sensitivity analysis).

- *Impact of using different model choices for C-R function - fixed effects log-linear (the core approach) vs. random effects log-linear or random effects log-log models*: This simulation considered two alternative C-R model forms obtained from Krewski et al., 2009 for modeling all-cause, CPD, IHD and lung cancer mortality, including (a) random effects log-linear model and (b) a random effects log-log model (note, the core effect estimate was derived using a fixed effects log-linear model obtained from Krewswki et al., 2009). The simulation also considered the use of multi-pollutant models that control for CO, NO_2, O_3 or SO_2. The results of the simulation suggest that the use of a random effects log-linear model, rather than the core fixed effects model, has a relatively small effect on risk estimates, increasing them by 12 to 23% across the mortality categories and urban study areas modeled (Appendix F, Table F-3). However, use of a random effects log-log model has a larger impact on risk estimates, increasing them by 50 to 159% (Appendix F, Table F-3). The greater impact of the log-log model results from this function having an incrementally steeper slope at lower PM levels, which quickly increases incidence estimates compared with the core log-linear model (whose slope has a much more gradual incremental increase in slope at lower PM levels). The use of multi-pollutant models that control for co-pollutants was shown to have moderate-large impact on risk estimates, with control for CO, NO_2, or O_3 resulting in increased $PM_{2.5}$-attributable risk estimates, while control for SO_2 resulted in a moderate-large decrease in estimated $PM_{2.5}$ risk.[52]
- *Impact of estimating risks down to PRB rather than down to LML*: This simulation compared long-term exposure mortality incidence associated with modeling risk down to PRB (which varies by region – see section 3.2.1) with the core approach of modeling down to LML (5.8 µg/m^3 for long-term mortality – see section 3.1). This simulation involved all 15 urban study areas, given that PRB is stratified by region and therefore, results of the

[52] Sensitivity analysis results generated using the copollutant model involving $PM_{2.5}$ and SO_2 have been de-emphasized since it is likely that control for SO_2 may be capturing a portion of $PM_{2.5}$ -attributable risk related to the secondary formation of sulfate, which is a component of the $PM_{2.5}$ mixture (i.e., the two pollutants are often highly correlated).

simulation could differ significantly across the 15 urban study areas, or at least across the six PM regions represented by those study areas. The results of this simulation suggest that modeling risk down to PRB could have a moderate to large impact on long-term exposure mortality incidence, with estimates ranging from 47 to 273% higher than the core estimates (for matching urban locations) (Appendix F, Table F-6). Note, however, that risk metrics based on considering the incremental reduction in risk (incidence) between two alternative suites of standards would not be impacted by this source of uncertainty, since it only affects estimates of absolute risk.

- *Impact of C-R function from alternative long-term exposure mortality study*: This simulation considered use of alternative C-R functions (and effect estimates) based on the reanalysis of the Six Cities study (Krewski et al., 2000). The results suggest that use of the alternative C-R function could have a moderate to moderate-large effect on CPD mortality (+45 to +74%), a large effect on all-cause mortality (+123 to +159%), a moderate-large to large effect on IHD mortality (+80 to +111%) and a moderate-large effect on lung cancer mortality (+67 to +94%) (Appendix F, Table F-9). The results of this simulation suggest that (at least with regard to application of C-R functions obtained from the Six Cities study) the potential impact of functions from alternative studies on long-term exposure mortality depends on the mortality category being considered. In this analysis, use of the alternative C-R functions was shown to have a significant impact on all of the long-term mortality categories considered.
- *Impact of using alternative rollback approaches (hybrid and peak shaving) to simulate just meeting the current and alternative suites of standards*. This sensitivity analysis assessed the impact of estimating risk for the current and alternative sets of standards using two alternatives to the proportional rollback strategy: (a) the hybrid rollback approach that reflects an initial localized pattern of ambient $PM_{2.5}$ reduction (resulting in non-proportional rollbacks of monitored $PM_{2.5}$ concentrations) with a second phase of more regional reductions in ambient $PM_{2.5}$ levels (based on proportional adjustments) and (b) peak shaving which represents a primarily local pattern of reductions in ambient $PM_{2.5}$ (see Section 3.5.4 for additional discussion of how these alternative rollback methods were integrated into the sensitivity analysis). We note that the core analysis utilized proportional rollback exclusively in simulating conditions for the current and alternative sets of standards, with this approach representing a regional pattern of ambient $PM_{2.5}$ reduction. A number of observations can be drawn from this sensitivity analysis including:
    - *Impact on estimates of $PM_{2.5}$-related risk remaining after simulation of just meeting a given suite of standards*: The sensitivity analysis results suggest that the use of alternative rollback methods can have a notable impact on estimates of the $PM_{2.5}$-attributable risk remaining after simulation of a given suite of standards (see Appendix F, Table F-50 and discussion in section 3.5.4). Generally, use of the hybrid approach had a small to moderate impact on absolute $PM_{2.5}$-attributable risk estimates, compared with the core approach of using proportional rollback. By contrast, use of the peak shaving approach had a moderate to moderate-large impact on absolute $PM_{2.5}$-attributable risk estimates. For example, Los Angeles had composite monitor values for the current suite of standards and several of the alternative suites of standards that were 40 to 60% greater when the peak shaving rollback method was used, compared with the proportional rollback

method (see Appendix F, Table F-50). By contrast, composite monitor values generated using hybrid rollback for Los Angeles, were between 13 and 38% higher than the proportional rollback methods.

- *Impact on degree of reduction across alternative suites of standards:* When the same rollback methods is used to simulate both the current and any alternative suite of standards, the pattern of risk reduction across alternative standards is generally similar regardless of the rollback approaches used (see Table F-49, in Appendix F). However, if one looks at meeting the current suite of standards with application of the peak-shaving approach, followed by application of proportional rollback to simulate alternative suites of standards, we can see notable differences in the pattern of risk reduction. This is particularly true for areas with peaky $PM_{2.5}$ distributions (i.e., areas with relatively high 24-hour design values and lower annual average design values). For example, with Los Angeles, which represents a study area with a relatively peaky $PM_{2.5}$ distribution, application of proportional rollback in simulating both the current suite of standards and the alternative annual standard of 12 $\mu g/m^3$ results in a 13% reduction in long-term exposure-related mortality (see Figure 4-3 and Table E-27 in Appendix E). By contrast, application of peak shaving in simulating the current suite of standard levels followed by proportional reduction in simulating the same alternative annual standard results in an estimated 48% reduction in long-term exposure-related mortality.[53]

Based on the simulations discussed above covering potential sources of uncertainty and variability impacting long-term mortality, we conclude that the following factors contribute potentially large sources of uncertainty to the core risk estimates: (a) use of alternative form of the C-R function, specifically use of a random-effects log-log model form obtained from the updated ACS study (Krewski et al., 2009) (b) use of an alternative C-R function with effects estimates obtained from the reanalysis of the Six Cities study (Krewski et al. 2000), and (c) estimation of risk down to PRB.[54] Other factors considered in the sensitivity analysis had smaller impacts on core risk estimates.

[53] The difference in risk reductions based on application of different rollback methods in simulating the current suite of standards reflects the fact that peak shaving rollback, when applied to a location where the 24hr standard level is controlling , such as Los Angeles, will produce a smaller degree of reduction in the composite monitor annual-average $PM_{2.5}$ level. By contrast, application of proportional rollback will produce a larger degree of rollback in the composite monitor annual-average (i.e., a level equal to that needed to get the 24hr design value to meet the 24hr standard). We also note that the risk reductions cited here reflecting application of peak-shaving in simulating the current suite of standards are based on comparison of composite monitor annual-averages presented in Table F-49 in Appendix F. In generating this surrogate for reduction in long-term exposure-related mortality between the two standard levels, we compared composite monitor annual-averages with consideration for the fact that long-term exposure-related mortality is only calculated down to LML.

[54] Use of peak-shaving as an alternative method for simulating ambient $PM_{2.5}$ concentrations for alternative standards had a moderate-large impact on risk estimates.

Short-term exposure mortality

This section summarizes the results of the sensitivity analysis focused on short-term exposure-related mortality endpoints (see Table 5-1 for the specific modeling elements considered in the sensitivity analysis).

- **Impact of using season-specific C-R functions (vs. an annual C-R function)**: This simulation considered the impact on short-term exposure mortality risk of using seasonally-differentiated effects estimates rather than the core approach of using a single C-R function for the whole year (note, that the seasonal models were based on the same study as the model used in the core analysis – Zanobetti and Schwartz, 2009). The results of the simulation suggest that this source of uncertainty can have a wide range of effects across urban study areas (including not only variation in the magnitude of effect, but also in the direction). Percent changes compared with the core risk estimate were large, ranging from -116% (Los Angeles) to +179% (Birmingham) (these results are for non-accidental mortality – see Appendix F, Table F-15). We note that these two locations also have relatively low overall incidence estimates, which does raise concerns over the degree of stability in the sensitivity analysis estimates. Furthermore, for 9 of the 15 urban study areas (for non-accidental morality), percent changes from the core were small, with absolute values of 12% or less (Appendix F, Tables F-15). The results for CV and respiratory mortality also demonstrate considerable variation across locations, but are generally smaller than results cited above for non-accidental, with one exception. Birmingham is estimated to have short-term CV mortality that is +500% higher using seasonal effects estimates compared with the core results (We note, however, that this endpoint category also has very small incidence, again raising concerns over the stability of the sensitivity analysis results) (see Table F-18). The results for respiratory-related mortality also demonstrate considerable variability with results that could suggest a moderate to large impact (i.e., -48 to +162% - see Appendix F, Table F-21). We note, however, that small incidence estimates again raise concerns regarding the stability of these percent difference results.
- **Impact of using alternative hybrid rollback approach**: This simulation evaluates the potential impact of using the hybrid (non-proportional) approach for simulating just meeting current and alternative sets of standards, as an alternative to the proportional approach used in the core analysis.[55] The results of this simulation (as contrasted with the impact of using the hybrid approach on long-term exposure mortality) suggest that use of the hybrid rollback approach has relatively little effect on short-term mortality risk (e.g., percentage differences relative to the core risk estimates were in the low single digits for most locations, with one location having a difference of +17% - see Appendix F, Table F-36).

---

[55] Note, that the peak shaving rollback method was only assessed in the context of the composite monitor values used in generating long-term exposure-related mortality estimates. Consequently, consideration of the peak shaving rollback method is only assessed in terms of its impact on long-term risk and not short-term exposure-related mortality. Note, however, that the impact of using peak shaving versus proportional rollback on short-term exposure-related risk is expected to be smaller than the impact on long-term exposure-related risk, since the latter is linked to composite annual averages which are expected to experience the greatest impact from application of alternative rollback methods.

The sensitivity analysis results discussed above, result in a number of overall observations regarding sources of uncertainty potentially impacting short-term exposure morality endpoints. The results of using the seasonally-differentiated effect estimates in modeling short-term exposure mortality appear to generally have a relatively small impact (e.g., <15%) in most study areas. For some study areas, the impact does appear to be much larger, with results including both substantial negative and positive percent differences from the core estimates. However, in all of these cases, the total incidence estimates involved are very small, raising concerns over the stability of the risk estimates generated as part of this particular sensitivity analysis (in many of these instances, the estimates include negative lower bounds, reflecting the use of non-statistically significant effects estimates). For these reasons, the results of this sensitivity analysis, while initially appearing to be notable in terms of magnitude in some study areas, need to be interpreted with care. At this point, we are uncertain as to how important this source of uncertainty is in the context of short-term exposure mortality estimation. Regarding the use of the alternative hybrid (non-proportional) approach for simulating conditions under alternative standard levels, the results suggest that this factor has a modest impact on short-term exposure mortality (significantly less impact than with the use of the hybrid approach in estimating long-term exposure mortality). With the exception of factors examined using the Moolgavkar et al., (2003) study in Los Angeles (see section 4.3.1.4), it would appear that the factors examined here do not have a large impact on risk estimates generated for short-term exposure mortality. However, we note that the overall scope of the sensitivity analysis completed for short-term exposure-related mortality and morbidity is far more limited than that completed for long-term exposure-related mortality.

<u>Short-term exposure morbidity</u>

This section summarizes the results of the sensitivity analysis focused on short-term exposure-related morbidity endpoints (see Table 5-1 for the specific modeling elements considered in the sensitivity analysis). The results of individual sensitivity analysis simulations are presented below, with overall observations presented at the end of the section.

- **Impact of using season-specific C-R functions (vs. an annual C-R function):** This simulation considered the impact on short-term exposure morbidity (HAs) of using seasonally-differentiated effects estimates rather than the core approach of using a single C-R function for the whole year (we note that the seasonal models were obtained from the same study as the model used in the core analysis – Bell et al, 2008). The results of the simulation suggest that, as with short-term exposure mortality this source of uncertainty can have a wide range of impacts on the risk estimates across urban study areas (including not only variation in the magnitude of risk, but also in the direction) depending on the specific health endpoint examined. We note, however, that the magnitude of impact appears to be less for short-term morbidity than for short-term mortality. Percent changes for most of the 15 urban study areas were small for CV HAs (generally less than a 20% difference in either direction, although there was a large impact for Tacoma (-105%)) (see Appendix F, Table F-24). This source of uncertainty has a moderate to moderate-large impact for respiratory-related HAs with most locations having greater than a 54% to 74% absolute effect (see Appendix F, Table F-27).

- **Impact of using a seasonal function for April through August (applied only to that period) in modeling asthma-related ED visits in New York, relative to the core approach of using a single annual effect estimate (and applying that to the whole year):** This sensitivity analysis involved the approach of using a season-specific estimate to model incidence for the period April through August (obtained from Ito et al., 2007). Because this sensitivity analysis estimate covers a period shorter than a year, we have not directly compared it with the annual estimate generated for this endpoint in the core risk assessment (i.e., we have not generated percent difference estimates as is done with other sensitivity analysis simulations). However, the results of this sensitivity analysis do suggest that the use of seasonally-differentiated estimates in modeling this endpoint can impact risk.
- **Impact of considering models with different lags:** To examine the impact of lag on modeling of short-term exposure-related morbidity, we used a range of effects estimates obtained from Bell et al., 2008 based on application of different lags, including 0-, 1- and 2-day lags, (for both respiratory and cardiovascular-related morbidity). Because lag-differentiated effects estimates were only available as national-averages and were not regionally-differentiated, we could not directly compare the results using different lag models to the results generated for the core analysis (i.e., the sensitivity analysis results would have mixed both the lag effect and the effect of regional differentiation, thereby preventing clear assessment of the importance of either factor considered in isolation). However, consideration of the magnitude of the risk estimates generated using different lag models, for the same endpoint at the same urban study are, suggests that choice of lag does effect estimates of short-term exposure-related morbidity (see Appendix F, Table F-48).

Given the results of the set of simulations completed for short-term exposure morbidity, both of which focused on the use of seasonally-differentiated effects estimates, it would appear that this factor does not have a substantial impact on risk estimates. The analysis considering different lag models does suggest that this factor could have a notable impact on risk estimates and should be carefully considered when specifying C-R functions to use in the risk assessment. Additional factors potentially impacting short-term exposure morbidity are addressed below in relation to the sensitivity analysis based on alternative models from Moolgavkar et al. (2003). As noted earlier, the scope of the sensitivity analysis completed for short-term exposure-related morbidity is limited.

<u>Short-term exposure-related mortality and morbidity (Moolgavkar et al., 2003 study-based analysis)</u>

As noted earlier in the introduction to section 4.3, the results of sensitivity analysis based on Moolgavkar et al., (2003) include percent difference estimates based on considering the range of risk estimates generated using alternative model specifications from this study for a given health endpoint and it is these results that are discussed below.

- **Impact of model selection (e.g., log-linear GAM with 30df, log-linear GAM with 100df, and log-linear GLM with 100df) on estimating short-term exposure mortality and morbidity**: Application of models obtained from Moolgavkar et al., (2003) with various formulations related to model selection (degrees of freedom, GLM vs. GAM) to the Los Angeles urban case study location results in a range of short-term exposure mortality estimates (for non-accidental and CV) that differ by 80% and 49%, respectively (see Appendix F, Table F-33). In the case of short-term exposure morbidity (specifically, CV-related HAs), incidence estimates differ by 36% (see Appendix F, Table F-33). These results suggest that these elements of model specification represent a moderate source of uncertainty in estimating short-term mortality and morbidity.
- **Impact of lag structure (0-day through 5-day) on estimating short-term exposure mortality:** Consideration of the range of risk estimates for non-accidental mortality generated using different lag structures (and associated effect estimates) provided in Moolgavkar et al., (2003), suggest that this factor could have a moderate impact on risk (in the range of 55% when comparing the lowest and highest positive incidence estimates generated). (see Appendix F, Table F-33).
- **Impact of considering multi-pollutant models on estimating short-term exposure mortality and morbidity**: The results of the Moolgavkar-based simulations (when considering the spread in risk estimates specifically across these simulations) suggest that the multi-pollutant versus single-pollutant model issue (i.e., including CO in addition to $PM_{2.5}$), could have a large impact on the estimation of short-term exposure mortality (106% for all-cause) and morbidity (140% for CV-related HAs).

Overall observations regarding key sources of uncertainty impacting short-term exposure mortality and morbidity risk estimates (based on the Moolgavkar et al., 2003 study) include the following. The spread in risk estimates generated across the Moolgavkar-based model specifications suggests that factor related to specifying the C-R model may have a moderate to large impact. More specifically, variation in the lag structure has a moderate impact on risk and use of single versus multi-pollutant models could have a potentially large impact on risk. Note, however, that as discussed earlier, the relevance of these sensitivity analysis results to the interpretation of core risk estimates is not clear and may be relatively low (see Section 4.3.1).

4.3.1.2 Multi-factor Sensitivity Analysis Results

The results of the multi-factor sensitivity analyses are intended to support both goals of the sensitivity analysis: (a) identify which factors (now in combination), appear to have a significant impact on estimation of the core estimates and (b) to derive a set of reasonable alternative risk estimates for use in considering uncertainty and variability associated with the core risk estimates. Regarding the latter application, because these multi-factor simulations combine multiple factors reflecting uncertainty and variability together in generating alternative risk estimates, they are likely to produce the highest sensitivity analysis results. Therefore, it is particularly important to consider the reasonableness of the results of these multi-factor simulations, to insure that only credible estimates are included in the set of reasonable alternative risk estimates. Consequently, we emphasize consideration for the reasonableness of these multi-factor simulations in the discussion presented below.

Long-term exposure mortality

This section summarizes the results of the sensitivity analysis focused on long-term exposure-related mortality endpoints (see Table 4-1 for the specific modeling elements considered in the sensitivity analysis).

- **Impact of using log-linear vs. log-log C-R model with fixed or random effects, estimating incidence down to the LML vs. PRB, and using proportional vs. hybrid rollback to estimate long-term exposure mortality**: This multi-factor sensitivity analysis focused on a number of model design choices related to modeling long-term exposure mortality (all-cause and IHD). Modeling elements reflected in the simulations included: (a) model form (log-linear vs log-log and random vs fixed effects), (b) modeling risk down to PRB (vs LML), and (c) use of an alternative hybrid rollback approach (vs proportional rollback) to simulate just meeting the current and alternative sets of standards. Various permutations of these design elements choices (relative to the elements selected for the core analysis) were considered. Percent difference estimates (for all-cause mortality) ranged from 27% (for a model estimating risk down to PRB and use of the hybrid rollback approach) to 1,089% (for a model with random effects log-log model, risk estimated down to PRB, and use of the hybrid rollback approach).

We believe that application of a log-log model with random effects is a reasonable alternative to the core model (fixed-effects log-linear model), based on our review of the discussion in Krewski et al. (2009). Similarly, the use of a hybrid rollback approach involving non-proportional adjustment where there is the potential for greater use of local control strategies to address local-sources is a reasonable alternative to solely using a proportional rollback approach in all study areas. Therefore, we believe that the combinations of modeling elements including these alternative choices are reasonable. However, there is more concern in predicting risk down to PRB. This is not because there is evidence for a threshold, but rather because we do not have data to support characterization of the nature of the C-R function in the vicinity of PRB. Specifically, there is increasing uncertainty in predicting the nature of the C-R function as you move below the LML. So, while we believe it is reasonable conceptually to estimate risk down to PRB, the quantitative process of doing this requires use of a function with very high uncertainty. Therefore, we concluded that those alternative risk estimates generated using risk estimated down to PRB should not be used in creating the reasonable alternative set of risk estimates in considering uncertainty associated with the core risk estimates.

A key limitation of the multi-factor sensitivity analysis is that the approach used did not allow us to consider the peak-shaving rollback method in concert with the other modeling elements described above. This means that the combined impact of peak shaving (which has a greater impact than the hybrid rollback method) with other model specifications is not characterized. However, as part of the integrative discussion in Chapter 6, we will consider the results of the single-factor sensitivity analysis examining rollback (with its consideration for peak shaving) along with the multi-factor sensitivity analysis results described here.

<u>Short-term exposure mortality</u>

This section summarizes the results of the sensitivity analysis focused on short-term exposure-related mortality endpoints (see Table 4-1 for the specific modeling elements considered in the sensitivity analysis).

- **Impact of using season-specific vs. annual effect estimates and proportional vs. hybrid rollback approaches in modeling short -term exposure mortality**: This multi-factor sensitivity analysis focused on a number of model design choices related to modeling short-term mortality (non-accidental). Modeling elements included in this sensitivity analysis were use of seasonal vs. annual effects estimates and use of hybrid vs proportional rollback to simulate just meeting current and alternative standard levels. Percent difference estimates (for non-accidental mortality) across the 7 urban study areas included in the simulation ranged from -109% (LA) to +119% (Birmingham) (see Appendix F, Table F-42). However, we note that the total incidence estimates associated with these higher-impact locations were relatively low, again raising the concern for the stability in relative differences with the core estimates.

Because of the more limited scope of the multi-factor sensitivity analysis completed for short-term exposure-related mortality, we have concluded that these results should not be used as an additional set of reasonable risk estimates to inform consideration of uncertainty associated with this category of risk estimates.

4.3.2 Additional Set of Reasonable Risk Estimates to Inform Consideration of Uncertainty in Core Risk Estimates

This section discusses the use of the output of the sensitivity analysis completed as part of this risk assessment as an additional set of reasonable risk estimates to inform consideration of uncertainty associated with the core risk estimates. Specifically, in the case of long-term exposure-related mortality endpoints, staff has concluded that the results of the sensitivity analysis represent a reasonable set of alternate risk estimates that fall within an overall set of plausible risk estimates surrounding the core estimates.[56]

[56] As noted in section 4.3.2 and in the integrative discussion in Section 6.4, while staff believes that the sensitivity analysis does provide insights into the potential impact of certain sources of uncertainty on short-term exposure-related mortality and morbidity risk, the sensitivity analysis conducted for short-term exposure-related endpoints

While not representing a formal uncertainty distribution, the output of the sensitivity analysis, when combined with the core risk estimates, represent a set of plausible risk estimates, which reflect consideration for uncertainty in various elements of the risk assessment model. Therefore, while the discussion of risk estimates in the context of assessing the degree of risk reduction associated with suites of alternative standards (see Chapter 6) does focus on the core risk estimates since these are judged to have the greatest overall confidence, the output of the sensitivity analysis can be used to provide additional perspective on the potential range of uncertainty around the core estimates. Note however, that we do not know the confidence interval captured by this uncertainty set, or the specific percentiles of the risk distribution are represented by points within that set.

As noted earlier, the quantitative single- and multi-factors sensitivity analyses generated an additional set of risk estimates for a subset of the urban study areas, air quality scenarios and health endpoints included in the core risk analysis (i.e., Los Angeles and Philadelphia assessed for the current standard level). However, the part of the sensitivity analysis focusing on alternative methods for simulating ambient $PM_{2.5}$ levels (i.e., rollback), did consider a larger number of study areas and air quality scenarios. In presenting the alternative sets of reasonable risk estimates, we focus on Los Angeles and Philadelphia for many of the modeling elements, although we expand the discussion in the context of discussing results related to conducting rollback..

In using the additional set of reasonable risk results to augment the core risk estimates, we begin by presenting both the core and alternative sets of estimates for Los Angeles and Philadelphia in Table 4-4. Then, in Figures 4-7 and 4-8, we present graphical display of the full uncertainty set comprising the core plus additional reasonable risk estimates for Los Angeles and Philadelphia, differentiated by mortality category (Figure 4-7 present results for IHD and Figure 4-8 presents results for all cause mortality). This section concludes with a set of observations resulting from consideration of information depicted in Table 4-4 and Figures 4-7 and 4-8 in the context of interpreting uncertainty in the core risk estimates.[57]

---

was not as comprehensive as that conducted for long-term exposure-related endpoints. Therefore, we do not believe that the results of the sensitivity analysis can be used as an additional set of reasonable risk estimates to supplement the core set in the case of short-term exposure-related endpoints.

[57] As noted earlier in 3.4.1, we have excluded several of the sensitivity analysis results in defining the set of alternative reasonable risk estimates. Specifically, we consider estimates based on modeling risk down to PRB to be less reasonable than the other scenarios included in the sensitivity analysis, since there is substantial uncertainty associated with the C-R function shape below the LML. In addition, as discussed in Section 4.3.1.1 risk estimates generated using the copollutant model involving $PM_{2.5}$ and SO_2 have been de-emphasized since it is likely that control for SO_2 may be capturing a portion of $PM_{2.5}$-attributable risk related to the secondary formation of sulfate.

Table 4-4 Derivation of a set of reasonable alternative risk estimates to supplement the core risk estimates (Los Angeles and Philadelphia, current standards, for long-term IHD mortality).

Core risk estimate	Sensitivity analysis: Description of simulation	Sensitivity analysis: Results (percent difference: sensitivity analysis versus core estimate)[4]	Adjusted set of risk estimate to supplement core risk estimates[1]
Percent of total incidence for IHD and all cause mortality (current suite of standards): **Los Angeles:** **IHD: 6.1 to 7.7%** **All cause: 1.6 to 2.0%** **Philadelphia:** **IHD: 10.5 to 13.2%** **All cause: 2.8 to 3.6%** (note, two core estimates are presented for each combination of urban study area and mortality endpoint category reflecting use of C-R functions derived using different periods of ambient data from Krewski et al., 2009 – see section 3.3.3)	*Single-element sensitivity analysis results*		
	(A) Impact of using different model choices: random effects log-linear model	Los Angeles and Philadelphia: IHD: +12%; All cause: +23%	Los Angeles and IHD: 8.6%, All cause: 2.5% Philadelphia: IHD: 14.8%, All cause: 4.4%
	(B) Impact of using different model choices: random effects log-log model	Los Angeles: IHD: +111%; All cause: +159 Philadelphia: IHD: +80%; All cause: +123%	Los Angeles and IHD: 16.2%, All cause: 5.2% Philadelphia: IHD: 23.8%, All cause: 8.0%
	(C) Impact of using different model choices (single vs. multi-pollutant – NO_2 Vs O_3/CO)[3]	Los Angeles and Philadelphia: All cause: +45 to +74% (O_3/CO and NO_2, respectively) and -74% for SO_2	Los Angeles and All cause: 2.9% and 3.5% (for O_3/CO and NO_2, respectively), 0.52% (SO_2) Philadelphia: All cause: 5.2% and 6.3% (for O_3/CO and NO_2, respectively), 0.94% (SO_2)
	(D) Impact of C-R function from alternative long-term exposure study (Krewski et al., 2000)	Los Angeles: All cause: +121% Philadelphia: All cause: +119%	Los Angeles: All cause: 4.4% Philadelphia: All cause: 7.9%
	(E) Impact of using alternative roll-back approach (hybrid and peak shaving) to simulate just meeting alternative standards	Los Angeles: Both all cause & IHD: +21 to +40% (hybrid and peak shaving, respectively) Philadelphia: Both all cause & IHD: +8% (peak shaving only)	Los Angeles and Hybrid: IHD: 9.3%, All cause: 2.4% Peak shaving: IHD: 10.8%, All cause: 2.8% Philadelphia: IHD: 14.3% All cause: 3.9%
	Multi-element sensitivity analysis results		
	(F) Random effects log-log & hybrid non-proportional rollback	Los Angeles: IHD: +149% All cause: +211 Philadelphia: NA[2]	Los Angeles: IHD: 19.2% All cause: 6.2% Philadelphia: NA[2]

[1] Percent of total incidence that is $PM_{2.5}$- related (note, the set of estimates for each entry reflect adjustment to the two core estimates generated for IHD and all-cause mortality)
[2] hybrid not run for Philadelphia, so multi-element sensitivity analysis not completed

---

Note, that the risk estimates for SO_2 are presented as open circles in Figures 4-6 and 4-7, to signify that they have lower confidence and are de-emphasized relative to the other alternative risk estimates presented.

[3] the two pollutant model for $PM_{2.5}$ and CO and $PM_{2.5}$ and O_3 had the same sensitivity result, so both models are referenced here with the same impact on mortality estimates.
[4] Sensitivity analysis based on comparison of alternative model formulations to the core risk estimates based on the C-R function derived using 1999-2001 ambient monitoring data (see section 3.5.4).

Figure 4-7 Comparison of core risk estimates with reasonable alternative set of risk estimates for Los Angeles and Philadelphia (IHD mortality).

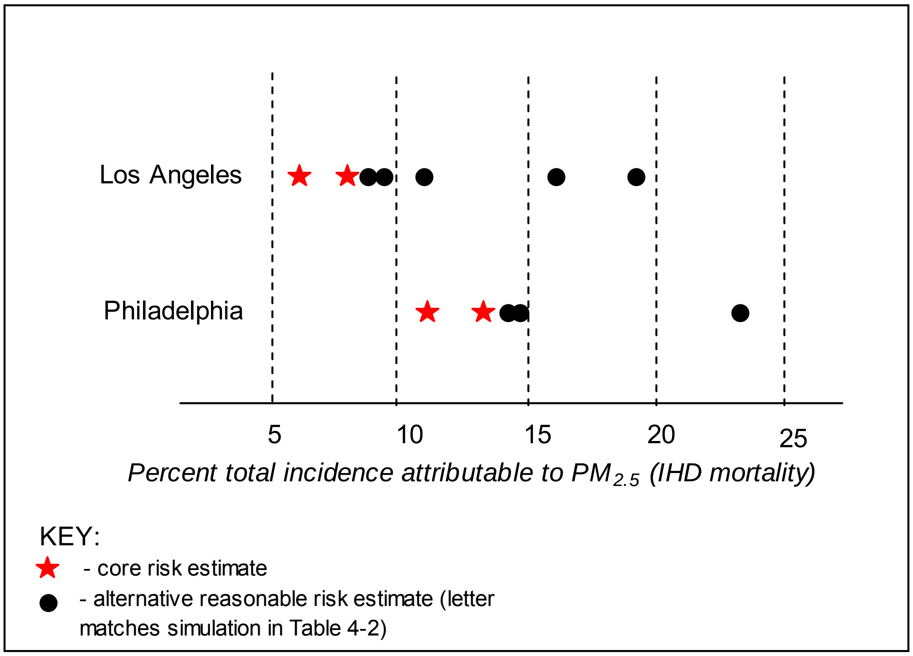
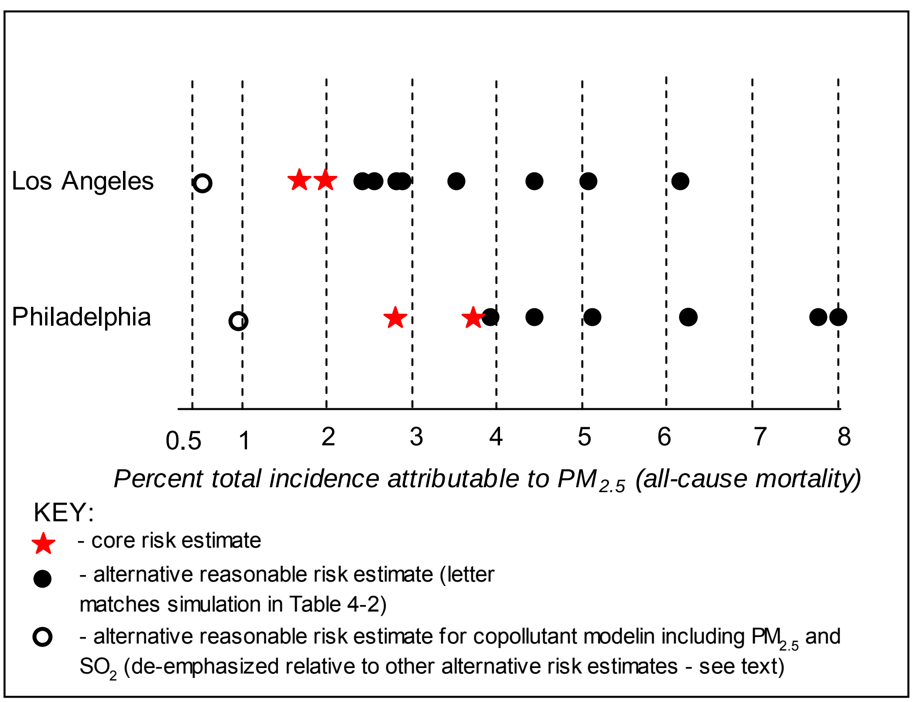


Figure 4-8 Comparison of core risk estimates with reasonable alternative set of risk estimates for Los Angeles and Philadelphia (all cause mortality).



Review of the set of risk estimates presented in Table 4-4 and displayed in Figures 4-7 and 4-8 results in a number of observations regarding uncertainty associated with the core risk estimates:

- *Consideration for uncertainty and variability in the core risk estimates results in a notable spread in risk estimates*: Given the factors considered in generating the alternative set of reasonable risk estimates, there appears to be a factor of 3 to 4 spread in risk estimates if we consider the lowest (core) estimates generated and the highest alternative risk estimates generated. This observation holds for both urban study areas considered, as well as for the two mortality endpoint categories. As noted earlier in this section, we have de-emphasized risk estimates generated using the copollutant model involving $PM_{2.5}$ and SO_2 due to concerns with collinearity between the two pollutants and the potential that SO_2 represents risk attributable to secondarily formed $PM_{2.5}$.
- *Uncertainty set of risk estimates generated to supplement the core risk estimates are skewed towards higher risk*: It appears that, given the factors considered in generating the alternative set of reasonable risk estimates, consideration of uncertainty could result in higher (more elevated) risk estimates, compared with the core risk estimates. In other words, most if not all of the alternative model specifications we considered resulted in risks that are higher than our core estimates.
- *Sensitivity analysis is limited in its scope (potentially important sources of uncertainty not considered)*: As noted earlier, the sensitivity analysis did not consider a number of potentially important sources of uncertainty, some of which were addressed as part of the qualitative analysis of uncertainty (see Table 3-13). For example, information is not available to consider compositional differences in $PM_{2.5}$ and the potential for differentiation of effects estimates. Further, not considering more refined patterns of intra-urban exposure to $PM_{2.5}$ in deriving effects estimates could result in under-estimation of risk.

It is important to reiterate that this set of alternative realizations presented in Table 4-4 and depicted in Figures 4-6 and 4-7, does not represent an uncertainty distribution. Therefore, we can not assign percentiles to the individual data points presented and (importantly), we do not draw any conclusions based on any clustering of the alternative risk estimates seen in Figures 4-6 and 4-7. Further, we do not know whether any of the higher-end estimates generated actually represent true bounding risk estimates given overall uncertainty associated with the core risk estimates. Despite these key caveats, having a set of risk estimates reflecting the impact of modeling element uncertainties does provide information that helps to inform our characterization of uncertainty related to the core risk estimates.

4.4 EVALUATING THE REPRESENTATIVENESS OF THE URBAN STUDY AREAS IN THE NATIONAL CONTEXT

The goal in selecting the 15 urban study areas included in this risk assessment was two-fold: (a) to choose urban locations with relatively elevated ambient PM levels (in order to evaluate risk for locations likely to experience some degree of risk reduction under alternative standards) and (b) to include a range of urban areas reflecting heterogeneity in other PM risk-related attributes across the country. To further support interpretation of risk estimates generated in this analysis, we are assessing the degree to which urban study areas represent the range of key $PM_{2.5}$ risk-related attributes that spatially vary across the nation. We have partially addressed this issue by selecting urban study areas that provide coverage for different PM regions of the country (see section 3.3.2). In addition, we are considering how well the selected urban areas represent the overall U.S. for a set of spatially-distributed $PM_{2.5}$ risk related variables (e.g., $PM_{2.5}$ composition, weather, demographics including SES, baseline health incidence rates). This analysis will help to inform how well the urban study areas reflect national-level variability in these key PM risk-related variables. Based on generally available data (e.g. from the 2000 Census, Centers for Disease Control (CDC), or other sources), distributions for risk-related variables across U.S. counties and for the specific counties represented in the urban study areas are generated. The specific values of these variables for the selected urban study areas are then plotted on these distributions, and an evaluation is conducted of how representative the selected study areas are with respect to these individual variables, relative to the national distributions.

Estimates of risk (either relative or absolute, e.g. number of cases) within our risk assessment framework are based on four elements: population, baseline incidence rates, air quality, and the coefficient relating air quality and the health outcome (i.e., the $PM_{2.5}$ effect estimates). Each of these elements can contribute to heterogeneity in risk across urban locations, and each is variable across locations. In addition, there may be additional identifiable factors that contribute to the variability of the four elements across locations. In this assessment, we examine the representativeness of the selected urban area locations for the four main elements, and also provide additional assessment of factors that have been identified as influential in determining the magnitude of the C-R function across locations.

The specific choice of variables which may affect the $PM_{2.5}$ effect estimates for which we will examine urban study area representativeness is informed by an assessment of the epidemiology literature. We particularly focused on meta-analyses and multi-city studies which identified variables that influence heterogeneity in $PM_{2.5}$ effect estimates, and exposure studies which explored determinants of differences in personal exposures to ambient $PM_{2.5}$. While personal exposure is not incorporated directly into PM epidemiology studies, differences in the $PM_{2.5}$ effect estimates between cities clearly is impacted by differing levels of exposure and differences in exposure are clearly related to a number of exposure determinants. Broadly speaking, determinants of $PM_{2.5}$ effect estimates can be grouped into three areas: demographics, baseline health conditions, and climate and air quality. Based on a review of these studies, we identified the following variables within each group as potentially determining the $PM_{2.5}$ effect estimates:

- Demographics: education (see Zeka et al, 2006; Ostro et al, 2006), age and gender (see Zeka et al, 2006), population density (see Zeka et al, 2005), unemployment rates (see Bell and Dominici, 2008), race (see Bell and Dominici, 2008), public transportation use (see Bell and Dominici, 2008),
- Baseline health conditions: disease prevalence (diabetes – Bateson and Schwartz, 2004; Ostro et al, 2006; Zeka et al, 2006; pneumonia – Zeka et al, 2006; stroke – Zeka et al, 2006; heart and lung disease – Bateson and Schwartz, 2004; acute myocardial infarction – Bateson and Schwartz, 2004).
- Climate and air quality: $PM_{2.5}$ levels (average, 98^{th} percentiles, and numbers of days over the level of the 24-hour standard, e.g. 35 $\mu g/m^3$), co-pollutant levels, PM composition (see Bell et al, 2009; Dominici et al, 2007; Samet, 2008; Tolbert, 2007), temperatures (temp) (days above 90 degrees, variance of summer temp, mean summer temp, 98^{th} percentile temp, mean winter temp -- see Roberts, 2004; Medina-Ramon et al, 2006; Zeka et al., 2005), air conditioning prevalence (see Zanobetti and Schwartz, 2009; Franklin et al, 2007; Medina-Ramon et al, 2006), ventilation (see Sarnat et al, 2006), percent of primary PM from traffic (see Zeka et al., 2005),

Based on these identified potential risk determinants, we identified possible datasets that could be used to generate nationally representative distributions for each parameter. We were not able to identify readily available national datasets for all variables. In these cases, if we were able to identify a broad enough dataset covering a large enough portion of the U.S., we used that dataset to generate the parameter distribution. In addition, we were not able to find exact matches for all of the variables identified through our review of the literature. In cases where an exact match was not available, we identified proxy variables to serve as surrogates. For each parameter, we report the source of the dataset, its degree of coverage, and whether it is a direct measure of the parameter or a proxy measure. The target variables and sources for the data are provided in Table 4-2. Summary statistics for the most relevant variables are provided in Table D-3.

Table 4-5 Data Sources for PM NAAQS Risk Assessment Risk Distribution Analysis.

Potential Risk Determinant	Metric	Year	Source	Degree of National Coverage
Demographics				
Age	Median Age	2005	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Age	Percent over 65	2005	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Age	Percent under 15	2005	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Education	Population with less than HS diploma	2000	USDA/ERS, http://www.ers.usda.gov/Data/Education/	All counties
Unemployment	Percent unemployed	2005	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Income	Per Capita Personal Income	2005	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Race	Percent nonwhite	2006	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Population	Total population	2008	Cumulative Estimates of Resident Population Change for the United States, States, Counties, Puerto Rico, and Puerto Rico Municipios: April 1, 2000 to July 1, 2008, Source: Population Division, U.S. Census Bureau	All counties
Population density	Population/square mile	2008	Cumulative Estimates of Resident Population Change for the United States, States, Counties, Puerto Rico, and Puerto Rico Municipios: April 1, 2000 to July 1, 2008, Source: Population Division, U.S. Census Bureau	All counties
Urbanicity	ERS Classification Code	2003	County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Climate and Air Quality				
$PM_{2.5}$ Levels	$PM_{2.5}$ Levels -- Monitored Ann Mean	2007	AQS	617 Monitored counties
$PM_{2.5}$ Levels	$PM_{2.5}$ Levels -- Monitored 98th %ile	2007	AQS	617 Monitored counties
$PM_{2.5}$ Levels	Average MCAPS		MCAPS website 204 counties	204 MCAPS counties

Potential Risk Determinant	Metric	Year	Source	Degree of National Coverage
$PM_{2.5}$ Levels	% days exceeding 35 $\mu g/m^3$		MCAPS website 204 counties	204 MCAPS counties
Copollutant Levels	Ozone		AQS	725 Monitored counties
Roadway emissions/Exposure	% of primary emissions from traffic	1999	NEI	All counties
Temperature	Annual Average		MCAPS website 204 counties	204 MCAPS counties
Temperature	Mean July Temp 1941-1970		County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Relative Humidity	Mean July RH 1941-1970		County Characteristics, 2000-2007 Inter-university Consortium for Political and Social Research	All counties
Ventilation	Air conditioning prevalence	2005	American Housing Survey, with additional processing as in Reid et al (2009)	83 urban areas
Baseline Health Conditions				
Baseline Mortality	All Cause		CDC Wonder 1999-2005	All counties
Baseline Mortality	Non Accidental		CDC Wonder 1999-2006	All counties
Baseline Mortality	Cardiovascular		CDC Wonder 1999-2007	All counties
Baseline Mortality	Respiratory		CDC Wonder 1999-2008	All counties
Baseline Morbidity	AMI prevalence	2007	BRFSS MSA estimates	184 BRFSS MSA
Baseline Morbidity	Diabetes Prevalence	2007	BRFSS MSA estimates	184 BRFSS MSA
Baseline Morbidity	Pneumonia Prevalence			
Baseline Morbidity	Stroke Prevalence	2007	BRFSS MSA estimates	184 BRFSS MSA
Baseline Morbidity	CHD Prevalence	2007	BRFSS MSA estimates	184 BRFSS MSA
Baseline Morbidity	COPD Prevalence			
Obesity	BMI	2007	BRFSS MSA estimates	184 BRFSS MSA
Level of exercise	vigorous activity 20 minutes	2007	BRFSS MSA estimates	184 BRFSS MSA
Level of exercise	moderate activity 30 minutes or vigorous activity 20 minutes	2007	BRFSS MSA estimates	184 BRFSS MSA
Respiratory Risk Factors	Current Asthma	2007	BRFSS MSA estimates	184 BRFSS MSA
Smoking	Ever Smoked	2007	BRFSS MSA estimates	184 BRFSS MSA
C-R Estimates				
Mortality Risk	All Cause	2009	Zanobetti and Schwartz (2009) 212 cities	212 cities
Mortality Risk	Respiratory	2009	Zanobetti and Schwartz (2009) 212 cities	212 cities
Mortality Risk	Cardiovascular	2009	Zanobetti and Schwartz (2009) 212 cities	212 cities

Table 4-6 Summary Statistics for Selected PM Risk Attributes.

Risk Attributes	Average		Standard Deviation		Maximum		Minimum		Sample Size	
	Urban study areas	**U.S. counties**	**Urban study areas**	**U.S. counties**	**Urban study areas**	**U.S. counties**	**Urban study areas**	**U.S. counties**	**Urban study areas (number of counties)**	**U.S. (number of counties)**
Demographics										
Population	1,410,331	97,020	1,870,237	312,348	9,862,049	9,862,049	57,441	42	31	3143
Population Density (Pop/sq mile)	7,212	258	14,960	1,757	71,758	71,758	87	0	31	3143
Median Age (years)	35.5	38.6	2.6	4.4	41.5	55.3	30.2	20.1	31	3141
% Age 65 Plus	11.3	14.9	2.6	4.1	17.2	34.7	5.8	2.3	31	3141
Unemployment rate (%)	5.4	5.4	1.5	1.8	9.0	20.9	2.7	1.9	31	3133
% with Less than High School Diploma	21.8	22.6	7.7	8.8	37.7	65.3	11.2	3.0	31	3141
Income ($2005)	35691	27367	12605	6604	93377	93377	23492	5148	31	3086
Air conditioning prevalence (%)	85.8	83.3	13.3	21.5	99.4	100.0	58.6	9.9	10	70
% Non-white	29.5	13.0	18.2	16.2	68.3	95.3	2.7	0.0	31	3141
Health Conditions										
Prevalence of CHD (%)	3.9	4.3	0.9	1.3	5.2	8.7	1.8	1.8	14	184
Prevalence of Obesity (%)	26.4	26.0	3.0	4.1	32.7	35.7	22.2	14.0	14	182
Prevalence of Stroke (%)	2.7	2.7	0.8	1.0	4.1	6.5	1.1	0.7	14	184
Prevalence of Smoking (ever) (%)	18.4	19.6	3.1	4.0	23.1	34.4	14.2	6.5	14	184
Prevalence of Exercise (20 minutes) (%)	28.4	28.0	3.6	4.8	33.9	44.1	20.5	15.4	14	183
All Cause Mortality (per 100,000 population)	833.7	1022.3	241.1	258.6	1342.9	2064.2	402.5	176.8	31	3142
Non-accidental Mortality (per 100,000 population)	774.1	950.6	227.3	249.6	1242.0	1958.4	361.6	117.7	31	3142
Cardiovascular Mortality (per 100,000 population)	317.5	392.1	100.6	121.0	535.7	970.4	122.4	37.5	31	3142
Respiratory Mortality (per 100,000 population)	70.8	97.3	23.0	32.3	130.3	351.0	34.8	13.3	31	3136
Air Quality and Climate										
AQ - PM25 Annual Mean (µg/m^3)	15.1	11.7	2.2	3.1	19.6	22.5	9.7	3.4	29	617
AQ - PM25 98th %ile 24-hour Average (µg/m^3)	38.7	30.7	11.6	9.3	79.2	81.1	26.8	9.1	29	617
AQ - O_3 4th High Maximum 8-hour Average (ppm)	0.087	0.077	0.009	0.010	0.105	0.126	0.064	0.033	27	725
% Mobile Source PM Emissions	34.0	44.4	11.2	21.9	56.6	97.6	13.7	0.3	31	3141

Risk Attributes	Average		Standard Deviation		Maximum		Minimum		Sample Size	
	Urban study areas	U.S. counties	Urban study areas	U.S. counties	Urban study areas	U.S. counties	Urban study areas	U.S. counties	Urban study areas (number of counties)	U.S. (number of counties)
July Temperature Long Term Average (°F)	78.1	75.9	4.5	5.4	91.2	93.7	64.8	55.5	31	3104
July Relative Humidity Long Term Average (°F)	58.2	56.2	14.0	14.6	70.0	80.0	19.0	14.0	31	3104
C-R Estimates										
All Cause Mortality $PM_{2.5}$ Risk Estimate	0.000971	0.000974	0.000340	0.000216	0.001349	0.001508	0.000159	-0.000099	15	112
Respiratory Mortality $PM_{2.5}$ Risk Estimate	0.001606	0.001670	0.000419	0.000305	0.002157	0.002221	0.000931	-0.000346	15	112
Cardiovascular Mortality $PM_{2.5}$ Risk Estimate	0.001013	0.000842	0.000586	0.000324	0.001958	0.001958	-0.000180	-0.000180	15	112

Formal comparisons of parameter distributions for the set of urban study areas and the national parameter distributions are conducted using standard statistical tests, e.g. the Kolmogorov-Smirnov non-parametric test for equality of distributions. In addition, visual comparisons are made using cumulative distribution functions, and boxplots.

The formal Kolmogorov-Smirnov test results are provided in Table 4-4. The K-S tests the hypotheses that two distributions are not significantly different. A high p-value indicates a failure to reject the null hypotheses that the case-study and national distributions are the same. We used a rejection criterion of $p \leq 0.05$, which is a standard rejection criteria. It should be noted that the K-S test provides a good overall measure of fit, but will not provide a test of how well specific percentiles of the distributions are matched. As such, the K-S test results will not be sufficient to determine whether the urban study areas adequately capture the tails of the distributions of specific risk related variables. Additional visual analyses are used to assess representativeness for the tails of the distributions. Overall, the K-S test results show that for many of the important risk variables such as population, air quality, age, and baseline mortality rates, the urban study areas are not representative of the distributions of these variables for the U.S. as a whole. However, for some important potential risk determinants, such as prevalence of underlying hear and lung diseases, the case study areas are representative of the national distributions. However, for these specific variables, the national distribution is represented primarily by large urban areas, so it is more accurate in these cases to suggest that the urban study areas are representative of the overall distribution across urban areas.

Figures 4-14 through 4-17 show for the four critical risk function elements (population, air quality, baseline incidence, and the $PM_{2.5}$ effect estimate) the cumulative distribution functions plotted for the nation, as well as for the urban study areas. These four figures focus on critical variables representing each type of risk determinant, e.g. we focus on all-cause mortality rates, but we also have conducted analyses for cardiovascular and respiratory mortality separately. The complete set of analyses is provided in Appendix D. The vertical black lines in each graph show the values of the variables for the individual urban study areas. These figures show that the selected urban study areas represent the upper percentiles of the distributions of population and air quality, while not representing lower population locations with lower 24-hour $PM_{2.5}$ levels. This is consistent with the objectives of our case study selection process, e.g. we are characterizing risk in areas that are likely to be experiencing excess risk due to PM levels above alternative standards. The urban case study locations represent the full distribution of $PM_{2.5}$ risk coefficients, but do not capture the upper end of the distribution of baseline all-cause mortality. The interpretation of this is that the case study risk estimates may not capture the additional risk that may exist in locations that have the highest baseline mortality rates.

Figures 4-18 through 4-21 shows for several selected potential risk attributes the CDF plotted for the nation as well as for the urban study areas. These potential risk attributes do not directly enter the risk equations, but have been identified in the literature as potentially affecting the magnitude of the $PM_{2.5}$ C-R functions reported in the epidemiological literature. The selected urban study areas do not capture the higher end percentiles of several risk characteristics, including populations over 65, income, and baseline cardiovascular disease prevalence. Comparison graphs for other risk attributes are provided in Appendix D. Summarizing the analyses of the other risk attributes, we conclude that the urban study areas provide adequate coverage across population, population density, annual and 24-hour $PM_{2.5}$ levels, ozone co-pollutant levels, temperature and relative humidity, unemployment rates, percent non-white population, asthma prevalence, obesity prevalence, stroke prevalence, exercise prevalence, and less than high school education. We also conclude that while the urban study areas cover a wide portion of the distributions, they do not provide coverage for the upper end of the distributions of age (all case study locations are below the 85th %ile), % of population 65 and older (below 85th %ile), percent of primary PM emissions from mobile sources (below 8oth %ile), prevalence of angina/coronary heart disease (below 85th %ile), prevalence of diabetes (below 85th %ile), prevalence of heart attack (below 80th %ile), prevalence of smoking (below 85th %ile), all-cause mortality rates (below 90th %ile), cardiovascular mortality rates (below 90th %ile) and respiratory mortality rates (below 90th %ile). In addition, all of the case study locations were above the 25th percentile of the distribution of personal income.

Based on the above analyses, we can draw several inferences regarding the representativeness of the urban case studies. First, the case studies represent urban areas that are among the most populated and most densely population in the U.S. Second, they represent areas with relatively higher levels of annual mean and 24-hour 98th percentile $PM_{2.5}$. Third, they capture well the range of effect estimates represented in the Zanobetti and Schwartz (2009) study. These three factors would suggest that the urban study areas should capture well overall risk for the nation, with a potential for better characterization of the high end of the risk distribution. However, there are several other factors that suggest that the urban study areas may not be representing areas that may have a high risk per microgram of $PM_{2.5}$. The analysis suggests that the urban study areas are not capturing areas with the highest baseline mortality risks, nor those with the oldest populations. These areas may have higher risks per microgram of $PM_{2.5}$, and thus the high end of the risk distribution may not be captured, although the impact on characterization of overall PM risk may not be as large, for the following reasons.

It should be noted that several of the factors with underrepresented tails, including age and baseline mortality (R=0.81) are spatially correlated, so that certain counties which have high proportions of older adults also have high baseline mortality and high prevalence of underlying chronic health conditions. Because of this, omission of certain urban areas with higher percentages of older populations, for example, cities in Florida, may lead to underrepresentation of high risk populations. However, with the exception of areas in Florida, most locations with high percentages of older populations have low overall populations, less than 50,000 people in a county. And even in Florida, the counties with the highest $PM_{2.5}$ levels do not have a high percent of older populations. This suggests that while the risk per exposed person per microgram of $PM_{2.5}$ may be higher in these locations, the overall risk to the population is likely to be within the range of risks represented by the urban case study locations.

Table 4-7 Results of Kolomogrov-Smirnoff Tests for Equality Between National and Urban Study Area Distributions for Selected National Risk Characteristic Variables

(null hypothesis is no difference between the distributions)

Risk Attributes	Reject H0?	p-value
Demographics		
Population	Y	0.0001
Population Density (Pop/sq mile)	Y	0.0001
Median Age	Y	0.0001
% Age 65 Plus	Y	0.0001
Unemployment rate	N	0.5850
% with Less than High School Diploma	N	0.8535
Income	Y	0.0001
Air Conditioning Prevalence (%)	N	0.9592
% Non-white	Y	0.0001
Health Conditions		
Prevalence of CHD	N	0.7705
Prevalence of Obesity	N	0.9180
Prevalence of Stroke	N	0.7064
Prevalence of Smoking (ever)	N	0.5748
Prevalence of Exercise (20 minutes)	N	0.7649
All Cause Mortality	Y	0.0001
Non-accidental Mortality	Y	0.0002
Cardiovascular Mortality	Y	0.0060
Respiratory Mortality	Y	0.0001
Air Quality and Climate		
AQ - PM25 Annual Mean	Y	0.0001
AQ - PM25 98th %ile 24-hour Average	Y	0.0001
AQ - PM25 % of days above 35 µg/m^3	Y	0.0248
AQ - O3 4th High Maximum 8-hour Average	Y	0.0003
% Mobile Source PM Emissions	Y	0.0133

Risk Attributes	Reject H0?	p-value
July Temperature Long Term Average	Y	0.0003
July Relative Humidity Long Term Average	N	0.0614
C-R Estimates		
All Cause Mortality $PM_{2.5}$ Risk	N	0.1585
Respiratory Mortality $PM_{2.5}$ Risk	N	0.2864
Cardiovascular Mortality $PM_{2.5}$ Risk	N	0.1161

Figure 4-9 Comparison of distributions for key elements of the risk equation: total population.

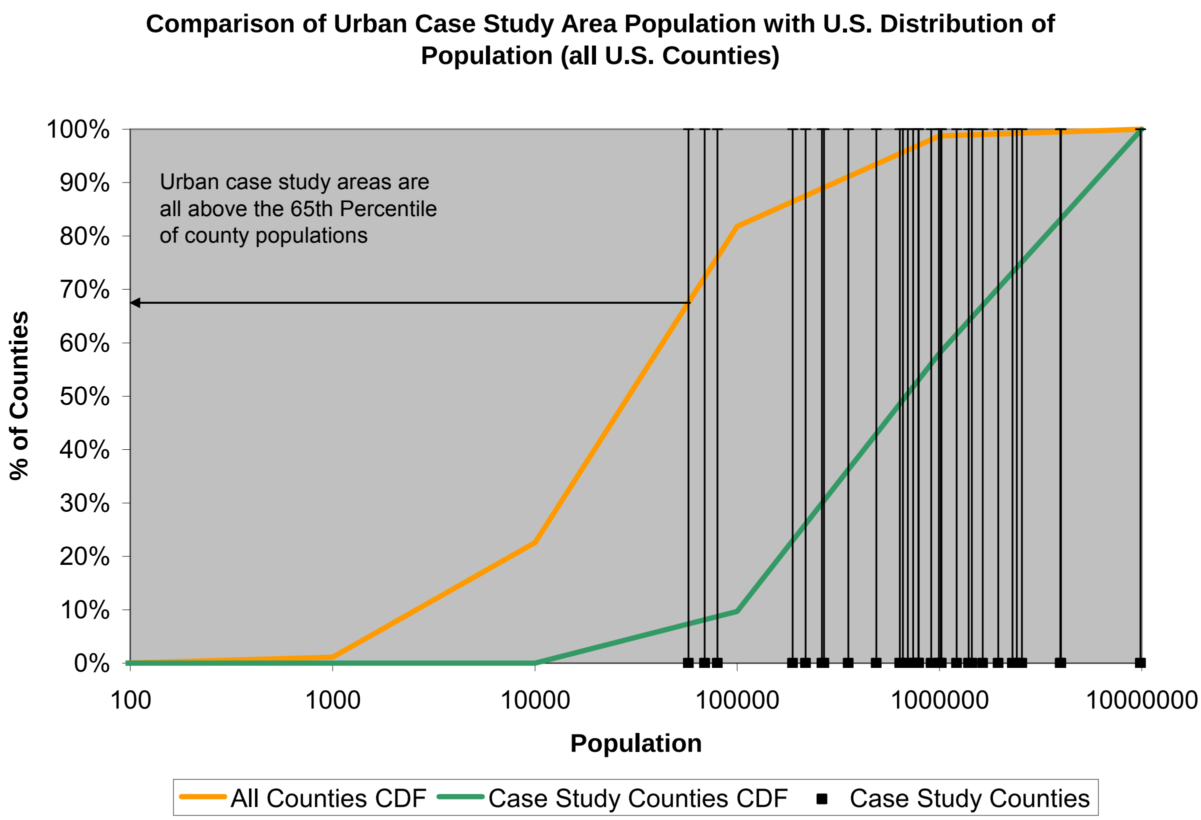


Figure 4-10 Comparison of distributions for key elements of the risk equation: 98^{th} percentile 24-hour average $PM_{2.5}$

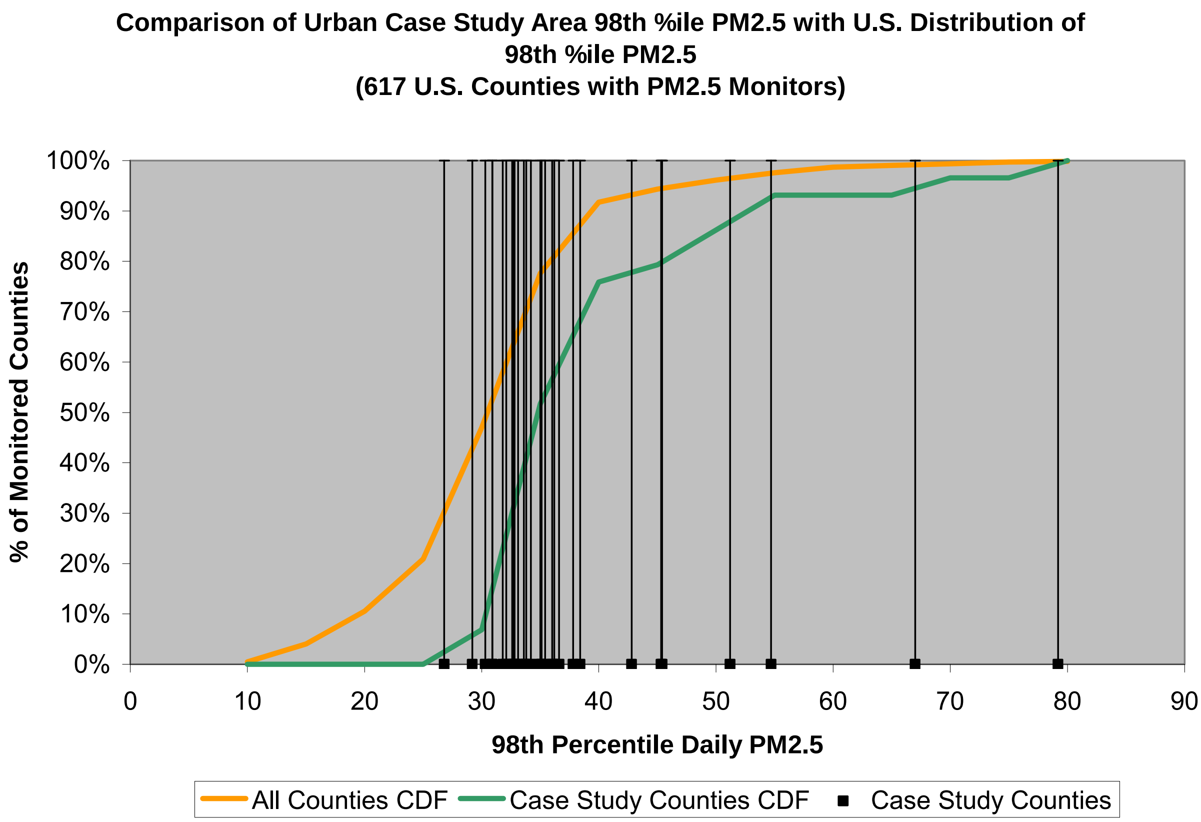


Figure 4-11 Comparison of distributions for key elements of the risk equation: all use mortality rate.

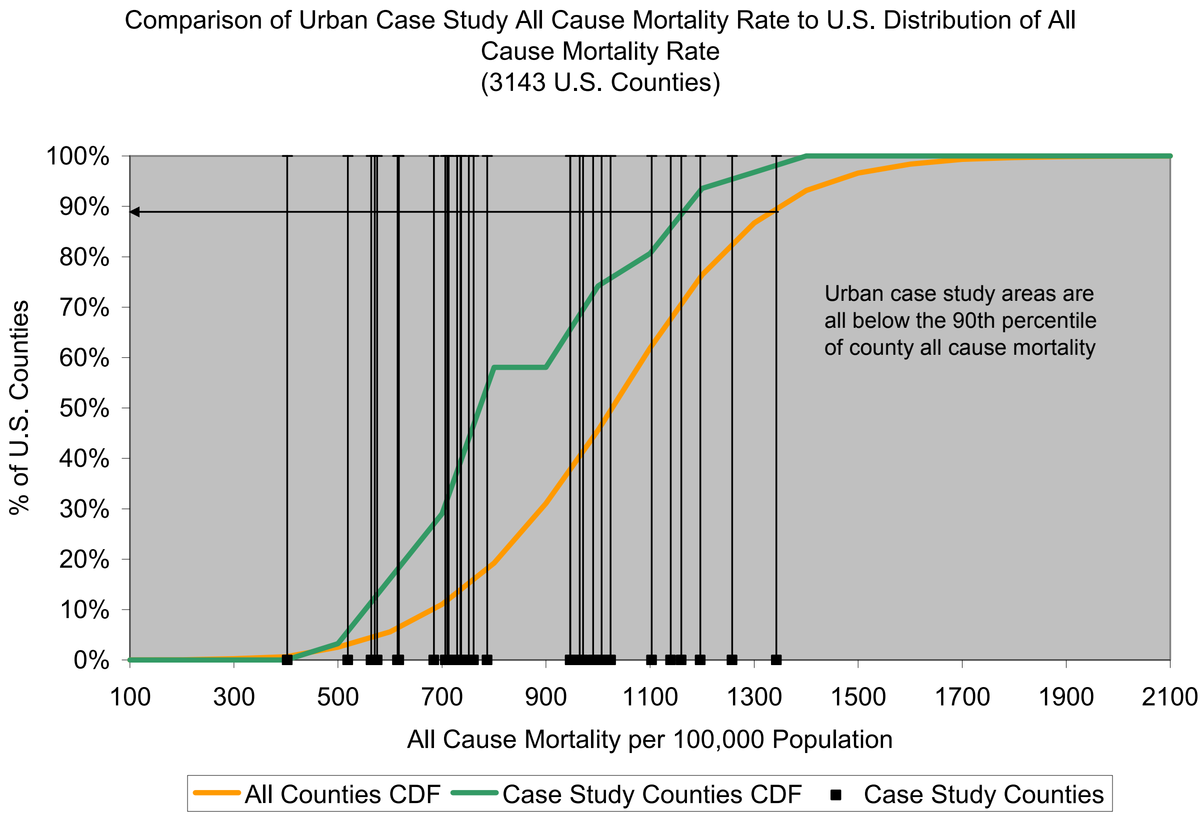


Figure 4-12 Comparison of distributions for key elements of the risk equation: Mortality risk effect estimate from Zanobetti and Schwartz (2008).

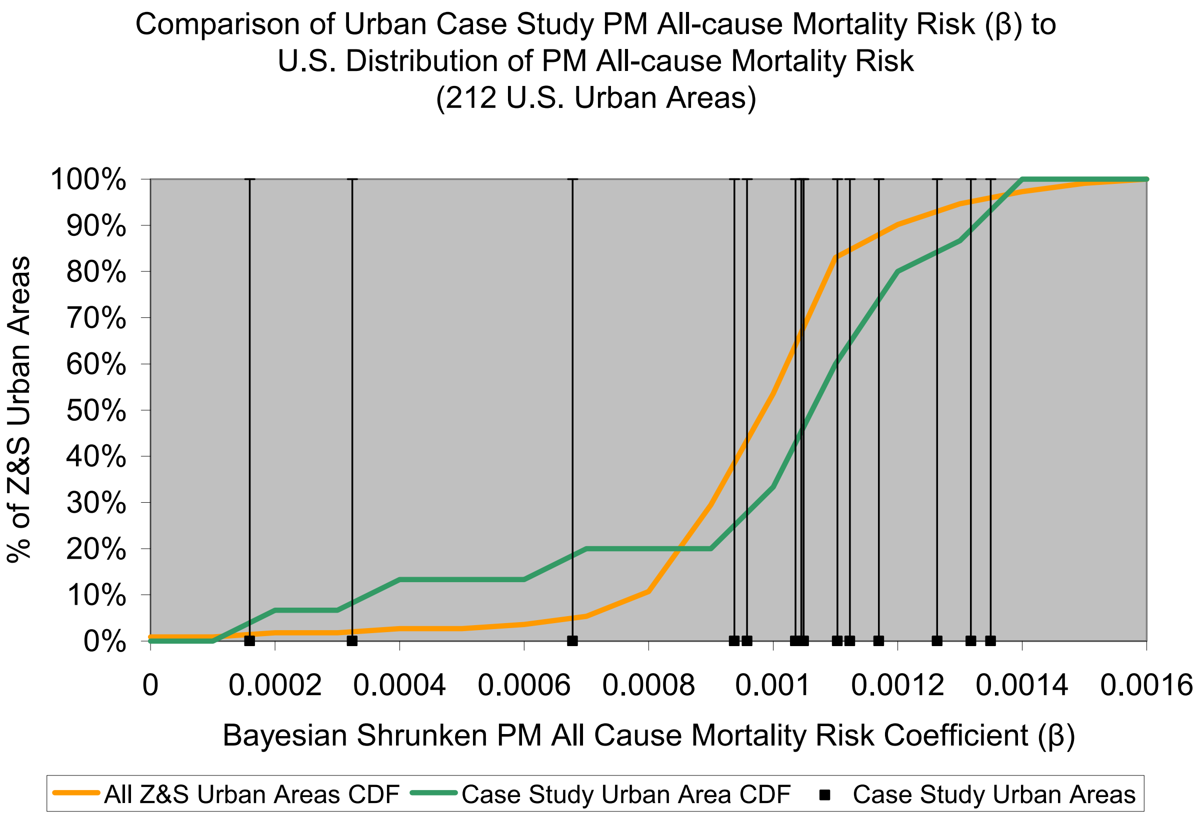


Figure 4-13 Comparison of distributions for selected variables expected to influence the relative risk from $PM_{2.5}$: long term average July temperature.

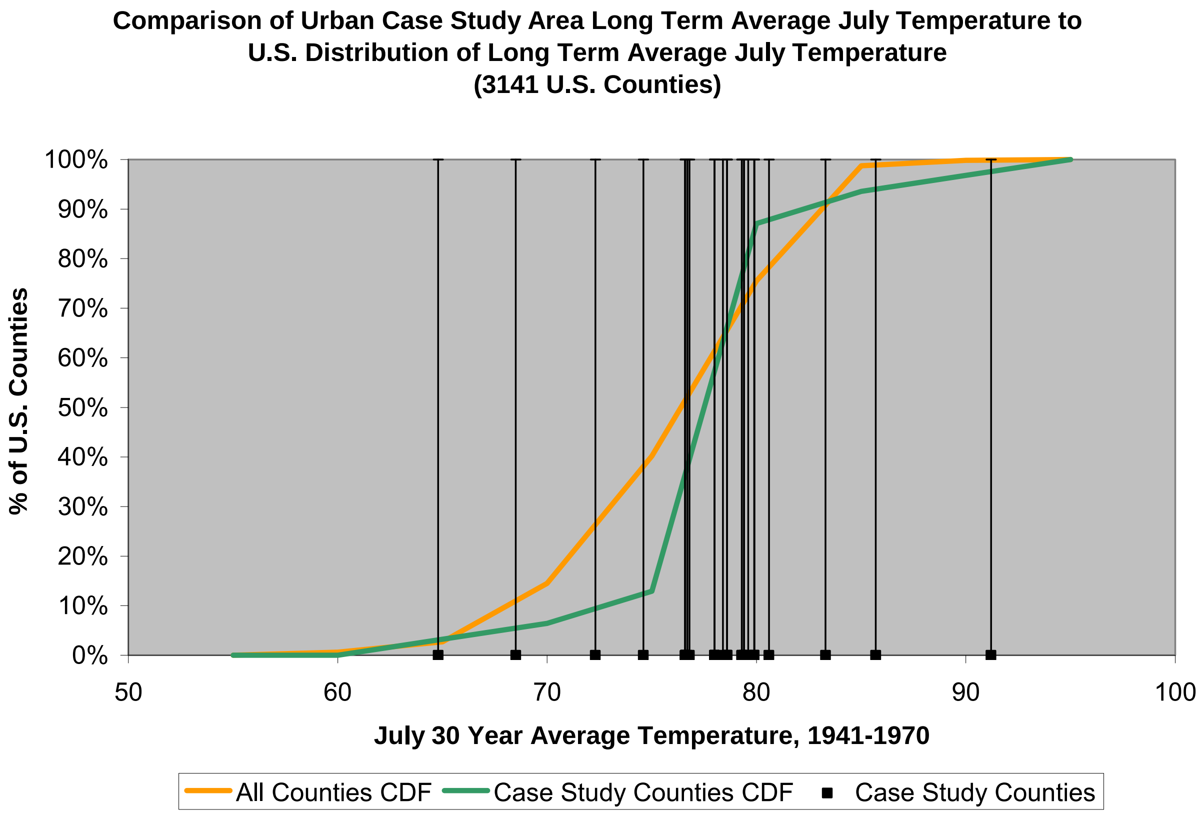


Figure 4-14 Comparison of distributions for selected variables expected to influence the relative risk from $PM_{2.5}$: percent of population 65 and older.

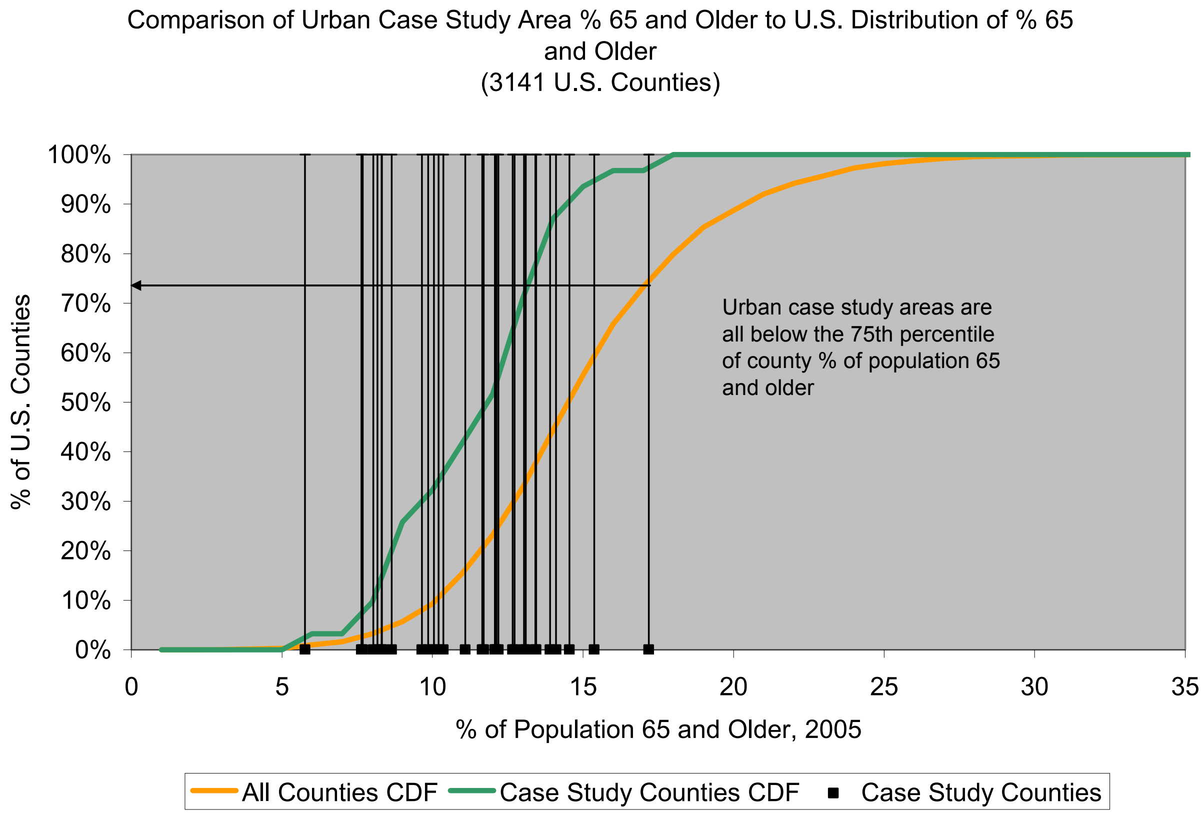


Figure 4-15 Comparison of distributions for selected variables expected to influence the relative risk from $PM_{2.5}$: per capita annual personal income.

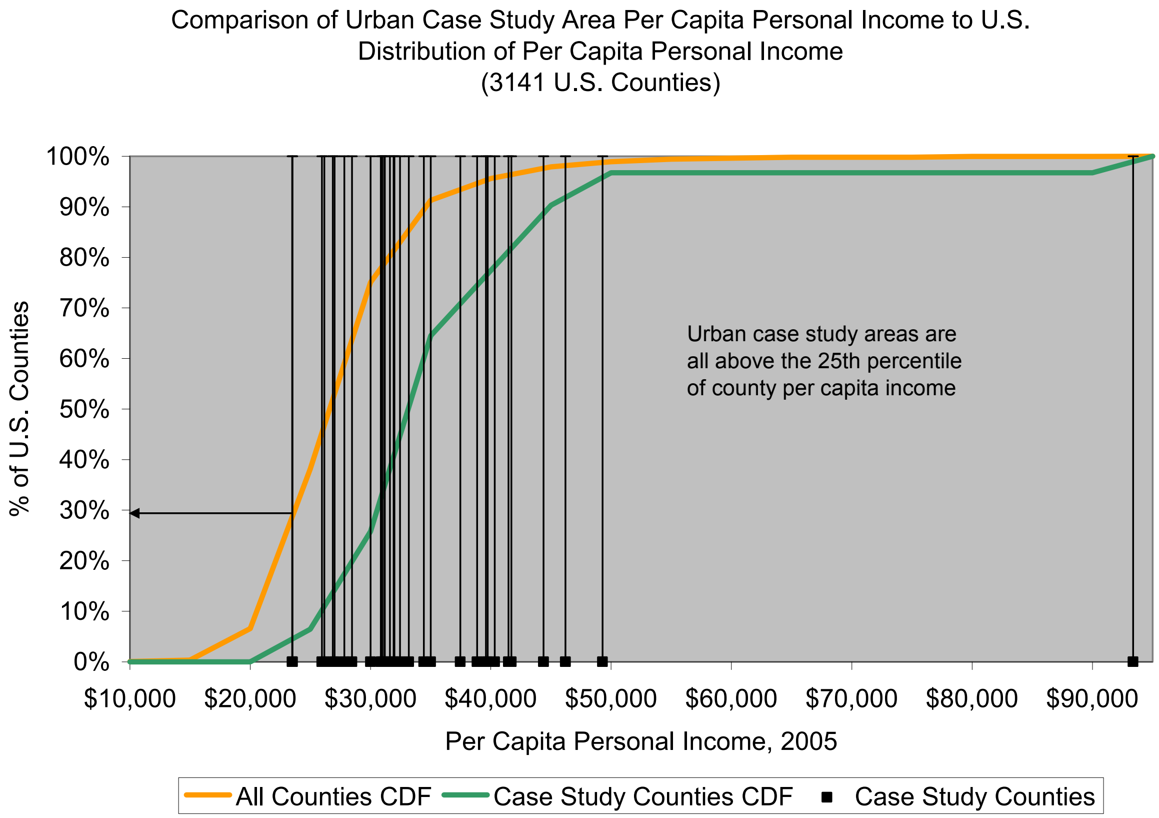
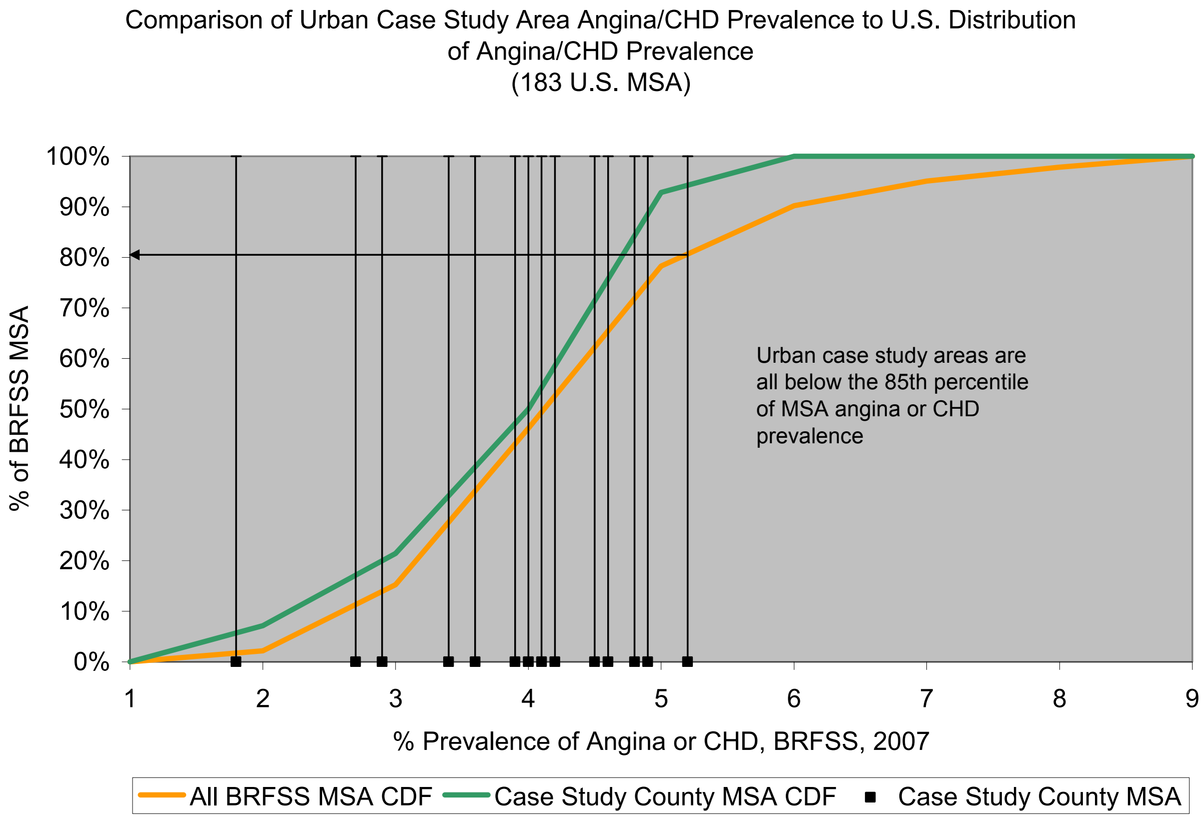


Figure 4-16 Comparison of distributions for selected variables expected to influence the relative risk from $PM_{2.5}$: per capita annual personal income.



4.5 CONSIDERATION OF DESIGN VALUES AND PATTERNS OF $PM_{2.5}$ MONITORING DATA IN INTREPRETING CORE RISK ESTIMATES

The degree of risk reduction associated with the current and alternative suites of standards at a particular urban study area depends to a great extent on the degree of reduction in $PM_{2.5}$ concentrations simulated for that location. This in turn depends on the interplay between the 24-hour and annual design values and the monitoring data used to characterize ambient $PM_{2.5}$ concentrations, since these factors determine the composite annual average and composite 24-hour $PM_{2.5}$ profiles used in modeling long-term and short-term exposure related risk for that study area. Because of the role that design values and underlying patterns in $PM_{2.5}$ monitoring data play in determining the degree of risk reductions, these factors can be used in helping to interpret risk estimates generated for the 15 urban study areas under the various standard levels considered in this risk assessment. Further, it is possible to consider, more broadly, patterns of design values across urban areas in the U.S. and contrast these with patterns seen for the 15 urban study areas to help to place risk estimates for the 15 urban study areas in a broader national context.

This section discusses consideration of patterns of design values (section 4.5.1) and underlying ambient monitoring $PM_{2.5}$ data (section 4.5.2) for the 15 urban study areas in the context of helping to interpret risk estimates. Each of these discussions begins by describing the methods used in each analysis and concludes with a set of key observations.

4.5.1 Design Values

The set of design values for an urban study area determines whether the 24-hour or annual standard will be controlling as well as the degree of reduction in ambient $PM_{2.5}$ concentrations associated with a particular suite of standards. Therefore, by plotting the relationship between 24-hour and annual design values for each of the 15 urban study areas, we can obtain a quick visual perspective on (a) which study areas will experience reductions in risk for a particular suite of standards, (b) whether the 24-hour or annual standard will control, and (c) the general magnitude of risk reduction. The last observations result from comparing the controlling standard level with the matching design value, which will determine the fractional reduction in $PM_{2.5}$ levels at monitors exceeding the standard level (for peak shaving rollback), or more broadly across all monitors (for proportional rollback).

Figures 4-17 through 4-19 present scatter plots of 24-hour and annual design values for a combination of the 15 urban study areas (red stars) and the broader set of larger urban areas in the U.S. (green circles). In addition to depicting the set of design values for these urban areas, each figure also includes a set of superimposed lines representing the current suite of standards (Figure 4-17) and three of the alternative suites of standards considered in the risk assessment (12/35 – Figure 4-18, and 12/25 – Figure 4-19). In each figure, the horizontal line represents the 24-hour standard level, while the vertical line represents the annual standard level. The line that intercepts the origin (i.e., the “35/15 line” in Figure 4-17) represents the point of demarcation between those study areas where the 24-hour standard controls (to the left of the intercept line) and those study area where the annual standard level controls (to the right of the intercept line). By superimposing these lines related to the current standard level on the scatter plot, we have created five zones within each figure including:

- Zone A: 24-hour design values exceeding the 24-hour standard level, but annual design values below the annual standard level (i.e., <u>24-hour standard is controlling</u>). Urban study areas in this zone are predicted to experience risk reduction with the degree of reduction reflecting the degree to which the 24-hour design value exceeds the 24-hour standard level. For example, in Figure 4-17 (depicting the current suite of standards), Tacoma and Salt Lake City fall in this zone, along with 20-30 additional urban areas in the U.S.

- Zone B: 24-hour design values and annual design values exceed 24-hour and annual standard levels, respectively, and the 24-hour standard is controlling. We have further transected this zone into B1 and B2, with the former representing those urban areas with notably high 24-hour design values (Fresno, Los Angeles in Figure 4-17) and B2 those with lower, although still controlling, 24-hour design values (Baltimore, New York, Detroit, Philadelphia, St. Louis in Figure 4-17). Those urban areas in B1 have exceptionally peaky $PM_{2.5}$ distributions relative to urban areas in B2 (i.e., relatively high 24-hour design values and lower annual average design values).
- Zone C: 24-hour design values and annual design values exceed 24-hour and annual standard levels, respectively, and the annual standard is controlling. Atlanta, Birmingham and Houston fall into this zone and represent a relatively small number of urban areas in the U.S..
- Zone D: annual design values exceed the annual standard level, but 24-hour design values are below the 24-hour standard level (i.e., annual standard is controlling). Houston is the only urban study area falling into this zone for the current standard level, along with a small number of additional urban areas in the U.S..
- Zone E: both the 24-hour and annual design values are below their respective standard levels (i.e., this is the only zone where urban areas would not be expected to experience risk reductions under the suite of standards being considered). The majority of urban areas in the U.S. depicted in these scatter plots fall into Zone E in Figure 4-17.

The five zones presented above are useful in interpreting the risk results generated for the current suite of standards (for the 15 urban study areas). Specifically, as noted above, they allow us to (a) quickly identify which of the 15 urban study areas experience risk reductions under the current standard level, (b) determine whether those reductions are due primarily to a controlling 24-hour or annual standard and (c) to see how well our set of urban study areas provide coverage for the broader set of urban areas in the U.S..

In addition to presenting Figures 4-17 through 4-19 as a means for supporting the interpretation of risk estimates generated for the 15 urban study areas (based on consideration for patterns in design values), we have also included Table 4-8 for this purpose. Table 4-8 presents the annual and 24-hour design values for each urban study area and also identifies which standard is controlling for a given suite of standards. For example, we see that in Atlanta (which has design values of 16.2 $\mu g/m^3$ and 35 $\mu g/m^3$, annual and 24-hour, respectively), the annual standard controls for the current suite of standards (15/35) as well as the first 4 alternative suites of standards considered (14/35, 13/35, 12/35 and 13/30). However, the 24-hour standard controls for the final suite of standards considered (12/25). This matches with information presented in Figures 4-17 through 4-19 (e.g., Figure 4-17 shows that the Atlanta is just inside of zone C, suggesting that it meets the 24-hour standard, but not the annual standard.

Figure 4-17 Design values in 15 urban study areas and broader set of U.S. urban areas relative to the current suite of standards (15/35)

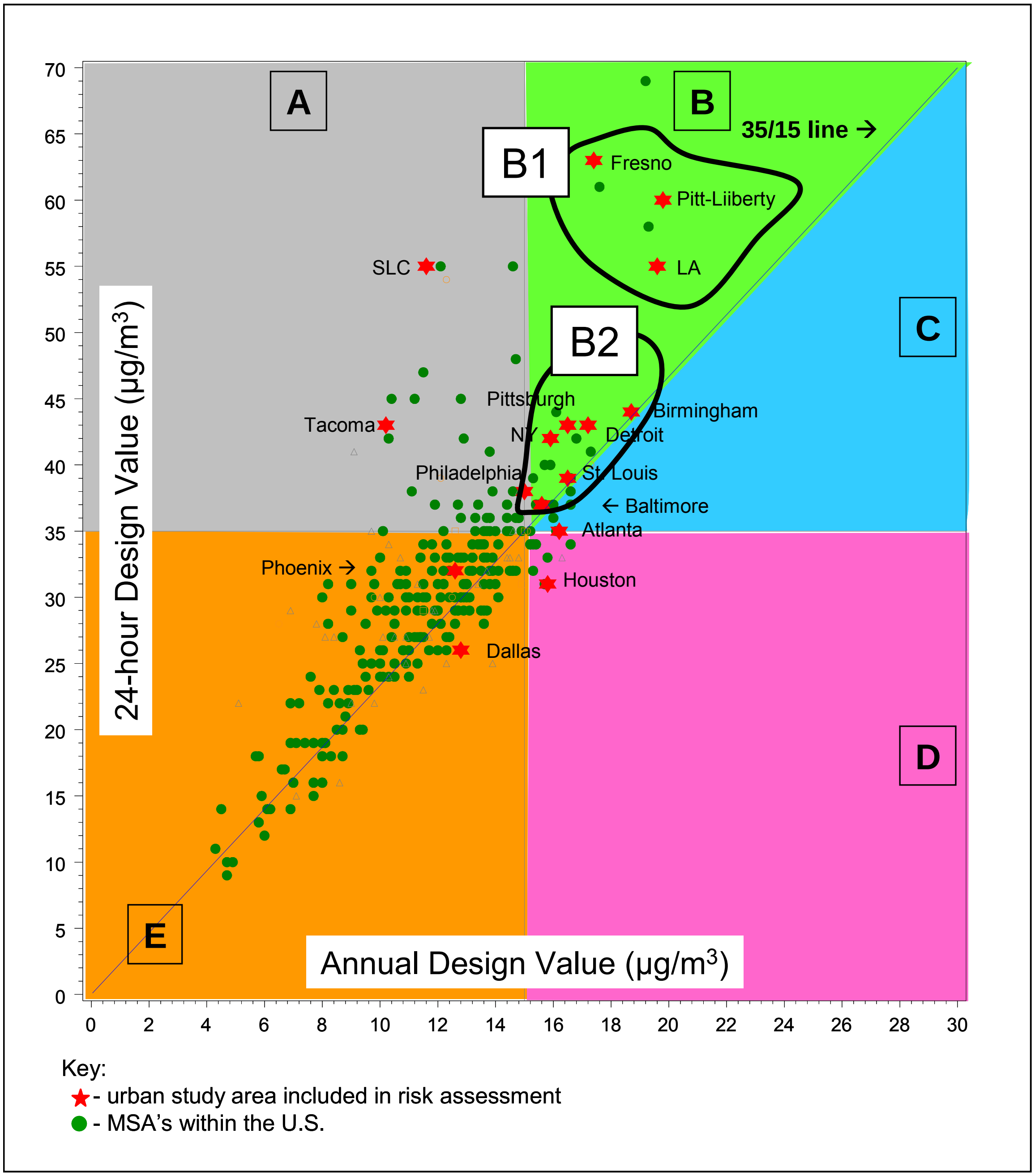


Figure 4-18 Design values in 15 urban study areas and broader set of U.S. urban areas relative to the 12/35 alternative suite of standards

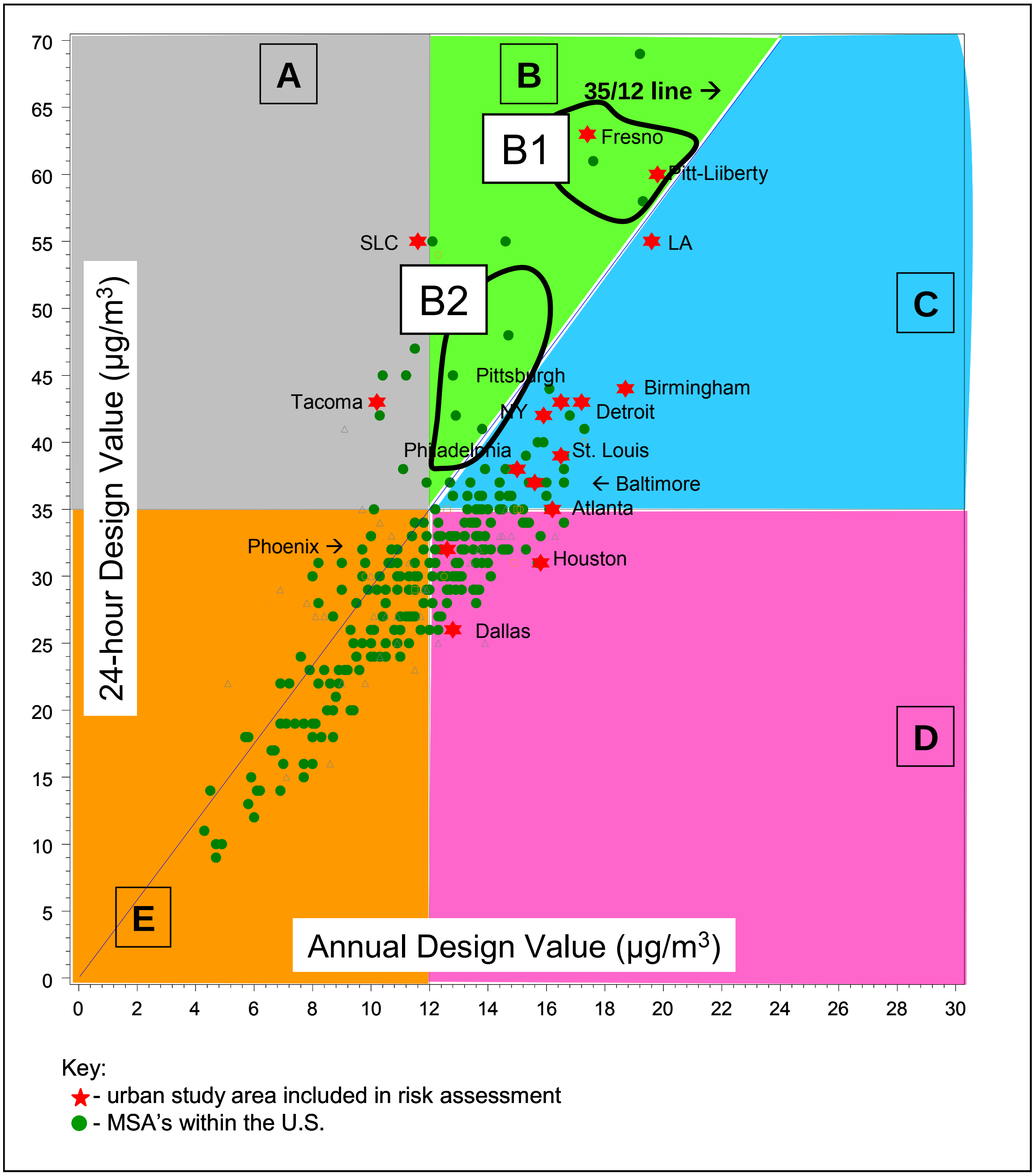


Figure 4-19 Design values in 15 urban study areas and broader set of U.S. urban areas relative to the 12/25 alternative suite of standards)

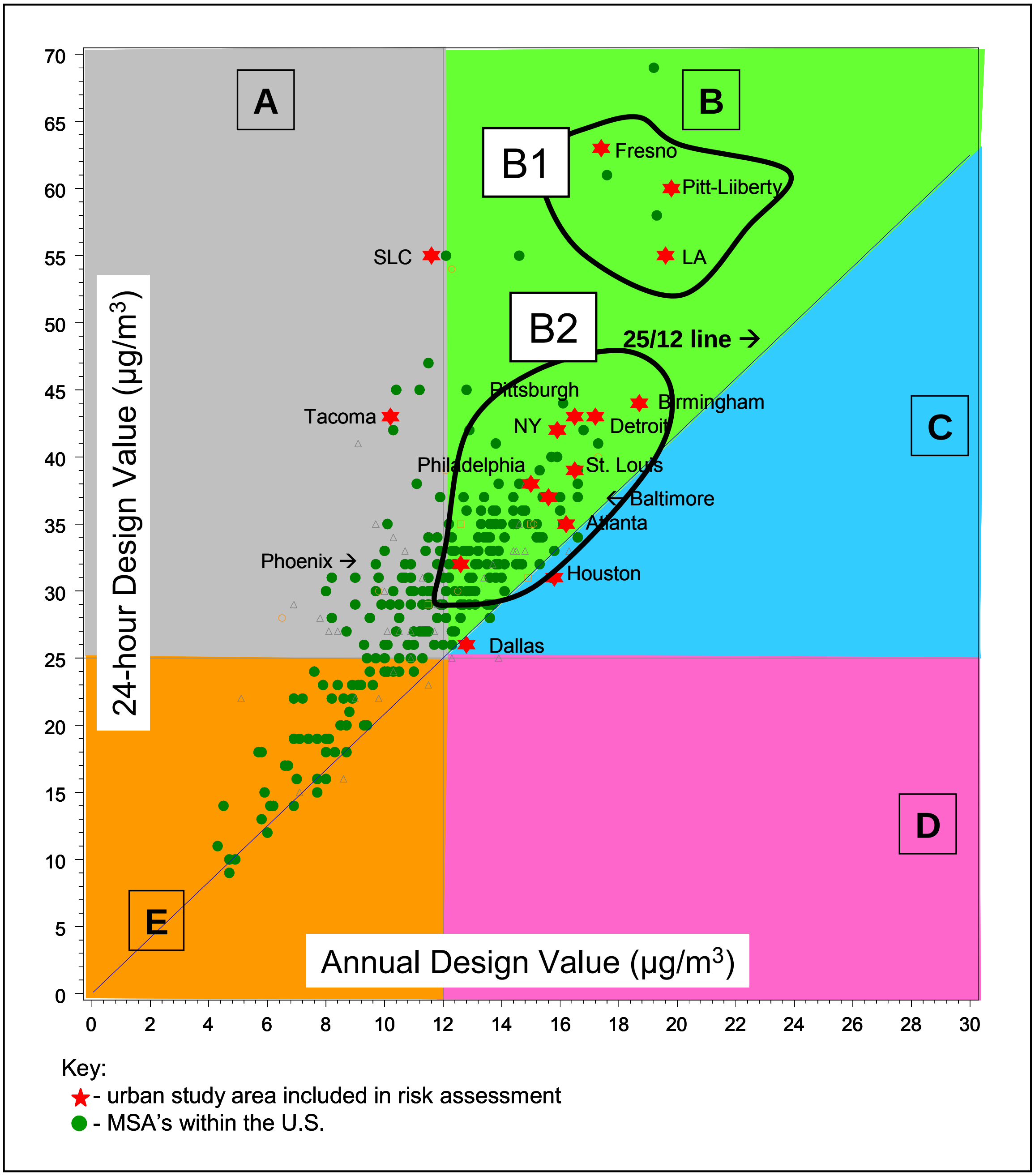


Table 4-8 Identification of controlling standard (24-hour or annual) for alternative suites of standard levels

Urban study area	Design Value		Combination of annual and 24-hour design values*					
			Current standard levels	Alternative annual standard levels			Combinations of alternative 24-hour and annual standard levels	
	Annual	24-Hr	15/35	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	16.2	35	A	A	A	A	A	24hr
Baltimore, MD	15.6	37	24hr	A	A	A	24hr	24hr
Birmingham, AL	18.7	44	A	A	A	A	A	24hr
Dallas, TX	12.8	26	-	-	-	A	A	A
Detroit, MI	17.2	43	24hr	A	A	A	24hr	24hr
Fresno, CA	17.4	63	24hr	24hr	24hr	24hr	24hr	24hr
Houston, TX	15.8	31	A	A	A	A	A	A
Los Angeles, CA	19.6	55	24hr	24hr	24hr	A	24hr	24hr
New York, NY	15.9	42	24hr	24hr	A	A	24hr	24hr
Philadelphia, PA	15.0	38	24hr	24hr	A	A	24hr	24hr
Phoenix, AZ	12.6	32	-	-	-	A	A	24hr
Pittsburgh, PA [5]	19.8	60	24hr	24hr	24hr	24hr	24hr	24hr
Salt Lake City, UT	11.6	55	24hr	24hr	24hr	24hr	24hr	24hr
St. Louis, MO	16.5	39	24hr	A	A	A	24hr	24hr
Tacoma, WA	10.2	43	24hr	24hr	24hr	24hr	24hr	24hr

* "24hr" denotes that the 24-hour standard is controlling. "A" denotes that the annual standard is controlling

Based on consideration of the zones defined in Figures 4-17 through 4-19, we can make the following observations regarding potential patterns of risk reduction across urban study areas in the U.S., given the current and alternative suites of standards considered. Further, we can characterize the degree to which the 15 urban study areas provide coverage for these groupings of U.S. urban study areas:

- *For the current suite of standards* (see Figure 4-17), Based on 2005-2007 air quality data, most urban areas in the country meet the current standards based on 2005-2007 air quality data (zone E). A smaller but still notable number meet the current annual standard but do not meet the current 23hr standard (Zone A). A similar number of areas do not meet either current standard (zones B and C). Only a few areas do not meet the current annual standard, but do meet the current 24hr standard (zone D). Of the 15 urban study areas included in the risk assessment most fall into zones that do not meet either standard (zones B and C) although some study areas are in each of the other zones.
- *Alternative suites of standards involving reduction of the annual standard levels* (see Figure 4-18) Based on 2005-2007 air quality data, as shown in Figure 4-18, reduction in the annual standard level down to 12 $\mu g/m^3$ results in a significant increase in the number of areas that

do not meet the annual standard (zones C and D). And of those areas, roughly similar numbers of urban areas do meet the 24hr standard as do not meet the 24hr standard (comparing numbers of urban areas in B and C to the number in zone D).

- *Alternative suite of standards involving reductions in both annual and 24-hour levels* (see Figure F-19): Based on 2005-2007 air quality data, a large fraction of urban areas are predicted not to meet the 24hr standard (zones A, B and C). Furthermore, the majority of these have the 24hr controlling (zone A and B). We also note that there are virtually no urban areas that exceed the annual standard while not meeting the 24hr standard (zone C). Of the 15 urban study areas, most do not meet either the 24hr or annual standards, while the 24hr is controlling in most (zone B).

4.5.2 Patterns in $PM_{2.5}$ Monitoring Data

As noted earlier, patterns in $PM_{2.5}$ monitoring data for each of the 15 urban study areas can be used (together with consideration of design values as described in section 4.5.1) to support interpretation of risk estimates generated for current and alternative standard levels. This is particularly true when considering the impact of using different rollback methods in supporting risk characterization for current and alternative standard levels, as discussed below.

To facilitate consideration of patterns in $PM_{2.5}$ monitoring data across the 15 urban study areas, we have developed Figures 4-20 and 4-21. Each of these figures presents 24-hour and annual design values (blue and green dots, respectively) for each $PM_{2.5}$ monitor within each study area. The figures also flag the highest design values for each study area (red and brown stars for the annual and 24-hour standard levels, respectively).[58] Each figure has been scaled to represent a particular suite of standards, with Figure 4-20 scaled to represent the current suite of standards (15/35) and Figure F-21 scaled to represent the 12/25 alternative suite of standards.[59] In addition, the figures allow identification of whether a study area had the highest design value (for the 24-hour and annual averaging periods) occurring at the same or at different monitors. This factor can influence the degree to which simulation of a controlling 24hr standard level, given application of peak shaving, results in reduction in annual-average $PM_{2.5}$ levels for that study area. If an area has both 24hr and annual design values occurring at the same monitor, then application of peak shaving to reduce the controlling 24hr standard will also bring down the

[58] Note, that it is the highest viable study-area level design values (represented as stars in the diagram) that were used as the basis for determining the degree of rollback needed to simulate a particular standard level in the risk assessment.
[59] For example, in Figure 4-20, the left y-axis, which represents the annual standard level extends from the 15/35 line up to a maximum of 30, with this representing a factor of two spread in the annual design value (i.e., from the current 15 up to 30). Similarly, the right hand y-axis represents the 24-hour standard level with the 15/35 line extending from 35 to a maximum of 70 (again a factor of 2 above the current standard of 35). This allows 24-hour and annual standard levels for a given study area to be compared directly in terms of how far they are above (or below) the 15/35 line in order to determine which standard is controlling (i.e., the standard which is higher on the plot).

annual design value (i.e., the annual-average $PM_{2.5}$ level for that study area is likely to be reduced to a greater extent). By contrast, if 24hr and annual design values are located at different monitors, then peak shaving focused on reduction of the 24hr design value monitor will potentially not impact the annual design value (i.e., there will be a smaller impact on the annual-average $PM_{2.5}$ level for that study area).[60]

To gain a better understanding of the information provided in Figures 4-20 and 4-21, we will provide a walkthrough for one of the urban study areas, highlighting key attributes related to 24-hour and annual design values. With Los Angeles (in Figure 4-20) we see that the study area has a relatively wide spread in 24-hour and annual design values across the monitors (i.e., it has a relatively peaky $PM_{2.5}$ distribution), with 24-hour values ranging from ~15 to ~55 and annual design values ranging from ~7 to ~19 (exact values are presented in Appendix A). In addition, we see that the 24-hour standard is clearly controlling, given how much farther the highest viable 24-hour design value is from the 15/35 line compared with the highest annual design value. In addition, we can compare these trends in 24-hour and annual design values for Los Angeles to those for the other urban study area and see that generally, Los Angeles (a) has some of the widest spreads in both 24-hour and annual design values (i.e., it has one of the more peaky $PM_{2.5}$ distributions across monitors) and (b) has one of the highest 24-hour design value of the 15 urban study areas (i.e., it will require more rollback in simulating just meeting the current suite of standards compared with most of the other study areas). The attributes described above match well with urban areas falling into zone B1 in Figure 4-17 (i.e., the zone where urban areas do not meet both the current 24-hour and annual standards, and where the 24-hour standard is controlling).

[60] When a star in either Figure 4-20 or 4-21 (signifying the highest design value for that study area) is placed over a point estimate, then the highest design value (for both 24-hour and annual levels) occurs at different monitors. This is the case, for example, with Phoenix, while Los Angeles represents a location where the highest 24-hour and annual design values occur at the same monitor.

Figure 4-20 Annual and 24-hour design values (for individual monitors and at the study-area level) for the 15 urban study areas (with the presentation of values scaled to reflect current standard of 15/35)

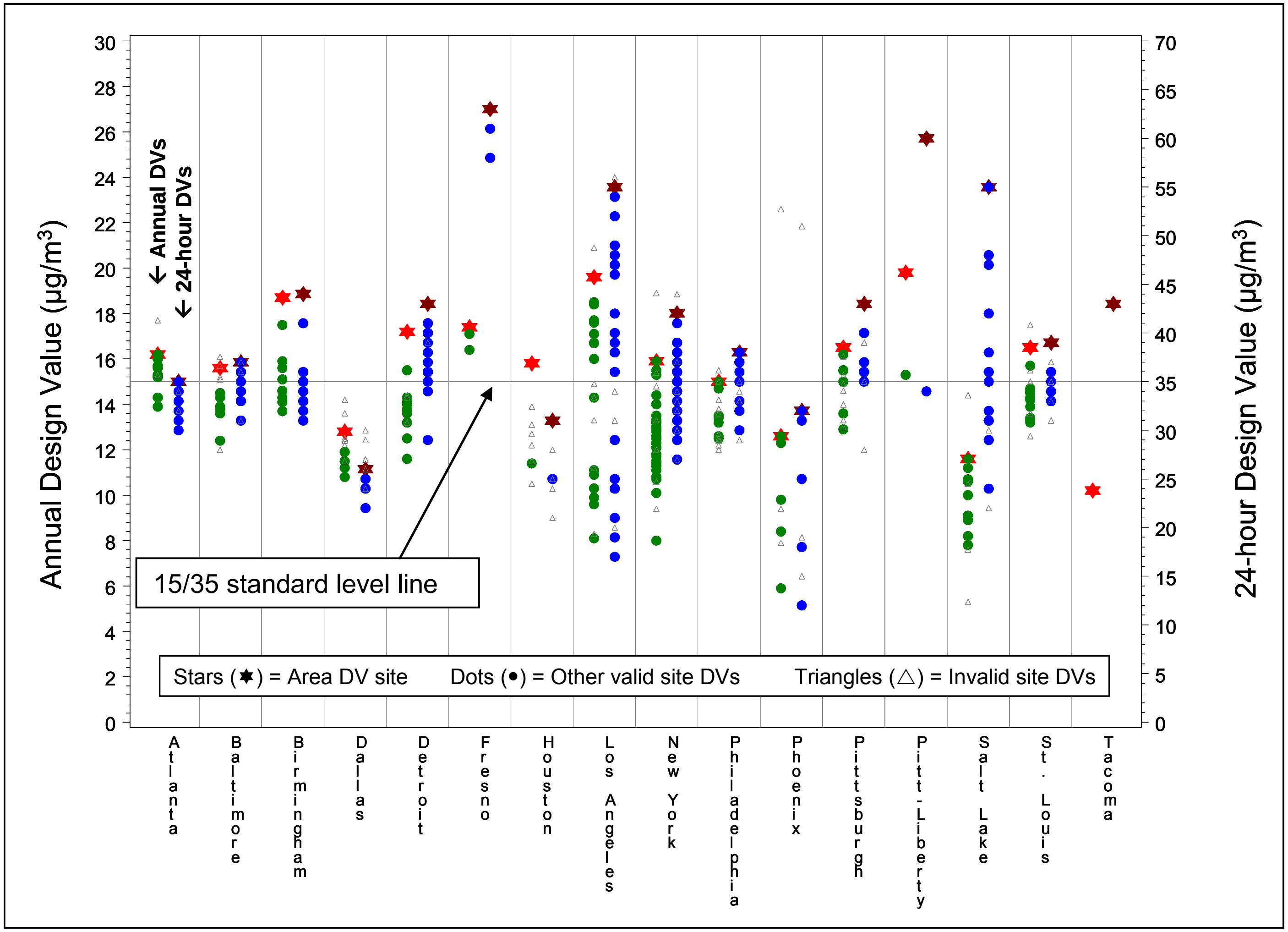
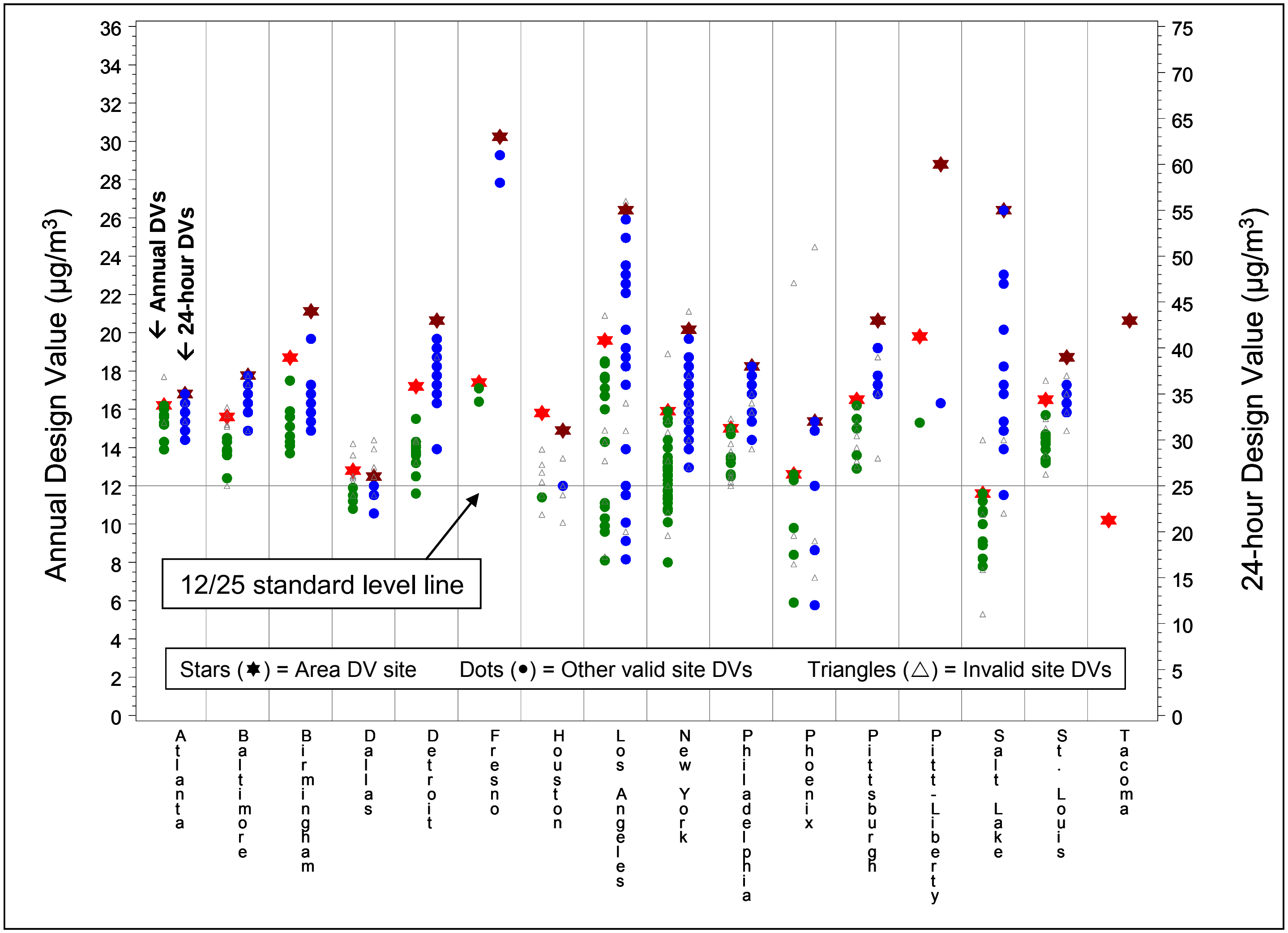


Figure 4-21 Annual and 24-hour design values (for individual monitors and at the study-area level) for the 15 urban study areas (with the presentation of values scaled to reflect current standard of 12/25)



The sensitivity analysis examining uncertainty related to conducting rollback demonstrated that for some of the study areas (e.g., Los Angeles and Salt Lake City) use of the peak shaving rollback method reflecting application of more localized controls resulted in composite monitor values that differed notably from values generated when the proportional rollback approach was used.[61] In contrast, many of the other urban study areas displayed little difference in composite monitor values based on application of proportional or peak shaving rollback methods.

Design value information provided in Figures 4-20 and 4-21 provide explanations for these sensitivity analysis results. For Los Angeles (which had composite monitor values 40% higher when using the peak shaving rollback method compared with the proportional approach – see Section 4.3.1.1), the 24-hour standard is controlling. This can be seen by noting that the maximum 24-hour design value is significantly further away from the 15/35 line in Figure 4-20 compared with the maximum annual design value. In addition, these two maximum design values do not occur at the same monitor.[62] This means that when the proportional rollback method is used, a relatively large fractional reduction is uniformly applied to all monitors, resulting in a new (adjusted) composite monitor value that has been reduced to a relatively large extent. However, if peak shaving rollback is used, then only those monitors with 24-hour design values exceeding the current 24-hour standard level are adjusted and only by the fraction required to get each 24-hour design value down to the current 24-hour standard level.[63] This means that in an overall sense, there is less adjustment to $PM_{2.5}$ levels, such that with peak shaving we will see higher composite monitor annual averages than with proportional rollback.

In the case of Salt Lake City (which also has significantly higher composite monitor annual averages with peak shaving than with proportional rollback), while the highest 24-hour and annual design values occur at the same monitor, which means that even with peak shaving, the monitor with the highest annual averages will be adjusted downward substantially, because the annual design values for monitors are closer to each other, the impact of peak shaving on the composite annual average is smaller. Specifically, while some of the monitors with 24-hour design values above the current 24-hour standard level will have their annual averages adjusted

---

[61] Recall that differences in composite monitor estimates represent surrogates for differences in long-term exposure-related mortality - long-see section 4.3.1.1.

[62] In figures 4-20 and 4-21, when the max viable 24-hour and annual design values occur at the same monitor, this is signified by showing the red stars for the max viable standard level superimposed over a green dot.

[63] With the peak shaving approach, many of the monitors will not have their $PM_{2.5}$ levels adjusted because their 24-hour levels do not exceed the current standard. Furthermore, because Los Angeles has its max 24-hour and annual standard levels occurring at different monitors, the max adjustment applied (that associated with the highest 24-hour monitor) will not be applied to the monitor having the highest annual design value, resulting in a lower overall impact to the composite annual average, compared with proportional rollback.

down, there is a fraction of the monitors (with 24-hour design values below the current standard) that will not be adjusted under peak shaving.

These two examples illustrate different conditions under which the type of rollback applied can have a significant impact on the degree of public health protection assessed for a particular standard level. By contrast, conditions at some of the other urban study areas result in little difference in risk from application of different rollback methods (i.e., simulation of more regional versus local control strategies). Specifically, if an urban location has 24-hour and annual design values at each monitor that display little variation, we expect to see less impact on risk from varying the type of rollback method used. Examples that fall into this latter category include Atlanta, Dallas, and St. Louis (see Figure 4-20).

5 NATIONAL-SCALE ASSESSMENT OF LONG-TERM MORTALITY RELATED TO $PM_{2.5}$ EXPOSURE

5.1 OVERVIEW

In this section we present the estimated nationwide premature mortality resulting from recent exposures to ambient $PM_{2.5.}$ The goal of this assessment is twofold: (1) estimate the incidence of premature mortality within the U.S. related to long-term $PM_{2.5}$ exposure; and (2) identify where the subset of counties assessed in the urban case study areas analysis fall along the distribution of national county-level risk.[64] To perform this assessment we use 2005 $PM_{2.5}$ fused air quality estimates from the Community Model for Air Quality (CMAQ) (Byun and Schere, 2006) in conjunction with the environmental Benefits Mapping and Analysis Program (BenMAP, Abt Associates Inc, 2008) to estimate long-term $PM_{2.5}$-related premature mortality nationwide.

To address the first goal of the assessment, we estimate excess $PM_{2.5}$-related long-term mortality by applying two estimates of all-cause mortality risk found in the Krewski et al. (2009) $PM_{2.5}$ mortality extended analysis of the American Cancer Society (ACS) cohort, and an estimate of all-cause mortality risk found in the Laden et al. (2006) $PM_{2.5}$ mortality extended analysis of the Six-Cities cohort. We estimate that total $PM_{2.5}$-related premature mortality ranges from 63,000 (39,000—87,000) (95th percentile confidence interval) and 88,000 (49,000—130,000), respectively; in each case we estimated deaths per year down to the lowest measured levels (LMLs) in each epidemiological study.

In addressing the second goal of this assessment, we observe that the subset of 31 counties for the 15 urban study areas considered in the urban case study fall toward the upper end of the national distribution. Specifically, all of the 31 counties were above the median of the national risk distribution and 23 of the 31 fell within the upper 5th percentile of the national distribution. Therefore, according to this analysis, we appear to be capturing high-end percentiles of the national risk distribution with the set of urban case study areas we are evaluating in the $PM_{2.5}$ NAAQS risk assessment.

We had considered expanding the national-scale mortality to include additional health endpoints (related to short-term $PM_{2.5}$ exposure) or additional air quality scenarios that simulate just meeting the current and alternative suites of standards. However, as noted in section 2.3, we

[64] We do not directly compare the estimated county-level risks generated in the urban case study assessment and the county-level risks generated in the national-scale analysis. Rather, we identify where the 31 counties modeled for urban case study fell along the national risk distribution. This assessment revealed whether the baseline $PM_{2.5}$ mortality risks in the 31counties modeled in the urban case study areas represented more typical or higher-end risk relative to the national risk distribution.

continue to conclude that any expansion of this assessment, is beyond the scope of what is needed or can reasonably be done within the time and resources available for this review. Here we provide additional discussion of the rationale for our decision not to expand the scope of the national-scale analysis.

The goal of the national-scale analysis is two-fold: to provide perspective on the magnitude of $PM_{2.5}$ health impacts on a national-scale and to help to place the risk estimates generated for the urban study areas in a national context. The analysis as currently implemented achieves the first goal by providing estimates of long-term exposure-related all-cause mortality under recent conditions. While simulation of risk for the current and alternative standard levels would provide additional perspective on the magnitude of national-scale risk, that assessment would be resource-intensive and subject to considerably uncertainty if it were conducted using air quality simulation methods similar to those used in the urban study area analysis (i.e., application of a combination of rollback methods that reflects both local and regional patterns in ambient $PM_{2.5}$ reductions implemented at the monitor-level). A particular area of uncertainty (and technical complexity) related to air quality simulation would be addressing the interplay between regional-scale reductions in ambient $PM_{2.5}$ in adjacent urbanized areas. In the urban study area analysis, each location is treated independently with regard to simulating ambient $PM_{2.5}$ under alternative suites of standards. However, if we were to expand the national analysis to include alternative standards, then simulation of rollbacks in ambient $PM_{2.5}$ levels would necessarily have to address this contiguity issue between adjacent urban areas and even between suburban areas and adjacent urbanized areas in the context of simulating monitor rollback.

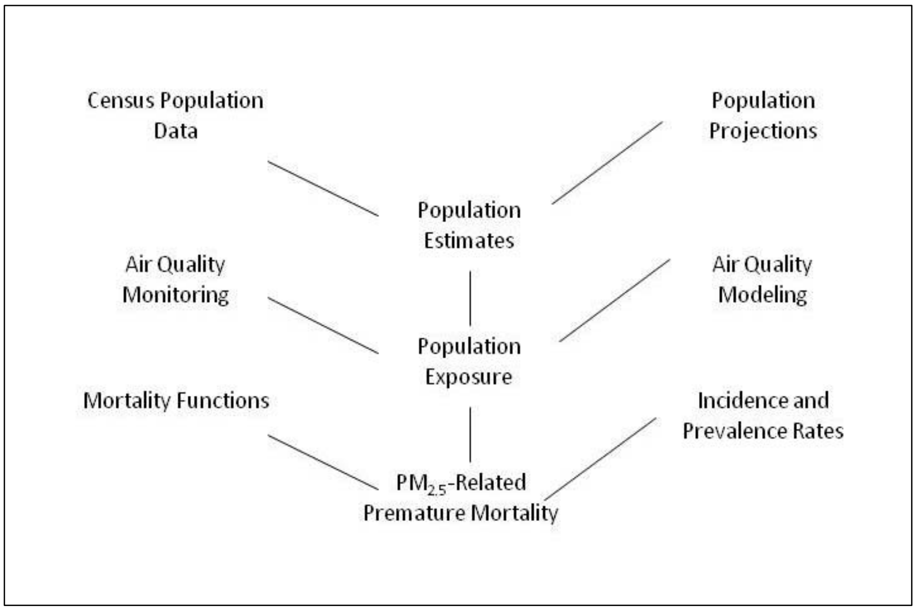
In addition, because long-term exposure-related mortality dominates $PM_{2.5}$ in terms of total incidence, providing coverage for this endpoint category ensures that the majority of $PM_{2.5}$-related mortality incidence is reflected in the analysis, without including short-term exposure-related mortality.

The national-scale mortality analysis, as currently implemented, also achieves its second goal: to help place risk estimates for the urban study areas in a national context. Because the national-scale analysis focuses on the long-term exposure-related mortality, which is the primary driver for $PM_{2.5}$-related health impacts, the analysis allows us to assess how the urban study areas "fall" across a national distribution of risk for this key health endpoint category (see discussion below). This then allows us to characterize the degree to which the set of urban study areas provides coverage for areas of the country likely to experience relatively elevated levels of $PM_{2.5}$-related health impacts.

5.2 METHODS

This assessment combines information regarding estimated $PM_{2.5}$ air quality levels, population projections, baseline mortality rates, and mortality risk coefficients to estimate $PM_{2.5}$-related premature mortality. Figure 5-1 below provides a conceptual diagram, detailing each of the key steps involved in performing this BenMAP-based health impact assessment. Appendix G contains additional information regarding the data inputs to this analysis.

Figure 5-1 Conceptual diagram of data inputs and outputs for national long-term mortality risk assessment



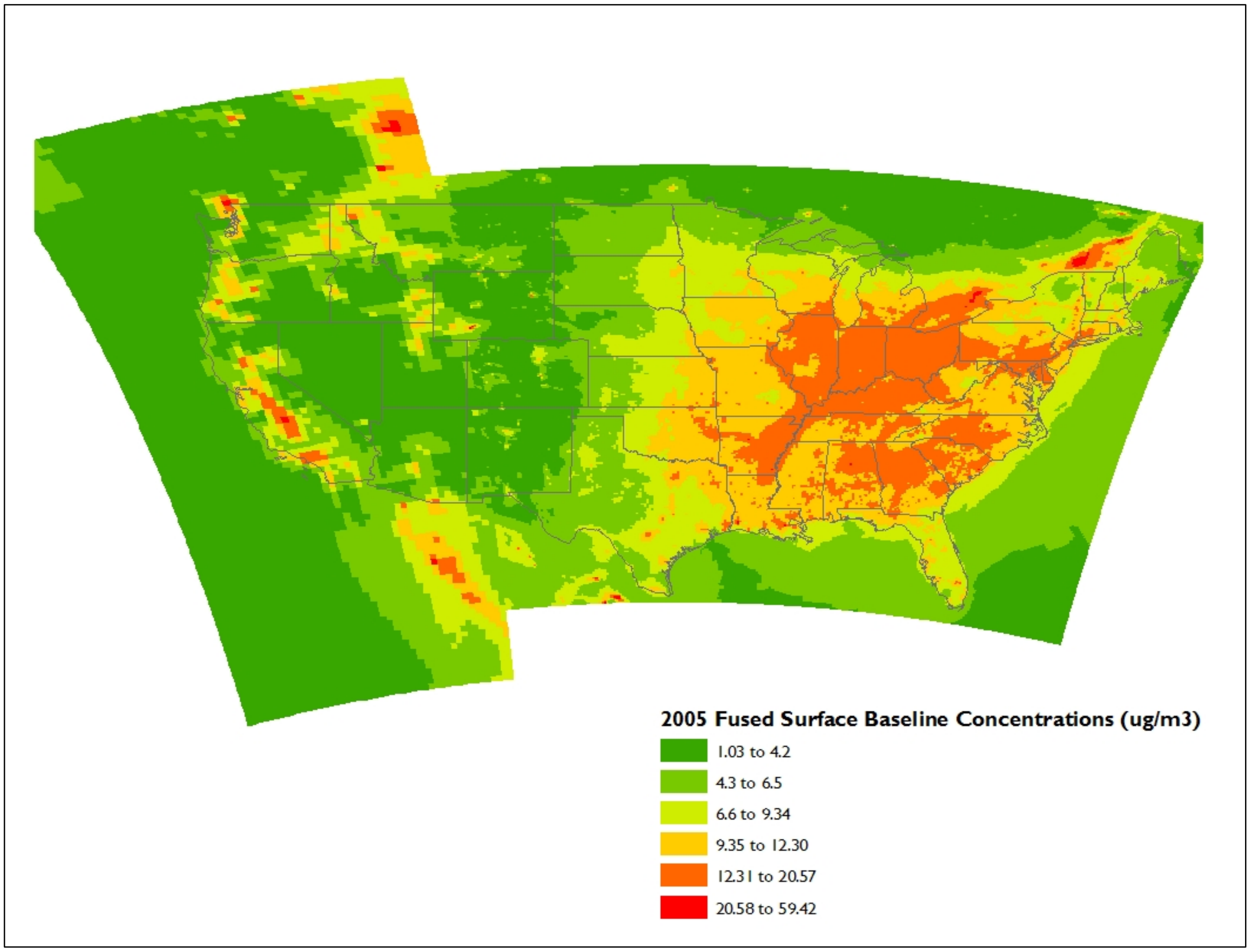
5.2.1 Population Estimates

The starting point for estimating the size and demographics of the potentially exposed population is the 2000 census-block level population, which BenMAP aggregates up to the same grid resolution as the air quality model. Using county-level growth factors based on economic projections (Woods and Poole Inc., 2001), BenMAP projects this 2000 population to the analysis year of 2005; we selected this population year because it matches both the year in which the emissions inventory was developed for the air quality modeling and the year to which the baseline mortality rates were projected (see below).

5.2.2 Population Exposure

Having first estimated the size and geographic distribution of the potentially exposed population, BenMAP then matches these population projections with estimates of the ambient levels of $PM_{2.5}$. In contrast to the urban study areas analysis, the national-scale analysis employed a data fusion approach, which joined 2005 monitored $PM_{2.5}$ concentrations with 2005 CMAQ-modeled air quality levels using the Voronoi Neighbor Averaging (VNA) technique (Abt, 2003). CMAQ was run at a horizontal grid resolution of 12km for the east and 36km in the west using 2005 estimated emission levels and meteorology. More information on this model run can be found in Appendix G of this document. Figure 5-2 shows the geographic distribution of baseline annual mean $PM_{2.5}$ concentrations across the continental U.S. The maximum predicted value within the U.S. is 31 $\mu g/m^3$, the mean $PM_{2.5}$ value is 8.7 $\mu g/m^3$, median is 8.8 $\mu g/m^3$ and the 95th percentile value is about 14 $\mu g/m^3$.

Figure 5-2 2005 fused surface baseline $PM_{2.5}$ concentrations



This assessment applies $PM_{2.5}$ mortality risk coefficients drawn from long-term cohort studies which estimate changes in risk based on annual mean changes in $PM_{2.5}$ concentration. For this reason, EPA used the CMAQ model to estimate annual mean concentrations at each grid cell. These grid-level annual average concentrations were then input to BenMAP.

5.2.3 Premature Mortality Estimates

In this assessment of $PM_{2.5}$-related premature mortality we considered risk estimates drawn from studies based on two prospective cohorts. The first study is the recently published Krewski et al. (2009) extended reanalysis of the ACS cohort. To remain consistent with the urban study areas analysis, we applied the two log-linear all-cause mortality risk coefficients based on the 1979-1983 and the 1999-2000 time periods that control for 44 individual and 7 ecologic covariates. We also applied a log-linear all-cause mortality risk coefficient drawn from the extended analysis of the Six Cities cohort as reported by Laden et al. (2006). When estimating premature mortality using these functions we considered air quality levels down to the lowest measured levels (LML) in each study; for the Krewski et al. (2009) study this is 5.8 $\mu g/m^3$ and for the Laden et al. (2006) study this is 10 $\mu g/m^3$. In general, we place a higher degree of confidence in health impacts estimated at air quality levels at or above the LML because the portion of the concentration-response curve below this point is extrapolated beyond the observed data. We also estimated health impacts down to Policy Relevant Background (PRB) levels (EPA, 2008). The final ISA presents estimates of annual mean PRB for each of 7 Health Effects Institute PM regions; this value ranges from 0.62 $\mu g/m^3$ in the southwest to 1.72 $\mu g/m^3$ in the southeast.

BenMAP contains baseline age-, cause- and county-specific mortality rates drawn from the CDC-WONDER. Current baseline mortality estimates are an average of a three year period from 1996-1998. EPA is in the process of updating these rates with 2006-2008 data; a sensitivity analysis suggests that the results reported here are largely insensitive to the use of more current mortality rates.

5.3 RESULTS

Table 5-1 and figures 5-3 through 5-4 below summarize the results of the national-scale analysis. Table 5-1 summarizes the total $PM_{2.5}$-related premature mortality associated with modeled 2005 $PM_{2.5}$ levels.

Estimated $PM_{2.5}$ -Related Premature Mortality Associated with Incremental Air Quality Differences Between 2005 Ambient Mean $PM_{2.5}$ Levels and LML from the Epidemiology Studies or PRB (90th percentile confidence interval)

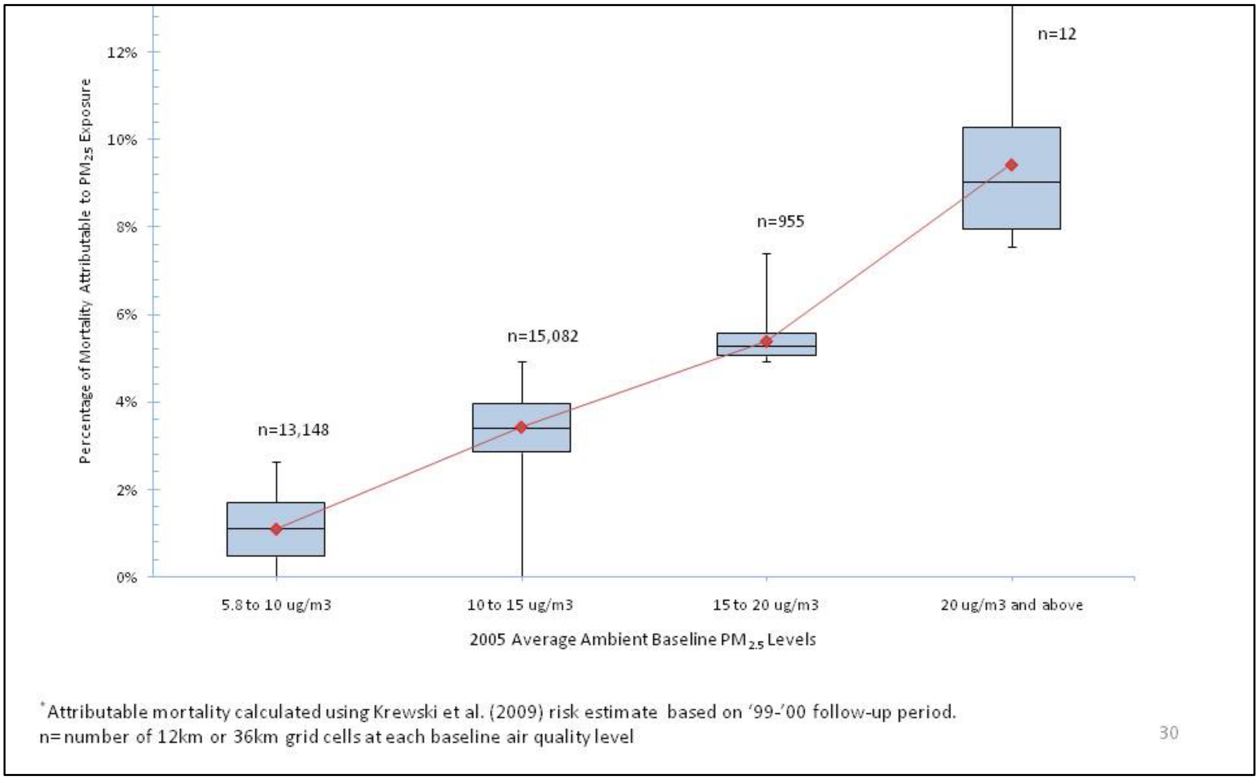
Table 5-1 Estimated $PM_{2.5}$-related premature mortality associated with incremental air quality differences between 2005 ambient mean $PM_{2.5}$ levels and lowest measured level from the epidemiology studies or policy relevant background (90th percentile confidence interval)

Air Quality Level	Estimates Based on Krewski et al. (2009)		Estimates Based on Laden et al. (2006) *(90th percentile confidence interval)*
	'79-'83 estimate (90th percentile confidence interval)	***'99-'00 estimate (90th percentile confidence interval)***	
10 µg/m³ (LML for Laden et al., 2006)	26,000 (16,000—36,000)	33,000 (22,000—44,000)	**88,000 (49,000—130,000)**
5.8 µg/m³ (LML for Krewski et al., 2009)	**63,000 (39,000—87,000)**	**80,000 (54,000—110,000)**	210,000 (120,000—300,000)
Policy-Relevant Background	110,000 (68,000—150,000)	140,000 (94,000—180,000)	360,000 (200,000—500,000)
Bold indicates that the minimum air quality level used to calculate this estimate corresponds to the lowest measured level identified in the epidemiological study			

In this table, the bold figures indicate the estimate that corresponds with the LML identified in the epidemiological study. The bold estimates in the column Krewski et al. (2009) were calculated using the same risk coefficients as the urban case study analysis. We place a greater emphasis on those results calculated using the LML reported in the epidemiological studies.[65] Figure 3 illustrates the percentage of baseline mortality attributable to $PM_{2.5}$ exposure in each of the grid cells according to the 2005 $PM_{2.5}$ air quality levels, using the Krewski et al. (2009) estimate based on 1999-2000 air quality levels.

[65] Note, that as stated in Section 4.3.2, modeling of risk down to PRB is subject to considerable uncertainty. While there is no evidence for a threshold (which conceptually supports estimation of risk below LML), we do not have information characterizing the nature of the C-R function for long-term mortality below the LML and consequently estimates of mortality based on incremental exposure below LML (and down to PRB) is subject to greater uncertainty.

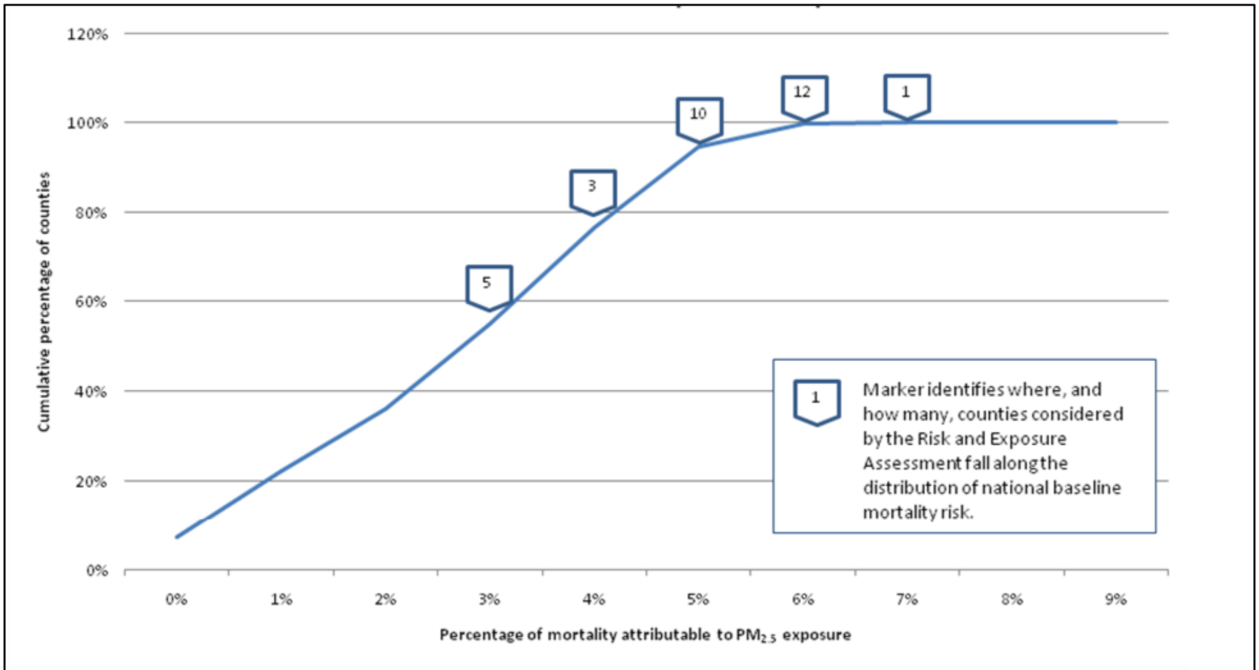
Figure 5-3 Percentage of premature mortality attributable to $PM_{2.5}$ exposure at various 2005 annual average $PM_{2.5}$ levels*



This figure illustrates the number of deaths attributable to $PM_{2.5}$ according to the baseline level of ambient average $PM_{2.5}$ levels down to 5.8 µg/m^3 (the LML for the Krewski et al. (2009) analysis). Each of four box plots characterizes the range of premature mortality attributable to $PM_{2.5}$ according to the baseline level of annual mean $PM_{2.5}$ levels in that model grid cell. Note that while the lower whisker of the box plots for the baseline air quality values of 5.8 µg/m^3 to 10 µg/m^3 appear to extend to zero, the minimum value is greater than zero. The number above each box plot indicates the number of grid cells summarized by that plot.

Figure 5-4 displays the cumulative distribution of total mortality attributable to $PM_{2.5}$ exposure at the county level developed as part of the national-scale analysis. The location of the 31 counties included in the urban case study analysis is then superimposed on top of the cumulative distribution.

Figure 5-4 Cumulative distribution of county-level percentage of total mortality attributable to $PM_{2.5}$ for the U.S. with markers identifying where along that distribution the urban case study area analysis fall*



*Attributable mortality calculated using Krewski et al. (2009) risk estimate based on '99-'00 follow-up period.

Counties considered in the urban scale analysis that are located toward the lower end of the distribution of all counties nationwide include Maricopa County, Arizona and Salt Lake City, Utah. Counties assessed in the urban scale analysis that are located toward the upper end of the distribution of all counties include Jefferson County, Alabama and Los Angeles County, California. The results of this analysis indicate that most of the 31 counties included in the urban case study counties fall toward the upper end of the national risk distribution and that 23 of these counties fall within the upper 5th percentile of the risk distribution—suggesting that the $PM_{2.5}$ mortality risk estimates included in the urban case study analysis generally represent the upper end of urban area mortality risks within the nation.

6 INTEGRATIVE DISCUSSION OF URBAN CASE STUDY ANALYSIS OF $PM_{2.5}$-RELATED RISKS

This chapter provides an integrative discussion of the risk-related analyses presented throughout this second draft RA, including the $PM_{2.5}$-related risk estimates generated for the set of urban study areas and the related uncertainty and sensitivity analyses, the representativeness analyses, and the national-scale long-term exposure $PM_{2.5}$ mortality assessment. The goal of this integrative discussion is to inform our understanding of important policy-relevant risk-based questions, including: (a) what is the magnitude of risk likely to remain if the urban study areas were just meeting the current suite of $PM_{2.5}$ standards, and what level of confidence do we have in those estimates?; (b) what is the degree and nature of risk reduction likely to be associated with just meeting the alternative suites of annual and 24-hour $PM_{2.5}$ standards considered in this risk assessment, and what roles do the annual and 24-hour standards play in bringing about such reductions?; and c) what is the distribution of risks associated with recent $PM_{2.5}$ air quality in areas across the U.S., and how representative are the risk results for the urban study areas from a national perspective?

In addressing the risk-based questions listed above, we have placed primary focus on risk associated with long-term exposure to $PM_{2.5}$. This choice reflects the fact that long-term exposure to $PM_{2.5}$ has been shown in this and previous quantitative risk assessments to produce substantially larger mortality risk (in terms of overall incidence and percent of total mortality) compared with short-term $PM_{2.5}$ exposure. Because of the emphasis placed on long-term $PM_{2.5}$ exposure-related mortality risk, the risk assessment has been designed to generate robust estimates for this risk category, including comprehensive analysis of uncertainty. For the assessment of mortality and morbidity risks related to short-term $PM_{2.5}$ exposure, the assessment of uncertainty and its impact on risk estimates has been more limited.

In characterizing risks associated with both long- and short-term exposure to $PM_{2.5}$ throughout this document, we have included those health endpoints for which sufficient information was available to generate quantitative risk estimates with a reasonable degree of confidence. It is important to emphasize that beyond the health endpoints evaluated quantitatively in this risk assessment, there is an array of additional health endpoints potentially associated with $PM_{2.5}$ that will be discussed as part of the evidence-based considerations presented in the policy assessment now being prepared..

The following discussion begins with a summary of analytical approaches used in this quantitative risk assessment, emphasizing the degree of confidence we have in the data, models, and assumptions we have used in developing our core risk estimates and in the results of our sensitivity analyses (section 6.1). We then summarize our core risk results for the urban study areas, and the confidence we have in those results in light of our uncertainty and variability analyses, and provide insights into how those results inform the policy-relevant considerations described above (section 6.2). Next we place these results into a national perspective (section 6.3). In so doing, we provide insights into how well the set of urban study areas represent the broader set of urban areas in the U.S. likely to experience increased risk from $PM_{2.5}$. We also integrate the results from the urban study areas with the national-scale mortality assessment to provide insights into the degree to which the $PM_{2.5}$-related risks estimated in the urban study areas are likely to be characteristic of risks in the broader U.S. population. Finally, in section 6.4, we highlight key points that address the policy-relevant questions that began this chapter.

6.1 KEY ANALYTICAL ELEMENTS IN THIS RISK ASSESSMENT

This quantitative risk assessment has been designed to generate estimates of risk for a set of urban study areas likely to represent those urban areas in the U.S. experiencing higher $PM_{2.5}$-related risk due to elevated $PM_{2.5}$ levels and/or other attributes related to $PM_{2.5}$ risk (e.g., meteorology, baseline health effects incidence rates, differences in $PM_{2.5}$ emissions sources and composition).[66] In addition, the risk assessment is designed to produce robust risk estimates that reflect consideration of the latest research into $PM_{2.5}$-related exposure and risk. To achieve these goals, a deliberative process has been used in specifying each of the analytical elements comprising the risk model, including selection of urban study areas as well as specification of other inputs such as C-R functions. This deliberative process involved rigorous review of available literature addressing both $PM_{2.5}$ exposure and risk combined with the application of a formal set of criteria to guide development of each of the key analytical elements in the risk assessment. In addition, the risk assessment design reflects consideration of CASAC and public comments on the initial risk assessment plan, as well as the first draft risk assessment. The application of this deliberative process increases overall confidence in the risk estimates by insuring that the estimates are based on the best available science and data characterizing $PM_{2.5}$ exposure and risk, and that they reflect consideration of input from experts on PM exposure and risk through CASAC and public reviews.

The approach used in specifying several of the key analytical elements used in the risk assessment is highlighted below for purposes of illustrating the systematic approach used in developing the model.

[66] As discussed in section 3.3.2, the seven PM regions were designed to capture regional differences in factors potentially related to PM risk. By providing coverage for these regions with the set of urban study areas selected, we have provided some degree of coverage for regional differences in attributes potentially related to PM risk. In addition, the representativeness analysis discussed in section 4.4 also allowed us to assess the degree to which the set of urban study areas captured key patterns in PM risk-related attributes across urban areas in the U.S..

- Selection of the 15 urban study areas included consideration of (a) whether a city of county had been included in multi-city epidemiology studies used in specifying C-R functions used in the core risk estimates, (b) providing coverage for urban areas with relatively high annual and 24-hour design values, and (c) providing coverage for the seven PM regions which reflect differences in key PM risk-related attributes (e.g., meteorology, demographic attributes, PM sources and composition). See section 3.3.2 for additional detail on selection of study areas.
- Simulation of ambient $PM_{2.5}$ levels under current and alternative standard levels included application of the proportional rollback approach used in previous risk assessments, which generally represents regional patterns of reductions in ambient $PM_{2.5}$ concentrations. Recognizing that simulating regional patterns in ambient $PM_{2.5}$ reductions alone does not capture the potential variability in future patterns of reductions that may occur, we also considered alternative rollback approaches, including hybrid and peak shaving approaches. Both of these approaches simulate more localized patterns of ambient $PM_{2.5}$ reductions combined with additional regional patterns of reductions in ambient $PM_{2.5.}$ Including these three rollback approaches allowed us to assess the degree to which differences in the spatial pattern of ambient $PM_{2.5}$ reductions resulting from simulations of just meeting current and alternative suites of $PM_{2.5}$ standards can impact risk profiles.
- Selection of health endpoints reflected consideration of the degree of support in the literature for a causal relationship between $PM_{2.5}$ exposure and the health effect of interest as assessed in the ISA, together with consideration of the health significance of the endpoint. In addition, we considered whether sufficient information existed in the literature to develop C-R functions and whether we could obtain the baseline incidence data necessary to generate risk estimates with a reasonable degree of confidence (see section 3.3.1).
- The selection of epidemiological studies and specification of C-R functions for use in modeling risk for these endpoints involved a rigorous review of existing literature based on application of criteria we identified for specifying robust C-R functions. These criteria took into account both study design as well as the potential scope of the C-R functions that could be drawn from the studies (e.g., geographic coverage, demographic groups covered and health endpoints involved). We outlined our rationale for the set of epidemiology studies we selected and the choices made in specifying C-R functions, and we discussed our rationale for not including other potential studies and/or forms of C-R functions in the risk assessment.

The systematic approach described above resulted in a core risk model which included those model inputs that in our judgment have the greatest degree of support in the literature. These core risk estimates are emphasized in addressing the policy-related questions outlined above. To provide a more comprehensive assessment of risk for the urban study areas, we have included an assessment of uncertainty and variability and their impact on the core risk estimates as part of this analysis. This assessment of uncertainty and variability includes both qualitative and quantitative elements, the latter taking the form of single- and multi-factor sensitivity analysis.[67] The goal of these assessments was to evaluate the robustness of the core risk estimates given identified sources of uncertainty and variability. Inclusion of the qualitative analysis of uncertainty, in additional to the sensitivity analyses, helped insure that a more complete list of potentially important sources of uncertainty was considered in the risk assessment and not only those sources for which it is possible to conduct a sensitivity analysis.

The assessment of uncertainty and variability completed for this analysis is more comprehensive than had been done for previous risk assessments. This reflects, in part, the development of methods by EPA staff to address potentially important sources of variability and uncertainty. For example, to more fully explore potential variability in the patterns of reductions in ambient $PM_{2.5}$ that may occur upon just meeting the current and alternative suites of standards, we incorporated as part of the sensitivity analysis two additional rollback approaches (hybrid and peak shaving) in addition to the proportional rollback used in the core analyses. In addition, recently published literature has allowed us to more rigorously examine the impact of uncertainty related to specifying C-R functions for long-term exposure-related mortality (i.e., the Krewski et al., 2009 study which provided extensive analysis of alternative model specifications for mortality which could be readily incorporated into our sensitivity analysis).[68]

In addition to enhanced sensitivity analyses, we also included a number of national-scale assessments that had not been done in past risk assessments (i.e., the representativeness analysis and national-scale assessment of long-term mortality). These national-scale assessments allowed us to more fully consider the degree to which the selected urban study areas are representative of the broader set of urban areas within the U.S., thereby allowing us to place risk estimates for the urban study areas in the broader national context.

6.2 INTERPREATION OF URBAN STUDY AREA RESULTS

This section describes the core risk estimates generated for the 15 urban study areas, focusing on the policy-relevant questions outlined above. An important factor to consider in interpreting these results is that the magnitude of both long- and short-term exposure-related risk depends primarily on annual-average $PM_{2.5}$ concentrations. Furthermore, reductions in both categories of risk, as we consider simulating just meeting alternative suites of standards, also depend on changes in annual-average $PM_{2.5}$ concentrations.

[67] As discussed in section 4.1, available information did not support a full probabilistic analysis of uncertainty and variability in the risk model and consequently, a combination of single- and multi-factor sensitivity analyses was used to assess the potential impact of these factors on core risk estimates.
[68] Given increased emphasis placed in this analysis on long-term exposure-related mortality, the uncertainty analyses completed for this health endpoint category are somewhat more comprehensive than those conducted for short-term exposure-related mortality and morbidity, which to some extent reflects limitations in study data available for addressing uncertainty in the later category.

The role of annual-average ambient $PM_{2.5}$ concentrations in driving long-term exposure-related risk is intuitive given that this risk category is modeled using the annual-average air quality metric.[69] The fact that short-term exposure-related risk is also driven by changes in long-term average $PM_{2.5}$ concentrations is less intuitive, since changes in average daily $PM_{2.5}$ concentrations are used to estimate changes in risk for this category.[70] Analyses in previous PM NAAQS risk assessments have shown that short-term exposure-related risks are not primarily driven by the small number of days with $PM_{2.5}$ concentrations in the upper tail of the air quality distribution, but rather by the large number of days with $PM_{2.5}$ concentrations at and around the mean of the distribution. Consequently, consideration of changes in annual-average $PM_{2.5}$ concentrations will explain to a large extent changes in short-term exposure-related risk. Therefore, in interpreting patterns of long-term exposure-related risk, and the similar patterns we observe in short-term exposure-related risk, we focus primarily on how simulating just meeting specific suites of $PM_{2.5}$ standards impacts the annual-average $PM_{2.5}$ concentration for the study areas.

In the case of simulating just meeting the current and alternative annual standards, this is straight forward, since the simulation produces a direct change in the annual-average $PM_{2.5}$ concentration. However, simulating just meeting the current and alternative 24-hour standards has a less direct effect on annual average $PM_{2.5}$ concentrations across study areas, which depends on a number of factors, including: (a) the type of rollback used to simulate just meeting the current or alternative standards, (b) the combination of 24-hour and annual design values in each study area (Table 4-8), and (c) the pattern of $PM_{2.5}$ monitoring data across each study area. If proportional rollback is used, the annual-average $PM_{2.5}$ concentrations will be reduced by the same percentage as was needed to lower the 24-hour design value to the level of the controlling 24-hour standard. However, our sensitivity analysis examining alternative rollback methods showed that application of a peak shaving rollback approach (reflecting more localized patterns of $PM_{2.5}$ reductions) can, under certain circumstances, produce notably smaller changes to annual average concentrations, which in turn, translate into smaller changes in both long-term and short-term exposure-related risks. Specifically, for those urban study areas where a peak shaving

[69] As noted in section 3.2.1, estimates of long-term exposure-related mortality are actually based on an average annual $PM_{2.5}$ level across monitors in a study area (i.e., the composite monitor annual-average). Therefore, in considering changes in long-term exposure-related mortality, it is most appropriate to compare composite monitor estimates generated for a study area under each suite of standards. The maximum monitor annual-average for a study area (i.e., the annual design value) determines the percent reduction in $PM_{2.5}$ levels required to attain a particular standard. Both types of air quality estimates are provided in Tables F-49 and F-50 in Appendix F and both are referenced in this discussion of core risk estimates, as appropriate.

[70] Estimates of short-term exposure-related mortality and morbidity are based on composite monitor daily $PM_{2.5}$. concentrations. However, similar to the case with long-term exposure-related mortality, it is the maximum monitor 98[th] percentile 24-hour concentration (the 24-hour design value) that will determine the degree of reduction required to meet a given 24-hour standard.

rollback approach was applied to a $PM_{2.5}$ distribution that was more "peaky" in nature (i.e., relatively high 24-hour design values and lower annual average design values), the resulting change in annual-average $PM_{2.5}$ concentrations was notably smaller than when proportional rollback was used.[71] We note also that an additional factor introducing variation in risk across urban study areas is the relationship between the annual-average $PM_{2.5}$ concentrations at the maximum monitor and the composite monitor, which varies across study areas. For this reason, two study areas that are simulated to just meet the same annual standard (and consequently will have the same adjusted maximum monitor annual-average $PM_{2.5}$ concentration) can have notably different composite monitor values.

In discussing the core risk estimates below, we focus on cardiovascular-related endpoints given the greater overall degree of confidence assigned to this category in the ISA relative to other health effect categories (e.g., respiratory-related effects). This means that for long-term exposure-related risk, we focus our discussion on IHD-related mortality; the related categories for short-term exposure-related risk include CV-related mortality and morbidity (the latter in the form of HA related to CV symptoms).

Finally, we note that the set of urban study areas selected for this assessment reflect the profile of urban areas in the U.S. with regard to the mix of annual and 24-hour design values. As illustrated in Figure 4-18, only a few urban areas have controlling annual standard levels exceeding the current standard level (i.e., fall into zones C or D in Figure 4-18). Therefore, there are not a large number of areas that will experience risk reductions due to simulation of the current annual standard alone. By contrast, there are a lot more urban areas in the U.S. in which the 24-hour standard is controlling and the 24-hour design value exceeds the level of the current standard (i.e., fall into zones A and B in Figure 4-18). Therefore, more of the urban study areas available for analysis are likely to see risk reductions under the current suite of standards driven by simulation of the 24-hour standard. Recognition of the profile of urban areas in the U.S. with regard to the interplay between the 24-hour and annual design values is important in fully understanding the core risk estimates summarized below and how those risk estimates can be interpreted in the national context.

The discussion below is organized as follows. First, we present observations regarding core risk estimates generated for the current suite of standards. We then present observations

---

[71] The results of the sensitivity analysis examining the hybrid rollback approach, which represents a combination of an initial localized pattern of ambient $PM_{2.5}$ reduction, followed by a more regional pattern of reduction, showed this approach not to vary substantially from the proportional approach in terms of its impact on annual-average $PM_{2.5}$ concentrations and consequently risk (i.e., the peak shaving rollback method was found to result in more substantial differences in annual-average $PM_{2.5}$ concentrations and consequently risk, relative to the proportional) (see section 4.3.1.1). Therefore, in discussing the results of the sensitivity analysis examining rollback, we focus here on contrasting results for the proportional approach with those for peak shaving.

related to simulation of alternative annual standards at levels of 14, 13, and 12 μg/m^3 in conjunction with the current 24-hour standard (35 μg/m^3). Finally, we discuss simulation of alternative suites of standards involving combinations of alternative annual and 24-hour levels (i.e., an annual standard of 13 μg/m^3 paired with a 24-hour standard of 30 μg/m^3 (denoted as the 13/30 suite of standards); an annual standard of 12 μg/m^3 paired with a 24-hour standard of 25 μg/m^3 (denoted as the 12/25 suite of standards).

6.2.1 Simulation of Just Meeting the Current Suite of $PM_{2.5}$ Standards

In characterizing $PM_{2.5}$-related risks likely to remain upon just meeting the current $PM_{2.5}$ annual and 24-hour standards in the 15 areas included in this assessment, we focus on the 13 areas that would not meet the current standards based on recent (2005-2007) air quality. These 13 areas have annual and/or 24-hour design values that are above the levels of the current standards (Table 4-8).[72] Based on the core risk estimates for these areas presented above in section 4.2.1, we make the following general observation regarding the magnitude of risk remaining upon simulation (using proportional rollback) of just meeting the current suite of standards:

- *Long-term exposure-related mortality*: Total incidence of long-term exposure-related IHD mortality attributable to $PM_{2.5}$ ranges from 15-20 deaths per year (Salt Lake City) to 1,760-2,220 deaths per year (New York) (Table 4-1). This translates into a percent of total mortality incidence attributable to $PM_{2.5}$ ranging from 3.7-4.7% (Tacoma) to 13.2-16.7% (Atlanta) (Table 4-2).

Variability in incidence estimates is obviously driven in large part by differences in the population in each study area, as well as by other factors such as differences in baseline incidence rates and in exposure patterns. Substantially less variability would be expected in estimates of the percent of total mortality attributable to $PM_{2.5}$ when each area is simulated to just meet the current suite if standards, since this risk metric should normalize for population and baseline incidence rates. Nonetheless, we see appreciable variability across study areas for this risk metric as well.

In considering the source of this variability, we recognize that, as noted above, the magnitude of long-term $PM_{2.5}$ exposure-related mortality estimated to remain upon just meeting the current suite of standards depends directly on the annual-average $PM_{2.5}$ concentrations that result from the simulated changes in air quality patterns. In the case of the three urban study areas out of the 13 experiencing risk reductions in which the annual standard is controlling (Atlanta, Birmingham, and Houston), simulation of the current suite of standards results in virtually the same annual-average $PM_{2.5}$ concentration (~15 μg/m^3) and, consequently, estimates

[72] Of the 15 study areas, only Dallas and Phoenix have both annual and 24-hour design values below the levels of the current standards based on 2005-2007 air quality.

of the percent of IHD-related mortality attributable to $PM_{2.5}$ for these study areas is similar (Table 4-2).[73]

However, the remaining 10 study areas in which the 24-hour standard is controlling display substantially greater variability in this risk metric when the proportional rollback approach is applied for the core analysis. This results because the simulation of just meeting the current 24-hour standard produces varying impacts on annual-average $PM_{2.5}$ concentrations. For example, the urban study area with the highest estimated risk remaining upon just meeting the current suite of standards (Baltimore, with 11.7 to 14.7% of total mortality incidence attributable to $PM_{2.5}$ - Table 4-2) has annual and 24-hour design values very close to the current suite of standard levels (Table 4-8). Therefore, simulating just meeting the current 24-hour standard does not much change the annual-average $PM_{2.5}$ concentration, which is fairly close to 15 $\mu g/m^3$, and therefore, long-term exposure-related IHD mortality (as a percent of total incidence) is reduced only by a very small amount below that estimated for recent air quality. In contrast, Salt Lake City, which has one of the lowest estimates of the percent of total mortality incidence attributable to $PM_{2.5}$ upon just meeting the current suite of standards (2.9 to 3.7% of total incidence – Table 4-2), has a relatively low annual design value (11.6 $\mu g/m^3$) and a relatively high 24-hour design value (55 $\mu g/m^3$) (Table 4-8). Therefore, simulating just meeting the current 24-hour standard results in a substantial change in the annual average, using proportional rollback, since the same fractional reduction required to get the 24-our design value to meet the current standard (i.e., a 35% reduction) is applied to the annual design value of 11.6 $\mu g/m^3$, resulting in an annual average of 7.7 $\mu g/m^3$. These two examples illustrate the varying impact that the 24-hour standard, if controlling, can have on annual-average $PM_{2.5}$ concentrations and consequently on the magnitude of long-term (and short-term) $PM_{2.5}$ exposure-related mortality associated with just meeting the current suite of standards.[74]

As discussed above, the sensitivity analysis examining alternative rollback approaches showed that in instances where $PM_{2.5}$ distributions are relatively peaky, application of peak shaving (reflecting more localized patterns of ambient $PM_{2.5}$ reductions) can result in a controlling 24-hour standard having a substantially smaller impact on annual-average $PM_{2.5}$ concentrations. Sensitivity analysis results for the examples referenced above (Baltimore and Salt Lake City) illustrate this issue related to application of alternative rollback methods. In the case of Baltimore, which has a less peaky $PM_{2.5}$ distribution (in that its 24-hour and annual

[73] Although, as noted earlier, composite monitor annual-averages will display differences across urban study areas, even in those cases where the maximum monitor annual-average has been adjusted to meet the same annual standard (see Table F-49 in Appendix F).
[74] As noted above, variation in the relationship between the maximum monitor annual-average and the composite monitor annual-average across study areas adds an additional degree of variability to the estimated long-term exposure-related mortality seen across the 10 study areas.

design values are both fairly close to the current suite of standard levels), application of peak shaving in simulating just meeting the current suite of standards resulted in an annual average only slightly higher than that simulated using proportional rollback (i.e., 15.2 $\mu g/m^3$ compared with 14.8 $\mu g/m^3$ – Table F-49). This means that long-term exposure-related IHD mortality for Baltimore would be relatively similar if either proportional or peak shaving rollback approaches were applied. In contrast, application of peak shaving in Salt Lake City resulted in annual-average concentrations substantially higher than those simulated by proportional rollback (i.e., 10.8 $\mu g/m^3$ compared with 7.7 $\mu g/m^3$, respectively – Table F-49). Therefore, for this study area, use of peak shaving rollback would result in estimates of IHD mortality risk that are larger than with proportional rollback (i.e., >50% higher than with proportional rollback – Table F-49). These examples further illustrate that variability in the pattern of estimated reductions in ambient $PM_{2.5}$ concentrations based on simulation of just meeting the current suite of standards can result in quite different percentage reductions in long-term $PM_{2.5}$ exposure-related mortality.

Additional sensitivity analyses considering sources of uncertainty impacting the core risk estimates focused on specification of the C-R function for long-term $PM_{2.5}$ exposure-related mortality. This analysis suggested that most of the alternative model specifications supported by available literature would produce risk estimates that were higher (by up to a factor of 2 to 3) than the core risk estimates. These findings would apply both to estimates of $PM_{2.5}$-attributable IHD mortality incidence, as well as to estimates of the percent of total IHD mortality incidence attributable to $PM_{2.5}$ exposure.

Taken together, the sensitivity analyses completed for this risk assessment, including those considering variability in rollback methods as well as uncertainty in the form of C-R functions, suggest that the set of alternative risk model specifications that we identified generally produced risk estimates that are higher than the core risk estimates. Furthermore, our decision to model risk down to the LML (rather than to lower PRB levels) for long-term $PM_{2.5}$ exposure-related mortality, despite the lack of evidence for a threshold, results in lower estimates of risk that would have resulted from modeling risk down to PRB. These considerations increase our overall confidence that we did not over-state risks with the core risk estimates.

In considering the results of the quantitative sensitivity analyses summarized above, we note that the qualitative analysis of uncertainty did identify areas of ongoing research which could impact risk estimates, including: (a) more refined characterization of intra-urban variability in ambient $PM_{2.5}$ concentrations and the resulting impact on risk characterization and (b) consideration of specific components within the mix of $PM_{2.5}$, including regional differences in composition, and potential implications for risk characterization. These considerations introduce further uncertainty into the overall risk assessment, although we do not believe that these additional sources of uncertainty are likely to alter the fundamental observations resulting from the core risk assessment of the current suite of standards.

6.2.2 Simulation of Just Meeting Alternative Annual Standards

In characterizing $PM_{2.5}$-related risks associated with simulation of the alternative annual standards, we estimate both the magnitude of risk reductions (relative to risk remaining upon just meeting the current suite of standards) as well as the magnitude of risk remaining upon just meeting the alternative standards. In discussing these risks, we focus on the set of urban study areas experiencing risk reductions under each alternative annual standard.

Based on the risk estimates for these areas presented in section 4.2.2 and in Appendix E, we make the following general observations regarding the magnitude of risk remaining upon simulation (using proportional rollback) of just meeting the alternative annual standards (in combination with the current 24-hour standard):

- *Patterns of risk reduction across alternative annual standard levels:* There is a consistent pattern of increasing risk reduction with decreasing alternative annual standard levels, both in terms of the number of study areas experiencing risk reductions and the magnitude of those reductions. Specifically, 5 of the 15 urban study areas experience risk reductions under the alternative annual standard level of 14 $\mu g/m^3$, with percent reductions in $PM_{2.5}$-attributable long-term exposure-related mortality ranging from 9% (Baltimore) to 12% (Houston) (Figure 4-3 and Table E-27 in Appendix E). For an annual standard level of 12 $\mu g/m^3$, 12 of the 15 urban study areas experience risk reductions, with percent reductions ranging from 11% (Phoenix) to 35% (Houston and Birmingham) (Figure 4-3 and Table E-27 in Appendix E).
- *Estimates of long-term $PM_{2.5}$ exposure-related mortality remaining upon just meeting alternative annual standards*: For an annual standard level of 14 $\mu g/m^3$, the percent of total incidence of IHD mortality attributable to $PM_{2.5}$ in the 5 urban study areas experiencing risk reductions ranges from 9-11.3% (Detroit) to 11.8-14.9% (Atlanta) (Tables E-24 and E-33 in Appendix E). For an annual standard of 12 $\mu g/m^3$, estimated risk remaining in the 12 urban study areas experiencing risk reductions ranges from 6-7.6% (Phoenix) to 9-11.4% (Atlanta) in terms of $PM_{2.5}$-attributable long-term exposure-related mortality (Tables E-24 and E-33 in Appendix E).

While there is a consistent pattern of risk reduction across the alternative annual standards with lower standard levels resulting in more urban study areas experiencing increasingly larger risk reductions, there is considerable variability in the magnitude of these reductions across study areas for a given alternative annual standard level (e.g., as noted above, for the alternative annual standard level of 12 $\mu g/m^3$, risk reduction ranges from 11% for Phoenix to 35% for Houston). This variability in risk reflects differing degrees of reduction in annual-average concentrations across the study areas. These differences in annual-averages result in part because the study areas begin with varying annual-average $PM_{2.5}$ concentrations after simulating just meeting the current suite of standards (see section 6.2.1). Therefore, even if study areas have similar "ending" annual average $PM_{2.5}$ concentrations after simulation of just meeting the a given alternative annual standard, because the starting point in the calculation (the annual-average $PM_{2.5}$ concentrations upon just meeting the current suite of standards) can be variable, the overall reduction in annual-average $PM_{2.5}$ concentrations across the standards can also be variable. This translates into variation in reductions in long-term exposure-related risk upon just meeting alternative annual standard levels across the study areas.[75]

The sensitivity analysis involving application of peak shaving rollback reveals that the pattern of reductions in ambient $PM_{2.5}$ concentrations upon just meeting the current suite of standards can impact the magnitude of additional risk reductions estimated for just meeting alternative (lower) annual standard levels. Specifically, for those study areas with more peaky $PM_{2.5}$ distributions, application of peak shaving rollback will result in higher annual-average $PM_{2.5}$ levels remaining upon just meeting the current suite of standards. If proportional rollback is then used to simulate just meeting alternative annual standard levels, a greater degree of reduction in annual-average $PM_{2.5}$ concentrations will result, since the "starting point" for the calculation (annual-average $PM_{2.5}$ levels upon just meeting the current suite of standards) will be higher.

For example, with Los Angeles, which represents a study area with a relatively peaky $PM_{2.5}$ distribution, application of proportional rollback in simulating both the current suite of standards and the alternative annual standard of 12 $\mu g/m^3$ results in a 13% reduction in long-term exposure-related mortality (see Figure 4-3 and Table E-27 in Appendix E - this calculations represents the approach used in the core risk assessment model, since proportional rollback was used in simulating both suites of standards). In contrast, application of peak shaving in simulating the current suite of standards followed by proportional reduction in simulating the alternative annual standard of 12 $\mu g/m^3$ results in an estimated 48% reduction in long-term exposure-related mortality.[76] This example illustrates that application of peak shaving in simulating just meeting the current suite of standards for urban areas such as Los Angeles which have relatively peaky $PM_{2.5}$ distributions can substantially increase the magnitude of risk reduction simulated for an alternative (lower) annual standard level.

[75] We note that additional variation in the risk estimates, in terms of both risk reduction across standard levels and residual risk for each of the alternative annual standard levels, results from differences across study areas in the relationship between the *maximum monitor annual-averages values* used in estimating percent reductions under an alternative standard and the *composite monitor annual-average values* used in estimating long-term exposure-related risk.

[76] These risk reductions reflecting application of peak-shaving in simulating the current suite of standards are based on comparison of composite monitor annual-averages presented in Table F-49 in Appendix F. In generating this surrogate for reduction in long-term exposure-related mortality between the two standard levels, we compared composite monitor annual-averages taking into account that long-term exposure-related mortality is only calculated down to the LML.

Observations made above in the context of the current suite of standards regarding uncertainty and its impact on risk estimates apply in this context as well. Specifically, given the results of the sensitivity analysis examining the form of the C-R functions for long-term exposure-related mortality, combined with only modeling risk down to the LML, we have increased confidence that we have not overstated either the magnitude of risk reductions across alternative standard levels, or the magnitude of risk remaining for a given standard level.

6.2.3 Simulation of Just Meeting Alternative Suites of Annual and 24-hour Standards

The two suites of standards involving alternative annual and alternative 24-hour standards can be used to consider the impact on risk of reducing the 24-hour standard. Specifically, by comparing risks estimated for the 13/30 and 13/35 suites of standards, we can consider a reduction of 5 $\mu g/m^3$ in the 24-hour standard. Similarly if we compare the 12/25 and 12/35 suites of standards we can consider a 10 $\mu g/m^3$ reduction. In both cases, the reduction in the 24-hour standard level is associated with a fixed annual standard level (i.e., 13 and 12 $\mu g/m^3$, respectively). These two comparisons of suites of alternative standards form the basis for the discussion presented below. As with the alternative annual standard levels, we address both the magnitude of risk reductions as well as the magnitude of risk remaining upon just meeting the alternative suites of standards. In discussing these risks, we also continue to focus on the set of urban study areas experiencing risk reductions under each alternative suite of standards.

Based on the risk estimates for these areas presented in section 4.2.2 and in Appendix E, we make the following general observations regarding the magnitude of risk remaining upon simulation (using proportional rollback) of these alternative suites of standards:

- *Patterns of reduction in long-term exposure-related mortality across alternative standards:* Comparing risks associated with just meeting the 13/35 and 13/30 suites of alternative standards, we see considerable variation in the magnitude of risk reduction across urban study areas. For example, St Louis, under with the 13/35 suite of alternative standards has IHD mortality risk attributable to $PM_{2.5}$ reduced by 22% relative to risk under the current suite of standards. Very little additional risk reduction (24%) is estimated under the 13/30 alternative suite of standards. In contrast, with Salt Lake City, we estimate that the 13/35 suite of alternative standards will produce no risk reduction relative to the current suite of standards, while the 13/30 suite would produce a 55% reduction in IHD mortality risk relative to risk under the current standard level (see Figure 4-3 and Table E-27 in Appendix E). The additional risk reduction provided by an alternative 24-hour standard is even more pronounced in comparing the 12/25 and 12/35 alternative suites of standards. In this case we see that for nine of the study areas (Detroit, Fresno, Los Angeles, New York, Philadelphia, Phoenix, Pittsburgh, Salt Lake City and Tacoma) the 12/25 suite of alternative standards produced estimated reductions in risk (relative to risk associated with just meeting the current suite of standards) that are twice as large as for the 12/35 suite of alternative standards (see Figure 4-3 and Table E-27 in Appendix E).
- *Estimates of long-term exposure-related mortality remaining upon just meeting the*

alternative 24-hour standards: There is appreciable variation in the estimated magnitude of risk remaining upon simulation of the 13/30 suite of alternative standards. For example, the percent of total IHD mortality incidence attributable to $PM_{2.5}$ (again, for urban study areas experiencing risk reductions) ranges from 2-2.5% (for Tacoma) to 8.9-11.3% (for Baltimore) (see Tables E-24 and E-33, in Appendix E). There continues to be variation in the levels of residual risk under the 12/25 alternative suite of standards with estimates ranging from 0.3-4.7% (for Tacoma) to 8.8-11.1% (for Atlanta) (see Tables E-24 and E-33, in Appendix E).

The observations presented above again highlight variability both in the magnitude of risk reduction as well as in the residual risk estimated from the simulation of just meeting alternative 24-hour standards. This reflects the fact that, as noted above, alternative 24-hour standards can produce different degrees of reduction in the annual-average $PM_{2.5}$ concentrations, depending on the relationship between 24-hour and annual design values at a particular location. For example, the fact that Salt Lake City is predicted to have a 55% reduction in long-term exposure-related mortality risk with the 13/30 suite of alternative standards (compared with risk under the current suite of standards), reflects the peaky nature of its $PM_{2.5}$ distribution. Specifically, simulating just meeting the 24-hour standard using proportional rollback will produce a substantial reduction in the annual-average $PM_{2.5}$ concentrations (i.e., from a recent conditions annual-average of 11.6 $\mu g/m^3$, to 7.7 $\mu g/m^3$ under the current suite of standards, to 6.7 $\mu g/m^3$ with the 13/30 suite of alternative standards – see Table F-49 in Appendix F). In contrast, with St Louis, which does not experience as substantial a risk reduction under the 13/30 suite of alternative standards, there is a far less peaky $PM_{2.5}$ distribution (i.e., the annual and 24-hour design values are relatively closer to each other – see Table F-49 in Appendix F). Therefore, simulation of the alternative 24-hour standard level of 30 $\mu g/m^3$ does not have as substantial an effect on annual-average concentrations (i.e., from a recent conditions annual-average of 16.5 $\mu g/m^3$, to 14.9 $\mu g/m^3$ under the current suite of standards, to 12.8 $\mu g/m^3$ under the 13/30 suite of alternative standards).

It is possible to stratify the set of urban study areas based on patterns of risk reduction estimated under the alternative 24-hour standards. In this discussion, we focus on risk estimates generated for the 12/25 suite of alternative standards, focusing on how risks under this scenario compare with risks under the current suite of standards.[77] The stratification of the study areas based on the magnitude of risk reduction highlights factors responsible for these differences across study areas. For example, when the 24-hour standard is controlling (in simulating the 12/25 suite of alternative standards) and the $PM_{2.5}$ distribution is relatively peaky, there is a greater potential for the annual-average $PM_{2.5}$ concentrations to be reduced more in simulating just meeting the alternative 24-hour standard (in some instances, well below 12 $\mu g/m^3$) resulting

[77] Further, in considering risk reduction, we are comparing risk under the alternative suites of standards to risk under the current suite of standards based solely on application of proportional rollback.

in larger estimated risk reductions. In fact, we see that the urban study areas having the largest risk reductions have annual-average $PM_{2.5}$ concentrations simulated under the 12/25 suite of standards (using proportional rollback) well below 12 µg/m^3, with some locations ranging down to ~6 µg/m^3.

We identified four strata in considering patterns of risk reduction across the 15 urban study areas under the 12/25 suite of alternative standards (all of the percent reductions presented are in terms of long-term exposure-related IHD mortality).

- *~100% reduction in risk*: Those study areas where the 24-hour standard was controlling and where the resulting annual-average $PM_{2.5}$ concentrations (under the 12/25 suite of standards) were ~ 6 µg/m^3. Because annual-average concentrations for these study areas are at or below the LML for long-term exposure-related mortality (5.8 µg/m^3), little to no risk is predicted under the alternative suite of standards, resulting in a near 100% reduction in risk relative to the current suite of standards. These study areas have the most peaky $PM_{2.5}$ distributions of the 15 urban study areas (i.e., relatively high 24-hour design values and lower annual average design values) and include study areas Tacoma and Salt Lake City.[78]
- *~70% reduction in risk*: Those study areas where the 24-hour standard is controlling and where the resulting annual-average $PM_{2.5}$ levels (under the 12/25 suite of standards) were ~7-9 µg/m^3. These study areas also have relatively peaky $PM_{2.5}$ distributions and include Los Angeles and Fresno.[79]
- *~50-60% reduction in risk*: Those study areas where the 24-hour standard is controlling and where the resulting annual-average $PM_{2.5}$ levels (under the 12/25 suite of standards) were ~9-11 µg/m^3. These study areas have less peaky $PM_{2.5}$ distributions (24-hour standard still controls, but there is not as great a disparity with the annual design values) and include the majority of the study areas (Detroit, NYC, Philadelphia, Pitts, St Louis, Baltimore, Birmingham, and Phoenix).[80]
- *~35-45% reduction in risk*: This category includes some study areas where the 24-hour standard controls and some where the annual standard controls. Annual average $PM_{2.5}$ concentrations under the 12/25 suite of standards are generally in the 12 µg/m^3 range. These study areas have relatively less peaky $PM_{2.5}$ distributions and include Atlanta and

[78] These study areas fall in zone A in Figure 4-20, which represents the largest grouping of urban areas in the U.S. predicted to be exceeding this alternative suite of standards (12/25). However, we note that Tacoma and Salt Lake City have some of the most peaky $PM_{2.5}$ distributions of the urban areas in this zone and therefore are likely to experience greater risk reductions than most of the urban areas in zone A.

[79] Los Angeles and Fresno fall in zone B and specifically, subarea B1, in Figure 4-20 (subarea B1 represents those study areas that exceed the 12/25 suite of alternative standards and that also have a greater degree of peakiness in their $PM_{2.5}$ distributions relative to other urban areas in zone B – see section 4.5.1). Consequently, these study areas are likely to experience greater risk reductions relative to other urban areas in zone B.

[80] These eight study areas fall in zone B in Figure 4-20 and specifically, subarea B2, which includes a relatively large fraction of those urban areas in the U.S. predicted to exceed the 12/25 suite of alternative standards. Urban areas in subarea B2 have less peaky $PM^{2.5}$ distributions compared to areas in subarea B1.

Houston.[81, 82]

Observations made earlier regarding the impact of variability in simulating changes in $PM_{2.5}$ distributions using different rollback approaches, and its impact on the degree of risk reduction, also hold here. Specifically, in those instances where $PM_{2.5}$ distributions are more peaky, application of peak shaving rollback would result in smaller reductions in annual-average $PM_{2.5}$ concentrations and consequently, smaller reductions in estimates of long-term exposure-related mortality. For example, with Salt Lake City, which has a peaky $PM_{2.5}$ distribution, under the 12/25 suite of standards application of proportional rollback results in an annual average $PM_{2.5}$ concentration of 5.7 $\mu g/m^3$, while application of peak shaving results in an estimate of 8.9 $\mu g/m^3$. In contrast, simulation of the 12/25 suite of standards for Baltimore, which has a less peaky $PM_{2.5}$ distribution, results in an annual average $PM_{2.5}$ concentration of 10.7 $\mu g/m^3$ for proportional rollback compared to 10.8 $\mu g/m^3$ with peak shaving (see Table F-49 in Appendix F).

A key observation made above in relation to the current suite of standards, that is even more relevant in considering the results discussed here, is that simulated annual-average $PM_{2.5}$ concentrations upon just meeting alternative suites of standards for many of the urban study areas are considerably lower than 12 $\mu g/m^3$. For example, with the current suite of standards, Fresno and Salt Lake City are simulated to have annual average $PM_{2.5}$ concentrations of 9.9 and 7.7 $\mu g/m^3$, respectively, which are in turn reflected in the risk estimates generated (see Table F-49, in Appendix F). Annual average concentrations in these study areas are even lower under the alternative suites of standards with lower 24-hour standard levels. For example, under the 13/30 suite of standards, simulated annual average concentrations range down to 6.7 $\mu g/m^3$ (Salt Lake City), with a number of urban study areas having annual-average concentrations simulated in the range of 7 to 11 $\mu g/m^3$ (Fresno, Los Angeles, and Tacoma). Under the 12/25 suite of standards, simulated annual-average concentrations are even lower, ranging down to 5.7 $\mu g/m^3$ (Salt Lake City). These very low annual-average $PM_{2.5}$ concentrations reflect lower annual design values to begin with as well as relatively peaky $PM_{2.5}$ distributions, which means that simulation of the 24-hour standard (when controlling) will produce appreciable impacts on the annual average concentration.

The results discussed above show that simulating just meeting alternative 24-hour standard levels in the range of 25 to 30 $\mu g/m^3$ can produce substantial reductions in estimated

[81] Atlanta and Houston fall into zones B and C in Figure 4-20, and specifically portions of those zones including urban areas with less peaky $PM_{2.5}$ distributions.

[82] We note that Dallas has a substantially smaller estimate of risk reduction (~13%) compared with the other 14 urban study areas. The relatively low risk reduction for this location reflects the fact that Dallas has annual and 24-hour design values (12.8 and 26 $\mu g/m^3$, respectively) that are well below the current suite of standards and only just exceed the 12/25 suite of standards. Therefore, the estimated risk reduction under this suite of standards is expected to be very low. Dallas just barely falls into Zone C in Figure 4-19.

risk, beyond that produced by simulations of just meeting lower annual standard level down to 12 µg/m^3 (combined with a 24-hour standard of 35 µg/m^3). This results from the simulations producing substantially lower annual-average $PM_{2.5}$ concentrations, which drive reductions in both long-term and short-term exposure-related risk. The results also show that there can be considerable variability across study areas in the degree to which alternative 24-hour standard levels produce reductions in annual average $PM_{2.5}$ concentrations and, consequently, reductions in risk. This variability is seen to depend largely on the peakiness of the $PM_{2.5}$ distribution in an area and on the rollback approach used to simulate just meeting the current and alternative suites of standards. These results suggest that while lowering the 24-hour standard can be used to reduce annual-average $PM_{2.5}$ concentrations, and thus to reduce estimated risk, the results are likely to be highly variable across urban areas. This analysis also suggests that more consistent annual-average $PM_{2.5}$ concentrations, and thus more consistent reductions in estimated risk, would result from simulating just meeting alternative annual standards at levels below 12 µg/m^3 which was the lowest annual standard level considered in this assessment. In general, considering suites of standards in which the annual standard is the controlling standard would be expected to provide more consistent reductions in annual-average $PM_{2.5}$ concentrations, thereby, providing more uniform public health protection across urban areas.

Observations made earlier regarding overall confidence in the estimates of long-term exposure-related mortality also hold for these estimates (i.e., the sensitivity analysis results combined with the fact that we modeled risk down to LML result in our concluding that it is unlikely we have overstated either the degree of risk reduction or the degree of residual risk).

6.3 NATIONAL PERSPECTIVE ON $PM_{2.5}$-RELATED RISKS

This section places the core risk estimates in the broader national-context by considering the degree to which the 15 urban study areas are representative of larger urban areas within the U.S., particularly areas likely to experience elevated risk related to PM exposure. As such, it draws on information presented in several sections of the risk assessment including: (a) the representativeness analysis discussed in section 4.4, (b) consideration of patterns of design values for the 15 urban study areas as contrasted with the broader set of larger urban areas within the US (section 4.5.1), and (c) the national-scale mortality analysis discussed in Chapter 5.

- The representativeness analysis presented in section 4.4, compared attributes of the 15 urban study eras (assessed at the county-level) against national distributions for the same attributes. The analysis suggests that the 15 urban study areas represent areas in the U.S. that are among the most densely populated, have relatively higher levels of annual and 24-hour 98th percentile $PM_{2.5}$ concentrations, and capture well the range of effect estimates represented by the Zanobetti and Schwartz (2009) study. Together, these factors suggest that the urban study areas should capture well the overall distribution of risk for the nation, with the potential for better characterization of the high end of that distribution.[83]

- Consideration of the mix of design values across the 15 urban study areas as contrasted with design values for the broader set of urban study areas in the U.S. suggests that the 15 urban study areas do a good job of capturing the key groupings of urban areas in the U.S. likely to experience elevated risk due to PM (i.e., we have coverage for each of the zones containing urban study areas likely to experience risk reductions under the suites of alternative standard levels considered – see section 4.5.1). Furthermore, this analysis suggested that we have also included study areas likely to experience relatively greater degrees of $PM_{2.5}$-related risk, considering the pattern of design values across urban areas in the U.S..
- Consideration of where the 15 urban study areas fell along the distribution of U.S. counties included in the national-scale mortality analysis further suggests that we have captured counties likely to experience elevated $PM_{2.5}$-related risk**.** As part of the national-scale mortality analysis (see Chapter 5), we created a cumulative distribution of the *percentage of mortality attributable to $PM_{2.5}$* based on the county-level estimates for the U.S.[84] We then identified where along this cumulative distribution the 31 counties comprising our 15 urban study areas fell. This analysis suggests that our urban study areas capture the upper end of the tail with regard to $PM_{2.5}$-attributable risk, with 23 of these counties falling within the upper 5th percentile of the distribution. These findings support the assertion based on the other analyses described above that the urban study areas are likely to capture risk at urban areas experiencing relatively elevated levels of $PM_{2.5}$-attributable mortality.

Our overall assessment of the representativeness of the 15 urban study areas in the national context, based on the three analyses summarized above, is that our study areas do a good job of representing urban areas in the U.S. experiencing elevated levels of risk related to ambient $PM_{2.5}$ exposure. The results of the national-scale mortality analysis also suggest that, while our 15 urban study areas do provide coverage for urban areas in the U.S. experiencing elevated levels of $PM_{2.5}$-related risk, there are many additional areas (counties) not modeled in the risk assessment that experience elevated $PM_{2.5}$-related risk. In other words, it should not be construed that significant $PM_{2.5}$-related risk is limited only to the urban study areas included in the risk assessment.

[83] This analysis also showed that the urban study areas do not capture areas with the highest baseline morality risks or the oldest populations (both of which can result in higher $PM_{2.5}$-related mortality estimates). However, some of the areas with the highest values for these attributes have relatively lower $PM_{2.5}$ levels (e.g., urban areas in Florida) and consequently failure to include these areas in the set of urban study areas is unlikely to bias the risk estimates in terms of excluding high $PM_{2.5}$-risk locations.

[84] Note that by using this risk metric, we avoid influence by difference in overall population size (as would be the case with raw incidence) and focus on a unitized estimate of $PM_{2.5}$-related mortality which reflects differences in (a) baseline mortality incidence, and (b) the annual $PM_{2.5}$ levels average for each county.

6.4 KEY OBSERVATIONS

Key observations from this quantitative risk assessment for $PM_{2.5}$, with emphasis on the observations made above in this chapter, are outlined below. These observations are organized around the three policy-relevant questions outlined at the beginning of this chapter.

(1) What is the magnitude of risk likely to remain if the urban study areas were just meeting the current suite of $PM_{2.5}$ standards (an annual standard of 15 $\mu g/m^3$ and a 24-hour standard of 35 $\mu g/m^3$), and what level of confidence do we have in those estimates?

- Upon simulation of just meeting the current suite of standards, the core analysis estimates that the urban study areas would have IHD-related mortality attributable to *long-term* $PM_{2.5}$ exposure ranging from <100 to approximately 2,000 cases per year, with this variability reflecting to a great extent differences in the size of study area populations. These estimates represent from 4 to 17% of all IHD-related mortality in a given year for the urban study areas, which is a measure of risk that takes into account differences in population size and baseline mortality rates. Estimates were also developed for other long-term exposure-related mortality endpoints, including all-cause, cardiopulmonary-related, and lung cancer mortality.

- Generally comparable estimates of CV-related mortality attributable to *short-term* $PM_{2.5}$ exposure are substantially lower than for long-term exposure-related IHD mortality. The core analysis estimates that the urban study areas would have CV-related mortality attributable to short-term $PM_{2.5}$ exposure ranging from approximately 10 to 470 cases per year. Estimates were also developed for other short-term exposure-related endpoints, including non-accidental and respiratory-related mortality, CV- and respiratory-related hospital admissions, and asthma-related emergency department visits.

- A broader array of health effects has also been associated with $PM_{2.5}$ exposures, including in particular effects on children, such as reproductive and developmental effects. While information was too limited to consider these effects in this quantitative risk assessment, such effects are appropriately considered based on the related evidence in the broader characterization of risks to be discussed in a separate Policy Assessment document.

- Given the quantitative and qualitative assessments of uncertainty and variability that we have completed as part of our quantitative risk assessment, we believe that it is unlikely that we have over-stated the degree of risk remaining upon simulation of just meeting the current suite of standards. While this conclusion applies to all quantitative estimates of risk, it applies most strongly for long-term $PM_{2.5}$ exposure-related mortality for which more extensive uncertainty and variability assessment has been done.

- Estimated risks remaining upon just meeting the current suite of standards vary substantially across study areas, even when considering risks normalized for differences in population size and baseline incidence rates. This variability in estimated risks is a consequence of the substantial variability in the annual-average $PM_{2.5}$ concentrations across study areas that result from simulating just meeting the current standards. This is important because annual-average concentrations are highly correlated with both long-term and short-term exposure-related risk. This variability in annual-average $PM_{2.5}$ concentrations occurs especially in those study areas in which the 24-hour standard is the "controlling" standard.[85] In such areas, the variability across study areas in estimated risks is largest when regional patterns of reductions in $PM_{2.5}$ concentrations are simulated (using proportional rollback, as was done in the core analyses), with less variability when more localized patterns of $PM_{2.5}$ reductions are simulated (using peak shaving rollback, as was done in a sensitivity analysis). When simulations are done using peak shaving rollback, estimated risks remaining upon just meeting the current suite of standards can be appreciably larger than those estimated in the core analysis.

- In simulating just meeting the current suite of standards, the resulting annual-average $PM_{2.5}$ concentrations range from about 15 $\mu g/m^3$ (for those study areas in which the annual standard was controlling) down to as low as about 8 $\mu g/m^3$ (for those study areas in which the 24-hour standard was controlling or the annual average was well below 15 $\mu g/m^3$ based on recent air quality). Thus, estimates of risk remaining upon just meeting the current standards are, in many cases, reflective of annual average $PM_{2.5}$ concentrations that are well below the level of the current annual standard.
- The 15 urban study areas included in this risk assessment are generally characteristic of urban areas across the U.S. that do not meet the current suite of standards. Of those urban areas in the U.S. that do not meet the current suite of standards (based on 2005-2007 air quality data), the 24-hour standard is controlling in most such areas – a pattern that is reflected in the urban study areas included in this assessment. Two areas are included in this assessment that meet the current suite of standards (reflective of the majority of urban areas in the U.S.), although these two areas fail to meet some of the alternative suites of standards considered in this assessment.

(2) What is the degree and nature of risk reduction likely to be associated with just meeting the alternative suites of annual and 24-hour $PM_{2.5}$ standards considered in this risk assessment, and what roles do the annual and 24-hour standards play in bringing about such reductions?

- Upon simulation of just meeting the *alternative annual standard levels* considered (14, 13, and 12 $\mu g/m^3$) in conjunction with the current 24-hour standard (denoted as 14/35, 13/35 and 12/35 suites of standards), the core analysis estimates reductions in long-term exposure-related mortality for 12 of the 15 urban study areas, with the degree of risk reduction increasing incrementally across the alternative standard levels (both in terms of the number of study areas experiencing risk reduction and the magnitude of those reductions). For the alternative annual standard level of 12 $\mu g/m^3$ (in conjunction with the current 24-hour standard), the core analysis estimates that these study areas have reductions in risk (relative to risk remaining upon just meeting the current suite of standards) ranging from about 11 to 35%. For some of those areas in which the 24-hour standard is controlling, larger risk reductions would have been estimated in this case (12/35 suite of standards) if peak shaving rollback had been used to simulate just meeting the current suite of standards. This result would be expected since the magnitude of risk remaining upon just meeting the current suite of standards would have been higher than that estimated based on the proportional rollback

[85] The controlling standard is the standard (either 24-hour or annual) that requires the largest percent reduction in the related design value to just meet that standard.

used in the core analysis. Therefore, while we are going down to the same level of risk (under the 12/35 suite of standards), we are starting with a higher level of risk from the current standard.

- Upon just meeting the *alternative suites of standards that included lower levels of both the annual and 24-hour standards* (denoted as13/30 and 12/25 suites of standards), the core analysis estimates that the lower 24-hour standard levels produce additional risk reductions beyond the reductions estimated for the lower annual standard levels alone. In the case of the 12/25 suite of standards, estimated risk reductions compared with reductions for the annual standard alone (12 $\mu g/m^3$), were roughly twice as large in many of the study areas, although in a few areas risk reductions were much higher (ranging up to ~100%) and in a few other areas, there was little to no risk reduction. These results show that lower 24-hour standards can have an appreciable and highly variable impact on long-term exposure-related mortality, particularly when just meeting the lower standards is simulated using a more regional pattern of $PM_{2.5}$ reductions (i.e., the proportional rollback used in the core analysis). However, the magnitude of risk reductions estimated for the lower 24-hour standards was reduced when simulations using a more localized pattern of $PM_{2.5}$ reductions (i.e., the peak shaving rollback used in a sensitivity analysis).

- The results of simulating *alternative suites of standards including lower levels of both annual and 24hr standards* suggest that while lowering the 24-hour standard can be used to reduce annual-average $PM_{2.5}$ concentrations, and thus to reduce estimated risk, the results are likely to be highly variable across urban areas. More consistent annual-average $PM_{2.5}$ concentrations across study areas, and thus more consistent reductions in estimated risk, would result from simulating just meeting a specific alternative annual standard level. In general, considering suites of standards in which the annual standard is the controlling standard would be expected to provide more consistent reductions in annual-average $PM_{2.5}$ concentrations, thereby, providing more uniform public health protection across urban areas.

- In simulating just meeting the alternative suites of standards, especially those with lower 24-hour standard levels, the resulting annual-average $PM_{2.5}$ concentrations are substantially lower than the lowest annual standard level considered in the analysis (12 $\mu g/m^3$). For example, under the 12/25 suite of standards, estimated annual-average $PM_{2.5}$ concentrations ranged down to approximately 6 $\mu g/m^3$, with eight urban study areas having annual average $PM_{2.5}$ levels in the 8-11 $\mu g/m^3$ range.

- Addressing overall confidence in risk estimates generated for just meeting the alternative suites of standards, as with the current suite of standards, we conclude based on our quantitative and qualitative analysis of uncertainty and variability that we have likely not over-stated risk reductions or levels of residual risk estimated for just meeting these alternative suites of standards.

(3) What is the distribution of risks associated with recent $PM_{2.5}$ air quality in areas across the U.S., and how representative are the risks estimated for the urban study areas from a national perspective?

- Based on recent air quality from 2005 to 2007, we estimate that within the continental U.S., total $PM_{2.5}$-related premature mortality ranges from 63,000 and 88,000 per year. Further, we estimate that the percent of total mortality attributable to $PM_{2.5}$ long-term exposure ranges from approximately 3 to 9% in about half of the counties in the U.S., with a, range from approximately 0 to 3% in the other half of counties.

- Efforts to place the 15 urban study areas and the core risk estimates generated for those areas into a broader national context suggest that these study areas likely capture well the full set of urban areas in the U.S. likely to experience relatively higher $PM_{2.5}$-related risk.
- It is important to recognize that there are many additional areas besides those included in the risk assessment that experience elevated PM2.5-related risk of similar magnitude to the risks estimated for the urban study areas included in this assessment.

7 REFERENCES

Abt Associates Inc. (2003), "Environmental Benefits Mapping and Analysis Program (BenMAP), User's Manual. Available on the Internet at <http://www.epa.gov/ttn/ecas/benmodels.html>.

Abt Associates Inc. (2005). Particulate Matter Health Risk Assessment for Selected Urban Areas. Prepared for Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 2005. Available electronically on the internet at: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr_td.html.

Abt Associates Inc. (2008). Environmental Benefits Mapping and Analysis Program (Version 3.0). Bethesda, MD. Prepared for Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Benefits and Costs Group. Research Triangle Park, NC.

American Farm Bureau Federation v. EPA, 559 F. 3d 512 (D.C. Cir. 2009).

Bateson, T.F.; Schwartz, J. (2004). Who is sensitive to the effects of particulate air pollution on mortality? A case-crossover analysis of effect modifiers. Epidemiology. 15(2):143-9.

Bell, M.L.; Ebisu, K.; Peng, R.D.; Walker, J.; Samet, JM; Zeger, S.L.; Dominici, F. (2008). Seasonal and regional short-term effects of fine particles on hospital admissions in 202 US counties, 1999-2005. Am J Epidemiol. 168(11):1301-1310.

Bell, M.L.; Dominici, F. (2008). Effect modification by community characteristics on the short-term effects of ozone exposure and mortality in 98 US communities. Am J Epidemiol. 167(8):986-97.

Bell (2009). Personal communication via e-mail between Dr. Michelle Bell and Beth Hasset-Sipple, June 26th, 2009 (e-mail with attachments placed in docket #EPA-HQ-OAR-2007-0492).

Bell M.L.; Ebisu K.; Peng R.D.; Samet J.M.; Dominici, F. (2009). Hospital admissions and chemical composition of fine particle air pollution. Am J Respir Crit Care Med. 179(12):1115-20.

Berkey, C.S.; Hoaglin, D.C.; Antczak-Bouckoms, A.; Mosteller, F.; Colditz, G.A. (1998). Meta-analysis of multiple outcomes by regression with random effects. Stat Med. 17(22):2537-2550.

Byun, D., and K.L. Schere, (2006). Review of the Governing Equations, Computational Algorithms, and Other Components of the Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. Applied Mechanics Reviews, 59, 51-77.

Dominici, F.; Peng, R.D.; Ebisu, K.; Zeger, S.L.; Samet, J.M.; Bell, M.L. (2007). Does the effect of PM10 on mortality depend on PM nickel and vanadium content? A reanalysis of the NMMAPS data. Environ Health Perspect. 115(12):1701-3.

Franklin, M.; Zeka, A.; Schwartz, J. (2007). Association between $PM_{2.5}$ and all-cause and specific-cause motrality in 27 US communities. J Expo Sci Environ Epidemiol. 17:279-287.

Henderson, R. (2005). EPA's Review of the National Ambient Air Quality Standards for Particulate Matter (Second Draft PM Staff Paper, January 2005): A review by the Particulate Matter Review Panel of the EPA Clean Air Scientific Advisory Committee. June 6, 2005. Available electronically on the internet at: http://www.epa.gov/sab/pdf/casac-05-007.pdf.

Henderson, R. (2006). Clean Air Scientific Advisory Committee Recommendations Concerning the Proposed National Ambient Air Quality Standards for Particulate Matter. March 21, 2006. Available electronically on the internet at: http://www.epa.gov/sab/pdf/casac-ltr-06-002.pdf

Henderson, R; Poirot, R.L.; Cowling, E.; Speizer, F.; Crapo, J.D.; Zielinska, B.; Miller, F.J. (2006). Clean Air Scientific Advisory Committee Recommendations Concerning the Final National Ambient Air Quality Standards for Particulate Matter. September 29, 2006. Available electronically on the internet at: http://www.epa.gov/sab/pdf/casac-ltr-06-003.pdf.

Hopke, P. (2002). Letter from Dr. Phil Hopke, Chair, Clean Air Scientific Advisory Committee (CASAC) Particulate Matter Review Panel, to Honorable Christine Todd Whitman, Administrator, U.S. EPA. Final advisory review report by the CASAC Particulate Matter Review Panel on the proposed particulate matter risk assessment. EPA-SAB-CASAC-ADV-02- 002. May 23. Available electronically on the internet at:http://www.epa.gov/sab/pdf/casacadv02002.pdf.

Hopke, P. (2004). Letter from Dr. Phil Hopke, Clean Air Scientific Advisory Committee

(CASAC) Particulate Matter (PM) Review Panel, to Honorable Michael O. Leavitt. CASAC PM Review Panel's Ongoing Peer Review of the Agency's *Fourth External Review Draft of Air Quality Criteria for Particulate Matter* (June 2003); and Peer Review of the *Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information (OAQPS Staff Paper - First Draft)* (August 2003) and a Related Draft Technical Report, *Particulate Matter Health Risk Assessment for Selected Urban Areas (Draft Report)* (August 2003). EPA-SAB-CASAC-04-004. February 18. Available electronically on the internet at: http://www.epa.gov/sab/pdf.

Ito, K.; Thurston, G.; Silverman, R.A. (2007). Characterization of $PM_{2.5}$ gaseous pollutants and meteorological interactions in the context of time-series health effects models. J Expo Sci Environ Epidemiol. 17: 45-60.

Jerrett. M.; Burnett, R.T.; Ma, R.; Pope, C.A. III; Krewski, D.; Newbold, K.B.; Thurston, G.; Shi, Y.; Finkelstein, N.; Calle, E.; Thun, M.J. (2005). Spatial analysis of air pollution and mortality in Los Angeles. Epidemiology. 6(6): 1-10.

Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. Meteorol Zeit. 15(3): 259-263.

Kottek, M. (2008). World Map of the Köppen-Geiger climate classification updated.Available: http://koeppen-geiger.vu-wien.ac.at/ [accessed 12/5/2008].

Krewski (2009). Letter from Dr. Daniel Krewski to HEI's Dr. Kate Adams (dated July July 7, 2009) regarding "EPA queries regarding HEI Report 140". Dr. Adams then forwarded the letter on July 10, 2009 to EPA's Beth Hassett-Sipple. (letter placed in docket #EPA-HQ-OAR-2007-0492).

Krewski, D.; Burnett, R.T.; Goldberg, M.S.; Hoover, K.; Siemiatycki, J.; Jerrett, M.; Abrahamowicz, M.; White, W.H. (2000). Reanalysis of the Harvard Six Cities study and the American Cancer Society study of particulate air matter pollution and mortality. HEI Research Report, Health Effects Institute, Boston, MA.

Krewski, D.; Jerrett, M.; Burnett, R.T.; Ma, R.; Hughes, E.; Shi, Y.; Turner, M.C.; Pope, C.A. III; Thurston, G.; Calle, E.E.; Thun, M.J. (2009). Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. HEI Research Report, 140, Health Effects Institute, Boston, MA.

Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. (2006). Reduction in Fine Particulate Air Pollution and Mortality. American Journal of Respiratory and Critical Care Medicine 173:667-672

Le Terte, A.; Schwartz, J.; Touloumi, G. (2005). Empirical bayes and adjusted estimates approach to estimating the relation of mortality to exposure of PM10. Risk Anal. 25(3):711-718.

Medina-Ramón, M.; Zanobetti, A.; Schwartz, J. (2006). The effect of ozone and PM10 on hospital admissions for pneumonia and chronic obstructive pulmonary disease: a national multicity study. Am J Epidemiol. 163(6):579-88.

Moolgavkar, S. (2000). Air pollution and hospital admissions for chronic obstructive pulmonary disease in three metropolitan areas in the United States. Inhal Toxicol. 12(Supplement 4): 75-90.

Moolgavkar, S. (2003). Air pollution and daily deaths and hospital admissions in Los Angeles and Cook counties. pp. 183-198. In: Health Effects Institute Special Report, Revised Analyses of Time-Series Studies of Air Pollution and Health. Health Effects Institute, Cambridge, MA.

Ostro, B.; Broadwin, R.; Green, S.; Feng, W.Y.; Lipsett, M. (2006). Fine particulate air pollution and mortality in nine California counties: results from CALFINE. Environ Health Perspect. 114(1):29-33.

Pope, C.A. III ; Burnett, R.T. ; Thun, M.J. ; Calle, E.E. ; Krewski, D. ; Ito, K. ; Thurston G.D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. JAMA. 287(9):1132-1141.

Roberts, S. (2004). Interactions between particulate air pollution and temperature in air pollution mortality time series studies. Environ Res. 96(3):328-37.

Samet, J.M. (2008). Air pollution risk estimates: determinants of heterogeneity. J Toxicol Environ Health A. 71(9-10):578-82.

Samet, 2009. Letter from Dr. Jonathan M. Samet, Chair Clean Air Scientific Advisory Committee, to Lisa P. Jackson, Administrator U.S. Environmental Protection Agency regarding "Consultation on EPA's Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Health Risk and Exposure Assessment." May, 21, 2009. (letter placed in docket #EPA-HQ-OAR-2007-0492).

Sarnat, S.E.; Coull, B.A.; Schwartz, J.; Gold, D.R.; Suh, H.H. (2006). Factors affecting the association between ambient concentrations and personal exposures to particles and gases. Environ Health Perspect. 114(5):649-54.

Schwartz, J. (2000). The distributed lag between air pollution and daily deaths. Epidemiology 11(3):320-326.

Tolbert, P.E. (2007). Invited commentary: heterogeneity of particulate matter health risks. Am J Epidemiol. 166(8):889-91; discussion 892-3.

Tolbert, P.E.; Klein, M.; Peel, J.L.; Sarnat, S.E.; Sarnat, J.A. (2007). Multipollutant Modeling Issues in a Study of Ambient Air Quality and Emergency Department Visits in Atlanta. J Expo Sci Environ Epidemiol. 17:S29-S35.

U.S. Environmental Protection Agency. (1996). Air Quality Criteria for Particulate Matter. National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711; report no. EPA/600/P-99/002aF and EPA/600/P-99/002bF. October 2004. Available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr_cd.html

U.S. Environmental Protection Agency. (2001). Risk assessment guidance for Superfund. Vol. III, Part A. Process for conducting probabilistic risk assessment (RAGS 3A). Washington, DC, United States Environmental Protection Agency, EPA 540-R-02-002; OSWER 9285.7-45; PB2002 963302; http://www.epa.gov/oswer/riskassessment/rags3adt/index.htm.

US Environmental Protection Agency. (2004a). Air Quality Criteria for Particulate Matter. National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711; report no. EPA/600/P-99/002aF and EPA/600/P-99/002bF. October 2004. Available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr_cd.html

U.S. Environmental Protection Agency. (2004b) EPA's risk assessment process for air toxics: History and overview. In: Air toxics risk assessment reference library. Vol. 1. Technical resource manual. Washington, DC, United States Environmental Protection Agency, pp. 3-1 – 3-30, EPA-453-K-04-001A; http://www.epa.gov/ttn/fera/data/risk/vol_1/chapter_03.pdf.

U.S. Environmental Protection Agency. (2005). Review of the National Ambient Air Quality Standards for Particulate Matter: Policy Assessment of Scientific and Technical Information - OAQPS Staff Paper, Office of Air Quality Planning and Standards, Research Triangle Park, NC, EPA-452/R-05-005. Available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr_sp.html

U.S. Environmental Protection Agency. (2007). Draft Integrated Review Plan for the National Ambient Air Quality Standards for Particulate Matter. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA 452/P-08-006.

U.S. Environmental Protection Agency. (2008a). Integrated Review Plan for the National Ambient Air Quality Standards for Particulate Matter. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA 452/R-08/004.

U.S. Environmental Protection Agency. (2008b). Integrated Science Assessment for Particulate Matter: First External Review Draft. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-08/139 and 139A. Available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_isa.html.

U.S. Environmental Protection Agency. (2009a). Integrated Science Assessment for Particulate Matter: Second External Review Draft. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA 600/R-08/139B. Available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_isa.html.

U.S. Environmental Protection Agency. (2009b). Particulate Matter National Ambient Air Quality Standards: Scope and Methods Plan for Health Risk and Exposure Assessment. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-452/P-09-002.

U.S. Environmental Protection Agency. (2009c). Particulate Matter Urban-Focused Visibility Assessment – External Review Draft. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. EPA-452/P-09/005. September 2009. Available: http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html.

U.S. Environmental Protection Agency. (2009d). Integrated Science Assessment for Particulate Matter: Final. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-08/139F. Available http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546 .

Woods & Poole Economics Inc. (2001). Population by Single Year of Age CD. CD-ROM. Woods & Poole Economics, Inc. Washington, D.C.

World Health Organization. (2008). Part 1: Guidance Document on Characterizing and Communicating Uncertainty in Exposure Assessment, Harmonization Project Document No. 6. Published under joint sponsorship of the World Health Organization, the International Labour Organization and the United Nations Environment Programme. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland (tel.: +41 22 791 2476).

Zanobetti (2009). Shrunken estimates for $PM_{2.5.}$ Personal Communication, June 1, 2009. (e-mail with attachments placed in docket #EPA-HQ-OAR-2007-0492).

Zanobetti, A.; Schwartz, J. (2009). The effect of fine and coarse particulate air pollution on mortality: A National Analysis. Environ Health Perspect. 117(6): 898-903.

Zeka, A.; Zanobetti, A.; Schwartz, J. (2005). Short term effects of particulate matter on cause specific mortality: effects of lags and modification by city characteristics. Occup Environ Med. 62(10):718-25.

Zeka, A.; Zanobetti, A.; Schwartz, J. (2006). Individual-level modifiers of the effects of particulate matter on daily mortality. American Journal of Epidemiology. 163(9): 849-859.

APPENDIX A: AIR QUALITY ASSESSMENT

Appendix A. Air Quality Assessment

This Appendix describes the PM data for the 15 urban study areas evaluated in the risk assessment, including summaries of $PM_{2.5}$ monitoring data associated with each study area as well as the composite monitor estimates generated for each study area based on that monitoring data (see section 3.2 for additional detail regarding selection of monitors and derivation of composite monitor values).

Table A-1. Air Quality Data for Atlanta

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
130630091 (3)	27	30	25	30	112	12.63	16.83	21.22	15.92	16.65	36.09
130670003 (1,2,3)	27	30	29	29	115	13.75	17.39	18.57	15.62	16.33	34.94
130670004 (1,2,3)	30	28	26	27	111	12.98	17.17	18.03	13.98	15.54	30.28
130890002 (1,2,3)	82	84	81	88	335	12.72	15.72	18.81	14.56	15.45	32.82
130892001 (1,2,3)	80	75	67	85	307	12.84	15.10	20.44	14.83	15.80	36.72
131210032 (1,2,3)	84	89	76	80	329	13.64	16.00	19.43	14.38	15.86	33.40
131210039 (1,2,3)	27	30	23	29	109	15.03	18.35	17.97	16.56	16.98	30.29
131210048 (1,2,3)	0	0	0	0	0	---	---	---	---	---	---
131350002 (1,3)	13	14	12	14	53	14.35	14.62	20.39	15.16	16.13	31.66
132230003 (3)	28	29	26	26	109	11.41	15.52	18.62	12.99	14.63	34.52
Composite monitor for Atlanta - 1	90	91	92	92	365	13.62	16.34	19.09	15.01	16.01	31.03
Composite monitor for Atlanta - 2	90	91	92	92	365	13.49	16.62	18.87	14.99	15.99	31.52
Composite monitor for Atlanta - 3	90	91	92	92	365	13.26	16.30	19.27	14.89	15.93	31.06
2006											
130630091 (3)	29	29	31	30	119	12.94	17.91	21.32	14.49	16.67	30.84
130670003 (1,2,3)	28	29	31	30	118	12.22	17.88	21.52	14.20	16.46	32.66
130670004 (1,2,3)	28	29	27	28	112	12.09	17.75	21.04	12.39	15.82	33.34
130890002 (1,2,3)	85	86	81	81	333	12.25	16.09	19.86	13.43	15.41	31.65
130892001 (1,2,3)	86	84	77	81	328	11.94	15.75	18.31	12.18	14.54	28.89
131210032 (1,2,3)	88	86	84	90	348	12.46	15.99	19.28	13.74	15.37	31.44
131210039 (1,2,3)	29	28	26	0	83	15.12	19.15	20.88	---	---	---
131210048 (1,2,3)	0	0	2	30	32	---	---	15.25	15.00	---	---
131350002 (1,3)	12	14	13	15	54	15.21	18.98	20.31	12.93	16.86	30.64
132230003 (3)	29	27	31	29	116	10.91	15.20	18.90	10.77	13.95	32.28
Composite monitor for Atlanta - 1	90	91	92	92	365	13.04	17.37	20.17	13.41	16.00	27.34
Composite monitor for Atlanta - 2	90	91	92	92	365	12.68	17.10	20.15	13.49	15.86	27.89
Composite monitor for Atlanta - 3	90	91	92	92	365	12.79	17.19	20.16	13.24	15.84	26.82

Table A-1 cont'd. Air Quality Data for Atlanta

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2007											
130630091 (3)	29	30	30	29	118	13.87	16.51	18.83	13.02	15.56	36.04
130670003 (1,2,3)	29	30	29	29	117	13.49	17.03	19.49	13.41	15.85	35.51
130670004 (1,2,3)	26	27	30	30	113	12.50	17.47	18.77	11.39	15.03	33.54
130890002 (1,2,3)	85	83	90	85	343	12.78	15.54	19.38	12.15	14.96	34.22
130892001 (1,2,3)	69	79	76	75	299	12.48	17.11	20.04	12.38	15.50	37.42
131210032 (1,2,3)	87	88	91	85	351	12.99	17.95	19.64	13.08	15.91	35.10
131210039 (1,2,3)	0	0	0	0	0	---	---	---	---	---	---
131210048 (1,2,3)	28	28	31	28	115	13.45	18.97	18.24	12.83	15.87	37.52
131350002 (1,3)	27	27	29	29	112	13.05	14.03	17.97	11.68	14.18	30.19
132230003 (3)	29	30	29	30	118	12.21	17.12	18.95	10.64	14.73	33.82
Composite monitor for Atlanta - 1	90	91	92	92	365	12.96	16.87	19.08	12.42	15.33	31.82
Composite monitor for Atlanta - 2	90	91	92	92	365	12.95	17.35	19.26	12.54	15.52	31.35
Composite monitor for Atlanta - 3	90	91	92	92	365	12.98	16.86	19.03	12.29	15.29	30.59

Note 1: Different definitions of Atlanta include different monitors. The number(s) shown in the parenthesis next to the monitor indicates the location(s) in which it is included. For example, monitor 130630091 is used in Atlanta - 3 only while 130670003 is used for all definitions of Atlanta.
Note 2: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-2. Air Quality Data for Baltimore

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
240051007	30	28	27	27	112	14.78	11.86	20.66	12.34	14.91	33.76
240053001	75	80	85	92	332	16.09	12.60	18.27	13.44	15.10	35.77
245100006	28	31	27	28	114	15.76	12.47	20.18	11.67	15.02	33.17
245100007	27	27	30	30	114	16.09	12.50	20.05	13.00	15.41	35.27
245100008	24	30	30	29	113	18.85	14.16	20.99	14.80	17.20	39.16
245100035	79	75	78	70	302	17.58	13.59	20.24	14.12	16.38	37.49
245100040	79	81	90	76	326	18.47	14.68	19.40	13.42	16.49	39.45
245100049	26	30	25	27	108	17.72	13.19	20.62	12.77	16.07	36.43
Composite Monitor for Baltimore	90	91	92	92	365	16.91	13.13	20.05	13.19	15.82	32.98
2006											
240051007	29	29	28	30	116	12.03	11.37	15.73	11.09	12.55	32.06
240053001	90	85	90	92	357	12.81	11.79	18.51	13.90	14.25	34.25
245100006	27	30	27	30	114	13.20	11.62	16.24	11.61	13.17	32.67
245100007	30	29	29	31	119	12.64	11.59	15.19	12.03	12.86	32.27
245100008	30	28	31	30	119	14.80	13.34	16.88	12.97	14.50	35.21
245100035	74	90	83	82	329	13.31	12.57	19.27	14.14	14.82	36.74
245100040	85	86	87	86	344	13.83	12.58	18.64	14.73	14.94	35.93
245100049	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Baltimore	90	91	92	92	365	13.23	12.12	17.21	12.92	13.87	31.34
2007											
240051007	29	29	31	30	119	12.09	13.54	15.53	12.04	13.30	31.46
240053001	74	87	83	89	333	12.53	12.95	16.93	13.70	14.03	34.01
245100006	30	29	31	27	117	12.10	12.83	16.28	11.16	13.09	31.55
245100007	29	30	30	28	117	12.07	13.20	15.84	12.44	13.39	33.31
245100008	30	30	31	27	118	13.53	14.68	16.90	14.79	14.97	35.25
245100035	79	85	74	76	314	12.11	14.03	17.23	13.23	14.15	33.77
245100040	82	85	89	76	332	13.42	13.66	16.32	13.35	14.19	34.39
245100049	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Baltimore	90	91	92	92	365	12.55	13.55	16.43	12.96	13.87	28.41

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-3. Air Quality Data for Birmingham

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
10730023*	90	90	89	92	361	14.35	20.49	26.42	17.27	19.63	49.68
10731005*	30	31	29	31	121	11.62	16.70	22.61	14.33	16.32	35.06
10731009*	30	31	29	31	121	9.82	16.12	20.26	11.87	14.52	37.68
10731010*	15	15	15	16	61	11.71	16.91	22.77	15.51	16.73	36.46
10732003*	88	90	91	91	360	14.49	18.48	23.75	15.03	17.94	44.41
10732006*	30	30	30	31	121	11.53	16.46	21.11	13.79	15.72	33.98
10735002*	30	31	30	31	122	10.84	16.33	21.08	12.61	15.21	36.23
10735003*	30	30	30	31	121	10.60	16.42	21.94	12.74	15.43	39.20
11170006	30	31	30	28	119	11.23	15.67	19.60	12.92	14.85	32.86
11270002	27	31	28	30	116	10.37	15.31	18.86	12.17	14.18	33.17
Composite Monitor for Birmingham - 1	90	91	92	92	365	11.66	16.89	21.84	13.82	16.05	35.47
Composite Monitor for Birmingham - 2	90	91	92	92	365	11.87	17.24	22.49	14.14	16.44	36.27
2006											
10730023*	89	91	92	92	364	13.61	20.57	22.35	17.02	18.39	39.55
10731005*	30	30	31	31	122	10.51	18.84	19.59	13.38	15.58	33.14
10731009*	30	29	30	30	119	8.81	17.16	17.78	10.02	13.44	31.69
10731010*	15	15	15	16	61	11.57	18.63	18.71	12.37	15.32	32.28
10732003*	89	90	90	92	361	14.41	20.48	21.62	15.67	18.05	40.18
10732006*	30	30	31	31	122	10.76	18.08	20.02	12.33	15.30	31.69
10735002*	30	30	31	31	122	9.87	17.15	19.61	10.60	14.31	33.16
10735003*	29	30	30	30	119	10.37	17.42	18.84	11.31	14.48	33.22
11170006	30	30	31	31	122	9.95	16.37	18.38	11.65	14.09	29.79
11270002	29	30	30	29	118	9.85	17.49	17.38	11.83	14.14	34.53
Composite Monitor for Birmingham - 1	90	91	92	92	365	10.97	18.22	19.43	12.62	15.31	30.49
Composite Monitor for Birmingham - 2	90	91	92	92	365	11.24	18.54	19.82	12.84	15.61	30.91

Table A-3 cont'd. Air Quality Data for Birmingham

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2007											
10731010*	15	15	15	15	60	14.53	18.69	19.31	13.63	16.54	37.92
10732003*	89	90	89	90	358	15.40	21.38	19.18	12.42	17.10	44.02
10732006*	30	30	31	30	121	12.24	19.29	18.53	10.93	15.25	39.92
10735002*	30	28	31	30	119	12.15	19.16	18.41	10.40	15.03	37.90
10735003*	29	30	31	30	120	11.79	18.99	17.83	10.38	14.75	38.56
11170006	29	30	31	30	120	12.97	18.27	17.52	10.84	14.90	38.52
11270002	28	29	31	29	117	11.97	17.81	17.72	10.95	14.61	34.91
Composite Monitor for Birmingham - 1	90	91	92	92	365	12.99	19.62	18.58	11.60	15.70	37.65
Composite Monitor for Birmingham - 2	90	91	92	92	365	13.12	20.02	18.82	11.78	15.93	38.40

Note 1: The monitors marked with * are used for Birmingham - 2. All monitors shown in this table are used for Birmingham - 1.

Note 2: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-4. Air Quality Data for Dallas

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m³)				Annual Average (ug/m³)	98th Percentile (ug/m³)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2005											
481130035	30	31	20	0	81	11.78	15.16	13.90	---	---	---
481130050	15	30	27	31	103	11.95	15.01	15.64	12.47	13.77	28.55
481130057	27	21	22	0	70	12.00	16.07	14.41	---	---	---
481130069	78	88	90	91	347	11.07	13.80	14.03	11.11	12.50	27.44
481130087	27	31	30	30	118	9.87	13.32	13.45	10.18	11.70	24.55
481133004	88	89	61	0	238	10.86	13.58	12.82	---	---	---
Composite Monitor for Dallas	90	91	92	92	365	11.26	14.49	14.04	11.25	12.76	26.93
2006											
481130035	0	0	0	0	0	---	---	---	---	---	---
481130050	28	30	31	31	120	10.99	12.53	12.98	10.68	11.79	22.16
481130057	0	0	0	0	0	---	---	---	---	---	---
481130069	84	90	92	90	356	9.97	12.15	11.73	9.26	10.78	21.99
481130087	30	30	30	28	118	9.22	11.66	10.89	8.45	10.05	19.55
481133004	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Dallas	90	91	92	92	365	10.06	12.11	11.87	9.46	10.88	19.22
2007											
481130035	0	0	0	0	0	---	---	---	---	---	---
481130050	29	28	30	0	87	11.54	11.76	15.42	---	---	---
481130057	0	0	0	0	0	---	---	---	---	---	---
481130069	88	91	91	79	349	10.13	10.91	13.78	10.14	11.24	23.24
481130087	28	21	29	30	108	9.96	11.16	12.70	9.30	10.78	20.03
481133004	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Dallas	90	91	92	92	365	10.54	11.27	13.97	9.72	11.38	21.87

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-5. Air Quality Data for Detroit

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2005											
261630001	88	87	89	86	350	18.45	13.87	17.15	14.38	15.96	42.31
261630015	27	27	30	30	114	20.20	14.73	18.73	15.18	17.21	48.27
261630016	87	79	84	88	338	18.92	14.78	16.62	13.70	16.01	47.80
261630019	28	31	29	29	117	19.82	14.48	17.43	14.20	16.48	51.37
261630025	26	28	30	30	114	17.86	11.74	17.45	12.68	14.94	39.50
261630033	28	31	28	28	115	21.50	16.57	18.22	17.90	18.55	48.69
261630036	29	28	29	27	113	16.96	14.92	18.58	15.19	16.41	46.22
261630038	28	25	22	0	75	16.98	14.60	17.66	---	---	---
261630039	0	0	7	28	35	---	---	18.20	14.25	---	---
Composite Monitor for Detroit	90	91	92	92	365	18.84	14.46	17.73	14.69	16.43	44.06
2006											
261630001	82	85	88	90	345	13.66	11.89	13.68	13.65	13.22	32.82
261630015	29	26	28	31	114	16.98	12.26	14.93	14.56	14.68	35.89
261630016	79	14	13	17	123	13.04	11.58	12.58	14.97	13.04	35.49
261630019	30	15	14	16	75	15.20	10.39	11.78	13.46	12.71	35.67
261630025	27	14	15	17	73	13.49	11.23	10.01	12.70	11.86	30.00
261630033	28	29	27	31	115	18.79	12.85	15.56	17.30	16.13	42.43
261630036	29	26	29	29	113	15.10	10.95	13.69	11.94	12.92	32.91
261630038	0	29	27	28	84	---	11.10	14.34	11.98	---	---
261630039	29	30	31	30	120	14.78	11.71	14.20	11.84	13.13	32.32
Composite Monitor for Detroit	90	91	92	92	365	15.13	11.55	13.42	13.60	13.42	28.34
2007											
261630001	86	89	87	92	354	12.92	10.28	14.00	14.08	12.82	31.19
261630015	28	30	27	29	114	15.15	13.06	15.12	14.82	14.54	32.73
261630016	26	26	30	29	111	13.98	12.12	14.74	14.61	13.86	33.72
261630019	30	28	31	27	116	13.20	11.16	14.36	13.31	13.01	31.09
261630025	26	30	31	27	114	12.23	10.59	13.76	14.42	12.75	32.49
261630033	29	29	29	27	114	18.84	15.20	16.02	17.49	16.89	36.60
261630036	29	28	30	29	116	13.75	11.96	14.60	13.47	13.45	28.48
261630038	27	27	28	30	112	13.63	12.85	15.35	14.23	14.01	33.38
261630039	29	30	30	28	117	13.83	12.98	14.65	13.86	13.83	33.97
Composite Monitor for Detroit	90	91	92	92	365	14.17	12.24	14.73	14.48	13.91	27.66

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-6. Air Quality Data for Fresno

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
60190008	85	78	89	91	343	19.53	7.19	11.42	28.65	16.70	67.64
60195001	30	15	15	22	82	17.11	7.55	10.78	29.95	16.35	64.56
60195025	30	15	13	31	89	20.24	8.29	11.24	27.92	16.92	71.90
Composite Monitor for Fresno	90	91	92	92	365	18.96	7.68	11.14	28.84	16.65	63.26
2006											
60190008	89	87	87	85	348	21.82	9.10	12.39	23.85	16.79	50.06
60195001	30	15	14	29	88	18.38	9.47	12.99	24.96	16.45	53.69
60195025	30	15	12	31	88	20.13	9.81	13.66	26.87	17.62	57.60
Composite Monitor for Fresno	90	91	92	92	365	20.11	9.46	13.01	25.22	16.95	47.46
2007											
60190008	87	90	88	91	356	27.61	8.32	10.70	28.71	18.84	66.95
60195001	29	13	14	27	83	23.70	7.16	9.91	24.91	16.42	61.01
60195025	29	14	15	30	88	24.91	8.73	9.65	24.10	16.85	57.53
Composite Monitor for Fresno	90	91	92	92	365	25.41	8.07	10.09	25.90	17.37	57.42

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-7. Air Quality Data for Houston

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
482010024	26	31	22	15	94	11.77	14.39	17.17	11.83	13.79	26.00
482010026	23	31	20	0	74	10.47	13.10	14.47	---	---	---
482010055	25	28	19	0	72	9.12	12.31	12.97	---	---	---
482010058	20	28	23	26	97	11.95	12.99	14.40	12.19	12.88	24.61
482011034	10	15	10	0	35	11.79	15.36	14.49	---	---	---
482011035	84	68	78	87	317	13.09	16.59	18.41	15.47	15.89	30.10
Composite Monitor for Houston	90	91	92	92	365	11.28	14.12	15.48	13.16	13.51	25.12
2006											
482010024	15	13	13	13	54	10.92	11.66	15.97	12.58	12.78	23.80
482010026	0	0	0	0	0	---	---	---	---	---	---
482010055	0	0	0	0	0	---	---	---	---	---	---
482010058	26	29	29	29	113	9.74	12.34	9.04	9.82	10.24	21.93
482011034	0	0	0	0	0	---	---	---	---	---	---
482011035	85	87	88	88	348	13.98	18.15	17.38	14.48	16.00	32.01
Composite Monitor for Houston	90	91	92	92	365	11.55	14.05	14.13	12.29	13.01	23.67
2007											
482010024	15	14	13	0	42	11.01	12.82	14.64	---	---	---
482010026	0	0	0	0	0	---	---	---	---	---	---
482010055	0	0	0	0	0	---	---	---	---	---	---
482010058	26	30	30	30	116	9.40	10.96	11.84	11.75	10.99	25.48
482011034	0	0	0	0	0	---	---	---	---	---	---
482011035	87	91	91	82	351	14.42	17.02	16.62	14.50	15.64	32.00
Composite Monitor for Houston	90	91	92	92	365	11.61	13.60	14.36	13.13	13.18	23.26

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-8. Air Quality Data for Los Angeles

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2005											
60370002	65	78	87	62	292	11.37	13.97	20.71	21.78	16.96	51.56
60371002	29	25	30	22	106	17.01	13.75	18.55	21.95	17.82	50.47
60371103	90	84	87	89	350	15.26	13.78	19.62	22.48	17.79	52.91
60371201	25	29	28	22	104	12.27	11.97	15.01	16.18	13.86	35.69
60371301	29	26	28	31	114	16.68	13.28	18.15	21.75	17.46	47.18
60371602	29	9	9	29	76	16.90	11.63	17.13	22.31	16.99	52.65
60372005	30	26	26	31	113	12.98	12.95	17.15	17.28	15.09	42.71
60374002	87	82	88	67	324	13.39	11.54	16.21	22.56	15.93	40.11
60374004	90	84	87	83	344	12.64	10.83	15.63	19.59	14.67	37.44
60379033	28	30	27	18	103	8.18	8.27	9.96	9.00	8.85	15.96
Composite Monitor for Los Angeles	90	91	92	92	365	13.67	12.26	16.78	19.49	15.55	38.75
2006											
60370002	66	73	84	55	278	12.62	16.17	16.95	15.87	15.40	36.83
60371002	25	24	30	25	104	15.33	18.34	15.87	16.66	16.55	43.21
60371103	89	82	85	74	330	14.49	14.69	16.34	16.80	15.58	38.55
60371201	20	27	28	17	92	11.19	14.21	12.95	13.00	12.84	30.42
60371301	28	28	27	24	107	17.62	14.76	15.11	19.26	16.69	43.98
60371602	29	28	31	28	116	16.82	13.92	17.19	18.57	16.63	42.34
60372005	29	27	28	29	113	12.85	14.64	13.46	12.51	13.37	31.95
60374002	73	81	73	63	290	15.19	12.27	13.53	15.57	14.14	33.89
60374004	89	86	79	66	320	14.35	11.99	14.21	17.22	14.44	34.17
60379033	15	15	14	14	58	6.13	7.27	8.36	8.00	7.44	12.86
Composite Monitor for Los Angeles	90	91	92	92	365	13.66	13.83	14.40	15.35	14.31	29.93

Table A-8 cont'd. Air Quality Data for Los Angeles

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2007											
60370002	64	77	74	77	292	13.57	17.11	14.68	17.47	15.71	48.71
60371002	23	26	27	22	98	13.64	15.96	15.36	22.47	16.86	45.32
60371103	67	83	90	84	324	16.25	16.05	14.62	20.19	16.78	49.41
60371201	22	26	28	19	95	9.50	13.24	12.55	17.72	13.25	28.90
60371301	25	27	29	25	106	16.98	14.05	13.00	19.99	16.00	45.22
60371602	27	27	21	26	101	16.75	14.01	15.18	20.45	16.60	49.40
60372005	28	23	30	27	108	12.62	15.60	14.02	15.24	14.37	43.62
60374002	76	86	88	82	332	15.45	12.42	11.50	19.04	14.60	39.96
60374004	65	81	90	90	326	13.84	12.26	11.30	17.31	13.68	33.25
60379033	15	15	15	15	60	6.73	7.67	9.00	8.67	8.02	19.28
Composite Monitor for Los Angeles	90	91	92	92	365	13.53	13.84	13.12	17.85	14.59	35.51

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-9. Air Quality Data for New York

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
360050080	28	31	29	27	115	18.59	14.78	18.42	15.68	16.87	37.50
360050083	30	31	30	31	122	13.77	12.21	16.90	12.71	13.90	36.05
360050110	90	91	91	91	363	14.93	12.17	15.38	12.30	13.69	36.58
360470122	28	30	28	27	113	16.04	13.74	17.31	14.13	15.31	35.94
360610056*	30	31	30	31	122	18.44	15.51	19.16	15.17	17.07	39.93
360610062*	27	31	30	31	119	17.14	13.84	18.34	13.54	15.71	38.96
360610079*	30	31	30	31	122	14.60	13.12	17.03	12.56	14.33	36.18
360610128*	25	31	30	31	117	17.74	14.11	18.37	15.21	16.36	37.66
360610134*	0	0	0	0	0	---	---	---	---	---	---
360810124	89	79	62	74	304	13.02	10.44	15.21	10.84	12.38	34.28
360850055	28	25	28	27	108	14.92	12.49	17.81	12.91	14.53	33.37
360850067	24	28	28	30	110	12.60	10.75	16.17	10.41	12.48	33.00
Composite Monitor for New York City - 1	90	91	92	92	365	15.62	13.02	17.28	13.22	14.78	31.19
Composite Monitor for New York City - 2	90	91	92	92	365	16.98	14.15	18.22	14.12	15.87	32.81
2006											
360050080	29	30	27	29	115	16.57	13.17	13.95	11.88	13.89	38.89
360050083	30	30	29	29	118	13.44	11.06	13.34	10.33	12.04	34.80
360050110	86	91	84	86	347	13.10	11.15	14.49	11.40	12.53	36.51
360470122	28	30	29	25	112	15.00	12.49	14.75	9.00	12.81	37.06
360610056*	30	30	27	30	117	16.61	14.03	14.41	12.59	14.41	40.60
360610062*	30	28	28	27	113	14.33	13.00	13.82	9.86	12.75	35.73
360610079*	30	30	31	29	120	14.12	12.08	13.32	10.59	12.53	36.92
360610128*	26	30	29	29	114	15.79	13.07	14.39	12.64	13.97	37.84
360610134*	0	0	0	0	0	---	---	---	---	---	---
360810124	69	86	84	76	315	11.17	10.67	13.68	10.91	11.61	33.10
360850055	25	27	29	29	110	12.27	12.07	14.06	10.56	12.24	35.89
360850067	30	26	31	29	116	10.01	10.49	12.60	8.54	10.41	31.85
Composite Monitor for New York City - 1	90	91	92	92	365	13.86	12.12	13.89	10.75	12.65	30.36
Composite Monitor for New York City - 2	90	91	92	92	365	15.21	13.04	13.99	11.42	13.42	33.78

Table A-9 cont'd. Air Quality Data for New York

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2007											
360050080	30	30	30	29	119	17.45	13.49	16.20	15.43	15.64	36.16
360050083	30	30	30	29	119	14.14	11.72	13.91	12.87	13.16	32.50
360050110	89	84	85	91	349	12.90	11.64	14.22	12.31	12.77	33.92
360470122	29	30	28	30	117	13.67	12.82	15.92	13.00	13.85	33.38
360610056*	30	27	31	30	118	18.43	14.73	15.99	15.29	16.11	36.12
360610062*	27	0	0	0	27	15.84	---	---	---	---	---
360610079*	30	30	31	30	121	14.11	12.48	14.92	12.89	13.60	33.86
360610128*	30	30	29	21	110	19.10	13.83	14.63	14.76	15.58	37.01
360610134*	3	30	31	30	94	8.53	14.12	16.43	14.08	13.29	33.66
360810124	74	86	80	92	332	11.34	10.66	12.30	11.35	11.41	30.81
360850055	30	28	31	30	119	13.04	12.37	14.55	11.91	12.97	31.58
360850067	27	30	26	26	109	10.60	10.49	14.29	10.54	11.48	28.56
Composite Monitor for New York City - 1	90	91	92	92	365	14.60	12.58	14.85	13.13	13.79	29.12
Composite Monitor for New York City - 2	90	91	92	92	365	16.87	13.79	15.49	14.25	15.10	30.12

Note 1: The monitors marked with * are used for New York City - 2. All monitors in the table are used for New York City - 1.
Note 2: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-10. Air Quality Data for Philadelphia

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
421010003	0	0	0	62	62	---	---	---	14.35	---	---
421010004	55	61	78	74	268	13.23	13.06	17.26	13.28	14.21	35.83
421010020	19	0	0	0	19	15.51	---	---	---	---	---
421010024	37	54	67	71	229	12.68	10.76	16.26	12.02	12.93	34.57
421010047	19	28	26	12	85	16.99	12.04	18.91	12.31	15.06	37.70
421010057	0	0	0	0	0	---	---	---	---	---	---
421010136	86	89	29	33	237	13.57	11.40	19.06	12.91	14.23	31.13
Composite Monitor for Philadelphia	90	91	92	92	365	14.40	11.81	17.87	12.97	14.26	32.12
2006											
421010003	85	26	0	0	111	12.21	8.74	---	---	---	---
421010004	81	70	53	84	288	12.74	11.85	17.23	12.41	13.56	38.08
421010020	0	0	0	0	0	---	---	---	---	---	---
421010024	34	70	71	80	255	11.52	10.56	16.17	11.34	12.40	34.60
421010047	40	67	45	47	199	14.44	14.57	18.04	15.04	15.52	35.91
421010057	0	0	0	0	0	---	---	---	---	---	---
421010136	47	50	79	73	249	11.97	12.06	16.29	12.25	13.14	36.36
Composite Monitor for Philadelphia	90	91	92	92	365	12.58	11.55	16.93	12.76	13.46	33.46
2007											
421010003	0	0	0	0	0	---	---	---	---	---	---
421010004	87	71	86	90	334	13.61	13.19	15.15	12.96	13.73	34.61
421010020	0	0	0	0	0	---	---	---	---	---	---
421010024	87	58	86	90	321	12.05	12.76	14.88	11.73	12.85	33.42
421010047	71	59	90	92	312	14.49	13.05	16.33	13.43	14.32	35.07
421010057	0	0	18	90	108	---	---	10.96	13.13	---	---
421010136	75	65	72	82	294	12.60	13.38	14.36	12.99	13.33	31.53
Composite Monitor for Philadelphia	90	91	92	92	365	13.19	13.09	14.33	12.85	13.37	32.44

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-11. Air Quality Data for Phoenix

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
40130019	32	32	30	31	125	11.04	10.78	11.11	18.37	12.83	39.88
40131003	0	22	30	29	81	---	8.77	8.26	9.72	---	---
40134003	29	31	27	31	118	10.94	13.04	10.40	16.98	12.84	34.73
40137020	0	30	29	31	90	---	8.08	7.72	9.46	---	---
40139997	29	31	30	31	121	9.04	8.69	7.58	13.56	9.72	27.48
Composite Monitor for Phoenix	90	91	92	92	365	10.34	9.87	9.01	13.62	10.71	26.03
2006											
40130019	30	30	31	31	122	14.17	13.58	8.07	17.82	13.41	28.51
40131003	26	28	31	31	116	8.87	9.52	8.92	11.33	9.66	20.07
40134003	28	28	31	29	116	13.53	10.34	9.31	17.58	12.69	28.38
40137020	29	30	31	30	120	8.09	7.98	7.14	9.12	8.08	15.35
40139997	29	29	30	30	118	10.74	8.66	7.46	14.04	10.22	24.29
Composite Monitor for Phoenix	90	91	92	92	365	11.08	10.01	8.18	13.98	10.81	26.84
2007											
40130019	32	30	31	30	123	10.26	8.85	8.63	15.42	10.79	26.63
40131003	29	28	30	30	117	7.66	10.45	9.50	11.27	9.72	18.20
40134003	30	29	30	29	118	10.54	11.76	11.32	15.45	12.27	27.33
40137020	30	30	31	20	111	5.85	7.81	7.35	8.21	7.31	13.44
40139997	30	29	32	30	121	8.85	8.12	8.21	12.75	9.48	22.02
Composite Monitor for Phoenix	90	91	92	92	365	8.63	9.40	9.00	12.62	9.91	18.70

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-12. Air Quality Data for Pittsburgh

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2005											
420030008	89	90	92	89	360	13.80	15.29	20.72	13.40	15.80	42.23
420030021	28	27	30	27	112	12.91	14.99	22.00	11.49	15.35	35.01
420030064	88	90	92	86	356	16.28	22.26	25.94	21.10	21.40	69.46
420030067	26	28	29	27	110	12.32	13.95	20.35	10.26	14.22	33.87
420030093	13	11	12	13	49	10.66	13.83	23.66	9.63	14.44	41.68
420030095	14	13	14	15	56	12.79	14.49	21.55	9.83	14.67	36.09
420030116	23	29	28	26	106	13.82	16.42	21.68	12.66	16.15	38.72
420030133	14	13	13	9	49	13.54	12.62	20.51	9.51	14.04	27.32
420031008	30	29	30	29	118	12.79	15.60	21.90	13.52	15.95	40.11
420031301	29	29	29	26	113	14.39	16.86	23.90	13.37	17.13	38.22
420033007	15	13	14	15	57	14.13	14.25	24.36	12.71	16.36	30.68
420039002	13	13	14	15	55	12.95	14.01	21.32	11.25	14.88	37.93
Composite Monitor for Pittsburgh	90	91	92	92	365	13.37	15.38	22.32	12.58	15.91	41.92
2006											
420030008	85	89	91	92	357	11.60	13.28	20.19	12.54	14.40	37.44
420030021	0	0	0	0	0	---	---	---	---	---	---
420030064	85	90	87	89	351	14.86	17.89	22.78	20.97	19.13	55.70
420030067	23	26	28	21	98	9.61	9.52	16.39	9.06	11.14	28.04
420030093	14	6	13	13	46	10.37	9.85	16.38	9.41	11.50	29.46
420030095	13	13	13	14	53	10.02	10.97	18.22	10.31	12.38	36.70
420030116	0	0	0	0	0	---	---	---	---	---	---
420030133	0	0	0	0	0	---	---	---	---	---	---
420031008	27	23	28	25	103	11.87	14.30	18.32	11.63	14.03	37.54
420031301	26	28	29	29	112	12.56	14.55	19.89	13.11	15.03	37.73
420033007	15	15	14	15	59	12.93	13.51	19.16	12.36	14.49	34.73
420039002	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Pittsburgh	90	91	92	92	365	11.49	13.05	18.69	11.95	13.79	33.16

Table A-12. Air Quality Data for Pittsburgh

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2007											
420030008	85	86	86	89	346	11.80	14.72	20.30	12.74	14.89	39.35
420030021	0	0	0	0	0	---	---	---	---	---	---
420030064	88	90	91	90	359	14.16	18.64	25.16	17.57	18.88	54.67
420030067	19	25	28	26	98	10.28	13.40	19.46	10.73	13.47	40.80
420030093	15	12	14	14	55	9.67	10.50	19.35	12.57	13.02	32.56
420030095	14	13	15	14	56	10.96	9.89	20.79	12.90	13.64	32.40
420030116	0	0	0	0	0	---	---	---	---	---	---
420030133	0	0	0	0	0	---	---	---	---	---	---
420031008	27	27	30	27	111	12.79	14.55	19.68	13.23	15.06	39.60
420031301	28	27	31	26	112	14.02	15.18	21.90	15.16	16.56	43.57
420033007	14	14	14	13	55	12.36	13.03	21.19	13.85	15.11	34.74
420039002	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Pittsburgh	90	91	92	92	365	11.87	13.51	20.74	13.36	14.87	36.08

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-13. Air Quality Data for Salt Lake City

Monitor	Quarterly Counts				Annual Total	Quarterly Averages (ug/m^3)				Annual Average (ug/m^3)	98th Percentile (ug/m^3)
	Q1	Q2	Q3	Q4		Q1	Q2	Q3	Q4		
2005											
490350003	30	29	30	31	120	14.16	6.58	8.98	14.49	11.06	41.66
490350012	82	89	85	85	341	16.73	9.59	12.68	17.24	14.06	43.36
490351001	29	30	28	30	117	11.85	5.47	8.61	11.35	9.32	36.25
490353006	88	90	90	85	353	13.95	6.27	9.56	14.17	10.99	43.23
490353007	28	27	29	28	112	13.64	7.40	10.57	16.36	11.99	39.37
490353008	30	31	24	31	116	9.90	6.03	7.76	7.45	7.79	26.61
490353010	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Salt Lake City	90	91	92	92	365	13.37	6.89	9.69	13.51	10.87	36.45
2006											
490350003	28	28	29	30	115	10.76	6.98	9.41	13.58	10.18	38.67
490350012	76	87	82	90	335	11.80	11.22	14.19	14.91	13.03	37.93
490351001	27	28	29	27	111	7.95	5.65	8.65	9.29	7.88	27.72
490353006	88	90	90	88	356	10.59	7.21	8.54	12.37	9.68	37.54
490353007	30	30	31	29	120	10.11	7.18	11.56	13.61	10.61	35.69
490353008	29	26	30	30	115	6.14	6.85	9.26	7.09	7.33	21.97
490353010	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for Salt Lake City	90	91	92	92	365	9.56	7.51	10.27	11.81	9.79	29.80
2007											
490350003	30	30	29	28	117	18.12	6.97	10.99	13.89	12.49	55.65
490350012	80	86	0	0	166	20.84	11.45	---	---	---	---
490351001	24	30	31	26	111	11.42	6.44	10.08	9.71	9.41	29.84
490353006	89	85	78	89	341	18.17	6.11	9.42	12.05	11.44	54.28
490353007	29	29	29	31	118	17.72	7.17	11.53	13.42	12.46	50.13
490353008	23	28	28	30	109	10.03	6.06	9.66	7.09	8.21	23.02
490353010	0	80	83	92	255	---	7.68	11.62	13.00	---	---
Composite Monitor for Salt Lake City	90	91	92	92	365	16.05	7.41	10.55	11.53	11.39	49.06

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-14. Air Quality Data for St. Louis

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
171190023*	28	28	29	29	114	18.01	19.10	21.49	16.95	18.89	41.17
171190024*	0	0	0	0	0	---	---	---	---	---	---
171191007*	26	31	29	30	116	18.40	16.49	21.47	16.27	18.16	43.68
171192009*	12	12	13	12	49	14.94	16.35	20.82	11.98	16.02	39.63
171193007*	29	31	27	29	116	16.42	15.20	19.99	12.49	16.02	41.08
171630010*	13	15	14	15	57	17.31	16.81	19.97	14.47	17.14	39.59
171634001*	30	30	29	28	117	17.86	14.17	17.20	14.69	15.98	37.61
290990012	90	87	90	91	358	15.22	14.69	19.26	12.42	15.40	39.86
291890004*	29	29	28	31	117	16.01	12.64	17.80	11.87	14.58	37.57
291892003*	57	30	29	31	147	16.73	14.15	18.44	12.65	15.49	40.00
295100007*	88	88	83	81	340	16.99	14.67	18.92	12.87	15.86	38.44
295100085*	90	86	78	88	342	16.78	14.46	19.67	13.33	16.06	39.81
295100086*	84	26	30	29	169	15.11	14.34	18.43	13.14	15.26	39.57
295100087*	90	87	82	81	340	17.02	14.80	18.74	12.94	15.88	40.80
295100093*	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for St Louis - 1	90	91	92	92	365	16.68	15.22	19.40	13.54	16.21	37.87
Composite Monitor for St Louis - 2	90	91	92	92	365	16.80	15.27	19.41	13.64	16.28	37.78
2006											
171190023*	30	26	31	29	116	15.21	17.34	19.40	12.11	16.02	32.81
171190024*	0	0	0	0	0	---	---	---	---	---	---
171191007*	27	24	24	27	102	14.95	16.12	20.18	14.05	16.32	36.24
171192009*	15	15	14	16	60	12.59	13.35	13.49	12.92	13.08	27.28
171193007*	28	30	31	31	120	13.08	12.00	16.47	10.87	13.11	27.54
171630010*	12	14	15	14	55	14.18	13.75	15.72	14.48	14.53	29.18
171634001*	28	28	31	29	116	13.43	12.87	15.20	12.00	13.38	27.92
290990012	82	81	91	89	343	11.62	11.79	15.46	11.49	12.59	30.20
291890004*	30	29	0	0	59	10.56	10.49	---	---	---	---
291892003*	29	29	28	26	112	11.36	10.69	13.87	11.00	11.73	27.61
295100007*	78	88	91	90	347	12.27	11.82	15.89	12.51	13.12	29.39
295100085*	86	77	84	92	339	13.04	12.46	15.26	12.68	13.36	28.52
295100086*	30	30	31	29	120	11.94	11.55	15.48	10.90	12.47	30.46
295100087*	85	90	86	91	352	12.92	12.32	16.17	13.18	13.65	29.60
295100093*	0	0	0	0	0	---	---	---	---	---	---
Composite Monitor for St Louis - 1	90	91	92	92	365	12.86	12.81	16.05	12.35	13.52	25.08
Composite Monitor for St Louis - 2	90	91	92	92	365	12.96	12.90	16.10	12.43	13.60	24.78

Table A-14 cont'd. Air Quality Data for St. Louis

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2007											
171190023*	0	0	0	0	0	---	---	---	---	---	---
171190024*	0	0	6	29	35	---	---	15.07	14.94	---	---
171191007*	29	27	29	26	111	14.28	15.31	17.61	13.23	15.11	35.86
171192009*	15	12	14	13	54	14.31	16.02	15.66	13.51	14.88	34.98
171193007*	29	28	26	30	113	12.42	14.84	17.39	12.32	14.24	34.45
171630010*	13	13	14	14	54	14.94	17.65	15.94	13.79	15.58	33.08
171634001*	26	30	31	29	116	13.35	13.95	14.83	10.90	13.26	32.27
290990012	82	81	90	86	339	11.94	14.44	16.23	12.13	13.68	31.92
291890004*	0	0	0	0	0	---	---	---	---	---	---
291892003*	89	90	91	90	360	11.63	12.96	15.25	12.49	13.09	30.28
295100007*	88	91	91	92	362	12.56	14.50	16.13	12.97	14.04	31.61
295100085*	90	88	89	90	357	12.59	13.79	16.09	13.30	13.94	32.06
295100086*	27	30	0	0	57	11.79	14.50	---	---	---	---
295100087*	90	86	92	86	354	13.24	14.43	16.61	13.10	14.34	33.72
295100093*	0	0	24	29	53	---	---	17.26	13.82	---	---
Composite Monitor for St Louis - 1	90	91	92	92	365	13.00	14.76	16.27	13.04	14.27	31.51
Composite Monitor for St Louis - 2	90	91	92	92	365	13.11	14.79	16.28	13.13	14.33	31.52

Note 1: The monitors marked with * are used for St Louis - 2. All monitors shown in the table are used for St Louis - 1.

Note 2: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

Table A-15. Air Quality Data for Tacoma

Monitor	Quarterly Counts Q1	Q2	Q3	Q4	Annual Total	Quarterly Averages (ug/m^3) Q1	Q2	Q3	Q4	Annual Average (ug/m^3)	98th Percentile (ug/m^3)
2005											
530530029	29	30	30	31	120	16.46	5.34	7.13	17.07	11.50	40.42
Composite Monitor for Tacoma	90	91	92	92	365	16.46	5.34	7.13	17.07	11.50	39.61
2006											
530530029	30	30	31	26	117	8.92	5.89	7.45	15.93	9.55	39.82
Composite Monitor for Tacoma	90	91	92	92	365	8.92	5.89	7.45	15.93	9.55	37.05
2007											
530530029	29	28	31	29	117	13.76	5.94	5.23	13.76	9.67	45.11
Composite Monitor for Tacoma	90	91	92	92	365	13.76	5.94	5.23	13.76	9.67	41.26

Note: The information on the composite monitors in this table is based on the composite monitors after missing values have been filled in.

APPENDIX B: HYBRID (NON-PROPORTIONAL) AND PEAK SHAVING ROLLBACK APPROACHES

Appendix B. Methodologies for Rolling Back $PM_{2.5}$ Concentrations Due to Local Source Impacts (hybrid non-proportional and peak shaving approaches)

During the last review of the Particulate Matter National Ambient Air Quality Standards (NAAQS), a technique was employed to simulate fine particulate concentrations under a series of attainment scenarios to determine the risk associated with each. The "rolling back" of the concentrations consisted of simply using a proportional rollback calculation where every measured concentration value was multiplied by a constant to obtain a set of concentrations which would meet alternative standard levels. This technique was reviewed by the Clean Air Scientific Advisory Committee (CASAC) and was considered to be a satisfactory way to simulate alternative $PM_{2.5}$ distributions. The rolled back values, however, constituted only a regional reduction in PM concentrations without accounting in any way for emission reductions at local point sources.

The Hybrid Non-Proportional Approach

For the current review, an alternative rollback approach reflecting the combined effects of both local and regional reduction strategies was considered (this alternative approach is referred to as the *hybrid non-proportional approach* in the risk assessment). In addition to utilizing a traditional proportional rollback to represent the regional PM reductions, a distance-weighted rollback was conducted on a subset of the 15 study areas which contain source-oriented monitors measuring concentrations higher than those observed at other sites within a particular area.[1]

Unique sites with high design values exceeding the NAAQS were further investigated to determine if they were in close proximity to a large source of $PM_{2.5}$ (Figure B-1). The presence of possible source-oriented sites in each area was visually determined using satellite photographs provided by Google Earth. Areas where source-oriented adjustments were made include Detroit MI, Pittsburgh PA, St. Louis MO-IL, Baltimore MD, New York NY, Los Angeles CA and Birmingham AL.

[1] In the risk assessment, as outlined in Section 3.1, the proportional rollback approach was used in generating the core risk estimates, while the hybrid non-proportional approach described here, was considered as part of the sensitivity analysis.

Figure B-1. Example of a monitor, in Dearborn MI, located near a large source of emissions

For those sites that were within proximity to a large emitter, the site's measured concentrations were reduced using a proportional rollback depending on the magnitude of the reduction needed to either the highest 24-hour or annual design value of a non-source oriented site within the area whose design values were close to those of the source oriented site (Figure B-2).

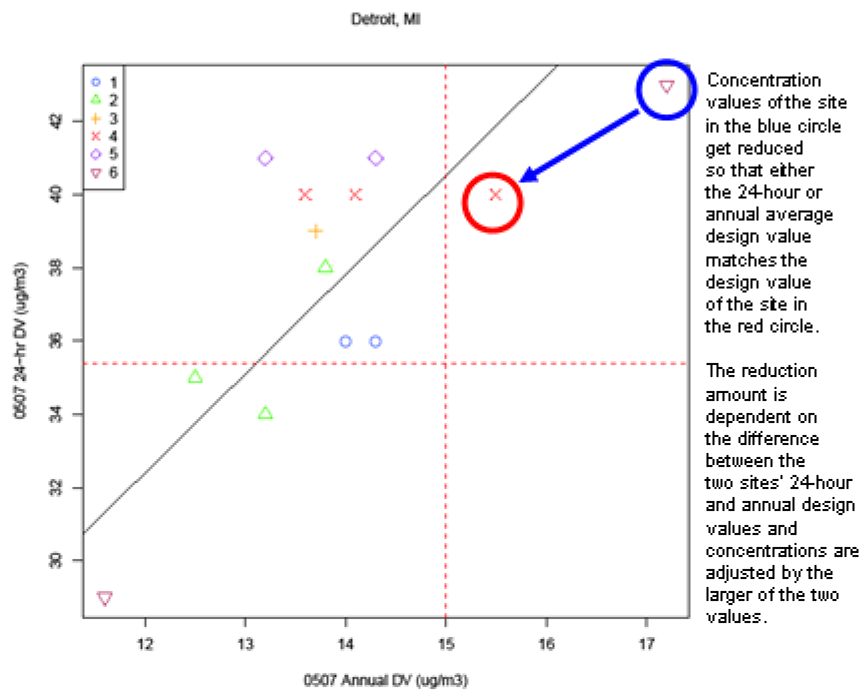


Figure B-2. Plot of the 24-hour versus the annual average $PM_{2.5}$ design values for individual sites in Detroit MI

The fractional reduction made to the site near the point source was then weighted by the inverse distance in kilometers between the source-oriented site and all of the other individual sites in the area to determine their fractional reductions in relation to the source-oriented site. If more than one source-oriented site was reduced, a distance-weighted average fractional reduction was calculated and implemented across the non-source-oriented sites. Sites within one kilometer of the source oriented site received the same amount of reduction as the source oriented site. An example of the effect of this reduction technique for Detroit is presented in Table B-1. For Detroit, adjustments were based on the difference between the two sites' annual design values.

Table B-1. Comparison of the original and adjusted design values for Detroit, MI

Site ID	Original Annual Design Value (2005-2007)	Adjusted Annual Design Value (2005-2007)	Original 24-hour Design Value (2005-2007)	Adjusted 24-hour Design Value (2005-2007)
260490021	11.6	11.5	29	29
260990009	12.5	12.4	35	35
261150005	13.8	13.7	38	38
261250001	13.6	13.5	40	40
261470005	13.2	13.1	41	40
261610005	13.2	13.1	39	39
261610008	13.7	13.6	39	39
261630001	14	13.9	36	36
261630015	**15.5**	**15.2**	**40**	**39**
261630016	14.3	14.2	41	41
261630019	14.1	14	40	40
261630025	13.2	13.1	34	34
261630033	**17.2**	**15.4**	**43**	**39**
261630036	14.3	14.2	36	36
261630038	14.3	14.1	40	39
261630039	14.4	14.3	37	37

Site in blue represents source-oriented site
Site in red represents reference site used for reduction

Reduction of the concentrations of the source-oriented site reduced either the 24-hour or annual design value of the site to either the maximum non-source-oriented site's 24-hour or annual design value. This did not necessarily mean that the adjusted values at the source-oriented site met either the 24-hour or annual standard after the reduction. Since the adjusted design values were calculated using the same data handling rules as contained within 40 CFR Part 50 Appendix N, truncation or rounding of the adjusted concentrations could sometimes give adjusted design values at the source-oriented site that were not exactly the same value as the original design value at the reference site. However, they were usually within 1 ug/m^3 for the 24-hour standard and a few tenths of a microgram per cubic meter for the annual standard.

The Peak Shaving Approach

The peak shaving approach was used to calculate annual averages for 2005, 2006, and 2007 at composite monitors for comparison with the composite monitor annual averages calculated using the proportional and hybrid rollback approaches. Because of time constraints, we did not calculate health risks when alternative standards are just met using the peak shaving approach. However, because the C-R functions used in the risk assessment are almost linear, a comparison of annual averages at composite monitors using the three different methods for simulating just attaining standards should give a good idea of the corresponding estimates of health risks when alternative standards are just met (see Section 3.5.4 for additional detail on the composite monitor-based comparison of the three rollback strategies completed as part of the sensitivity analysis).

We applied the peak shaving method only in those cases in which the daily standard in a location is controlling (i.e., the percent rollback necessary to meet the daily standard is greater than the percent rollback necessary to meet the annual standard in that location). Like the proportional and hybrid rollback methods, the peak shaving method for calculating annual averages at composite monitors starts with monitor-specific quarterly averages that have been calculated as described in Section 3.2.1.

In contrast to the proportional and hybrid rollback approaches, the peak shaving method uses monitor-specific design values. For each monitor, we compared the monitor-specific daily design value to the daily standard and calculated the percent rollback necessary to get each monitor above the 24hr standard level into attainment (using a formula that is analogous to the proportional rollback formula given in Section 3.2.3.1). We then rolled back each quarterly average at the monitor by this percent rollback. We calculated the average quarterly average across all monitors in the location, for each quarter. Finally, we calculated the annual average at the composite monitor under the standard by averaging the four quarterly averages calculated on the previous step. See Section 3.2.2 for more detail.

The results of the peak shaving analysis are presented, along with results based on the hybrid and proportional rollback approaches, as part of the sensitivity analysis results (see Appendix F, Tables F-49 and F-50).

APPENDIX C: EPI STUDY SPECIFIC INFORMATION ON $PM_{2.5}$

Appendix C. Epidemiology Study-Specific Information for $PM_{2.5}$ Risk Assessment

This Appendix provides detailed summary information for the epidemiological studies used to obtain the concentration-response (C-R) functions used in the risk assessment. For additional details on selection of epidemiological studies and specification of the C-R functions, see section 3.3.3.

Table C-1. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Health Effects Associated with Long-Term Exposure to $PM_{2.5}$:											
Krewski et al. (2009) - exposure period 1979-1983	Mortality, all-cause	All	30+	log-linear	none	n/a	annual mean	National	0.00431	0.00276	0.00583
	Mortality, cardiopulmonary	401-440, 460-519							0.00898	0.00677	0.01115
	Mortality, ischemic heart disease	410-414							0.01689	0.01363	0.02005
	Mortality, lung cancer	162							0.00880	0.00325	0.01432
Krewski et al. (2009) - exposure period 1999-2000	Mortality, all-cause	All	30+	log-linear	none	n/a	annual mean	National	0.00554	0.00354	0.00760
	Mortality, cardiopulmonary	401-440, 460-519							0.01293	0.01007	0.01587
	Mortality, ischemic heart disease	410-414							0.02167	0.01748	0.02585
	Mortality, lung cancer	162							0.01293	0.00554	0.02029
	Mortality, all-cause	All	30+	log-linear (random effects)	none	n/a	annual mean		0.00686	0.00315	0.01053
	Mortality, ischemic heart disease	410-414							0.02437	0.01450	0.03429
	Mortality, all-cause	All	30+	log-log	none	n/a	annual mean		0.10966	0.06758	0.15306
	Mortality, cardiopulmonary	401-440, 460-519							0.17225	0.11261	0.23161
	Mortality, ischemic heart disease	410-414							0.35942	0.24629	0.47210
	Mortality, lung cancer	162							0.19284	0.09861	0.28797
Krewski et al. (2000) [reanalysis of Six Cities Study]	Mortality, all-cause	All	25+	log-linear	none	n/a	annual mean	Six U.S. Cities	0.00414	0.00414	0.02071
	Mortality, cardiopulmonary	400-440, 485-495							0.00561	0.00561	0.02789
	Mortality, lung cancer	162							-0.01133	-0.01133	0.04525

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Health Effects Associated with Short-Term Exposure to $PM_{2.5}$:											
Bell et al. (2008)	HA (unscheduled), cardiovascular	426–427, 428, 430–438; 410–414, 429; 440–449	65+	log-linear	none	0-day	24-hr avg.	Northeast	0.00107	0.00079	0.00136
								Northwest	0.00074	-0.00176	0.00324
								Southeast	0.00029	-0.00019	0.00077
								Southwest	0.00053	0.00000	0.00104
	HA (unscheduled), respiratory	490–492; 464–466, 480–487	65+	log-linear	none	2-day	24-hr avg.	Northeast	0.00028	-0.00017	0.00072
								Northwest	0.00019	-0.00255	0.00294
								Southeast	0.00035	-0.00044	0.00113
								Southwest	0.00094	0.00022	0.00166
Ito et al. (2007)	ER visits, asthma	493	all ages	log-linear	none	avg of 0- and 1-day	24-hr avg.	New York	0.00453	0.00286	0.00621
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Mortality, cardiovascular	390-429	all ages	log-linear, GAM (stringent), 30 df	none	0 day	24-hr avg.	Los Angeles	0.00099	0.00010	0.00188
				log-linear, GAM (stringent), 100 df					0.00097	0.00014	0.00180
				log-linear, GLM, 100 df					0.00097	-0.00002	0.00196
				log-linear, GAM (stringent), 100 df	CO				0.00178	0.00075	0.00281
				log-linear, GLM, 100 df					0.00188	0.00067	0.00309
				log-linear, GAM (stringent), 30 df	none	1 day			0.00103	0.00015	0.00191
				log-linear, GAM (stringent), 100 df					0.00080	-0.00003	0.00163
				log-linear, GLM, 100 df					0.00069	-0.00032	0.00170
				log-linear, GAM (stringent), 100 df	CO				0.00091	-0.00013	0.00195
				log-linear, GLM, 100 df					0.00091	-0.00035	0.00217

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Mortality, non-accidental	<800	all ages	log-linear, GAM (stringent), 30 df	none	0 day	24-hr avg.	Los Angeles	0.00054	-0.00007	0.00115
				log-linear, GLM, 30 df	none	0 day	24-hr avg.		0.00040	-0.00034	0.00114
				log-linear, GAM (stringent), 100 df	none	0 day	24-hr avg.		0.00032	-0.00023	0.00087
				log-linear, GLM, 100 df	none	0 day	24-hr avg.		0.00030	-0.00043	0.00103
				log-linear, GAM (stringent), 30 df	none	1 day	24-hr avg.		0.00059	0.00000	0.00118
				log-linear, GLM, 30 df	none	1 day	24-hr avg.		0.00055	-0.00017	0.00127
				log-linear, GAM (stringent), 100 df	none	1 day	24-hr avg.		0.00010	-0.00046	0.00066
				log-linear, GLM, 100 df	none	1 day	24-hr avg.		-0.00001	-0.00099	0.00097
				log-linear, GAM (stringent), 30 df	CO	1 day	24-hr avg.		-0.00053	-0.00131	0.00025
				log-linear, GAM (stringent), 100 df	CO	1 day	24-hr avg.		-0.00033	-0.00105	0.00039
				log-linear, GLM, 100 df	CO	1 day	24-hr avg.		-0.00033	-0.00117	0.00051
				log-linear, GAM (stringent), 30 df	none	0 day	24-hr avg.		0.00054	-0.00007	0.00115
						1 day			0.00059	0.00000	0.00118
						2 day			0.00038	-0.00019	0.00095
						3 day			-0.00015	-0.00073	0.00043
						4 day			-0.00009	-0.00064	0.00046
						5 day			-0.00056	-0.00115	0.00003

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Moolgavkar (2003) [reanalysis of Moolgavkar (2000a)]	Mortality, respiratory (COPD+)	490-496	all ages	log-linear, GAM (stringent), 30 df	none	0 day	24-hr avg.	Los Angeles	-0.00056	-0.00300	0.00188
				log-linear, GAM (stringent), 100 df					-0.00142	-0.00380	0.00096
				log-linear, GLM, 100 df					-0.00121	-0.00407	0.00165
				log-linear, GAM (stringent), 30 df	none	1 day	24-hr avg.		0.00038	-0.00210	0.00286
				log-linear, GAM (stringent), 100 df					0.00086	-0.00158	0.00330
				log-linear, GLM, 100 df					0.00020	-0.00282	0.00322
Moolgavkar (2003) [reanalysis of Moolgavkar (2000b)]	HA, cardiovascular	390-429	65+	log-linear, GAM (stringent), 30 df	none	0 day	24-hr avg.	Los Angeles	0.00158	0.00091	0.00225
				log-linear, GAM (stringent), 100 df					0.00116	0.00050	0.00182
				log-linear, GLM, 100 df					0.00126	0.00045	0.00207
				log-linear, GAM (stringent), 100 df	CO	0 day	24-hr avg.		0.00039	-0.00044	0.00122
				log-linear, GLM, 100 df					0.00058	-0.00041	0.00157
				log-linear, GAM (stringent), 30 df	none	1 day	24-hr avg.		0.00139	0.00069	0.00209
				log-linear, GAM (stringent), 100 df					0.00113	0.00046	0.00180
				log-linear, GLM, 100 df					0.00120	0.00038	0.00202
				log-linear, GAM (stringent), 100 df	CO	1 day	24-hr avg.		0.00024	-0.00065	0.00113
				log-linear, GLM, 100 df					0.00027	-0.00075	0.00129

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Moolgavkar (2003) [reanalysis of Moolgavkar (2000c)]	HA, respiratory (COPD+)	490-496	all ages	log-linear, GAM (stringent), 30 df	none	0 day	24-hr avg.	Los Angeles	0.00167	0.00068	0.00266
				log-linear, GAM (stringent), 100 df					0.00138	0.00052	0.00224
				log-linear, GLM, 100 df					0.00149	0.00041	0.00257
				log-linear, GAM (stringent), 30 df	none	1 day	24-hr avg.		0.00119	0.00022	0.00216
				log-linear, GAM (stringent), 100 df					0.00075	-0.00011	0.00161
				log-linear, GLM, 100 df					0.00077	-0.00027	0.00181
				log-linear, GAM (stringent), 30 df	none	2 day	24-hr avg.		0.00185	0.00082	0.00288
				log-linear, GAM (stringent), 100 df					0.00114	0.00021	0.00207
				log-linear, GLM, 100 df					0.00103	-0.00012	0.00218
				log-linear, GAM (stringent), 100 df	NO2	0 day	24-hr avg.		0.00042	-0.00091	0.00175
						1 day			-0.00004	-0.00161	0.00153
						2 day			0.00035	-0.00102	0.00172
						3 day			-0.00109	-0.00238	0.00020
Tolbert et al. (2007)	ER visits, cardiovascular	410–414, 427, 428, 433–437, 440, 443–445, 451–453	all ages	log-linear	none	avg of 0-,1-day, and 2-day	24-hr avg.	Atlanta	0.00046	-0.00064	0.00154
	ER visits, respiratory	493, 786.07, 786.09; 491, 492, and 496; 460–465, 460.0, and 477; 480–486; 466.1, 466.11, and 466.19	all ages	log-linear	none	avg of 0-,1-day, and 2-day	24-hr avg.	Atlanta	0.00046	-0.00046	0.00136

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, cardiovascular	I01-I59	all ages	log-linear	none	avg of 0- and 1-day	24-hr avg.	Atlanta	0.00066	-0.00066	0.00198
								Baltimore	0.00128	-0.00009	0.00265
								Birmingham	-0.00002	-0.00140	0.00135
								Dallas	0.00086	-0.00056	0.00228
								Detroit	0.00097	-0.00012	0.00205
								Fresno	0.00082	-0.00056	0.00219
								Houston	0.00084	-0.00056	0.00223
								Los Angeles	-0.00018	-0.00080	0.00044
								New York	0.00196	0.00114	0.00278
								Philadelphia	0.00179	0.00046	0.00313
								Phoenix	0.00142	-0.00006	0.00291
								Pittsburgh	0.00102	-0.00020	0.00225
								Salt Lake City	0.00117	-0.00027	0.00260
								St. Louis	0.00158	0.00035	0.00282
								Tacoma	0.00104	-0.00055	0.00262

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, non-accidental	A00-R99	all ages	log-linear	none	avg of 0- and 1-day	24-hr avg.	Atlanta	0.00094	0.00018	0.00170
								Baltimore	0.00135	0.00054	0.00215
								Birmingham	0.00032	-0.00050	0.00115
								Dallas	0.00112	0.00027	0.00198
								Detroit	0.00068	-0.00012	0.00147
								Fresno	0.00096	0.00014	0.00178
								Houston	0.00104	0.00021	0.00188
								Los Angeles	0.00016	-0.00023	0.00055
								New York	0.00132	0.00077	0.00186
								Philadelphia	0.00126	0.00046	0.00206
								Phoenix	0.00110	0.00018	0.00202
								Pittsburgh	0.00104	0.00030	0.00177
								Salt Lake City	0.00105	0.00021	0.00188
								St. Louis	0.00105	0.00030	0.00180
								Tacoma	0.00117	0.00020	0.00214

Table C-1 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: All-Year Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Model	Other Pollutants in Model	Lag	Metric	Region Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, respiratory	J00-J99	all ages	log-linear	none	avg of 0- and 1-day	24-hr avg.	Atlanta	0.00121	-0.00048	0.00290
								Baltimore	0.00211	0.00039	0.00384
								Birmingham	0.00096	-0.00076	0.00268
								Dallas	0.00093	-0.00084	0.00270
								Detroit	0.00169	0.00008	0.00330
								Fresno	0.00175	0.00006	0.00344
								Houston	0.00211	0.00033	0.00388
								Los Angeles	0.00112	0.00011	0.00213
								New York	0.00216	0.00075	0.00356
								Philadelphia	0.00157	-0.00015	0.00329
								Phoenix	0.00194	0.00015	0.00374
								Pittsburgh	0.00149	-0.00014	0.00313
								Salt Lake City	0.00194	0.00024	0.00364
								St. Louis	0.00132	-0.00034	0.00298
								Tacoma	0.00179	-0.00005	0.00363

Table C-2. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Bell et al. (2008)	HA (unscheduled), cardiovascular	426–427, 428, 430–438; 410–414, 429; 440–449	65+	none	0-day	Northeast	Winter	0.00199	0.00138	0.00260
							Spring	0.00095	0.00032	0.00157
							Summer	0.00055	0.00008	0.00101
							Fall	0.00102	0.00048	0.00157
						Northwest	Winter	0.00085	-0.00420	0.00589
							Spring	-0.00007	-0.01324	0.01309
							Summer	-0.00156	-0.01651	0.01337
							Fall	-0.00067	-0.00721	0.00587
						Southeast	Winter	0.00105	-0.00007	0.00219
							Spring	0.00075	-0.00026	0.00176
							Summer	-0.00067	-0.00161	0.00026
							Fall	0.00017	-0.00072	0.00106
						Southwest	Winter	0.00076	-0.00025	0.00177
							Spring	0.00176	-0.00087	0.00441
							Summer	-0.00121	-0.00502	0.00262
							Fall	0.00030	-0.00098	0.00158
	HA (unscheduled), respiratory	490–492; 464–466, 480–487	65+		2-day	Northeast	Winter	0.00079	-0.00021	0.00178
							Spring	0.00004	-0.00088	0.00097
							Summer	0.00077	-0.00001	0.00155
							Fall	0.00012	-0.00082	0.00106
						Northwest	Winter	-0.00006	-0.00674	0.00663
							Spring	0.00226	-0.01539	0.01991
							Summer	0.00074	-0.02074	0.02220
							Fall	-0.00074	-0.01062	0.00915
						Southeast	Winter	0.00040	-0.00146	0.00224
							Spring	0.00075	-0.00082	0.00231
							Summer	-0.00052	-0.00209	0.00105
							Fall	0.00014	-0.00130	0.00158
						Southwest	Winter	0.00119	-0.00010	0.00249
							Spring	0.00104	-0.00220	0.00430
							Summer	0.00238	-0.00264	0.00741
							Fall	0.00097	-0.00137	0.00330
Ito et al. (2007)	ER visits, asthma	493	all ages	none	avg of 0- and 1-day	New York	April-August	0.00759	0.00486	0.01032
				O3		New York	April-August	0.00602	0.00322	0.00883
				NO2		New York	April-August	0.00334	0.00029	0.00640
				CO		New York	April-August	0.00647	0.00356	0.00939
				SO2		New York	April-August	0.00469	0.00163	0.00775

Table C-2 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, short-term cardiovascular	I01-I59	all ages	none	avg of 0- and 1-day	Atlanta	Winter	0.00135	-0.00193	0.00462
						Atlanta	Spring	0.00076	-0.00273	0.00425
						Atlanta	Summer	0.00062	-0.00222	0.00347
						Atlanta	Fall	-0.00018	-0.00293	0.00257
						Baltimore	Winter	0.00104	-0.00196	0.00405
						Baltimore	Spring	0.00085	-0.00269	0.00438
						Baltimore	Summer	0.00067	-0.00251	0.00384
						Baltimore	Fall	0.00296	-0.00017	0.00609
						Birmingham	Winter	0.00080	-0.00283	0.00443
						Birmingham	Spring	0.00016	-0.00333	0.00365
						Birmingham	Summer	-0.00004	-0.00301	0.00293
						Birmingham	Fall	-0.00189	-0.00485	0.00106
						Dallas	Winter	0.00120	-0.00214	0.00454
						Dallas	Spring	0.00125	-0.00222	0.00472
						Dallas	Summer	0.00115	-0.00223	0.00453
						Dallas	Fall	-0.00022	-0.00349	0.00306
						Detroit	Winter	-0.00006	-0.00203	0.00191
						Detroit	Spring	0.00166	-0.00045	0.00378
						Detroit	Summer	0.00136	-0.00099	0.00371
						Detroit	Fall	0.00226	-0.00001	0.00452
						Fresno	Winter	-0.00033	-0.00201	0.00135
						Fresno	Spring	0.00050	-0.00138	0.00238
						Fresno	Summer	0.00019	-0.00173	0.00211
						Fresno	Fall	0.00071	-0.00105	0.00248
						Houston	Winter	0.00070	-0.00285	0.00425
						Houston	Spring	0.00013	-0.00347	0.00373
						Houston	Summer	0.00183	-0.00142	0.00509
						Houston	Fall	0.00046	-0.00246	0.00337
						Los Angeles	Winter	-0.00014	-0.00109	0.00080
						Los Angeles	Spring	0.00007	-0.00113	0.00127
						Los Angeles	Summer	-0.00106	-0.00253	0.00042
						Los Angeles	Fall	0.00000	-0.00099	0.00099

Table C-2 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, short-term cardiovascular	I01-I59	all ages	none	avg of 0- and 1-day	New York	Winter	0.00204	0.00048	0.00360
						New York	Spring	0.00231	0.00050	0.00412
						New York	Summer	0.00202	0.00038	0.00366
						New York	Fall	0.00205	0.00047	0.00363
						Philadelphia	Winter	0.00214	-0.00042	0.00470
						Philadelphia	Spring	0.00153	-0.00135	0.00441
						Philadelphia	Summer	0.00178	-0.00082	0.00438
						Philadelphia	Fall	0.00300	0.00044	0.00555
						Phoenix	Winter	---[1]	---	---
						Phoenix	Spring	---	---	---
						Phoenix	Summer	---	---	---
						Phoenix	Fall	---	---	---
						Pittsburgh	Winter	0.00150	-0.00102	0.00401
						Pittsburgh	Spring	0.00284	0.00026	0.00543
						Pittsburgh	Summer	0.00085	-0.00148	0.00318
						Pittsburgh	Fall	0.00047	-0.00185	0.00279
						Salt Lake City	Winter	---	---	---
						Salt Lake City	Spring	---	---	---
						Salt Lake City	Summer	---	---	---
						Salt Lake City	Fall	---	---	---
						St. Louis	Winter	-0.00013	-0.00297	0.00270
						St. Louis	Spring	0.00278	-0.00013	0.00568
						St. Louis	Summer	0.00188	-0.00084	0.00459
						St. Louis	Fall	0.00253	-0.00022	0.00527
						Tacoma	Winter	0.00006	-0.00182	0.00193
						Tacoma	Spring	0.00020	-0.00173	0.00212
						Tacoma	Summer	0.00025	-0.00168	0.00219
						Tacoma	Fall	0.00053	-0.00136	0.00242

Table C-2 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, short-term non-accidental	A00-R99	all ages	none	avg of 0- and 1-day	Atlanta	Winter	0.00133	0.00020	0.00246
						Atlanta	Spring	0.00123	0.00007	0.00238
						Atlanta	Summer	0.00078	-0.00027	0.00184
						Atlanta	Fall	0.00069	-0.00035	0.00172
						Baltimore	Winter	0.00126	0.00016	0.00236
						Baltimore	Spring	0.00119	0.00002	0.00236
						Baltimore	Summer	0.00100	-0.00011	0.00212
						Baltimore	Fall	0.00129	0.00017	0.00240
						Birmingham	Winter	0.00097	-0.00022	0.00216
						Birmingham	Spring	0.00105	-0.00012	0.00222
						Birmingham	Summer	0.00049	-0.00061	0.00160
						Birmingham	Fall	0.00035	-0.00074	0.00144
						Dallas	Winter	0.00099	-0.00017	0.00215
						Dallas	Spring	0.00090	-0.00027	0.00208
						Dallas	Summer	0.00106	-0.00008	0.00221
						Dallas	Fall	0.00132	0.00018	0.00247
						Detroit	Winter	-0.00009	-0.00125	0.00107
						Detroit	Spring	0.00174	0.00043	0.00304
						Detroit	Summer	0.00090	-0.00053	0.00233
						Detroit	Fall	0.00072	-0.00066	0.00210
						Fresno	Winter	0.00002	-0.00159	0.00163
						Fresno	Spring	0.00225	-0.00021	0.00471
						Fresno	Summer	0.00054	-0.00217	0.00325
						Fresno	Fall	0.00088	-0.00090	0.00266
						Houston	Winter	0.00106	-0.00011	0.00223
						Houston	Spring	0.00129	0.00010	0.00248
						Houston	Summer	0.00092	-0.00023	0.00207
						Houston	Fall	0.00092	-0.00015	0.00199
						Los Angeles	Winter	0.00012	-0.00059	0.00083
						Los Angeles	Spring	0.00059	-0.00031	0.00149
						Los Angeles	Summer	-0.00084	-0.00208	0.00039
						Los Angeles	Fall	-0.00002	-0.00067	0.00064

Table C-2 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, short-term non-accidental	A00-R99	all ages	none	avg of 0- and 1-day	New York	Winter	0.00168	0.00061	0.00275
						New York	Spring	0.00123	0.00001	0.00245
						New York	Summer	0.00074	-0.00029	0.00177
						New York	Fall	0.00181	0.00078	0.00285
						Philadelphia	Winter	0.00195	0.00041	0.00350
						Philadelphia	Spring	0.00078	-0.00090	0.00247
						Philadelphia	Summer	0.00064	-0.00089	0.00217
						Philadelphia	Fall	0.00200	0.00050	0.00350
						Phoenix	Winter	---	---	---
						Phoenix	Spring	---	---	---
						Phoenix	Summer	---	---	---
						Phoenix	Fall	---	---	---
						Pittsburgh	Winter	0.00135	-0.00013	0.00283
						Pittsburgh	Spring	0.00193	0.00034	0.00352
						Pittsburgh	Summer	0.00090	-0.00047	0.00227
						Pittsburgh	Fall	0.00062	-0.00073	0.00197
						Salt Lake City	Winter	0.00113	-0.00013	0.00240
						Salt Lake City	Spring	0.00152	-0.00047	0.00352
						Salt Lake City	Summer	0.00106	-0.00095	0.00308
						Salt Lake City	Fall	0.00131	-0.00051	0.00314
						St. Louis	Winter	0.00054	-0.00055	0.00164
						St. Louis	Spring	0.00136	0.00025	0.00247
						St. Louis	Summer	0.00097	-0.00009	0.00203
						St. Louis	Fall	0.00129	0.00022	0.00236
						Tacoma	Winter	0.00006	-0.00236	0.00249
						Tacoma	Spring	0.00154	-0.00123	0.00431
						Tacoma	Summer	0.00088	-0.00203	0.00378
						Tacoma	Fall	0.00145	-0.00099	0.00389

Table C-2 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, short-term respiratory	J00-J99	all ages	none	avg of 0- and 1-day	Atlanta	Winter	0.00093	-0.00144	0.00329
						Atlanta	Spring	0.00035	-0.00205	0.00275
						Atlanta	Summer	0.00077	-0.00155	0.00310
						Atlanta	Fall	0.00096	-0.00134	0.00325
						Baltimore	Winter	0.00107	-0.00127	0.00340
						Baltimore	Spring	0.00144	-0.00097	0.00384
						Baltimore	Summer	0.00116	-0.00120	0.00353
						Baltimore	Fall	0.00103	-0.00134	0.00340
						Birmingham	Winter	0.00043	-0.00197	0.00282
						Birmingham	Spring	0.00079	-0.00160	0.00318
						Birmingham	Summer	-0.00018	-0.00252	0.00217
						Birmingham	Fall	0.00145	-0.00087	0.00377
						Dallas	Winter	0.00040	-0.00198	0.00278
						Dallas	Spring	0.00106	-0.00135	0.00347
						Dallas	Summer	0.00060	-0.00180	0.00300
						Dallas	Fall	0.00038	-0.00202	0.00278
						Detroit	Winter	0.00104	-0.00128	0.00335
						Detroit	Spring	0.00226	-0.00015	0.00467
						Detroit	Summer	0.00253	0.00009	0.00498
						Detroit	Fall	0.00247	0.00001	0.00492
						Fresno	Winter	-0.00022	-0.00423	0.00380
						Fresno	Spring	0.00496	-0.00093	0.01085
						Fresno	Summer	0.00263	-0.00375	0.00900
						Fresno	Fall	0.00099	-0.00383	0.00580
						Houston	Winter	0.00138	-0.00102	0.00377
						Houston	Spring	0.00129	-0.00114	0.00372
						Houston	Summer	0.00100	-0.00140	0.00341
						Houston	Fall	0.00092	-0.00143	0.00327
						Los Angeles	Winter	0.00165	-0.00016	0.00345
						Los Angeles	Spring	0.00237	-0.00018	0.00493
						Los Angeles	Summer	-0.00134	-0.00500	0.00233
						Los Angeles	Fall	-0.00003	-0.00190	0.00183

Table C-2 cont'd. Information about the Concentration-Response Functions Used in the $PM_{2.5}$ Risk Assessment: Season-Specific Functions

Study	Health Endpoint	ICD-9 or 10 Codes	Ages Covered	Other Pollutants in Model	Lag	Region Covered	Season Covered	Coefficient	Lower Bound	Upper Bound
Zanobetti and Schwartz (2009)	Mortality, short-term respiratory	J00-J99	all ages	none	avg of 0- and 1-day	New York	Winter	0.00334	0.00122	0.00547
						New York	Spring	0.00172	-0.00058	0.00403
						New York	Summer	0.00157	-0.00066	0.00381
						New York	Fall	0.00235	0.00013	0.00457
						Philadelphia	Winter	0.00217	-0.00030	0.00463
						Philadelphia	Spring	0.00219	-0.00033	0.00471
						Philadelphia	Summer	0.00182	-0.00068	0.00432
						Philadelphia	Fall	0.00186	-0.00062	0.00435
						Phoenix	Winter	0.00251	-0.00253	0.00755
						Phoenix	Spring	0.00538	-0.00140	0.01215
						Phoenix	Summer	0.00577	-0.00083	0.01238
						Phoenix	Fall	0.00887	0.00285	0.01489
						Pittsburgh	Winter	0.00134	-0.00110	0.00377
						Pittsburgh	Spring	0.00223	-0.00024	0.00470
						Pittsburgh	Summer	0.00188	-0.00052	0.00428
						Pittsburgh	Fall	0.00231	-0.00009	0.00472
						Salt Lake City	Winter	0.00301	-0.00088	0.00690
						Salt Lake City	Spring	0.00438	-0.00459	0.01336
						Salt Lake City	Summer	-0.00353	-0.01304	0.00598
						Salt Lake City	Fall	-0.00138	-0.00915	0.00639
						St. Louis	Winter	0.00019	-0.00212	0.00250
						St. Louis	Spring	0.00123	-0.00112	0.00357
						St. Louis	Summer	0.00060	-0.00171	0.00292
						St. Louis	Fall	0.00127	-0.00106	0.00360
						Tacoma	Winter	0.00011	-0.00563	0.00585
						Tacoma	Spring	0.00287	-0.00349	0.00924
						Tacoma	Summer	0.00190	-0.00467	0.00848
						Tacoma	Fall	0.00138	-0.00458	0.00733

1 --- indicates that results were not available.

APPENDIX D: SUPPLEMENT TO THE REPRESENTATIVENESS ANALYSIS OF THE 15 URBAN STUDY AREAS

Appendix D. Supplement to the Representativeness Analysis of the 15 Urban Study Areas (additional graphical comparisons of distributions for key contributors to $PM_{2.5}$ risk)

Following the analysis discussed in Section 4.4, this appendix provides graphical comparisons of the empirical distributions of components of the risk function, and additional variables that have been identified as potentially influencing the risk associated with PM exposures.

In each graph, the orange line represents the empirical cumulative distribution function (CDF) for the complete set of data available for the variable. In some cases, this may encompass all counties in the U.S., while in others it may be based on a subset of the U.S., usually for large urban areas. The green line in each graph represents the empirical cumulative distribution function for the variable based only on the data available for the set of urban case study locations. The black squares at the bottom of each graph represents the specific value of the variable for one of the case study locations, with the line showing where that value intersects the two empirical CDFs.

D.1 Elements of the Risk Equation

Figure D-1. Comparison of Distributions for Key Elements of the Risk Equation: Total Population

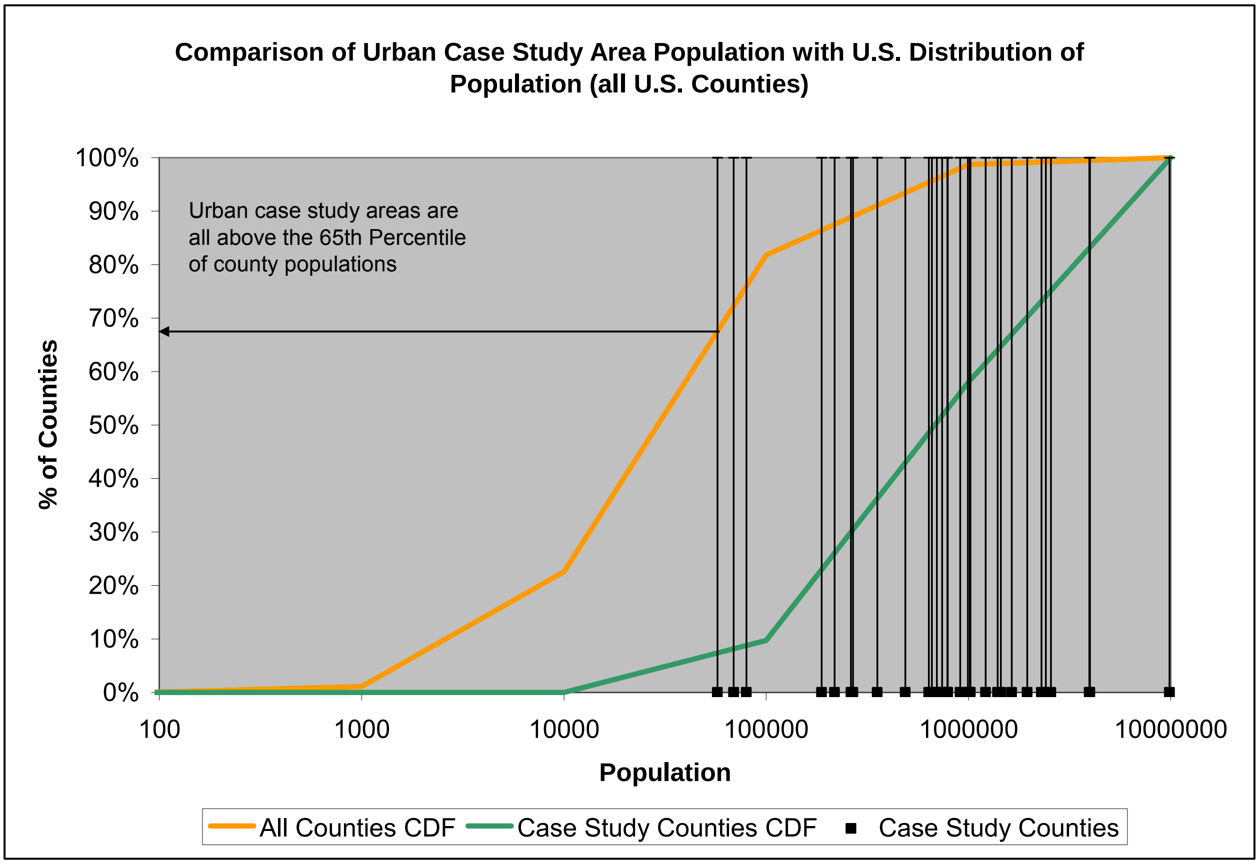


Figure D-2. Comparison of Distributions for Key Elements of the Risk Equation: Percent of Population Under 15 Years of Age

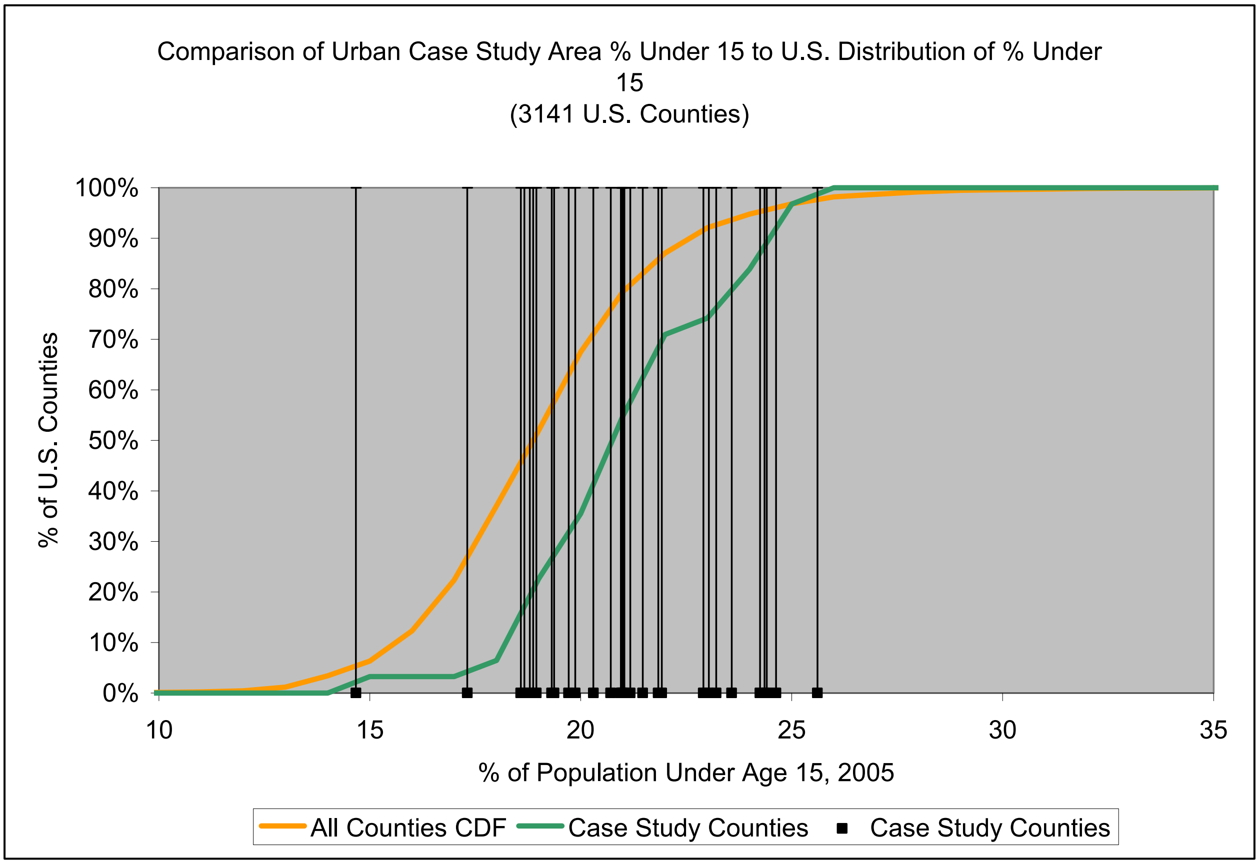


Figure D-3. Comparison of Distributions for Key Elements of the Risk Equation: Percent of Population 65 Years of Age and Older

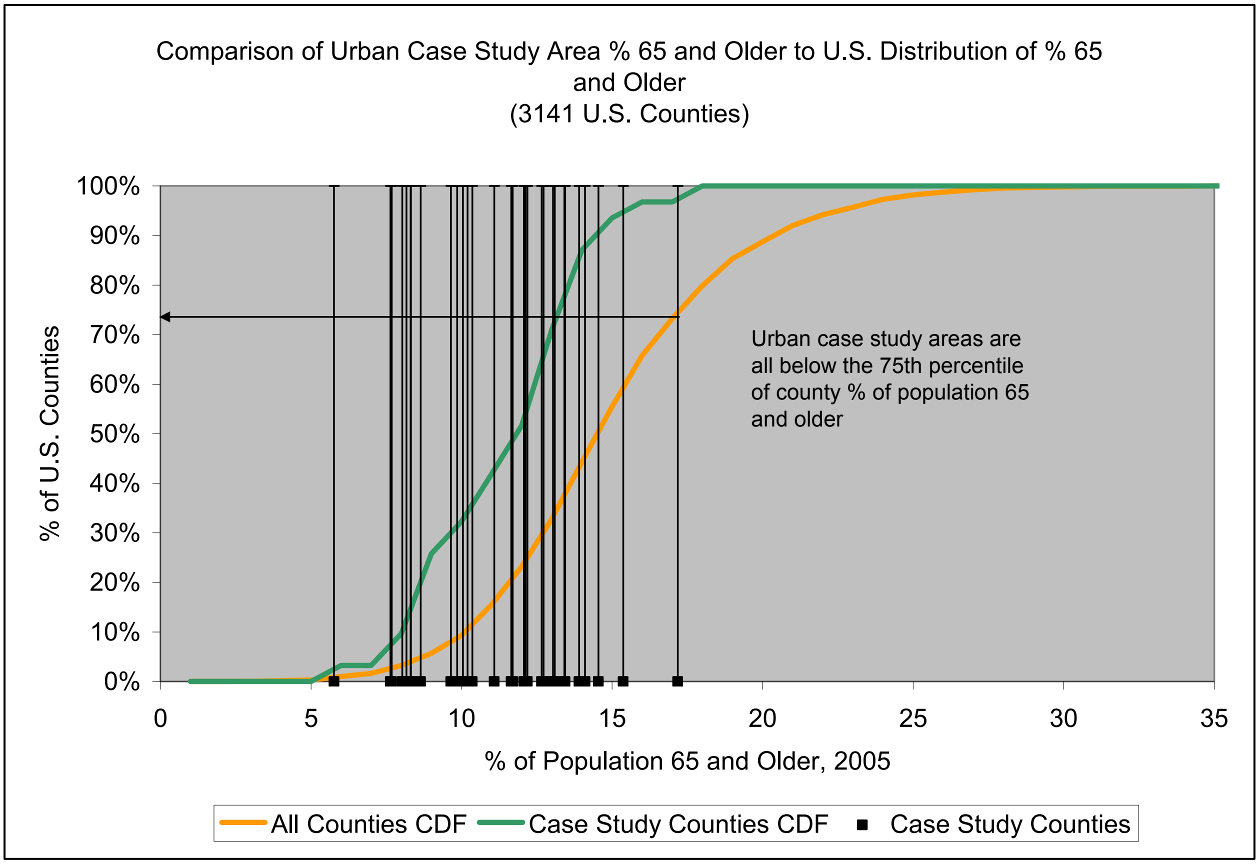


Figure D-4. Comparison of Distributions for Key Elements of the Risk Equation: Percent of Population 85 Years of Age and Older

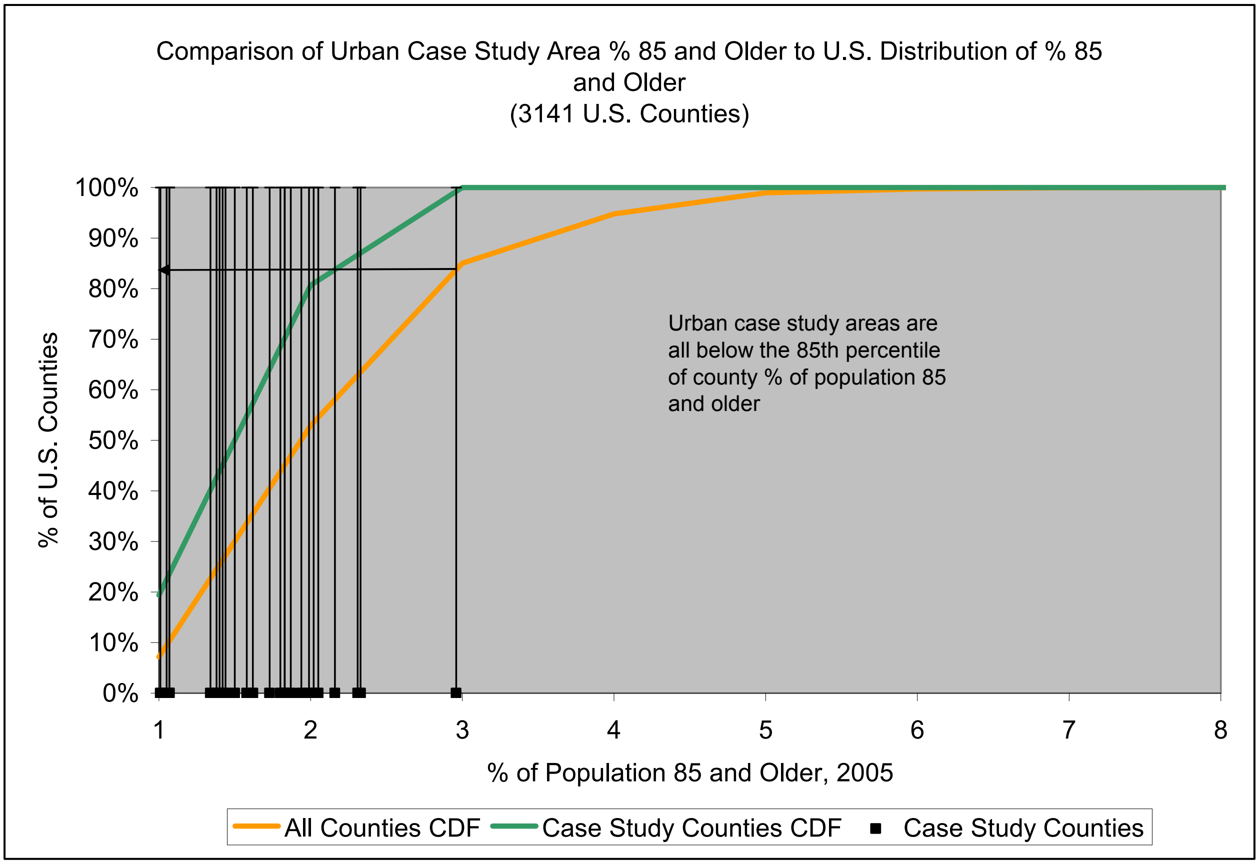


Figure D-5. Comparison of Distributions for Key Elements of the Risk Equation: Annual Mean $PM_{2.5}$

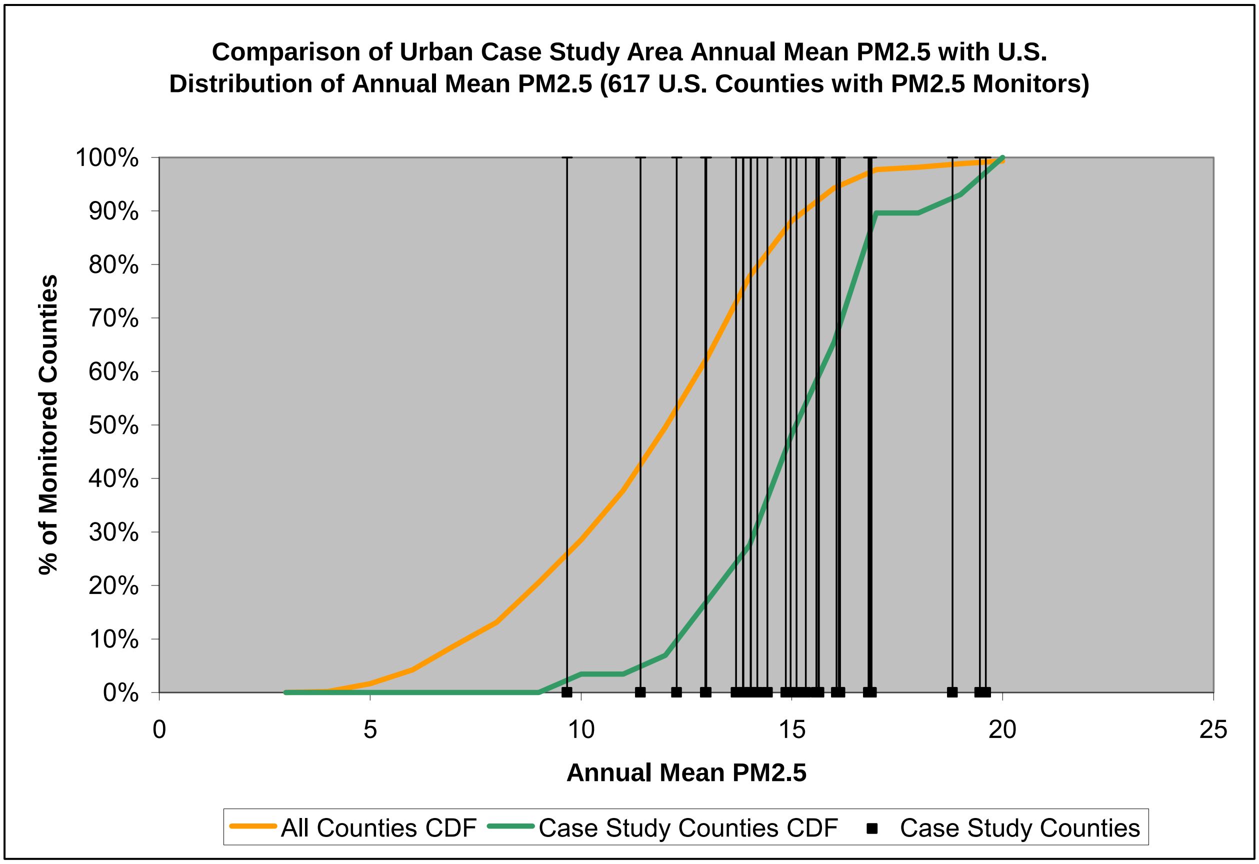


Figure D-6. Comparison of Distributions for Key Elements of the Risk Equation: 98th %ile Daily Average $PM_{2.5}$

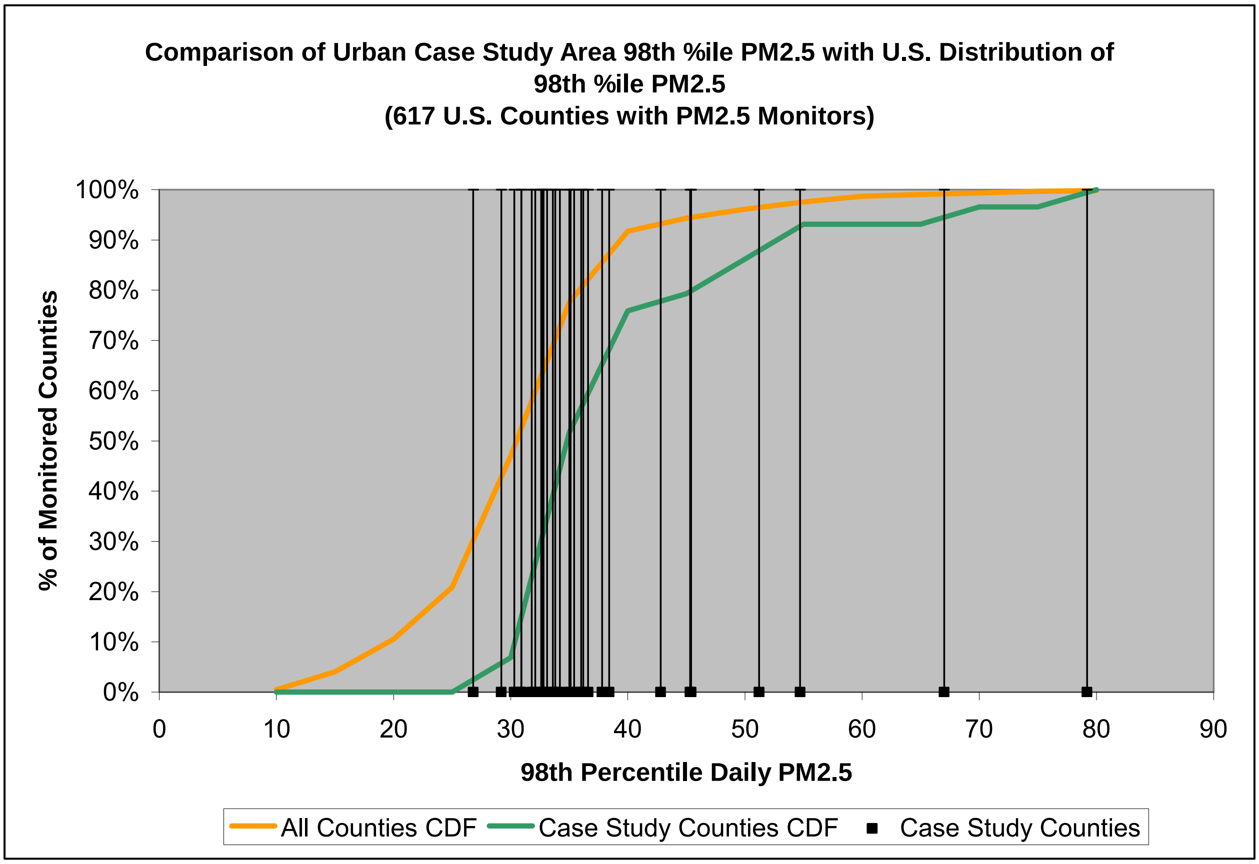


Figure D-7. Comparison of Distributions for Key Elements of the Risk Equation: % of Days with $PM_{2.5} > 35\ \mu g/m^3$

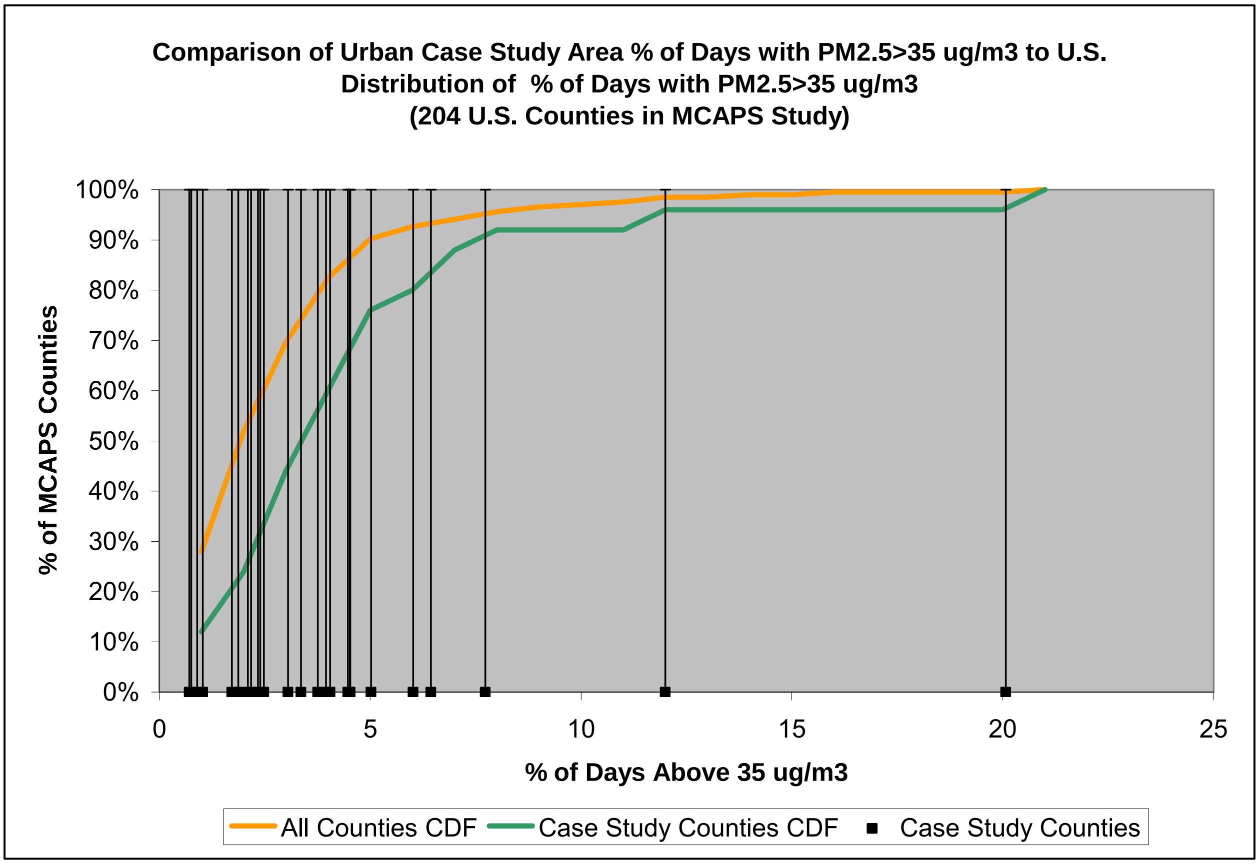


Figure D-8. Comparison of Distributions for Key Elements of the Risk Equation: All Cause Mortality Rate

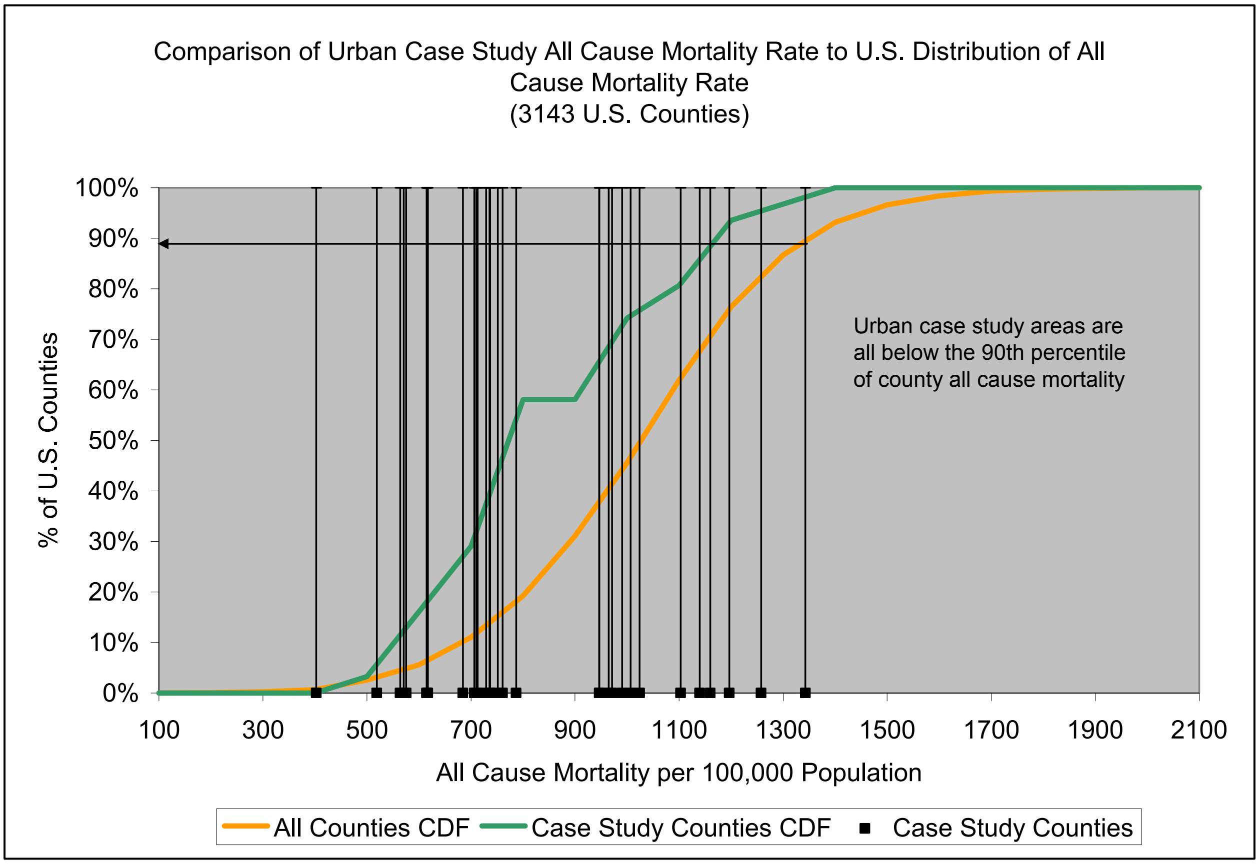


Figure D-9. Comparison of Distributions for Key Elements of the Risk Equation: Non-Accidental Mortality Rate

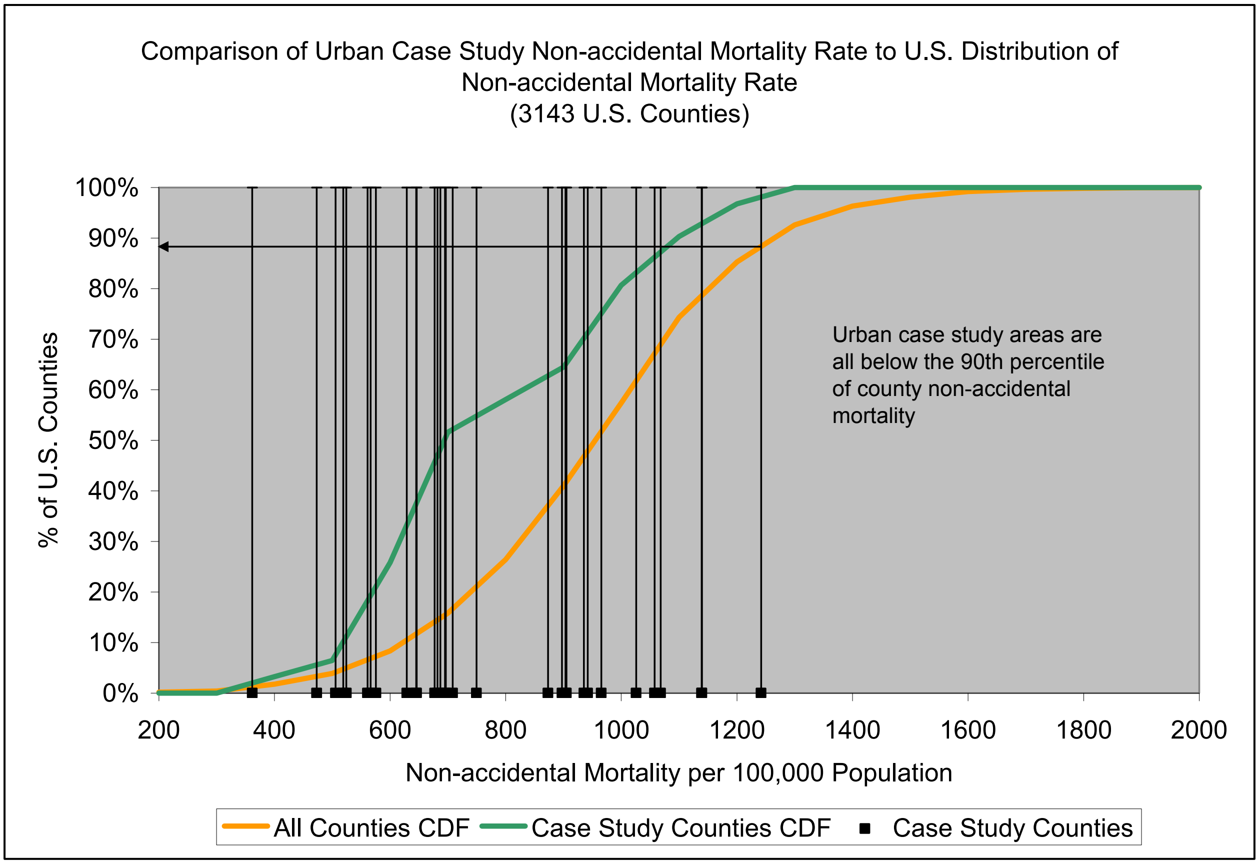


Figure D-10. Comparison of Distributions for Key Elements of the Risk Equation: Cardiovascular Mortality Rate

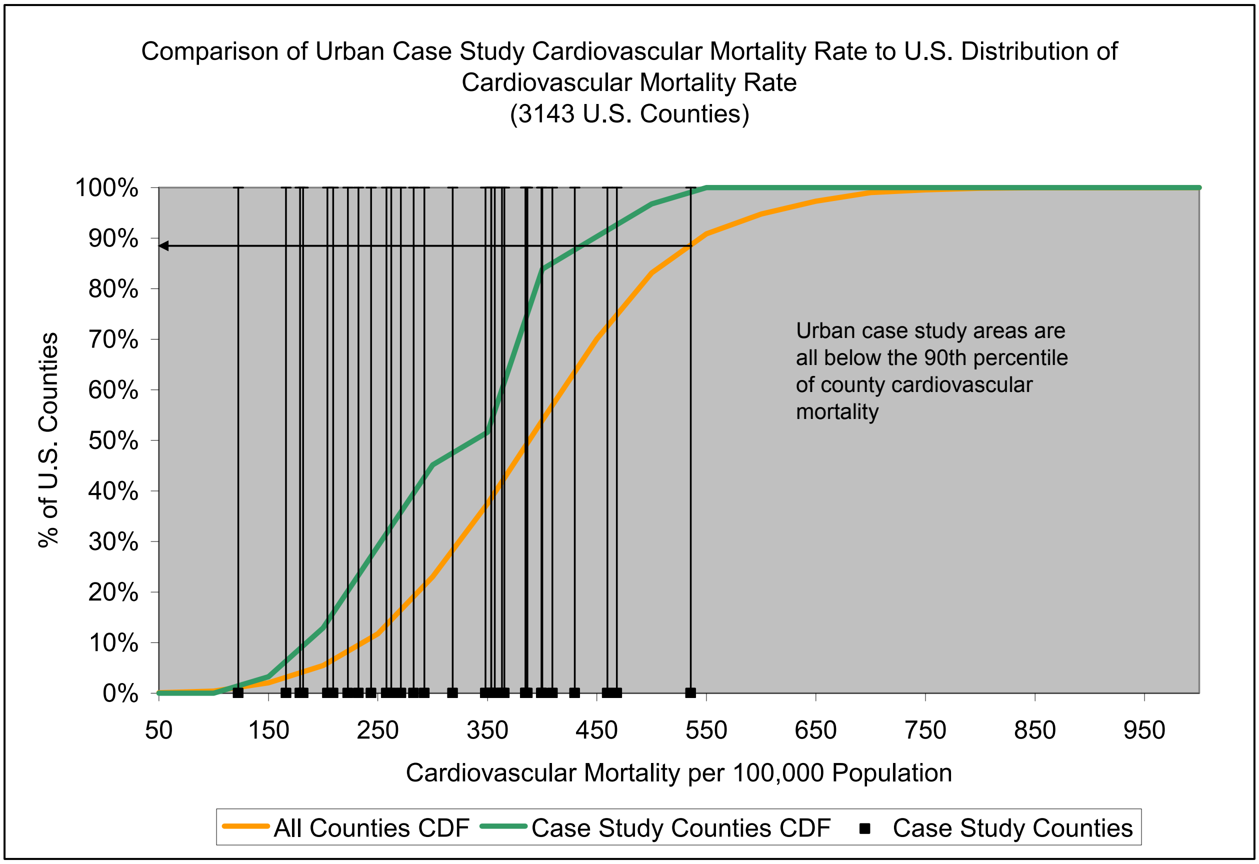


Figure D-11. Comparison of Distributions for Key Elements of the Risk Equation: Respiratory Mortality Rate

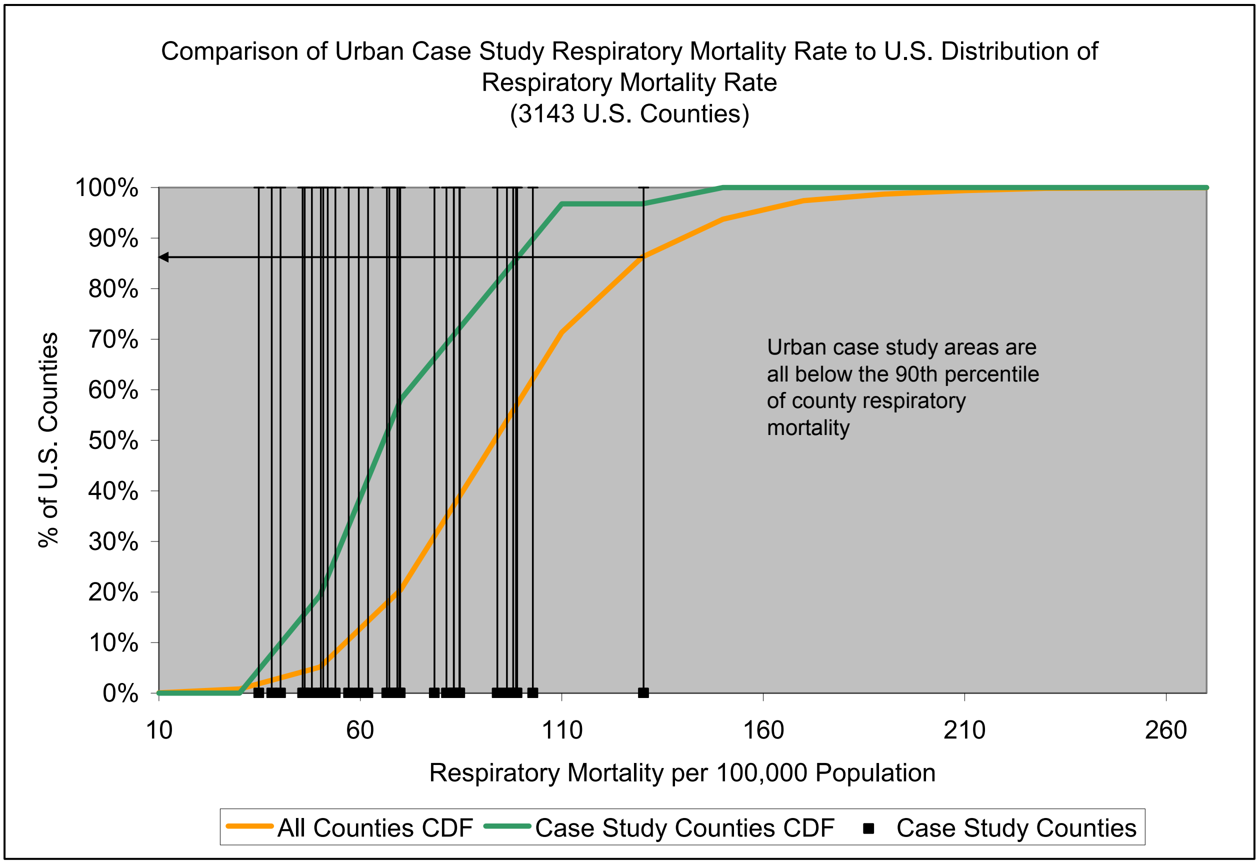


Figure D-12. Comparison of Distributions for Key Elements of the Risk Equation: All Cause Mortality Risk Effect Estimate from Zanobetti and Schwartz (2008)

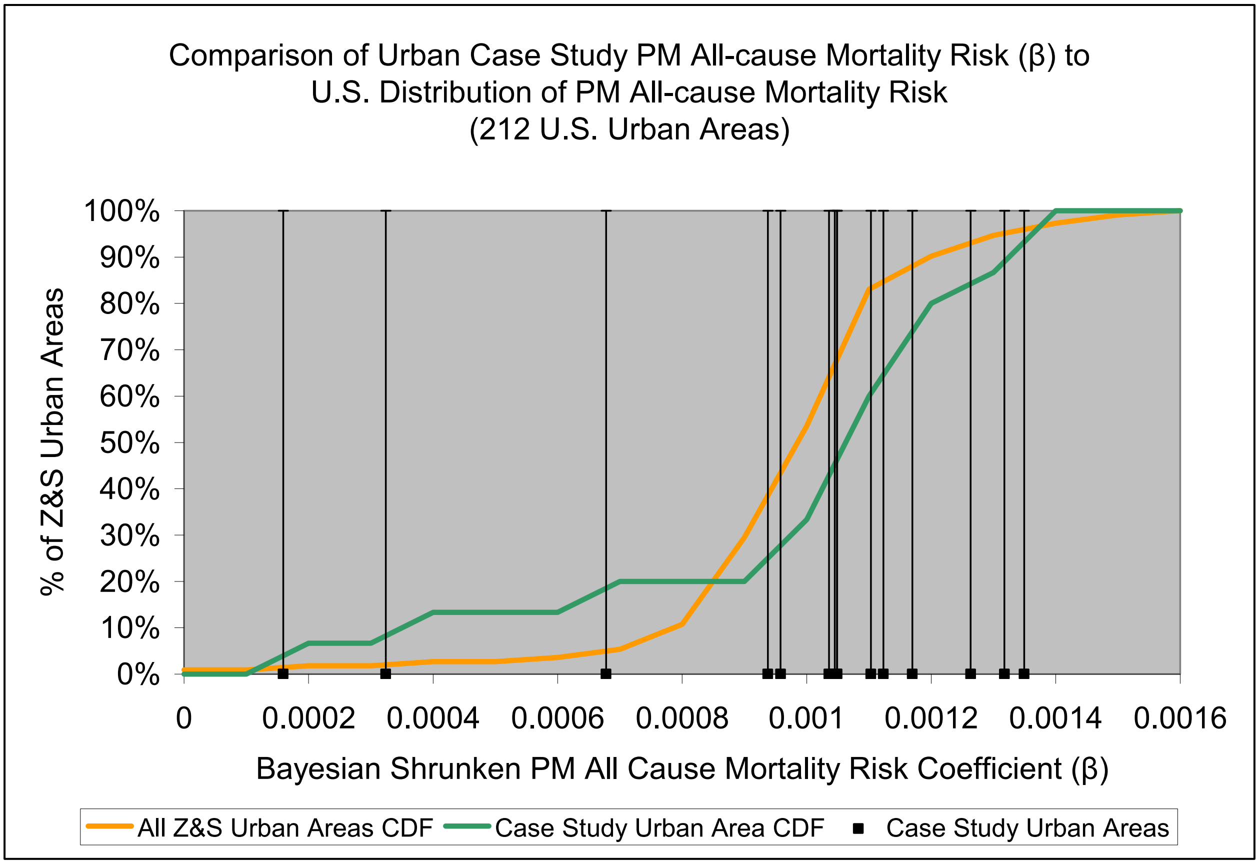


Figure D-13. Comparison of Distributions for Key Elements of the Risk Equation: Cardiovascular Mortality Risk Effect Estimate from Zanobetti and Schwartz (2008)

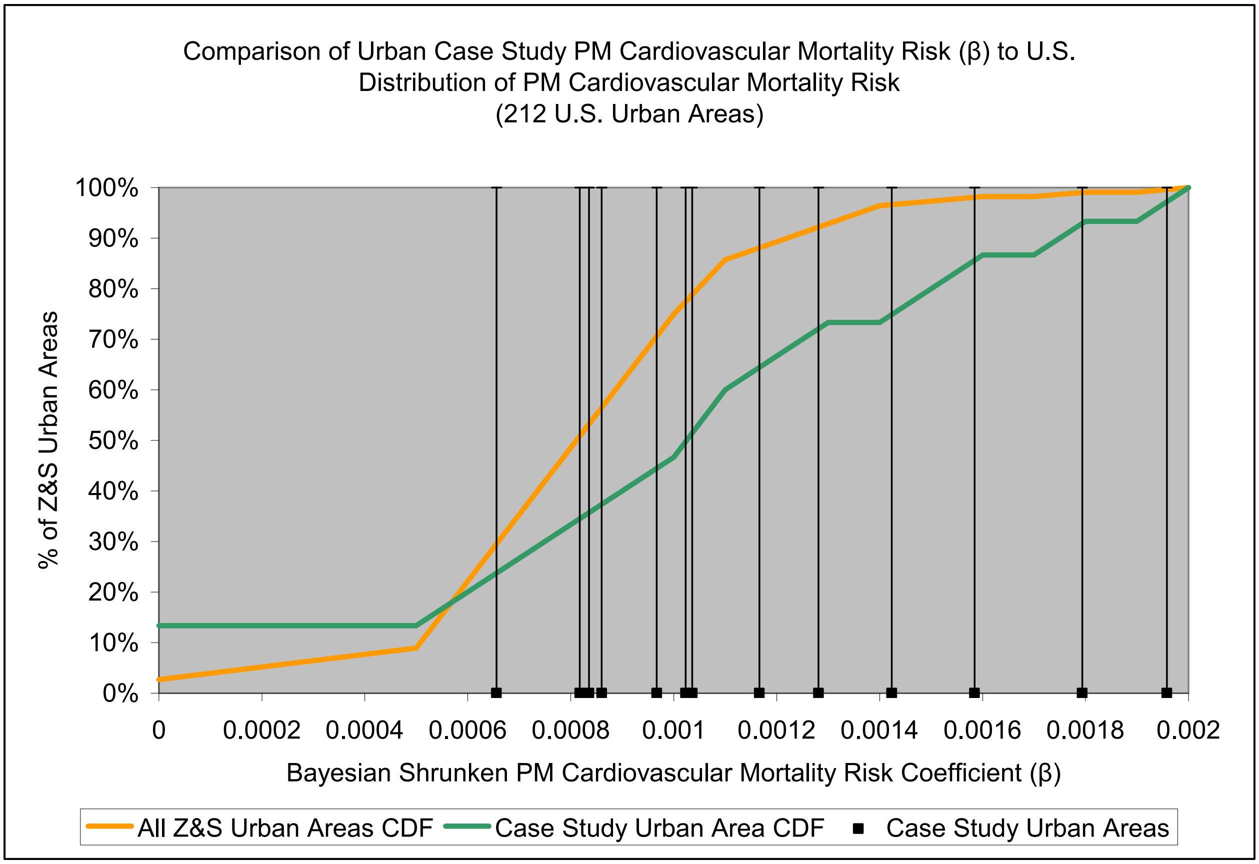
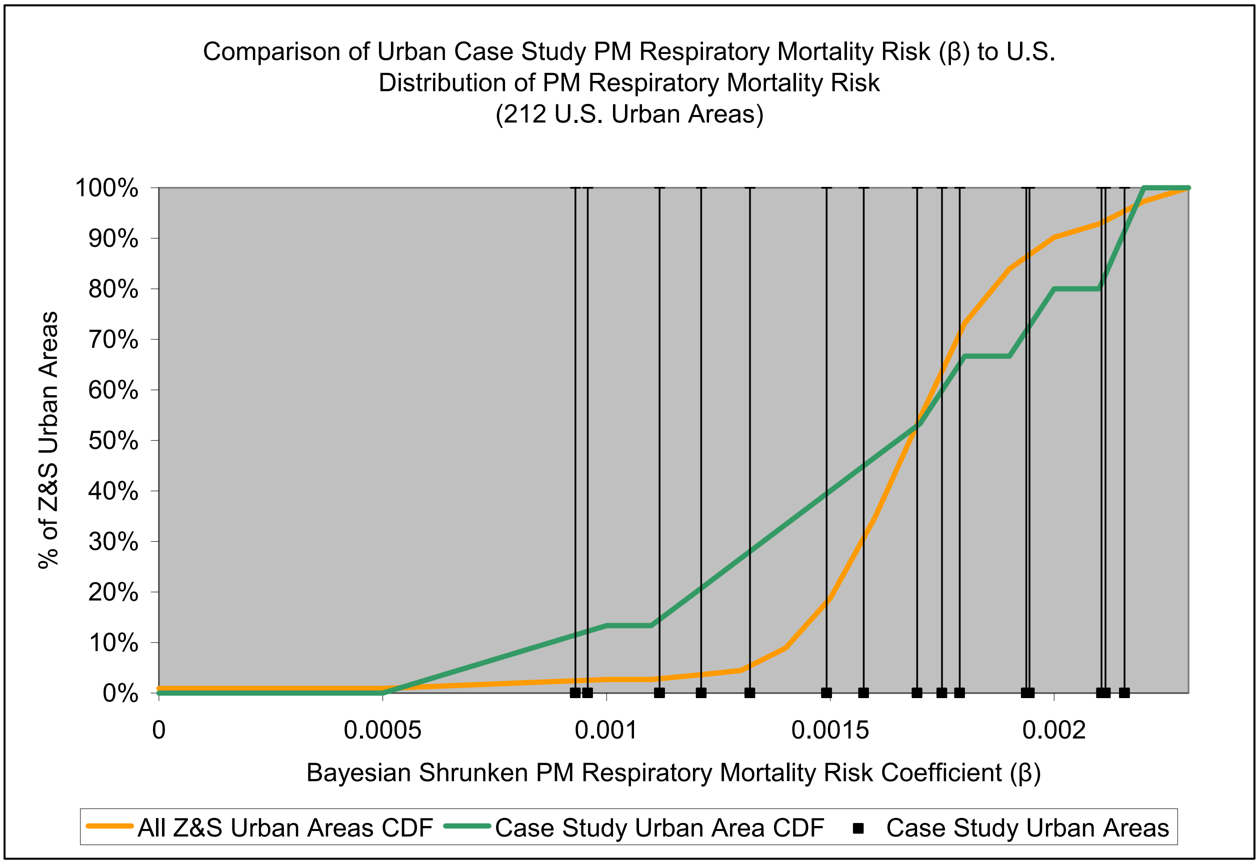


Figure D-14. Comparison of Distributions for Key Elements of the Risk Equation: Respiratory Mortality Risk Effect Estimate from Zanobetti and Schwartz (2008)



D.2. Variables Expected to Influence the Relative Risk from $PM_{2.5}$

D.2.1. Demographic Variables

Figure D-15. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Population Density

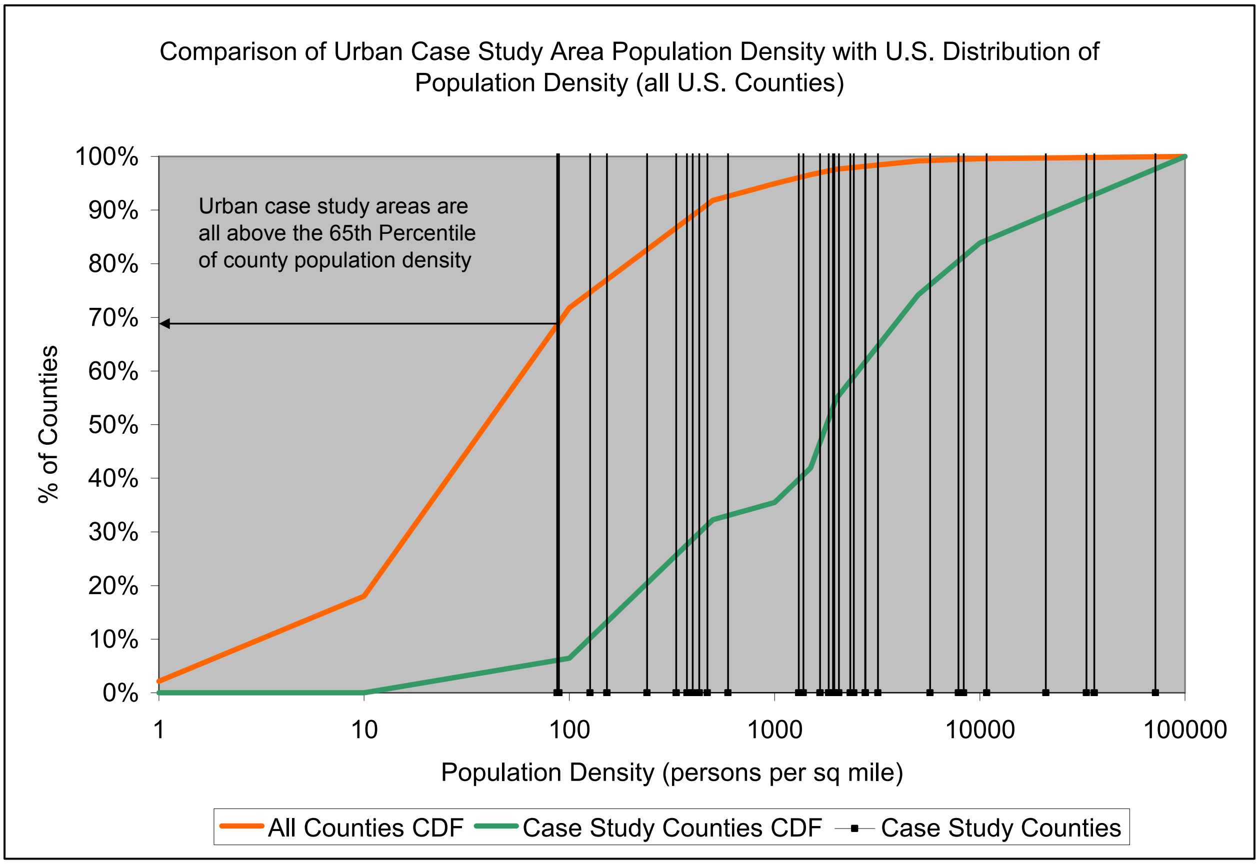


Figure D-16. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Unemployment Rate

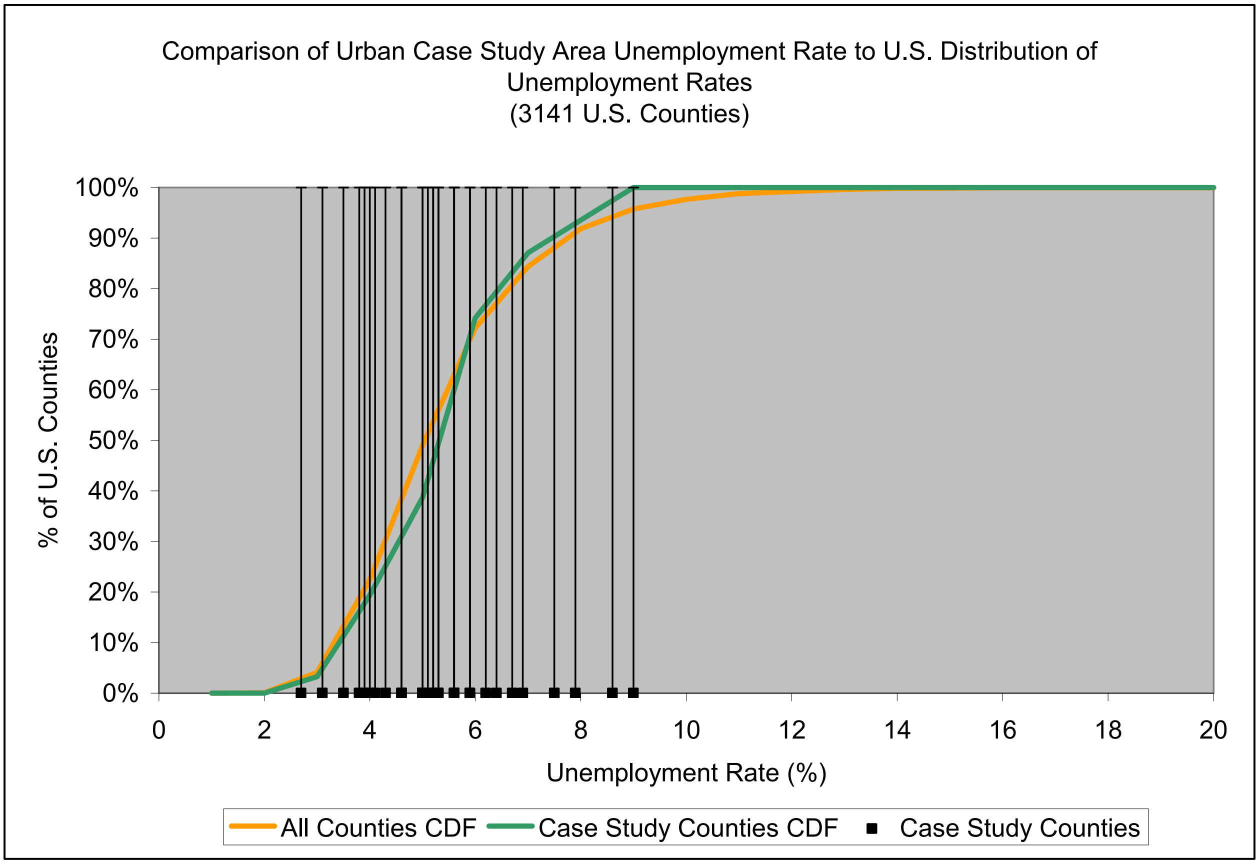


Figure D-17. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: % with Less than a High School Education

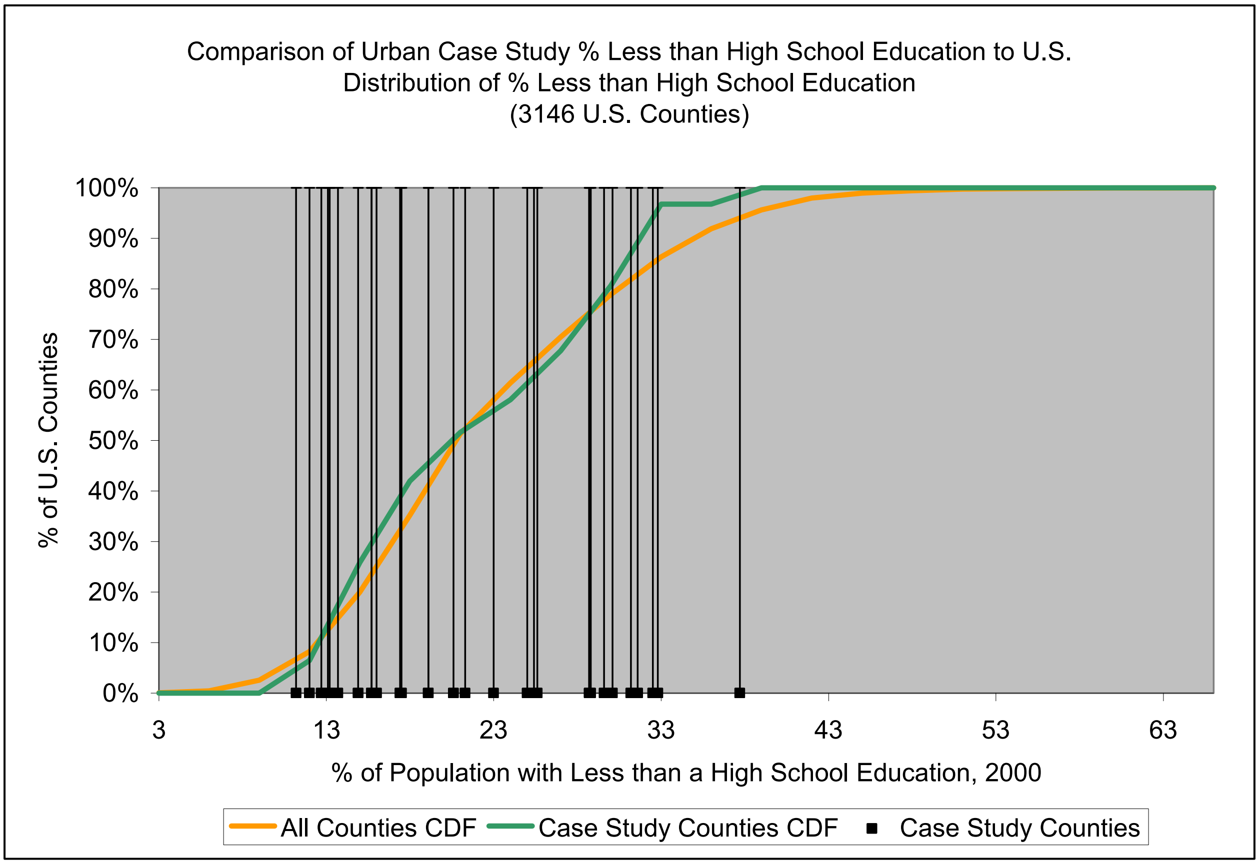


Figure D-18. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Per Capita Personal Income

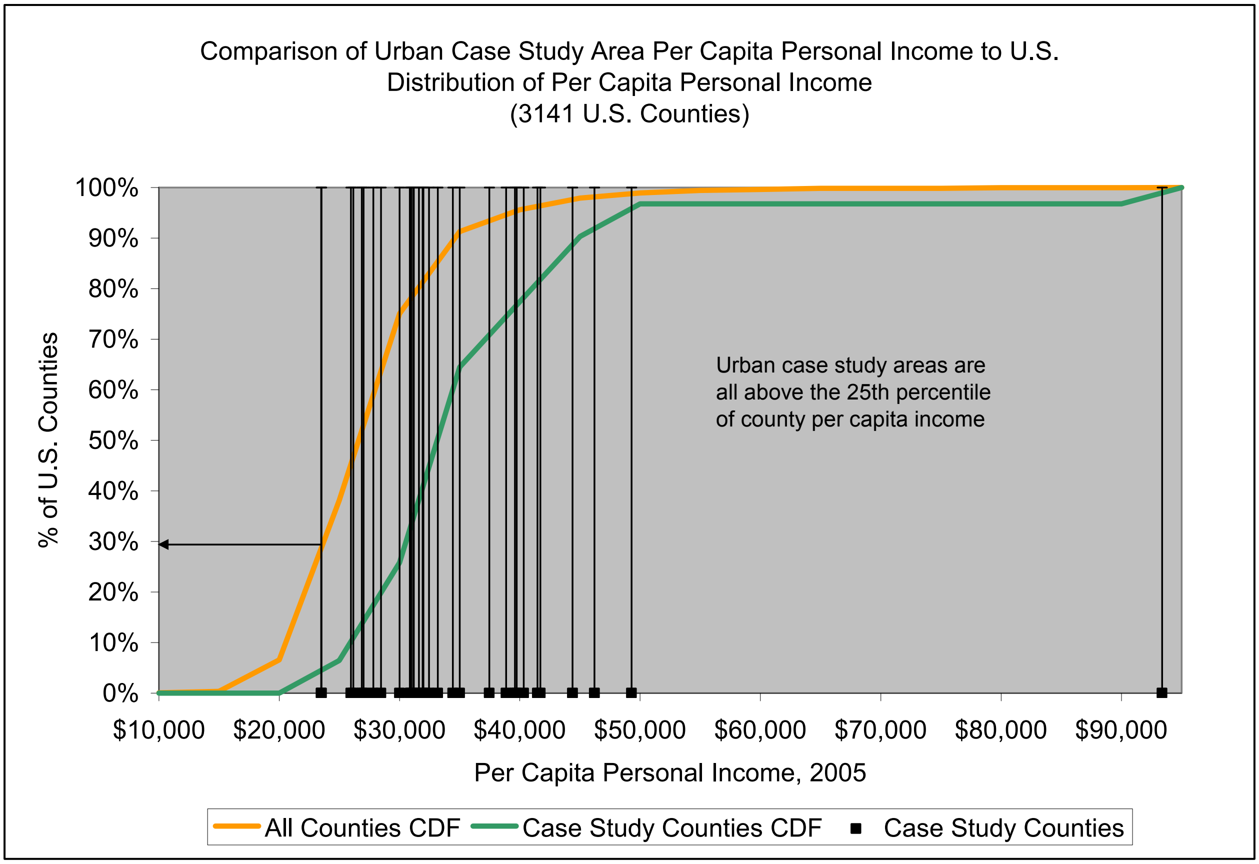


Figure D-19. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Air Conditioning Prevalence

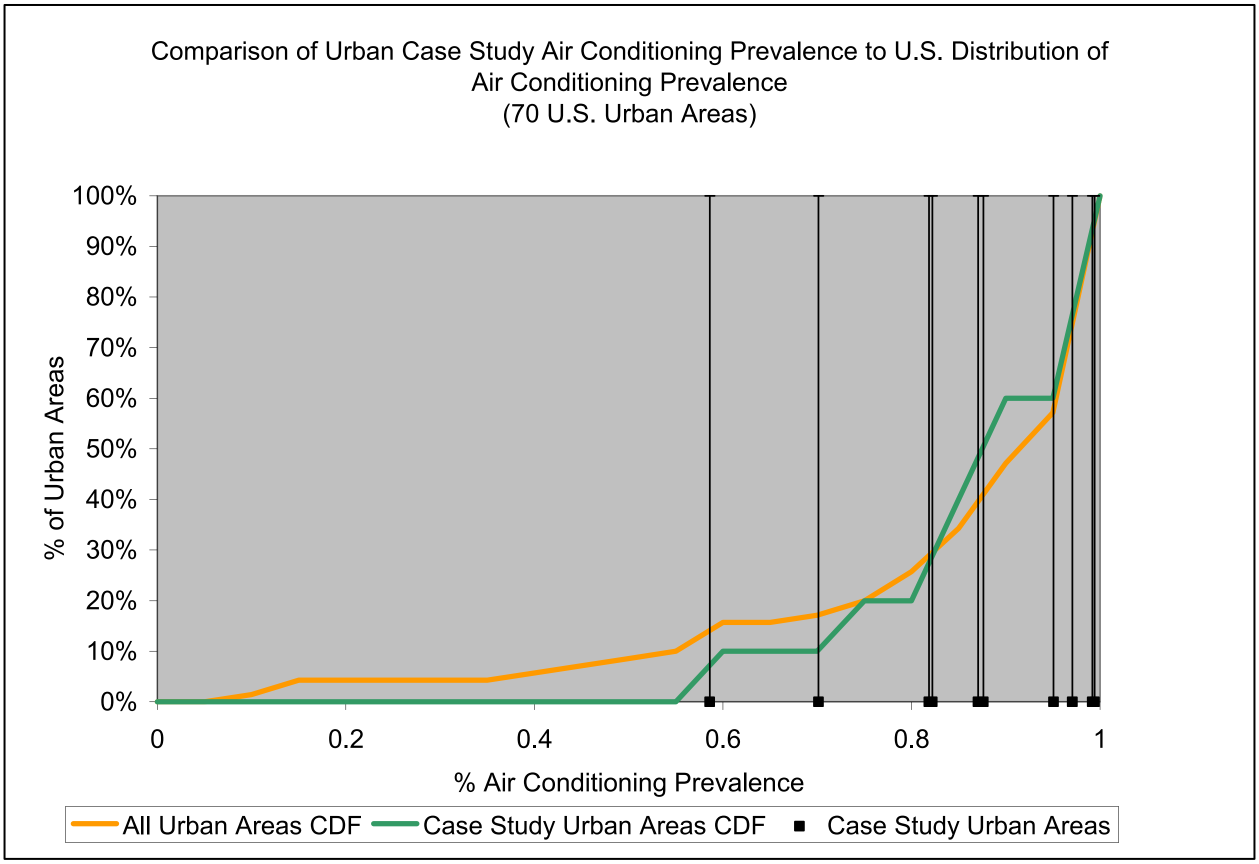
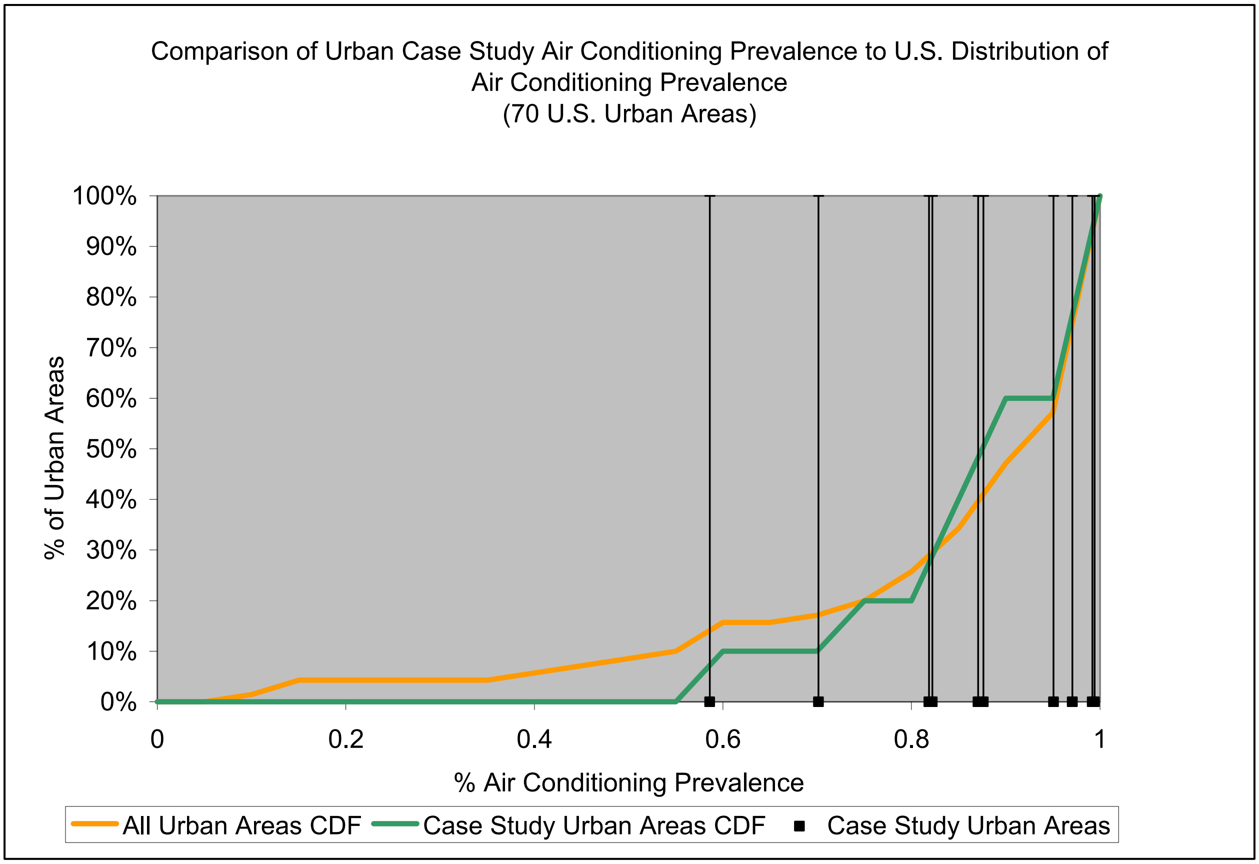


Figure D-20. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: % Non-White Population



D.2.2. Health Conditions

Figure D-21. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Angina/Coronary Heart Disease Prevalence

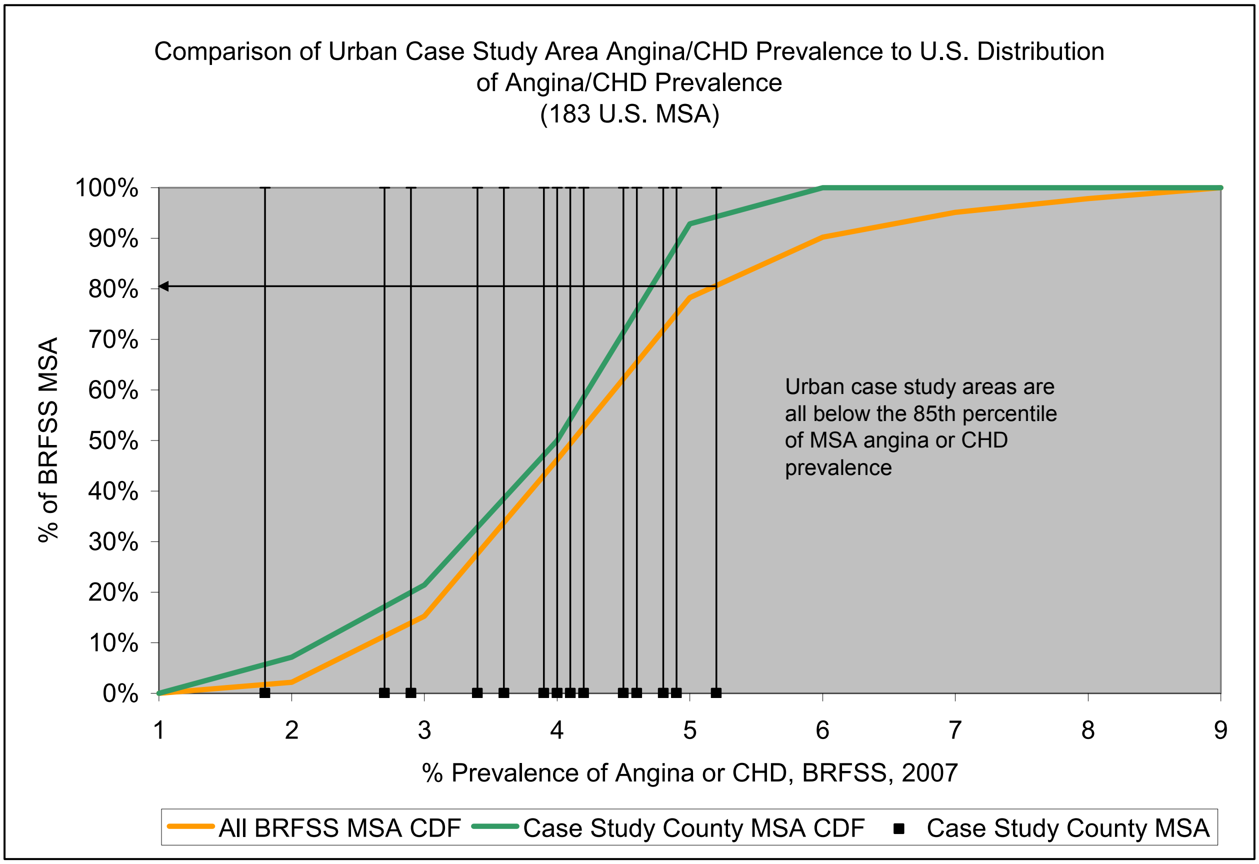


Figure D-22. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Asthma Prevalence

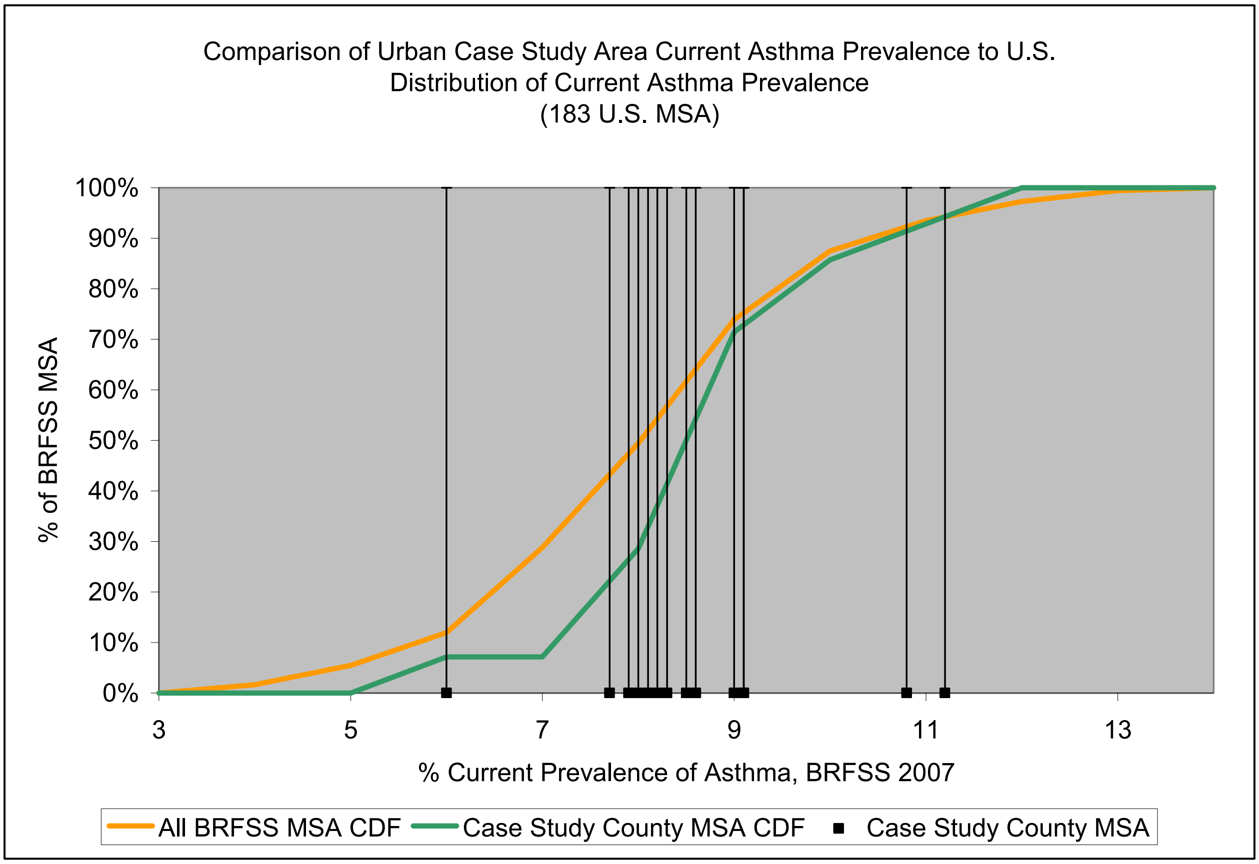


Figure D-23. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Diabetes Prevalence

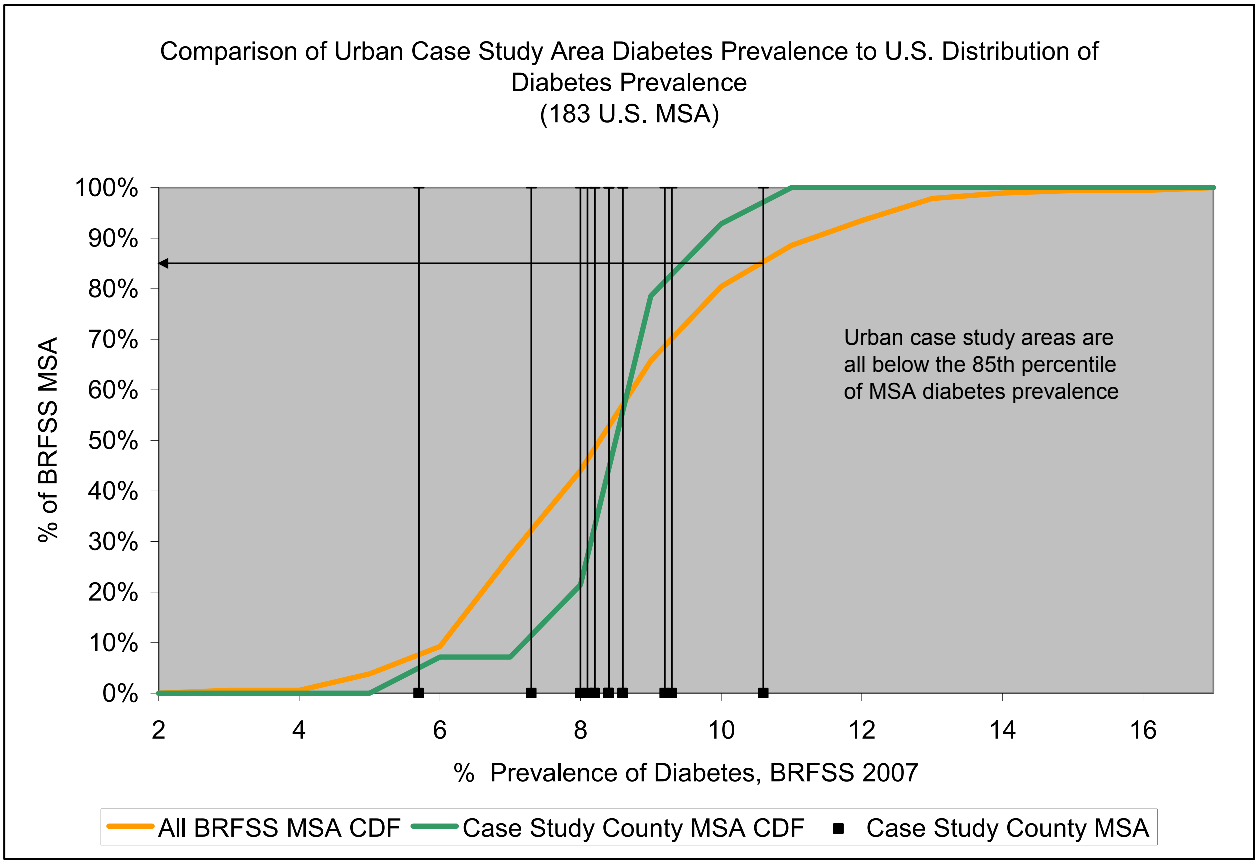


Figure D-24. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Heart Attack Prevalence

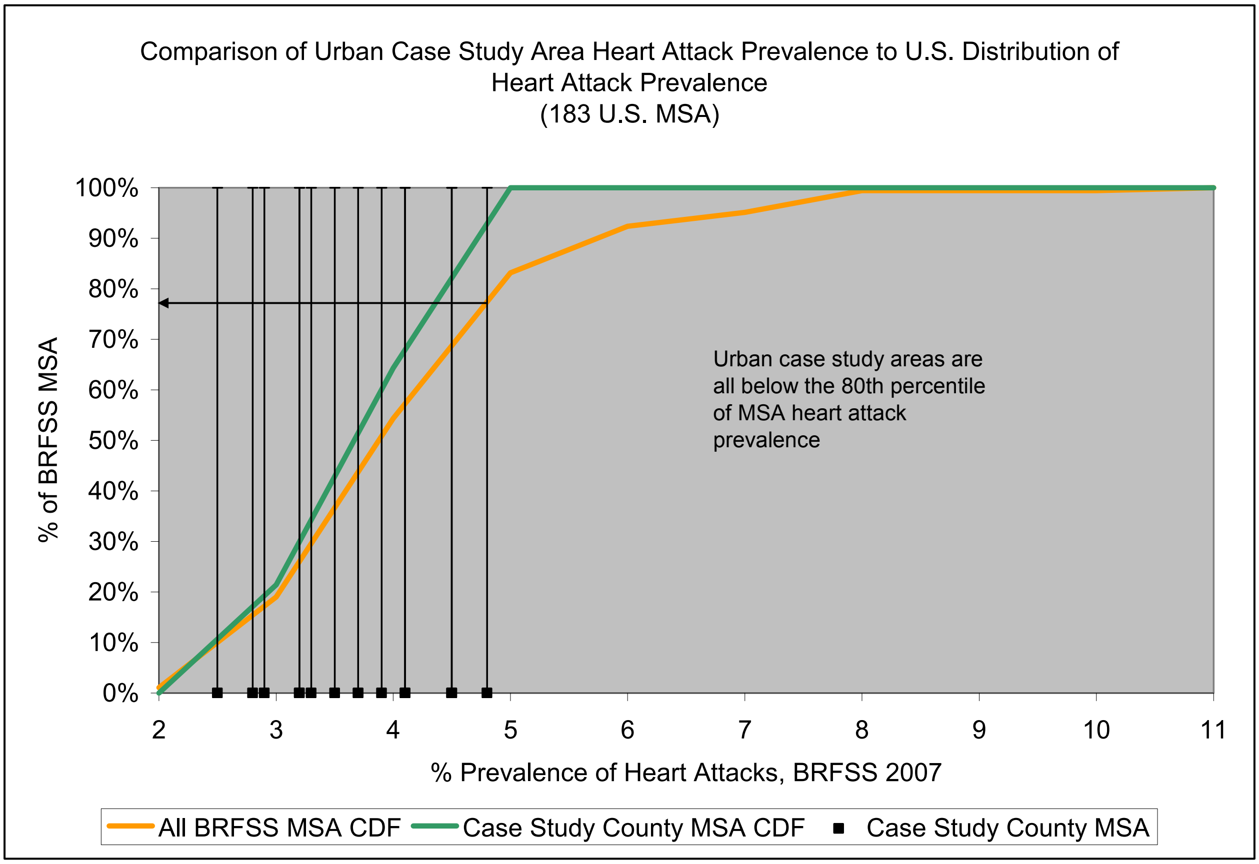


Figure D-25. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Obesity Prevalence

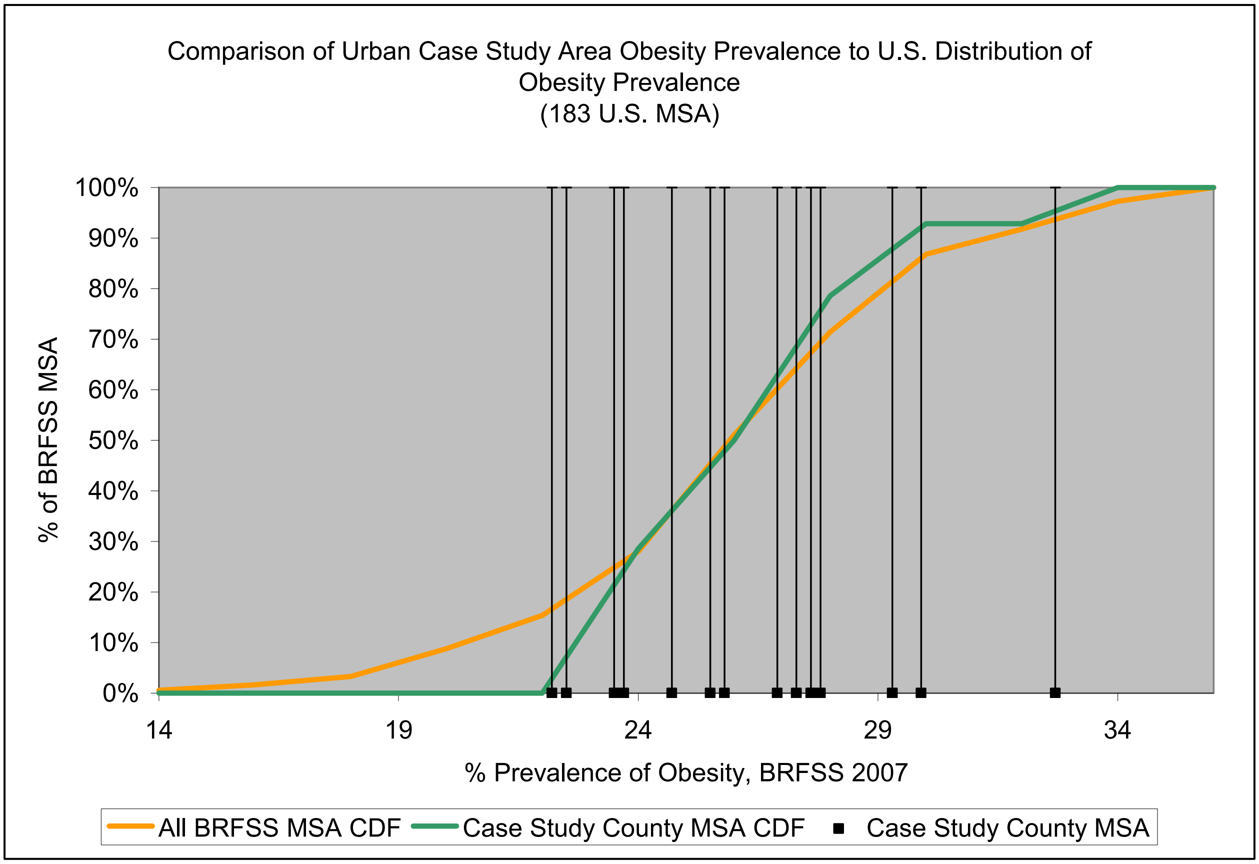


Figure D-26. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Stroke Prevalence

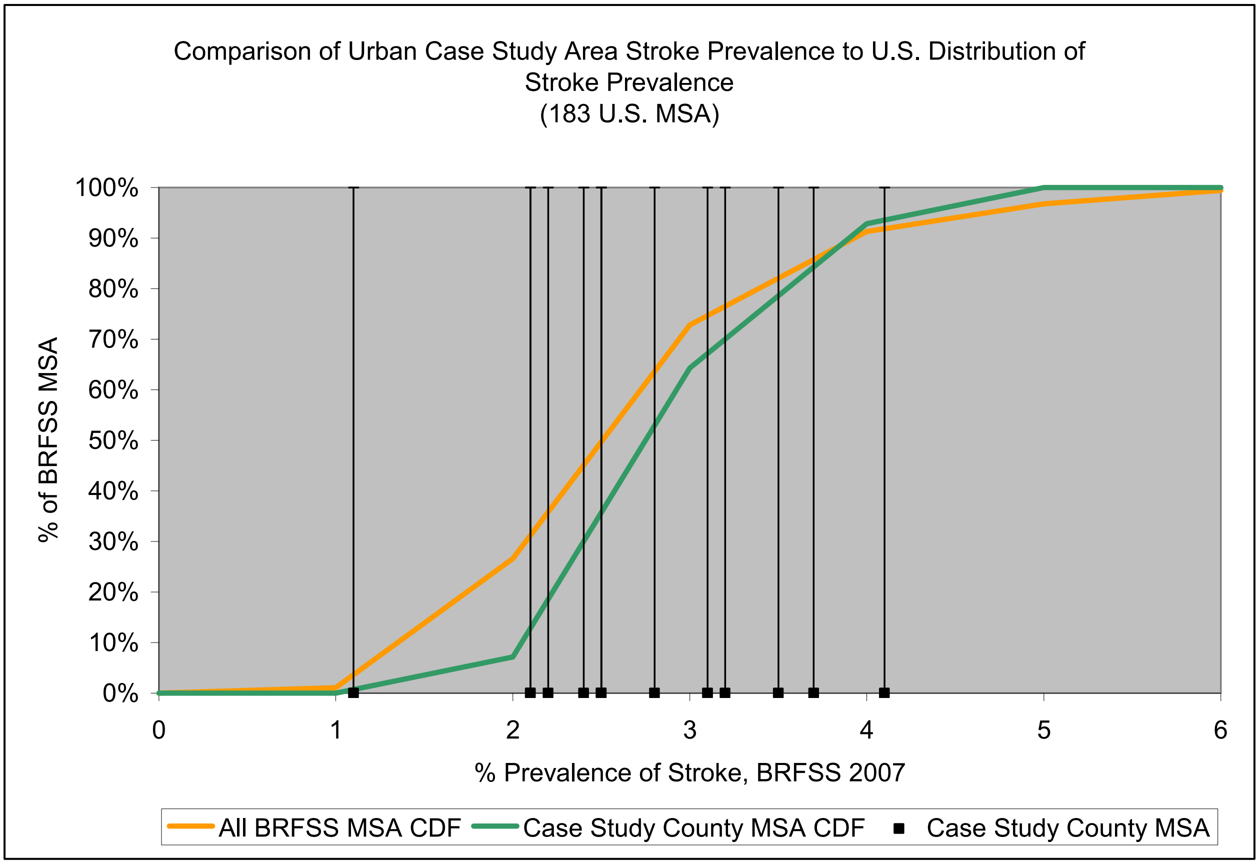


Figure D-27. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Smoking Prevalence

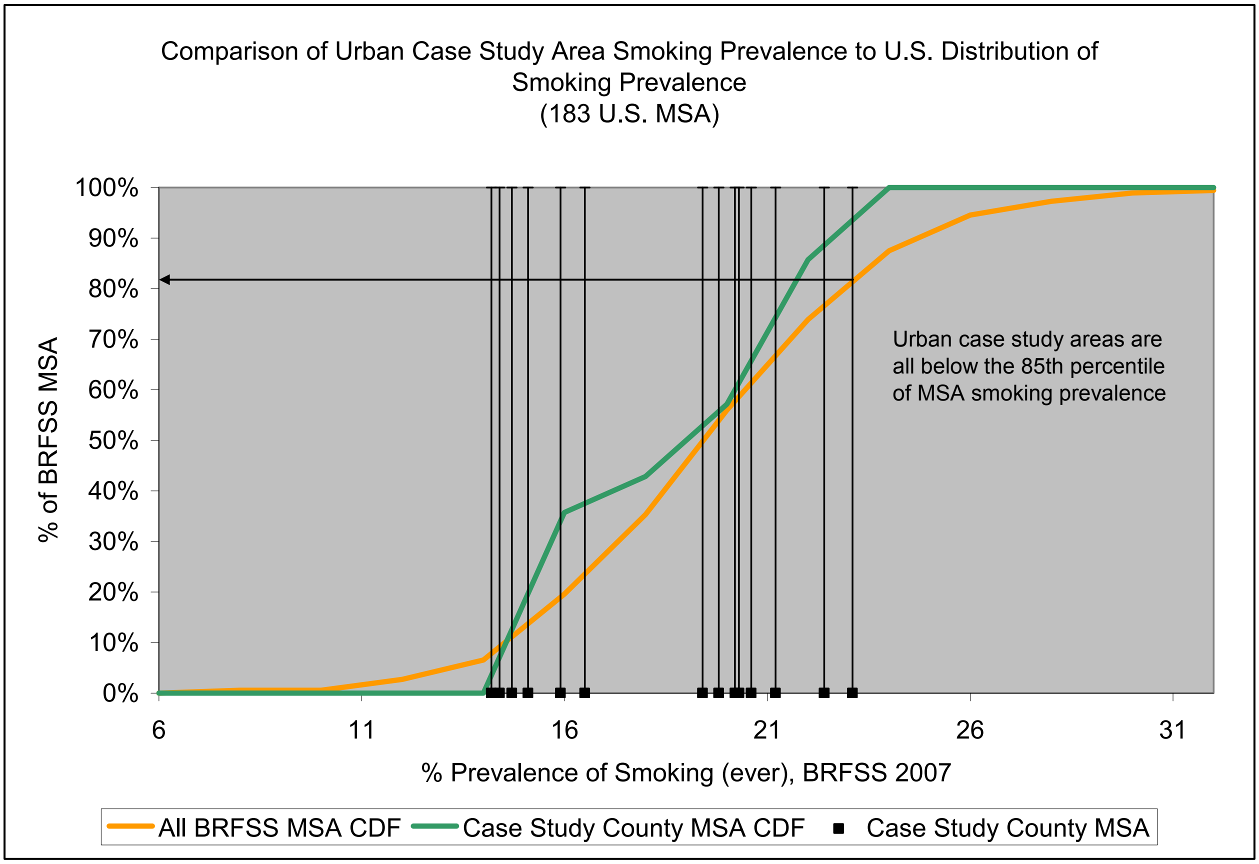
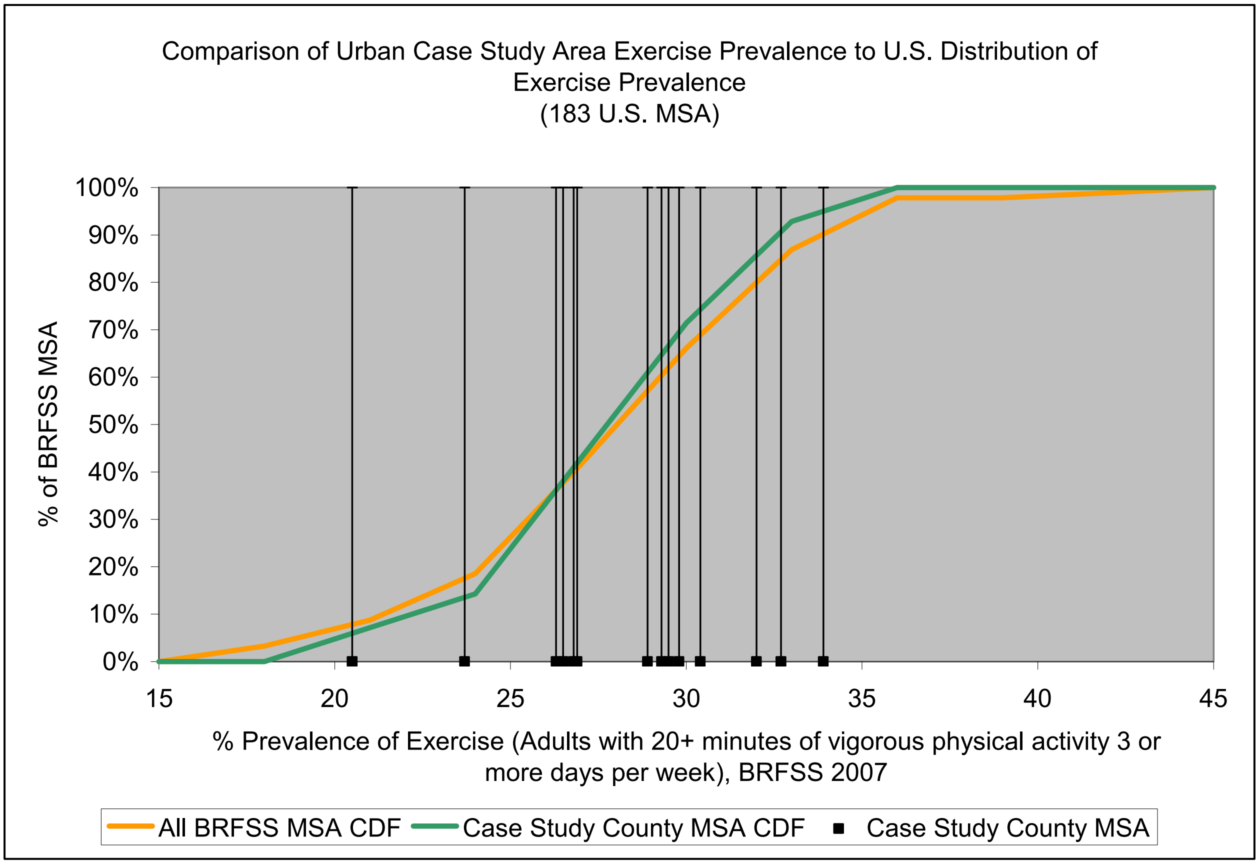


Figure D-28. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: Exercise Prevalence



D.2.3. Air Quality and Climate Variables

Figure D-29. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: 4th Highest Daily Max 8-hour Average

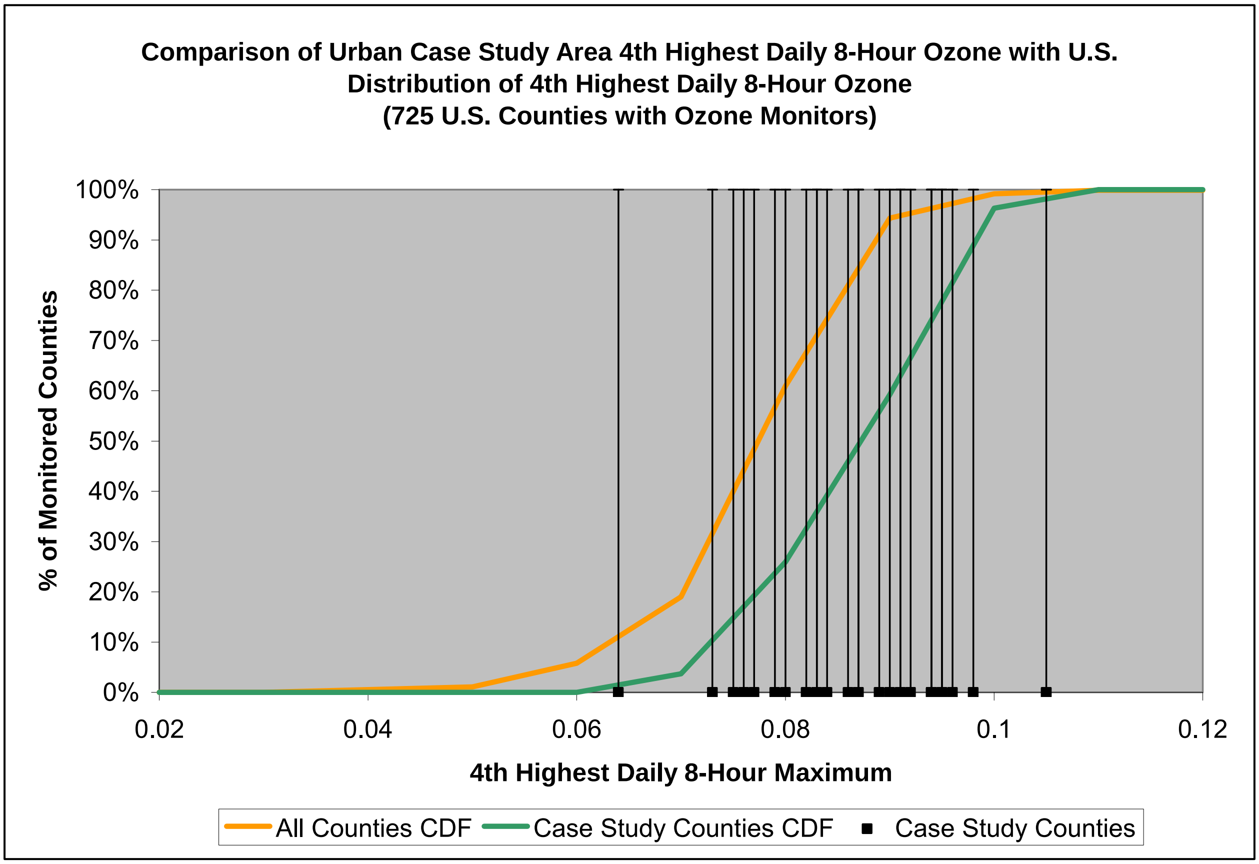


Figure D-30. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: % Mobile Source Direct $PM_{2.5}$ Emissions

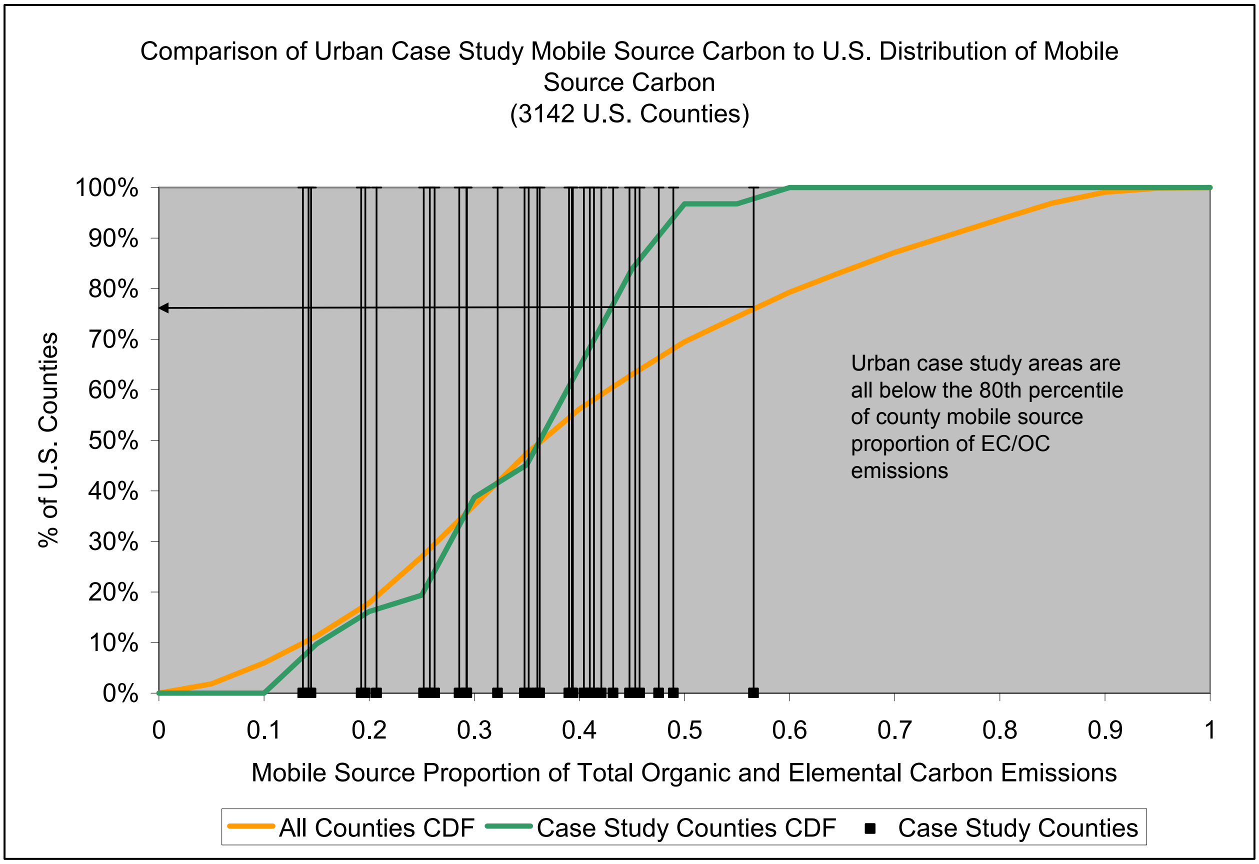


Figure D-31. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: July Temperature Long Term Average

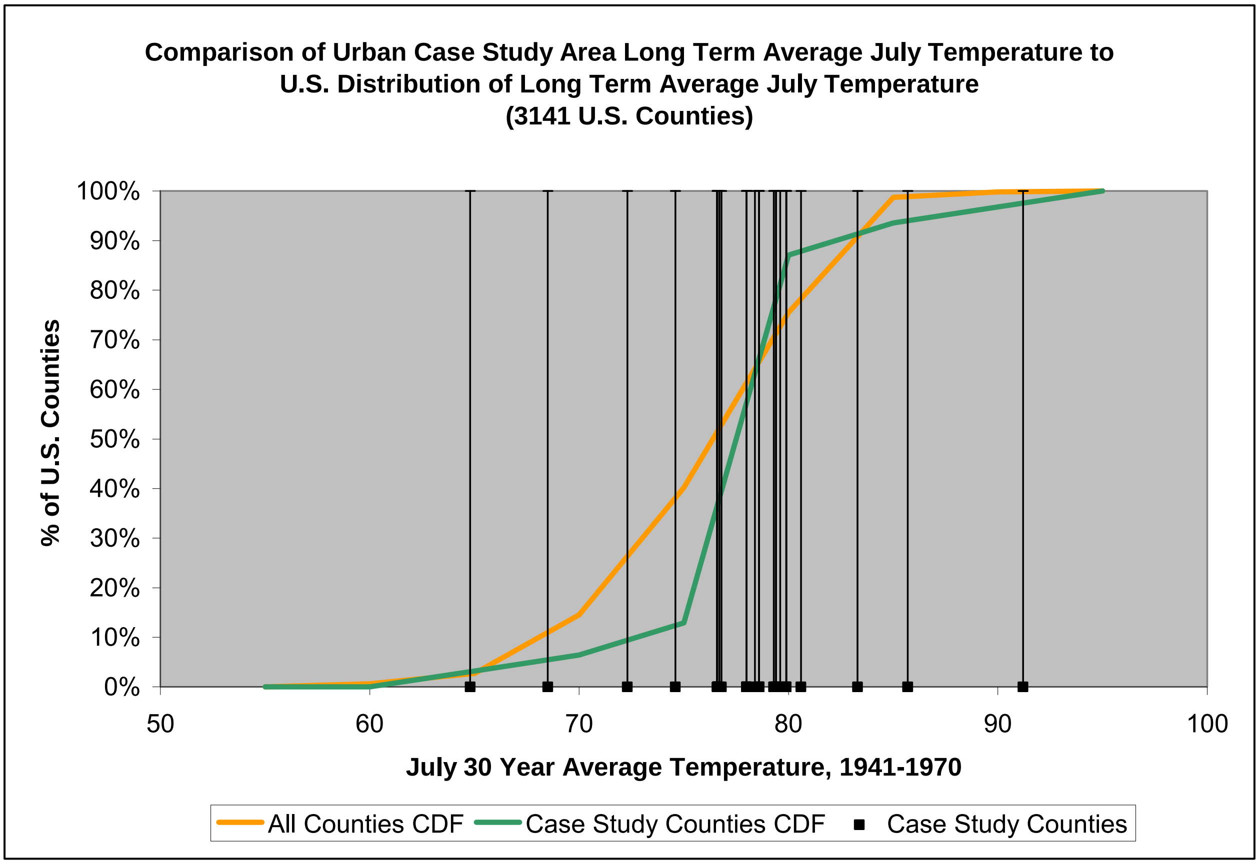
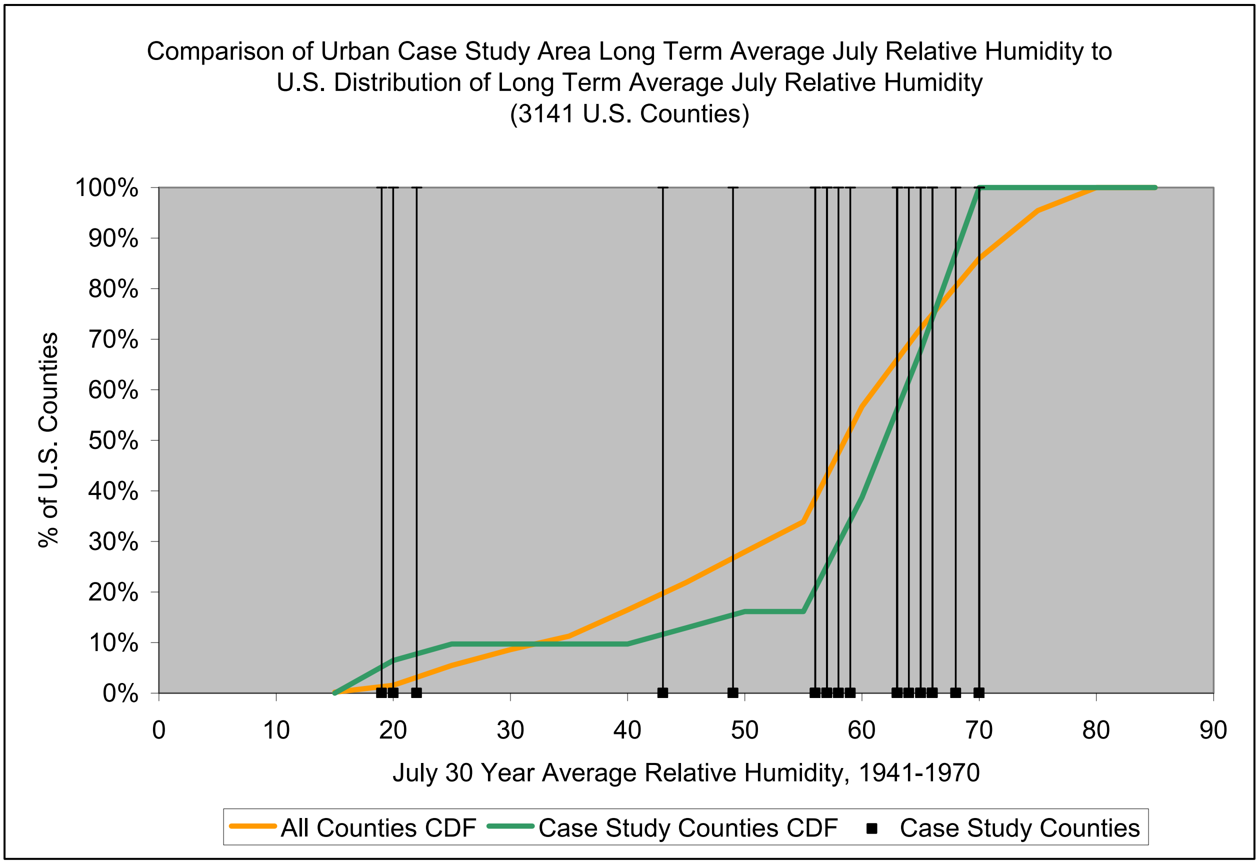


Figure D-32. Comparison of Distributions for Selected Variables Expected to Influence the Relative Risk from $PM_{2.5}$: July Relative Humidity Long Term Average



APPENDIX E: RISK ESTIMATES (CORE ANALYSIS)

Appendix E. Risk Estimates (core analysis)

This Appendix provides detailed risk estimates generated for the core analysis for the 15 urban study areas. The tables cover all of the air quality scenarios modeled, including recent conditions, the current standard, and alternative standard levels. For additional detail on the types of risk metrics (and figures summarizing key metrics) presented in this Appendix, see section 4.0.

Table E-1. Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	649 (421 - 873)	575 (373 - 774)	513 (333 - 692)	451 (292 - 608)	389 (252 - 525)	451 (292 - 608)	379 (245 - 512)
Baltimore, MD	597 (387 - 803)	548 (355 - 738)	502 (325 - 676)	442 (286 - 596)	382 (247 - 516)	426 (276 - 574)	303 (196 - 409)
Birmingham, AL	424 (275 - 571)	297 (192 - 400)	262 (170 - 354)	227 (147 - 307)	192 (124 - 260)	227 (147 - 307)	160 (103 - 216)
Dallas, TX	379 (245 - 511)	379 (245 - 511)	379 (245 - 511)	379 (245 - 511)	336 (218 - 454)	379 (245 - 511)	336 (218 - 454)
Detroit, MI	798 (518 - 1073)	580 (376 - 782)	573 (371 - 772)	502 (325 - 677)	431 (279 - 581)	442 (286 - 597)	303 (196 - 410)
Fresno, CA	254 (165 - 342)	89 (57 - 120)	89 (57 - 120)	89 (57 - 120)	89 (57 - 120)	59 (38 - 79)	28 (18 - 38)
Houston, TX	609 (394 - 820)	557 (360 - 751)	491 (318 - 663)	426 (275 - 575)	360 (233 - 486)	426 (275 - 575)	360 (233 - 486)
Los Angeles, CA	2333 (1514 - 3141)	1045 (676 - 1413)	1045 (676 - 1413)	1045 (676 - 1413)	919 (593 - 1242)	719 (464 - 972)	390 (252 - 528)
New York, NY	2000 (1297 - 2693)	1477 (956 - 1992)	1477 (956 - 1992)	1410 (912 - 1902)	1205 (779 - 1627)	1100 (711 - 1486)	721 (465 - 975)
Philadelphia, PA	521 (338 - 703)	455 (295 - 614)	455 (295 - 614)	406 (263 - 548)	348 (225 - 470)	345 (223 - 465)	233 (151 - 315)
Phoenix, AZ	483 (312 - 652)	483 (312 - 652)	483 (312 - 652)	483 (312 - 652)	433 (280 - 586)	420 (271 - 568)	263 (170 - 356)
Pittsburgh, PA	593 (385 - 798)	387 (251 - 523)	387 (251 - 523)	363 (235 - 490)	318 (206 - 430)	289 (187 - 390)	190 (122 - 257)
Salt Lake City, UT	102 (66 - 138)	29 (19 - 39)	29 (19 - 39)	29 (19 - 39)	29 (19 - 39)	10 (7 - 14)	0 (0 - 0)
St. Louis, MO	826 (536 - 1111)	700 (454 - 943)	634 (411 - 855)	557 (361 - 752)	480 (310 - 648)	543 (351 - 732)	383 (248 - 518)
Tacoma, WA	123 (80 - 166)	80 (52 - 109)	80 (52 - 109)	80 (52 - 109)	80 (52 - 109)	53 (34 - 72)	26 (17 - 36)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-2. Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	668 (434 - 899)	592 (384 - 797)	528 (342 - 712)	464 (301 - 626)	400 (259 - 540)	464 (301 - 626)	390 (253 - 527)
Baltimore, MD	483 (313 - 651)	441 (285 - 594)	400 (259 - 539)	347 (225 - 469)	295 (191 - 398)	333 (216 - 450)	225 (145 - 304)
Birmingham, AL	399 (259 - 536)	276 (179 - 373)	243 (157 - 328)	209 (135 - 283)	176 (114 - 238)	209 (135 - 283)	144 (93 - 195)
Dallas, TX	284 (183 - 383)	284 (183 - 383)	284 (183 - 383)	284 (183 - 383)	247 (160 - 334)	284 (183 - 383)	247 (160 - 334)
Detroit, MI	576 (373 - 776)	398 (257 - 537)	392 (253 - 529)	334 (216 - 451)	276 (178 - 373)	285 (184 - 386)	172 (111 - 233)
Fresno, CA	265 (172 - 356)	94 (61 - 127)	94 (61 - 127)	94 (61 - 127)	94 (61 - 127)	63 (41 - 85)	32 (20 - 43)
Houston, TX	589 (381 - 794)	537 (348 - 725)	472 (306 - 638)	407 (263 - 550)	342 (221 - 462)	407 (263 - 550)	342 (221 - 462)
Los Angeles, CA	2054 (1332 - 2767)	863 (557 - 1166)	863 (557 - 1166)	863 (557 - 1166)	745 (481 - 1008)	561 (362 - 759)	257 (166 - 348)
New York, NY	1548 (1002 - 2087)	1096 (708 - 1481)	1096 (708 - 1481)	1038 (671 - 1403)	861 (556 - 1164)	771 (498 - 1043)	444 (286 - 601)
Philadelphia, PA	471 (305 - 636)	409 (265 - 552)	409 (265 - 552)	363 (235 - 490)	308 (199 - 417)	305 (197 - 412)	200 (129 - 271)
Phoenix, AZ	512 (331 - 691)	512 (331 - 691)	512 (331 - 691)	512 (331 - 691)	460 (297 - 622)	446 (288 - 603)	281 (181 - 380)
Pittsburgh, PA	468 (303 - 631)	290 (187 - 392)	290 (187 - 392)	270 (174 - 364)	231 (149 - 312)	205 (133 - 278)	120 (78 - 163)
Salt Lake City, UT	84 (54 - 113)	16 (10 - 21)	16 (10 - 21)	16 (10 - 21)	16 (10 - 21)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	618 (401 - 834)	514 (332 - 693)	458 (296 - 619)	394 (255 - 532)	329 (213 - 445)	382 (247 - 515)	249 (160 - 336)
Tacoma, WA	83 (54 - 112)	47 (30 - 64)	47 (30 - 64)	47 (30 - 64)	47 (30 - 64)	25 (16 - 33)	2 (1 - 3)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-3. Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	642 (416 - 864)	567 (368 - 764)	505 (327 - 680)	442 (286 - 596)	379 (245 - 512)	442 (286 - 596)	370 (239 - 499)
Baltimore, MD	482 (313 - 650)	440 (285 - 593)	399 (258 - 538)	347 (224 - 468)	294 (190 - 398)	333 (215 - 449)	225 (145 - 304)
Birmingham, AL	418 (271 - 563)	291 (189 - 393)	257 (166 - 347)	222 (144 - 300)	187 (121 - 253)	222 (144 - 300)	155 (100 - 209)
Dallas, TX	317 (205 - 428)	317 (205 - 428)	317 (205 - 428)	317 (205 - 428)	278 (180 - 375)	317 (205 - 428)	278 (180 - 375)
Detroit, MI	607 (393 - 818)	424 (274 - 572)	418 (270 - 564)	358 (232 - 484)	299 (193 - 404)	308 (199 - 417)	192 (124 - 260)
Fresno, CA	279 (181 - 375)	101 (65 - 137)	101 (65 - 137)	101 (65 - 137)	101 (65 - 137)	69 (44 - 93)	36 (23 - 49)
Houston, TX	615 (398 - 829)	561 (363 - 757)	494 (320 - 667)	427 (276 - 577)	359 (232 - 486)	427 (276 - 577)	359 (232 - 486)
Los Angeles, CA	2134 (1384 - 2874)	911 (588 - 1232)	911 (588 - 1232)	911 (588 - 1232)	791 (511 - 1070)	601 (388 - 813)	289 (187 - 392)
New York, NY	1812 (1174 - 2443)	1316 (852 - 1777)	1316 (852 - 1777)	1253 (810 - 1692)	1058 (684 - 1430)	959 (620 - 1296)	600 (387 - 811)
Philadelphia, PA	466 (302 - 629)	405 (262 - 546)	405 (262 - 546)	359 (232 - 484)	304 (197 - 411)	301 (195 - 407)	197 (127 - 266)
Phoenix, AZ	433 (280 - 586)	433 (280 - 586)	433 (280 - 586)	433 (280 - 586)	385 (248 - 520)	371 (240 - 502)	216 (139 - 292)
Pittsburgh, PA	527 (342 - 710)	339 (219 - 457)	339 (219 - 457)	316 (205 - 427)	274 (177 - 371)	247 (160 - 334)	156 (100 - 211)
Salt Lake City, UT	120 (78 - 162)	38 (24 - 51)	38 (24 - 51)	38 (24 - 51)	38 (24 - 51)	17 (11 - 23)	0 (0 - 0)
St. Louis, MO	679 (440 - 915)	568 (368 - 766)	509 (330 - 687)	441 (285 - 596)	373 (241 - 504)	428 (277 - 578)	287 (186 - 389)
Tacoma, WA	87 (56 - 118)	50 (32 - 68)	50 (32 - 68)	50 (32 - 68)	50 (32 - 68)	27 (17 - 36)	4 (2 - 5)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-4. Estimated Percent of Total Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	4.3% (2.8% - 5.8%)	3.8% (2.5% - 5.1%)	3.4% (2.2% - 4.6%)	3% (1.9% - 4%)	2.6% (1.7% - 3.5%)	3% (1.9% - 4%)	2.5% (1.6% - 3.4%)
Baltimore, MD	4.2% (2.7% - 5.7%)	3.9% (2.5% - 5.2%)	3.6% (2.3% - 4.8%)	3.1% (2% - 4.2%)	2.7% (1.8% - 3.7%)	3% (2% - 4.1%)	2.1% (1.4% - 2.9%)
Birmingham, AL	4.3% (2.8% - 5.8%)	3% (2% - 4.1%)	2.7% (1.7% - 3.6%)	2.3% (1.5% - 3.1%)	2% (1.3% - 2.6%)	2.3% (1.5% - 3.1%)	1.6% (1.1% - 2.2%)
Dallas, TX	3% (1.9% - 4%)	3% (1.9% - 4%)	3% (1.9% - 4%)	3% (1.9% - 4%)	2.6% (1.7% - 3.5%)	3% (1.9% - 4%)	2.6% (1.7% - 3.5%)
Detroit, MI	4.5% (2.9% - 6%)	3.3% (2.1% - 4.4%)	3.2% (2.1% - 4.3%)	2.8% (1.8% - 3.8%)	2.4% (1.6% - 3.3%)	2.5% (1.6% - 3.3%)	1.7% (1.1% - 2.3%)
Fresno, CA	4.6% (3% - 6.1%)	1.6% (1% - 2.2%)	1.6% (1% - 2.2%)	1.6% (1% - 2.2%)	1.6% (1% - 2.2%)	1.1% (0.7% - 1.4%)	0.5% (0.3% - 0.7%)
Houston, TX	3.3% (2.1% - 4.4%)	3% (1.9% - 4%)	2.6% (1.7% - 3.6%)	2.3% (1.5% - 3.1%)	1.9% (1.2% - 2.6%)	2.3% (1.5% - 3.1%)	1.9% (1.2% - 2.6%)
Los Angeles, CA	4.1% (2.7% - 5.5%)	1.8% (1.2% - 2.5%)	1.8% (1.2% - 2.5%)	1.8% (1.2% - 2.5%)	1.6% (1% - 2.2%)	1.3% (0.8% - 1.7%)	0.7% (0.4% - 0.9%)
New York, NY	3.8% (2.5% - 5.1%)	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.7% (1.7% - 3.6%)	2.3% (1.5% - 3.1%)	2.1% (1.3% - 2.8%)	1.4% (0.9% - 1.8%)
Philadelphia, PA	3.6% (2.3% - 4.8%)	3.1% (2% - 4.2%)	3.1% (2% - 4.2%)	2.8% (1.8% - 3.8%)	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	1.6% (1% - 2.2%)
Phoenix, AZ	2.1% (1.4% - 2.8%)	2.1% (1.4% - 2.8%)	2.1% (1.4% - 2.8%)	2.1% (1.4% - 2.8%)	1.9% (1.2% - 2.5%)	1.8% (1.2% - 2.5%)	1.1% (0.7% - 1.5%)
Pittsburgh, PA	4.3% (2.8% - 5.7%)	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.6% (1.7% - 3.5%)	2.3% (1.5% - 3.1%)	2.1% (1.3% - 2.8%)	1.4% (0.9% - 1.8%)
Salt Lake City, UT	2.2% (1.4% - 2.9%)	0.6% (0.4% - 0.8%)	0.6% (0.4% - 0.8%)	0.6% (0.4% - 0.8%)	0.6% (0.4% - 0.8%)	0.2% (0.1% - 0.3%)	0% (0% - 0%)
St. Louis, MO	4.4% (2.8% - 5.9%)	3.7% (2.4% - 5%)	3.4% (2.2% - 4.5%)	3% (1.9% - 4%)	2.5% (1.6% - 3.4%)	2.9% (1.9% - 3.9%)	2% (1.3% - 2.7%)
Tacoma, WA	2.4% (1.6% - 3.3%)	1.6% (1% - 2.1%)	1.6% (1% - 2.1%)	1.6% (1% - 2.1%)	1.6% (1% - 2.1%)	1.1% (0.7% - 1.4%)	0.5% (0.3% - 0.7%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-5. Estimated Percent of Total Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	4.3% (2.8% - 5.8%)	3.8% (2.5% - 5.1%)	3.4% (2.2% - 4.6%)	3% (1.9% - 4%)	2.6% (1.7% - 3.5%)	3% (1.9% - 4%)	2.5% (1.6% - 3.4%)
Baltimore, MD	3.4% (2.2% - 4.6%)	3.1% (2% - 4.2%)	2.8% (1.8% - 3.8%)	2.5% (1.6% - 3.3%)	2.1% (1.3% - 2.8%)	2.4% (1.5% - 3.2%)	1.6% (1% - 2.2%)
Birmingham, AL	4% (2.6% - 5.4%)	2.8% (1.8% - 3.8%)	2.4% (1.6% - 3.3%)	2.1% (1.4% - 2.8%)	1.8% (1.1% - 2.4%)	2.1% (1.4% - 2.8%)	1.5% (0.9% - 2%)
Dallas, TX	2.2% (1.4% - 2.9%)	2.2% (1.4% - 2.9%)	2.2% (1.4% - 2.9%)	2.2% (1.4% - 2.9%)	1.9% (1.2% - 2.5%)	2.2% (1.4% - 2.9%)	1.9% (1.2% - 2.5%)
Detroit, MI	3.2% (2.1% - 4.4%)	2.2% (1.4% - 3%)	2.2% (1.4% - 3%)	1.9% (1.2% - 2.5%)	1.5% (1% - 2.1%)	1.6% (1% - 2.2%)	1% (0.6% - 1.3%)
Fresno, CA	4.7% (3% - 6.3%)	1.7% (1.1% - 2.2%)	1.7% (1.1% - 2.2%)	1.7% (1.1% - 2.2%)	1.7% (1.1% - 2.2%)	1.1% (0.7% - 1.5%)	0.6% (0.4% - 0.8%)
Houston, TX	3.1% (2% - 4.1%)	2.8% (1.8% - 3.8%)	2.5% (1.6% - 3.3%)	2.1% (1.4% - 2.9%)	1.8% (1.1% - 2.4%)	2.1% (1.4% - 2.9%)	1.8% (1.1% - 2.4%)
Los Angeles, CA	3.6% (2.3% - 4.8%)	1.5% (1% - 2%)	1.5% (1% - 2%)	1.5% (1% - 2%)	1.3% (0.8% - 1.8%)	1% (0.6% - 1.3%)	0.5% (0.3% - 0.6%)
New York, NY	2.9% (1.9% - 3.9%)	2.1% (1.3% - 2.8%)	2.1% (1.3% - 2.8%)	2% (1.3% - 2.6%)	1.6% (1% - 2.2%)	1.4% (0.9% - 2%)	0.8% (0.5% - 1.1%)
Philadelphia, PA	3.2% (2.1% - 4.4%)	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.5% (1.6% - 3.4%)	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.8%)	1.4% (0.9% - 1.9%)
Phoenix, AZ	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.9%)	1.9% (1.2% - 2.6%)	1.9% (1.2% - 2.5%)	1.2% (0.8% - 1.6%)
Pittsburgh, PA	3.4% (2.2% - 4.6%)	2.1% (1.4% - 2.8%)	2.1% (1.4% - 2.8%)	1.9% (1.3% - 2.6%)	1.7% (1.1% - 2.3%)	1.5% (1% - 2%)	0.9% (0.6% - 1.2%)
Salt Lake City, UT	1.7% (1.1% - 2.3%)	0.3% (0.2% - 0.4%)	0.3% (0.2% - 0.4%)	0.3% (0.2% - 0.4%)	0.3% (0.2% - 0.4%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	#DIV/0! #DIV/0!	2.7% (1.8% - 3.7%)	2.4% (1.6% - 3.3%)	2.1% (1.3% - 2.8%)	1.7% (1.1% - 2.4%)	2% (1.3% - 2.7%)	1.3% (0.8% - 1.8%)
Tacoma, WA	3.3% (2.1% - 4.4%)	0.9% (0.6% - 1.2%)	0.9% (0.6% - 1.2%)	0.9% (0.6% - 1.2%)	0.9% (0.6% - 1.2%)	0.5% (0.3% - 0.6%)	0% (0% - 0.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-6. Estimated Percent of Total Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	4% (2.6% - 5.4%)	3.6% (2.3% - 4.8%)	3.2% (2% - 4.3%)	2.8% (1.8% - 3.7%)	2.4% (1.5% - 3.2%)	2.8% (1.8% - 3.7%)	2.3% (1.5% - 3.1%)
Baltimore, MD	3.4% (2.2% - 4.6%)	3.1% (2% - 4.2%)	2.8% (1.8% - 3.8%)	2.5% (1.6% - 3.3%)	2.1% (1.3% - 2.8%)	2.4% (1.5% - 3.2%)	1.6% (1% - 2.2%)
Birmingham, AL	4.2% (2.7% - 5.6%)	2.9% (1.9% - 3.9%)	2.6% (1.7% - 3.5%)	2.2% (1.4% - 3%)	1.9% (1.2% - 2.5%)	2.2% (1.4% - 3%)	1.5% (1% - 2.1%)
Dallas, TX	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	2.1% (1.3% - 2.8%)	2.4% (1.5% - 3.2%)	2.1% (1.3% - 2.8%)
Detroit, MI	3.4% (2.2% - 4.6%)	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	2% (1.3% - 2.7%)	1.7% (1.1% - 2.3%)	1.7% (1.1% - 2.4%)	1.1% (0.7% - 1.5%)
Fresno, CA	4.9% (3.2% - 6.5%)	1.8% (1.1% - 2.4%)	1.8% (1.1% - 2.4%)	1.8% (1.1% - 2.4%)	1.8% (1.1% - 2.4%)	1.2% (0.8% - 1.6%)	0.6% (0.4% - 0.9%)
Houston, TX	3.1% (2% - 4.2%)	2.9% (1.8% - 3.9%)	2.5% (1.6% - 3.4%)	2.2% (1.4% - 2.9%)	1.8% (1.2% - 2.5%)	2.2% (1.4% - 2.9%)	1.8% (1.2% - 2.5%)
Los Angeles, CA	3.7% (2.4% - 5%)	1.6% (1% - 2.1%)	1.6% (1% - 2.1%)	1.6% (1% - 2.1%)	1.4% (0.9% - 1.9%)	1% (0.7% - 1.4%)	0.5% (0.3% - 0.7%)
New York, NY	3.4% (2.2% - 4.6%)	2.5% (1.6% - 3.3%)	2.5% (1.6% - 3.3%)	2.3% (1.5% - 3.2%)	2% (1.3% - 2.7%)	1.8% (1.2% - 2.4%)	1.1% (0.7% - 1.5%)
Philadelphia, PA	3.2% (2.1% - 4.3%)	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.5% (1.6% - 3.3%)	2.1% (1.4% - 2.8%)	2.1% (1.3% - 2.8%)	1.4% (0.9% - 1.8%)
Phoenix, AZ	1.8% (1.1% - 2.4%)	1.8% (1.1% - 2.4%)	1.8% (1.1% - 2.4%)	1.8% (1.1% - 2.4%)	1.6% (1% - 2.1%)	1.5% (1% - 2%)	0.9% (0.6% - 1.2%)
Pittsburgh, PA	3.8% (2.5% - 5.2%)	2.5% (1.6% - 3.3%)	2.5% (1.6% - 3.3%)	2.3% (1.5% - 3.1%)	2% (1.3% - 2.7%)	1.8% (1.2% - 2.4%)	1.1% (0.7% - 1.5%)
Salt Lake City, UT	2.4% (1.5% - 3.2%)	0.7% (0.5% - 1%)	0.7% (0.5% - 1%)	0.7% (0.5% - 1%)	0.7% (0.5% - 1%)	0.3% (0.2% - 0.5%)	0% (0% - 0%)
St. Louis, MO	3.6% (2.3% - 4.8%)	3% (1.9% - 4%)	2.7% (1.7% - 3.6%)	2.3% (1.5% - 3.1%)	2% (1.3% - 2.7%)	2.3% (1.5% - 3.1%)	1.5% (1% - 2.1%)
Tacoma, WA	1.7% (1.1% - 2.2%)	1% (0.6% - 1.3%)	1% (0.6% - 1.3%)	1% (0.6% - 1.3%)	1% (0.6% - 1.3%)	0.5% (0.3% - 0.7%)	0.1% (0% - 0.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-7. Percent Reduction from the Current Standards: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	22% (21% - 22%)	32% (32% - 33%)	22% (21% - 22%)	34% (34% - 34%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	8% (8% - 9%)	19% (19% - 19%)	30% (30% - 30%)	22% (22% - 22%)	45% (45% - 45%)
Birmingham, AL	-43% (-43% - -43%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 35%)	23% (23% - 24%)	46% (46% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-38% (-37% - -38%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 14%)	26% (26% - 26%)	24% (24% - 24%)	48% (48% - 48%)
Fresno, CA	-187% (-185% - -188%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (34% - 34%)	68% (68% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	35% (35% - 35%)	24% (23% - 24%)	35% (35% - 35%)
Los Angeles, CA	-123% (-122% - -124%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	63% (63% - 63%)
New York, NY	-35% (-35% - -36%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	18% (18% - 18%)	26% (25% - 26%)	51% (51% - 51%)
Philadelphia, PA	-14% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (23% - 24%)	24% (24% - 24%)	49% (49% - 49%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	46% (45% - 46%)
Pittsburgh, PA	-53% (-53% - -54%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	18% (18% - 18%)	25% (25% - 26%)	51% (51% - 51%)
Salt Lake City, UT	-255% (-254% - -256%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-18% (-18% - -18%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 21%)	31% (31% - 32%)	23% (22% - 23%)	45% (45% - 45%)
Tacoma, WA	-53% (-53% - -54%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (34% - 34%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-8. Percent Reduction from the Current Standards: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	22% (21% - 22%)	32% (32% - 33%)	22% (21% - 22%)	34% (34% - 34%)
Baltimore, MD	-10% (-10% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (33% - 33%)	24% (24% - 24%)	49% (49% - 49%)
Birmingham, AL	-44% (-44% - -45%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	48% (48% - 48%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	0% (0% - 0%)	13% (13% - 13%)
Detroit, MI	-45% (-45% - -45%)	0% (0% - 0%)	1% (1% - 1%)	16% (16% - 16%)	31% (30% - 31%)	28% (28% - 28%)	57% (57% - 57%)
Fresno, CA	-182% (-180% - -184%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	66% (66% - 66%)
Houston, TX	-10% (-10% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	36% (36% - 36%)
Los Angeles, CA	-138% (-137% - -139%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	14% (14% - 14%)	35% (35% - 35%)	70% (70% - 70%)
New York, NY	-41% (-41% - -41%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	30% (30% - 30%)	59% (59% - 60%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	25% (25% - 25%)	25% (25% - 26%)	51% (51% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 45%)
Pittsburgh, PA	-61% (-61% - -62%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	29% (29% - 29%)	58% (58% - 59%)
Salt Lake City, UT	-438% (-437% - -440%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-20% (-20% - -21%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 23%)	36% (36% - 36%)	26% (26% - 26%)	52% (51% - 52%)
Tacoma, WA	-76% (-76% - -76%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	48% (48% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-9. Percent Reduction from the Current Standards: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	22% (22% - 22%)	33% (33% - 33%)	22% (22% - 22%)	35% (35% - 35%)
Baltimore, MD	-10% (-10% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (33% - 33%)	24% (24% - 24%)	49% (49% - 49%)
Birmingham, AL	-44% (-43% - -44%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	47% (47% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-43% (-43% - -44%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	30% (29% - 30%)	27% (27% - 27%)	55% (55% - 55%)
Fresno, CA	-176% (-175% - -178%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (32% - 32%)	64% (64% - 64%)
Houston, TX	-10% (-9% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	36% (36% - 36%)
Los Angeles, CA	-134% (-133% - -135%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (34% - 34%)	68% (68% - 68%)
New York, NY	-38% (-37% - -38%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	20% (20% - 20%)	27% (27% - 27%)	54% (54% - 55%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	25% (25% - 25%)	26% (26% - 26%)	51% (51% - 52%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (50% - 50%)
Pittsburgh, PA	-56% (-55% - -56%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	19% (19% - 19%)	27% (27% - 27%)	54% (54% - 54%)
Salt Lake City, UT	-218% (-217% - -219%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-20% (-19% - -20%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 22%)	34% (34% - 34%)	25% (25% - 25%)	49% (49% - 50%)
Tacoma, WA	-74% (-73% - -74%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-10. Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	830 (531 - 1123)	736 (470 - 997)	657 (420 - 891)	578 (369 - 785)	499 (318 - 677)	578 (369 - 785)	487 (310 - 661)
Baltimore, MD	763 (488 - 1033)	702 (448 - 950)	643 (410 - 871)	566 (361 - 768)	490 (312 - 665)	546 (348 - 741)	388 (247 - 528)
Birmingham, AL	543 (347 - 734)	380 (243 - 516)	336 (214 - 457)	292 (186 - 397)	247 (157 - 336)	292 (186 - 397)	205 (130 - 280)
Dallas, TX	486 (310 - 659)	486 (310 - 659)	486 (310 - 659)	486 (310 - 659)	431 (275 - 586)	486 (310 - 659)	431 (275 - 586)
Detroit, MI	1021 (653 - 1380)	743 (474 - 1008)	734 (468 - 996)	643 (410 - 874)	552 (352 - 751)	567 (361 - 770)	389 (247 - 530)
Fresno, CA	325 (208 - 439)	114 (72 - 155)	114 (72 - 155)	114 (72 - 155)	114 (72 - 155)	75 (48 - 103)	36 (23 - 50)
Houston, TX	780 (498 - 1058)	713 (455 - 968)	630 (401 - 856)	546 (348 - 743)	462 (294 - 629)	546 (348 - 743)	462 (294 - 629)
Los Angeles, CA	2986 (1910 - 4042)	1342 (854 - 1827)	1342 (854 - 1827)	1342 (854 - 1827)	1180 (750 - 1607)	924 (587 - 1258)	502 (318 - 684)
New York, NY	2560 (1636 - 3468)	1893 (1207 - 2571)	1893 (1207 - 2571)	1808 (1152 - 2455)	1546 (984 - 2101)	1412 (898 - 1920)	926 (588 - 1261)
Philadelphia, PA	668 (427 - 905)	584 (372 - 792)	584 (372 - 792)	521 (332 - 707)	447 (285 - 607)	442 (282 - 601)	299 (190 - 408)
Phoenix, AZ	620 (394 - 843)	620 (394 - 843)	620 (394 - 843)	620 (394 - 843)	557 (354 - 757)	539 (343 - 734)	338 (214 - 460)
Pittsburgh, PA	759 (485 - 1026)	497 (317 - 674)	497 (317 - 674)	466 (297 - 633)	409 (260 - 555)	371 (236 - 504)	244 (155 - 332)
Salt Lake City, UT	132 (84 - 179)	37 (24 - 51)	37 (24 - 51)	37 (24 - 51)	37 (24 - 51)	13 (8 - 18)	0 (0 - 0)
St. Louis, MO	1056 (676 - 1429)	897 (573 - 1215)	813 (519 - 1102)	714 (456 - 970)	616 (392 - 836)	696 (443 - 944)	492 (313 - 669)
Tacoma, WA	158 (101 - 215)	103 (66 - 141)	103 (66 - 141)	103 (66 - 141)	103 (66 - 141)	69 (44 - 94)	34 (21 - 46)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-11. Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 PM2.5 Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	854 (547 - 1156)	758 (484 - 1026)	677 (432 - 918)	595 (380 - 808)	513 (327 - 697)	595 (380 - 808)	501 (319 - 681)
Baltimore, MD	619 (395 - 839)	565 (360 - 766)	513 (327 - 696)	446 (284 - 606)	378 (241 - 515)	428 (272 - 581)	289 (184 - 394)
Birmingham, AL	510 (326 - 691)	354 (226 - 481)	312 (198 - 423)	269 (171 - 365)	226 (144 - 307)	269 (171 - 365)	186 (118 - 253)
Dallas, TX	364 (232 - 495)	364 (232 - 495)	364 (232 - 495)	364 (232 - 495)	317 (202 - 432)	364 (232 - 495)	317 (202 - 432)
Detroit, MI	737 (471 - 1000)	510 (325 - 694)	503 (320 - 684)	429 (273 - 584)	355 (225 - 483)	366 (233 - 499)	222 (141 - 302)
Fresno, CA	338 (217 - 457)	121 (77 - 164)	121 (77 - 164)	121 (77 - 164)	121 (77 - 164)	81 (51 - 110)	41 (26 - 55)
Houston, TX	755 (481 - 1024)	689 (439 - 935)	606 (386 - 823)	523 (333 - 711)	439 (279 - 598)	523 (333 - 711)	439 (279 - 598)
Los Angeles, CA	2631 (1680 - 3565)	1108 (704 - 1509)	1108 (704 - 1509)	1108 (704 - 1509)	958 (608 - 1305)	721 (457 - 983)	331 (210 - 451)
New York, NY	1984 (1265 - 2693)	1407 (895 - 1913)	1407 (895 - 1913)	1333 (848 - 1813)	1106 (703 - 1506)	990 (629 - 1349)	571 (362 - 779)
Philadelphia, PA	604 (386 - 819)	525 (335 - 713)	525 (335 - 713)	466 (297 - 633)	396 (252 - 538)	392 (249 - 533)	257 (163 - 350)
Phoenix, AZ	657 (418 - 893)	657 (418 - 893)	657 (418 - 893)	657 (418 - 893)	591 (376 - 803)	572 (364 - 779)	361 (229 - 492)
Pittsburgh, PA	599 (383 - 813)	372 (237 - 506)	372 (237 - 506)	346 (220 - 471)	297 (189 - 404)	264 (168 - 359)	155 (98 - 211)
Salt Lake City, UT	107 (68 - 146)	20 (13 - 27)	20 (13 - 27)	20 (13 - 27)	20 (13 - 27)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	792 (506 - 1075)	659 (420 - 894)	588 (374 - 799)	506 (322 - 688)	423 (269 - 575)	490 (312 - 666)	319 (203 - 435)
Tacoma, WA	107 (68 - 145)	61 (38 - 83)	61 (38 - 83)	61 (38 - 83)	61 (38 - 83)	32 (20 - 43)	3 (2 - 3)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-12. Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	821 (525 - 1112)	726 (464 - 984)	647 (413 - 877)	567 (361 - 769)	486 (310 - 661)	567 (361 - 769)	474 (302 - 644)
Baltimore, MD	618 (394 - 838)	564 (360 - 765)	512 (326 - 695)	445 (283 - 605)	378 (240 - 514)	427 (272 - 580)	289 (184 - 393)
Birmingham, AL	535 (342 - 724)	374 (238 - 507)	330 (210 - 448)	285 (182 - 388)	241 (153 - 327)	285 (182 - 388)	199 (126 - 271)
Dallas, TX	407 (259 - 553)	407 (259 - 553)	407 (259 - 553)	407 (259 - 553)	356 (227 - 485)	407 (259 - 553)	356 (227 - 485)
Detroit, MI	778 (496 - 1054)	544 (346 - 739)	536 (341 - 729)	460 (293 - 626)	384 (244 - 522)	396 (252 - 539)	247 (157 - 336)
Fresno, CA	357 (228 - 482)	130 (82 - 177)	130 (82 - 177)	130 (82 - 177)	130 (82 - 177)	88 (56 - 120)	46 (29 - 63)
Houston, TX	788 (502 - 1069)	719 (459 - 977)	634 (404 - 861)	548 (349 - 745)	461 (293 - 628)	548 (349 - 745)	461 (293 - 628)
Los Angeles, CA	2732 (1746 - 3702)	1170 (744 - 1593)	1170 (744 - 1593)	1170 (744 - 1593)	1016 (645 - 1384)	773 (490 - 1053)	372 (236 - 508)
New York, NY	2322 (1482 - 3148)	1689 (1076 - 2295)	1689 (1076 - 2295)	1607 (1023 - 2185)	1359 (864 - 1848)	1232 (783 - 1676)	771 (489 - 1051)
Philadelphia, PA	598 (381 - 811)	519 (331 - 704)	519 (331 - 704)	460 (293 - 625)	391 (249 - 531)	386 (246 - 525)	253 (161 - 344)
Phoenix, AZ	556 (354 - 757)	556 (354 - 757)	556 (354 - 757)	556 (354 - 757)	494 (314 - 673)	477 (303 - 650)	278 (176 - 379)
Pittsburgh, PA	675 (431 - 914)	434 (277 - 590)	434 (277 - 590)	406 (258 - 552)	352 (224 - 479)	318 (202 - 432)	200 (127 - 273)
Salt Lake City, UT	154 (98 - 209)	48 (31 - 66)	48 (31 - 66)	48 (31 - 66)	48 (31 - 66)	22 (14 - 30)	0 (0 - 0)
St. Louis, MO	869 (555 - 1178)	728 (464 - 988)	653 (416 - 887)	566 (360 - 769)	478 (304 - 651)	549 (350 - 747)	369 (235 - 503)
Tacoma, WA	112 (71 - 152)	64 (41 - 88)	64 (41 - 88)	64 (41 - 88)	64 (41 - 88)	35 (22 - 47)	5 (3 - 6)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-13. Estimated Percent of Total Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	5.5% (3.5% - 7.4%)	4.9% (3.1% - 6.6%)	4.4% (2.8% - 5.9%)	3.8% (2.4% - 5.2%)	3.3% (2.1% - 4.5%)	3.8% (2.4% - 5.2%)	3.2% (2.1% - 4.4%)
Baltimore, MD	5.4% (3.5% - 7.3%)	5% (3.2% - 6.7%)	4.5% (2.9% - 6.2%)	4% (2.6% - 5.4%)	3.5% (2.2% - 4.7%)	3.9% (2.5% - 5.2%)	2.8% (1.8% - 3.7%)
Birmingham, AL	5.5% (3.5% - 7.5%)	3.9% (2.5% - 5.3%)	3.4% (2.2% - 4.7%)	3% (1.9% - 4%)	2.5% (1.6% - 3.4%)	3% (1.9% - 4%)	2.1% (1.3% - 2.8%)
Dallas, TX	3.8% (2.4% - 5.1%)	3.8% (2.4% - 5.1%)	3.8% (2.4% - 5.1%)	3.8% (2.4% - 5.1%)	3.4% (2.1% - 4.6%)	3.8% (2.4% - 5.1%)	3.4% (2.1% - 4.6%)
Detroit, MI	5.7% (3.7% - 7.7%)	4.2% (2.7% - 5.6%)	4.1% (2.6% - 5.6%)	3.6% (2.3% - 4.9%)	3.1% (2% - 4.2%)	3.2% (2% - 4.3%)	2.2% (1.4% - 3%)
Fresno, CA	5.8% (3.7% - 7.9%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	1.4% (0.9% - 1.8%)	0.7% (0.4% - 0.9%)
Houston, TX	4.2% (2.7% - 5.7%)	3.8% (2.4% - 5.2%)	3.4% (2.2% - 4.6%)	2.9% (1.9% - 4%)	2.5% (1.6% - 3.4%)	2.9% (1.9% - 4%)	2.5% (1.6% - 3.4%)
Los Angeles, CA	5.3% (3.4% - 7.1%)	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	2.4% (1.5% - 3.2%)	2.1% (1.3% - 2.8%)	1.6% (1% - 2.2%)	0.9% (0.6% - 1.2%)
New York, NY	4.9% (3.1% - 6.6%)	3.6% (2.3% - 4.9%)	3.6% (2.3% - 4.9%)	3.4% (2.2% - 4.7%)	2.9% (1.9% - 4%)	2.7% (1.7% - 3.6%)	1.8% (1.1% - 2.4%)
Philadelphia, PA	4.6% (2.9% - 6.2%)	4% (2.6% - 5.4%)	4% (2.6% - 5.4%)	3.6% (2.3% - 4.9%)	3.1% (2% - 4.2%)	3% (1.9% - 4.1%)	2.1% (1.3% - 2.8%)
Phoenix, AZ	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.4% (1.5% - 3.3%)	2.3% (1.5% - 3.2%)	1.5% (0.9% - 2%)
Pittsburgh, PA	5.5% (3.5% - 7.4%)	3.6% (2.3% - 4.8%)	3.6% (2.3% - 4.8%)	3.3% (2.1% - 4.5%)	2.9% (1.9% - 4%)	2.7% (1.7% - 3.6%)	1.8% (1.1% - 2.4%)
Salt Lake City, UT	2.8% (1.8% - 3.8%)	0.8% (0.5% - 1.1%)	0.8% (0.5% - 1.1%)	0.8% (0.5% - 1.1%)	0.8% (0.5% - 1.1%)	0.3% (0.2% - 0.4%)	0% (0% - 0%)
St. Louis, MO	5.6% (3.6% - 7.6%)	4.8% (3% - 6.5%)	4.3% (2.8% - 5.9%)	3.8% (2.4% - 5.1%)	3.3% (2.1% - 4.4%)	3.7% (2.4% - 5%)	2.6% (1.7% - 3.6%)
Tacoma, WA	3.1% (2% - 4.2%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	1.3% (0.9% - 1.8%)	0.7% (0.4% - 0.9%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-14. Estimated Percent of Total Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	5.5% (3.5% - 7.4%)	4.9% (3.1% - 6.6%)	4.4% (2.8% - 5.9%)	3.8% (2.4% - 5.2%)	3.3% (2.1% - 4.5%)	3.8% (2.4% - 5.2%)	3.2% (2.1% - 4.4%)
Baltimore, MD	4.4% (2.8% - 5.9%)	4% (2.5% - 5.4%)	3.6% (2.3% - 4.9%)	3.1% (2% - 4.3%)	2.7% (1.7% - 3.6%)	3% (1.9% - 4.1%)	2% (1.3% - 2.8%)
Birmingham, AL	5.1% (3.3% - 7%)	3.6% (2.3% - 4.8%)	3.1% (2% - 4.3%)	2.7% (1.7% - 3.7%)	2.3% (1.4% - 3.1%)	2.7% (1.7% - 3.7%)	1.9% (1.2% - 2.5%)
Dallas, TX	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.8% (1.8% - 3.8%)	2.4% (1.5% - 3.3%)	2.8% (1.8% - 3.8%)	2.4% (1.5% - 3.3%)
Detroit, MI	4.1% (2.6% - 5.6%)	2.9% (1.8% - 3.9%)	2.8% (1.8% - 3.8%)	2.4% (1.5% - 3.3%)	2% (1.3% - 2.7%)	2.1% (1.3% - 2.8%)	1.2% (0.8% - 1.7%)
Fresno, CA	6% (3.8% - 8.1%)	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.9%)	2.1% (1.4% - 2.9%)	1.4% (0.9% - 1.9%)	0.7% (0.5% - 1%)
Houston, TX	3.9% (2.5% - 5.3%)	3.6% (2.3% - 4.9%)	3.1% (2% - 4.3%)	2.7% (1.7% - 3.7%)	2.3% (1.4% - 3.1%)	2.7% (1.7% - 3.7%)	2.3% (1.4% - 3.1%)
Los Angeles, CA	4.6% (2.9% - 6.2%)	1.9% (1.2% - 2.6%)	1.9% (1.2% - 2.6%)	1.9% (1.2% - 2.6%)	1.7% (1.1% - 2.3%)	1.3% (0.8% - 1.7%)	0.6% (0.4% - 0.8%)
New York, NY	3.7% (2.4% - 5.1%)	2.6% (1.7% - 3.6%)	2.6% (1.7% - 3.6%)	2.5% (1.6% - 3.4%)	2.1% (1.3% - 2.8%)	1.9% (1.2% - 2.5%)	1.1% (0.7% - 1.5%)
Philadelphia, PA	4.2% (2.7% - 5.6%)	3.6% (2.3% - 4.9%)	3.6% (2.3% - 4.9%)	3.2% (2% - 4.4%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	1.8% (1.1% - 2.4%)
Phoenix, AZ	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.5% (1.6% - 3.4%)	2.4% (1.5% - 3.3%)	1.5% (1% - 2.1%)
Pittsburgh, PA	4.3% (2.8% - 5.9%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.7%)	2.5% (1.6% - 3.4%)	2.1% (1.4% - 2.9%)	1.9% (1.2% - 2.6%)	1.1% (0.7% - 1.5%)
Salt Lake City, UT	2.2% (1.4% - 3%)	0.4% (0.3% - 0.6%)	0.4% (0.3% - 0.6%)	0.4% (0.3% - 0.6%)	0.4% (0.3% - 0.6%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	4.2% (2.7% - 5.7%)	3.5% (2.2% - 4.7%)	3.1% (2% - 4.2%)	2.7% (1.7% - 3.6%)	2.2% (1.4% - 3%)	2.6% (1.6% - 3.5%)	1.7% (1.1% - 2.3%)
Tacoma, WA	2.1% (1.3% - 2.8%)	1.2% (0.7% - 1.6%)	1.2% (0.7% - 1.6%)	1.2% (0.7% - 1.6%)	1.2% (0.7% - 1.6%)	0.6% (0.4% - 0.8%)	0% (0% - 0.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-15. Estimated Percent of Total Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	5.1% (3.3% - 7%)	4.6% (2.9% - 6.2%)	4.1% (2.6% - 5.5%)	3.6% (2.3% - 4.8%)	3% (1.9% - 4.1%)	3.6% (2.3% - 4.8%)	3% (1.9% - 4%)
Baltimore, MD	4.4% (2.8% - 5.9%)	4% (2.5% - 5.4%)	3.6% (2.3% - 4.9%)	3.2% (2% - 4.3%)	2.7% (1.7% - 3.6%)	3% (1.9% - 4.1%)	2% (1.3% - 2.8%)
Birmingham, AL	5.3% (3.4% - 7.2%)	3.7% (2.4% - 5.1%)	3.3% (2.1% - 4.5%)	2.8% (1.8% - 3.9%)	2.4% (1.5% - 3.3%)	2.8% (1.8% - 3.9%)	2% (1.3% - 2.7%)
Dallas, TX	3% (1.9% - 4.1%)	3% (1.9% - 4.1%)	3% (1.9% - 4.1%)	3% (1.9% - 4.1%)	2.7% (1.7% - 3.6%)	3% (1.9% - 4.1%)	2.7% (1.7% - 3.6%)
Detroit, MI	4.4% (2.8% - 6%)	3.1% (2% - 4.2%)	3% (1.9% - 4.1%)	2.6% (1.7% - 3.5%)	2.2% (1.4% - 3%)	2.2% (1.4% - 3%)	1.4% (0.9% - 1.9%)
Fresno, CA	6.2% (4% - 8.4%)	2.3% (1.4% - 3.1%)	2.3% (1.4% - 3.1%)	2.3% (1.4% - 3.1%)	2.3% (1.4% - 3.1%)	1.5% (1% - 2.1%)	0.8% (0.5% - 1.1%)
Houston, TX	4% (2.6% - 5.4%)	3.7% (2.3% - 5%)	3.2% (2.1% - 4.4%)	2.8% (1.8% - 3.8%)	2.3% (1.5% - 3.2%)	2.8% (1.8% - 3.8%)	2.3% (1.5% - 3.2%)
Los Angeles, CA	4.8% (3% - 6.4%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	2% (1.3% - 2.8%)	1.8% (1.1% - 2.4%)	1.3% (0.9% - 1.8%)	0.6% (0.4% - 0.9%)
New York, NY	4.3% (2.8% - 5.9%)	3.2% (2% - 4.3%)	3.2% (2% - 4.3%)	3% (1.9% - 4.1%)	2.5% (1.6% - 3.4%)	2.3% (1.5% - 3.1%)	1.4% (0.9% - 2%)
Philadelphia, PA	4.1% (2.6% - 5.6%)	3.6% (2.3% - 4.8%)	3.6% (2.3% - 4.8%)	3.2% (2% - 4.3%)	2.7% (1.7% - 3.7%)	2.7% (1.7% - 3.6%)	1.7% (1.1% - 2.4%)
Phoenix, AZ	2.3% (1.4% - 3.1%)	2.3% (1.4% - 3.1%)	2.3% (1.4% - 3.1%)	2.3% (1.4% - 3.1%)	2% (1.3% - 2.7%)	1.9% (1.2% - 2.6%)	1.1% (0.7% - 1.5%)
Pittsburgh, PA	4.9% (3.1% - 6.6%)	3.2% (2% - 4.3%)	3.2% (2% - 4.3%)	2.9% (1.9% - 4%)	2.6% (1.6% - 3.5%)	2.3% (1.5% - 3.1%)	1.5% (0.9% - 2%)
Salt Lake City, UT	3% (1.9% - 4.1%)	1% (0.6% - 1.3%)	1% (0.6% - 1.3%)	1% (0.6% - 1.3%)	1% (0.6% - 1.3%)	0.4% (0.3% - 0.6%)	0% (0% - 0%)
St. Louis, MO	4.6% (2.9% - 6.2%)	3.8% (2.4% - 5.2%)	3.4% (2.2% - 4.7%)	3% (1.9% - 4.1%)	2.5% (1.6% - 3.4%)	2.9% (1.8% - 3.9%)	1.9% (1.2% - 2.7%)
Tacoma, WA	2.1% (1.3% - 2.9%)	1.2% (0.8% - 1.7%)	1.2% (0.8% - 1.7%)	1.2% (0.8% - 1.7%)	1.2% (0.8% - 1.7%)	0.7% (0.4% - 0.9%)	0.1% (0.1% - 0.1%)

[1] Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2] Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-16. Percent Reduction from the Current Standards: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	21% (21% - 22%)	32% (32% - 32%)	21% (21% - 22%)	34% (34% - 34%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	8% (8% - 8%)	19% (19% - 19%)	30% (30% - 30%)	22% (22% - 22%)	45% (44% - 45%)
Birmingham, AL	-43% (-42% - -43%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	46% (46% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-37% (-37% - -38%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 13%)	26% (25% - 26%)	24% (24% - 24%)	48% (47% - 48%)
Fresno, CA	-185% (-183% - -187%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (34% - 34%)	68% (68% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 35%)	23% (23% - 24%)	35% (35% - 35%)
Los Angeles, CA	-122% (-121% - -124%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	63% (63% - 63%)
New York, NY	-35% (-35% - -36%)	0% (0% - 0%)	0% (0% - 0%)	5% (4% - 5%)	18% (18% - 18%)	25% (25% - 26%)	51% (51% - 51%)
Philadelphia, PA	-14% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 24%)	24% (24% - 24%)	49% (49% - 49%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 46%)
Pittsburgh, PA	-53% (-52% - -53%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	18% (18% - 18%)	25% (25% - 25%)	51% (51% - 51%)
Salt Lake City, UT	-254% (-253% - -256%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-18% (-18% - -18%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 20%)	31% (31% - 32%)	22% (22% - 23%)	45% (45% - 45%)
Tacoma, WA	-53% (-53% - -53%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (33% - 34%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-17. Percent Reduction from the Current Standards: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	21% (21% - 22%)	32% (32% - 32%)	21% (21% - 22%)	34% (34% - 34%)
Baltimore, MD	-10% (-10% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (33% - 33%)	24% (24% - 24%)	49% (49% - 49%)
Birmingham, AL	-44% (-44% - -44%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	48% (47% - 48%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	0% (0% - 0%)	13% (13% - 13%)
Detroit, MI	-45% (-44% - -45%)	0% (0% - 0%)	1% (1% - 1%)	16% (16% - 16%)	30% (30% - 31%)	28% (28% - 28%)	57% (56% - 57%)
Fresno, CA	-181% (-179% - -183%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	66% (66% - 66%)
Houston, TX	-10% (-10% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	36% (36% - 36%)
Los Angeles, CA	-137% (-136% - -139%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	14% (14% - 14%)	35% (35% - 35%)	70% (70% - 70%)
New York, NY	-41% (-41% - -41%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	30% (29% - 30%)	59% (59% - 60%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	25% (24% - 25%)	25% (25% - 26%)	51% (51% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 45%)
Pittsburgh, PA	-61% (-61% - -62%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	29% (29% - 29%)	58% (58% - 58%)
Salt Lake City, UT	-437% (-435% - -439%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-20% (-20% - -20%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 23%)	36% (36% - 36%)	26% (26% - 26%)	51% (51% - 52%)
Tacoma, WA	-76% (-76% - -76%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	48% (48% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-18. Percent Reduction from the Current Standards: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	22% (22% - 22%)	33% (33% - 33%)	22% (22% - 22%)	35% (35% - 35%)
Baltimore, MD	-10% (-10% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (33% - 33%)	24% (24% - 24%)	49% (49% - 49%)
Birmingham, AL	-43% (-43% - -44%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (35% - 36%)	24% (24% - 24%)	47% (47% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-43% (-43% - -43%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	29% (29% - 30%)	27% (27% - 27%)	55% (54% - 55%)
Fresno, CA	-175% (-173% - -177%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (32% - 32%)	64% (64% - 64%)
Houston, TX	-9% (-9% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	36% (36% - 36%)
Los Angeles, CA	-134% (-132% - -135%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (34% - 34%)	68% (68% - 68%)
New York, NY	-37% (-37% - -38%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	20% (19% - 20%)	27% (27% - 27%)	54% (54% - 55%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	25% (25% - 25%)	26% (25% - 26%)	51% (51% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (50% - 50%)
Pittsburgh, PA	-55% (-55% - -56%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	19% (19% - 19%)	27% (27% - 27%)	54% (54% - 54%)
Salt Lake City, UT	-217% (-216% - -218%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-19% (-19% - -20%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 22%)	34% (34% - 34%)	25% (24% - 25%)	49% (49% - 49%)
Tacoma, WA	-74% (-73% - -74%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-19. Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	249 (205 - 291)	222 (182 - 260)	199 (163 - 234)	176 (144 - 207)	153 (125 - 180)	176 (144 - 207)	149 (122 - 176)
Baltimore, MD	396 (326 - 464)	366 (301 - 429)	337 (276 - 395)	298 (244 - 351)	259 (212 - 306)	288 (236 - 339)	207 (169 - 245)
Birmingham, AL	186 (153 - 218)	133 (109 - 156)	118 (96 - 139)	103 (84 - 121)	87 (71 - 103)	103 (84 - 121)	73 (59 - 86)
Dallas, TX	231 (189 - 272)	231 (189 - 272)	231 (189 - 272)	231 (189 - 272)	206 (169 - 243)	231 (189 - 272)	206 (169 - 243)
Detroit, MI	689 (567 - 806)	509 (418 - 599)	504 (413 - 592)	444 (363 - 523)	383 (313 - 452)	393 (321 - 463)	272 (222 - 322)
Fresno, CA	187 (154 - 219)	68 (56 - 81)	68 (56 - 81)	68 (56 - 81)	68 (56 - 81)	45 (37 - 54)	22 (18 - 26)
Houston, TX	370 (304 - 435)	340 (278 - 400)	302 (247 - 356)	263 (215 - 310)	223 (182 - 264)	263 (215 - 310)	223 (182 - 264)
Los Angeles, CA	2124 (1746 - 2489)	984 (802 - 1163)	984 (802 - 1163)	984 (802 - 1163)	867 (707 - 1026)	682 (555 - 808)	373 (303 - 443)
New York, NY	2614 (2147 - 3068)	1959 (1603 - 2307)	1959 (1603 - 2307)	1874 (1533 - 2208)	1610 (1315 - 1900)	1475 (1204 - 1742)	976 (795 - 1156)
Philadelphia, PA	333 (273 - 391)	293 (240 - 345)	293 (240 - 345)	263 (215 - 309)	226 (185 - 267)	224 (183 - 264)	153 (125 - 181)
Phoenix, AZ	351 (286 - 414)	351 (286 - 414)	351 (286 - 414)	351 (286 - 414)	316 (258 - 374)	307 (250 - 362)	194 (158 - 230)
Pittsburgh, PA	436 (359 - 511)	291 (238 - 343)	291 (238 - 343)	274 (224 - 323)	241 (197 - 285)	219 (179 - 259)	146 (119 - 172)
Salt Lake City, UT	40 (33 - 47)	12 (9 - 14)	12 (9 - 14)	12 (9 - 14)	12 (9 - 14)	4 (3 - 5)	0 (0 - 0)
St. Louis, MO	636 (523 - 744)	544 (447 - 639)	496 (406 - 583)	438 (359 - 516)	379 (310 - 447)	427 (350 - 503)	305 (249 - 361)
Tacoma, WA	93 (76 - 109)	61 (50 - 72)	61 (50 - 72)	61 (50 - 72)	61 (50 - 72)	41 (33 - 48)	20 (16 - 24)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-20. Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	256 (211 - 300)	229 (188 - 268)	205 (168 - 241)	181 (149 - 214)	157 (129 - 185)	181 (149 - 214)	154 (126 - 181)
Baltimore, MD	325 (266 - 382)	297 (244 - 350)	271 (222 - 319)	237 (194 - 279)	202 (165 - 239)	228 (186 - 268)	155 (127 - 184)
Birmingham, AL	176 (144 - 206)	124 (101 - 146)	110 (90 - 129)	95 (77 - 112)	80 (65 - 95)	95 (77 - 112)	66 (54 - 78)
Dallas, TX	175 (143 - 207)	175 (143 - 207)	175 (143 - 207)	175 (143 - 207)	153 (125 - 181)	175 (143 - 207)	153 (125 - 181)
Detroit, MI	506 (415 - 595)	355 (290 - 418)	350 (286 - 413)	300 (244 - 354)	249 (203 - 294)	257 (209 - 304)	157 (127 - 186)
Fresno, CA	194 (160 - 227)	72 (59 - 85)	72 (59 - 85)	72 (59 - 85)	72 (59 - 85)	49 (40 - 58)	25 (20 - 29)
Houston, TX	359 (294 - 423)	329 (269 - 388)	291 (238 - 343)	252 (206 - 298)	213 (173 - 252)	252 (206 - 298)	213 (173 - 252)
Los Angeles, CA	1884 (1546 - 2212)	815 (664 - 965)	815 (664 - 965)	815 (664 - 965)	707 (575 - 837)	534 (434 - 633)	247 (200 - 293)
New York, NY	2050 (1678 - 2413)	1470 (1200 - 1736)	1470 (1200 - 1736)	1394 (1138 - 1648)	1163 (947 - 1375)	1043 (850 - 1235)	606 (492 - 719)
Philadelphia, PA	303 (248 - 356)	264 (216 - 311)	264 (216 - 311)	236 (193 - 278)	201 (164 - 238)	199 (163 - 235)	132 (107 - 156)
Phoenix, AZ	372 (303 - 439)	372 (303 - 439)	372 (303 - 439)	372 (303 - 439)	335 (273 - 396)	325 (265 - 384)	207 (168 - 245)
Pittsburgh, PA	349 (286 - 410)	220 (180 - 260)	220 (180 - 260)	205 (167 - 242)	177 (144 - 209)	157 (128 - 186)	93 (76 - 110)
Salt Lake City, UT	33 (27 - 39)	6 (5 - 7)	6 (5 - 7)	6 (5 - 7)	6 (5 - 7)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	484 (397 - 569)	405 (331 - 477)	363 (297 - 428)	314 (256 - 370)	263 (215 - 311)	304 (248 - 359)	200 (163 - 237)
Tacoma, WA	63 (51 - 75)	36 (29 - 43)	36 (29 - 43)	36 (29 - 43)	36 (29 - 43)	19 (15 - 23)	2 (1 - 2)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-21. Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	247 (203 - 290)	220 (180 - 258)	197 (161 - 231)	173 (142 - 204)	149 (122 - 176)	173 (142 - 204)	146 (119 - 172)
Baltimore, MD	324 (266 - 381)	297 (243 - 349)	271 (221 - 319)	236 (193 - 279)	202 (165 - 238)	227 (186 - 268)	155 (126 - 184)
Birmingham, AL	184 (151 - 216)	131 (107 - 154)	116 (95 - 136)	101 (82 - 119)	85 (70 - 101)	101 (82 - 119)	71 (58 - 84)
Dallas, TX	195 (159 - 230)	195 (159 - 230)	195 (159 - 230)	195 (159 - 230)	172 (140 - 203)	195 (159 - 230)	172 (140 - 203)
Detroit, MI	532 (436 - 625)	377 (308 - 445)	372 (304 - 439)	321 (262 - 379)	269 (219 - 318)	277 (226 - 327)	174 (142 - 206)
Fresno, CA	204 (169 - 239)	77 (63 - 92)	77 (63 - 92)	77 (63 - 92)	77 (63 - 92)	53 (43 - 63)	28 (23 - 33)
Houston, TX	375 (307 - 441)	344 (281 - 405)	304 (249 - 358)	264 (215 - 312)	223 (182 - 264)	264 (215 - 312)	223 (182 - 264)
Los Angeles, CA	1953 (1604 - 2293)	860 (701 - 1018)	860 (701 - 1018)	860 (701 - 1018)	749 (610 - 887)	572 (465 - 678)	278 (225 - 330)
New York, NY	2384 (1955 - 2802)	1755 (1435 - 2070)	1755 (1435 - 2070)	1673 (1367 - 1974)	1421 (1160 - 1679)	1292 (1053 - 1527)	815 (663 - 966)
Philadelphia, PA	300 (245 - 352)	261 (214 - 308)	261 (214 - 308)	233 (190 - 275)	199 (162 - 235)	197 (160 - 232)	130 (106 - 154)
Phoenix, AZ	317 (258 - 374)	317 (258 - 374)	317 (258 - 374)	317 (258 - 374)	282 (230 - 333)	272 (222 - 322)	160 (130 - 189)
Pittsburgh, PA	390 (321 - 458)	256 (209 - 302)	256 (209 - 302)	239 (196 - 283)	209 (170 - 246)	189 (154 - 223)	120 (98 - 142)
Salt Lake City, UT	47 (38 - 55)	15 (12 - 18)	15 (12 - 18)	15 (12 - 18)	15 (12 - 18)	7 (6 - 8)	0 (0 - 0)
St. Louis, MO	529 (434 - 621)	446 (365 - 525)	402 (329 - 474)	350 (286 - 413)	297 (243 - 351)	340 (278 - 401)	231 (188 - 273)
Tacoma, WA	66 (54 - 78)	38 (31 - 46)	38 (31 - 46)	38 (31 - 46)	38 (31 - 46)	21 (17 - 25)	3 (2 - 3)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-22. Estimated Percent of Total Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	15.8% (13% - 18.6%)	14.1% (11.6% - 16.6%)	12.7% (10.4% - 14.9%)	11.2% (9.2% - 13.2%)	9.7% (8% - 11.5%)	11.2% (9.2% - 13.2%)	9.5% (7.8% - 11.2%)
Baltimore, MD	15.6% (12.8% - 18.2%)	14.4% (11.8% - 16.9%)	13.2% (10.9% - 15.5%)	11.7% (9.6% - 13.8%)	10.2% (8.3% - 12%)	11.3% (9.3% - 13.3%)	8.1% (6.7% - 9.6%)
Birmingham, AL	15.9% (13.1% - 18.6%)	11.3% (9.3% - 13.4%)	10.1% (8.2% - 11.9%)	8.8% (7.2% - 10.4%)	7.5% (6.1% - 8.8%)	8.8% (7.2% - 10.4%)	6.2% (5.1% - 7.4%)
Dallas, TX	11.1% (9.1% - 13.1%)	11.1% (9.1% - 13.1%)	11.1% (9.1% - 13.1%)	11.1% (9.1% - 13.1%)	9.9% (8.1% - 11.7%)	11.1% (9.1% - 13.1%)	9.9% (8.1% - 11.7%)
Detroit, MI	16.4% (13.5% - 19.2%)	12.2% (10% - 14.3%)	12% (9.8% - 14.1%)	10.6% (8.7% - 12.5%)	9.1% (7.5% - 10.8%)	9.4% (7.7% - 11.1%)	6.5% (5.3% - 7.7%)
Fresno, CA	16.8% (13.8% - 19.6%)	6.1% (5% - 7.2%)	6.1% (5% - 7.2%)	6.1% (5% - 7.2%)	6.1% (5% - 7.2%)	4.1% (3.3% - 4.8%)	2% (1.6% - 2.4%)
Houston, TX	12.2% (10% - 14.4%)	11.2% (9.2% - 13.2%)	9.9% (8.1% - 11.7%)	8.7% (7.1% - 10.2%)	7.4% (6% - 8.7%)	8.7% (7.1% - 10.2%)	7.4% (6% - 8.7%)
Los Angeles, CA	15.2% (12.5% - 17.8%)	7% (5.7% - 8.3%)	7% (5.7% - 8.3%)	7% (5.7% - 8.3%)	6.2% (5.1% - 7.3%)	4.9% (4% - 5.8%)	2.7% (2.2% - 3.2%)
New York, NY	14.1% (11.6% - 16.5%)	10.6% (8.6% - 12.4%)	10.6% (8.6% - 12.4%)	10.1% (8.3% - 11.9%)	8.7% (7.1% - 10.2%)	7.9% (6.5% - 9.4%)	5.3% (4.3% - 6.2%)
Philadelphia, PA	13.3% (10.9% - 15.6%)	11.7% (9.6% - 13.8%)	11.7% (9.6% - 13.8%)	10.5% (8.6% - 12.4%)	9.1% (7.4% - 10.7%)	9% (7.3% - 10.6%)	6.1% (5% - 7.3%)
Phoenix, AZ	8% (6.5% - 9.4%)	8% (6.5% - 9.4%)	8% (6.5% - 9.4%)	8% (6.5% - 9.4%)	7.2% (5.9% - 8.5%)	7% (5.7% - 8.2%)	4.4% (3.6% - 5.2%)
Pittsburgh, PA	15.7% (12.9% - 18.4%)	10.5% (8.6% - 12.3%)	10.5% (8.6% - 12.3%)	9.9% (8.1% - 11.6%)	8.7% (7.1% - 10.2%)	7.9% (6.4% - 9.3%)	5.2% (4.3% - 6.2%)
Salt Lake City, UT	8.2% (6.7% - 9.7%)	2.4% (1.9% - 2.8%)	2.4% (1.9% - 2.8%)	2.4% (1.9% - 2.8%)	2.4% (1.9% - 2.8%)	0.8% (0.7% - 1%)	0% (0% - 0%)
St. Louis, MO	16.1% (13.3% - 18.9%)	13.8% (11.3% - 16.2%)	12.6% (10.3% - 14.8%)	11.1% (9.1% - 13.1%)	9.6% (7.9% - 11.4%)	10.8% (8.9% - 12.8%)	7.7% (6.3% - 9.2%)
Tacoma, WA	9.2% (7.5% - 10.8%)	6.1% (4.9% - 7.2%)	6.1% (4.9% - 7.2%)	6.1% (4.9% - 7.2%)	6.1% (4.9% - 7.2%)	4.1% (3.3% - 4.8%)	2% (1.6% - 2.4%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-23. Estimated Percent of Total Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	15.8% (13% - 18.5%)	14.1% (11.6% - 16.6%)	12.7% (10.4% - 14.9%)	11.2% (9.2% - 13.2%)	9.7% (8% - 11.5%)	11.2% (9.2% - 13.2%)	9.5% (7.8% - 11.2%)
Baltimore, MD	12.7% (10.5% - 15%)	11.7% (9.6% - 13.7%)	10.6% (8.7% - 12.5%)	9.3% (7.6% - 11%)	7.9% (6.5% - 9.4%)	8.9% (7.3% - 10.5%)	6.1% (5% - 7.2%)
Birmingham, AL	14.8% (12.2% - 17.4%)	10.5% (8.6% - 12.3%)	9.3% (7.6% - 10.9%)	8% (6.5% - 9.5%)	6.8% (5.5% - 8%)	8% (6.5% - 9.5%)	5.6% (4.5% - 6.6%)
Dallas, TX	8.2% (6.7% - 9.7%)	8.2% (6.7% - 9.7%)	8.2% (6.7% - 9.7%)	8.2% (6.7% - 9.7%)	7.2% (5.9% - 8.5%)	8.2% (6.7% - 9.7%)	7.2% (5.9% - 8.5%)
Detroit, MI	12.1% (9.9% - 14.2%)	8.5% (6.9% - 10%)	8.4% (6.8% - 9.9%)	7.2% (5.8% - 8.5%)	5.9% (4.8% - 7%)	6.1% (5% - 7.3%)	3.7% (3% - 4.4%)
Fresno, CA	17.2% (14.1% - 20.1%)	6.4% (5.2% - 7.5%)	6.4% (5.2% - 7.5%)	6.4% (5.2% - 7.5%)	6.4% (5.2% - 7.5%)	4.3% (3.5% - 5.1%)	2.2% (1.8% - 2.6%)
Houston, TX	11.5% (9.4% - 13.5%)	10.5% (8.6% - 12.4%)	9.3% (7.6% - 10.9%)	8% (6.6% - 9.5%)	6.8% (5.5% - 8%)	8% (6.6% - 9.5%)	6.8% (5.5% - 8%)
Los Angeles, CA	13.4% (11% - 15.7%)	5.8% (4.7% - 6.9%)	5.8% (4.7% - 6.9%)	5.8% (4.7% - 6.9%)	5% (4.1% - 5.9%)	3.8% (3.1% - 4.5%)	1.8% (1.4% - 2.1%)
New York, NY	10.9% (9% - 12.9%)	7.8% (6.4% - 9.3%)	7.8% (6.4% - 9.3%)	7.4% (6.1% - 8.8%)	6.2% (5.1% - 7.3%)	5.6% (4.5% - 6.6%)	3.2% (2.6% - 3.8%)
Philadelphia, PA	12.1% (9.9% - 14.3%)	10.6% (8.7% - 12.5%)	10.6% (8.7% - 12.5%)	9.4% (7.7% - 11.1%)	8.1% (6.6% - 9.5%)	8% (6.5% - 9.4%)	5.3% (4.3% - 6.3%)
Phoenix, AZ	8.1% (6.6% - 9.6%)	8.1% (6.6% - 9.6%)	8.1% (6.6% - 9.6%)	8.1% (6.6% - 9.6%)	7.3% (6% - 8.7%)	7.1% (5.8% - 8.4%)	4.5% (3.7% - 5.4%)
Pittsburgh, PA	12.6% (10.4% - 14.8%)	8% (6.5% - 9.4%)	8% (6.5% - 9.4%)	7.4% (6.1% - 8.8%)	6.4% (5.2% - 7.6%)	5.7% (4.6% - 6.7%)	3.4% (2.7% - 4%)
Salt Lake City, UT	6.5% (5.3% - 7.7%)	1.2% (1% - 1.5%)	1.2% (1% - 1.5%)	1.2% (1% - 1.5%)	1.2% (1% - 1.5%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	12.2% (10% - 14.4%)	10.2% (8.4% - 12.1%)	9.2% (7.5% - 10.8%)	7.9% (6.5% - 9.4%)	6.7% (5.4% - 7.9%)	7.7% (6.3% - 9.1%)	5.1% (4.1% - 6%)
Tacoma, WA	6.1% (5% - 7.3%)	3.5% (2.9% - 4.2%)	3.5% (2.9% - 4.2%)	3.5% (2.9% - 4.2%)	3.5% (2.9% - 4.2%)	1.8% (1.5% - 2.2%)	0.1% (0.1% - 0.2%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-24. Estimated Percent of Total Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	14.9% (12.2% - 17.4%)	13.2% (10.9% - 15.5%)	11.8% (9.7% - 13.9%)	10.4% (8.5% - 12.3%)	9% (7.4% - 10.6%)	10.4% (8.5% - 12.3%)	8.8% (7.2% - 10.4%)
Baltimore, MD	12.7% (10.5% - 15%)	11.7% (9.6% - 13.7%)	10.6% (8.7% - 12.5%)	9.3% (7.6% - 11%)	7.9% (6.5% - 9.4%)	8.9% (7.3% - 10.5%)	6.1% (5% - 7.2%)
Birmingham, AL	15.4% (12.7% - 18%)	10.9% (8.9% - 12.9%)	9.7% (7.9% - 11.4%)	8.4% (6.9% - 9.9%)	7.1% (5.8% - 8.4%)	8.4% (6.9% - 9.9%)	5.9% (4.8% - 7%)
Dallas, TX	9% (7.3% - 10.6%)	9% (7.3% - 10.6%)	9% (7.3% - 10.6%)	9% (7.3% - 10.6%)	7.9% (6.5% - 9.3%)	9% (7.3% - 10.6%)	7.9% (6.5% - 9.3%)
Detroit, MI	12.8% (10.5% - 15%)	9.1% (7.4% - 10.7%)	9% (7.3% - 10.6%)	7.7% (6.3% - 9.1%)	6.5% (5.3% - 7.6%)	6.7% (5.4% - 7.9%)	4.2% (3.4% - 5%)
Fresno, CA	17.7% (14.6% - 20.7%)	6.7% (5.5% - 8%)	6.7% (5.5% - 8%)	6.7% (5.5% - 8%)	6.7% (5.5% - 8%)	4.6% (3.7% - 5.5%)	2.4% (2% - 2.9%)
Houston, TX	11.7% (9.6% - 13.8%)	10.7% (8.8% - 12.6%)	9.5% (7.8% - 11.2%)	8.2% (6.7% - 9.7%)	7% (5.7% - 8.3%)	8.2% (6.7% - 9.7%)	7% (5.7% - 8.3%)
Los Angeles, CA	13.8% (11.3% - 16.2%)	6.1% (4.9% - 7.2%)	6.1% (4.9% - 7.2%)	6.1% (4.9% - 7.2%)	5.3% (4.3% - 6.3%)	4% (3.3% - 4.8%)	2% (1.6% - 2.3%)
New York, NY	12.6% (10.4% - 14.8%)	9.3% (7.6% - 11%)	9.3% (7.6% - 11%)	8.9% (7.2% - 10.5%)	7.5% (6.1% - 8.9%)	6.8% (5.6% - 8.1%)	4.3% (3.5% - 5.1%)
Philadelphia, PA	12% (9.8% - 14.1%)	10.5% (8.6% - 12.3%)	10.5% (8.6% - 12.3%)	9.3% (7.6% - 11%)	8% (6.5% - 9.4%)	7.9% (6.4% - 9.3%)	5.2% (4.2% - 6.2%)
Phoenix, AZ	6.7% (5.5% - 7.9%)	6.7% (5.5% - 7.9%)	6.7% (5.5% - 7.9%)	6.7% (5.5% - 7.9%)	6% (4.9% - 7.1%)	5.8% (4.7% - 6.8%)	3.4% (2.8% - 4%)
Pittsburgh, PA	14.2% (11.7% - 16.7%)	9.3% (7.6% - 11%)	9.3% (7.6% - 11%)	8.7% (7.1% - 10.3%)	7.6% (6.2% - 9%)	6.9% (5.6% - 8.1%)	4.4% (3.5% - 5.2%)
Salt Lake City, UT	9% (7.4% - 10.6%)	2.9% (2.4% - 3.4%)	2.9% (2.4% - 3.4%)	2.9% (2.4% - 3.4%)	2.9% (2.4% - 3.4%)	1.3% (1.1% - 1.6%)	0% (0% - 0%)
St. Louis, MO	13.3% (10.9% - 15.7%)	11.2% (9.2% - 13.2%)	10.1% (8.3% - 11.9%)	8.8% (7.2% - 10.4%)	7.5% (6.1% - 8.9%)	8.6% (7% - 10.1%)	5.8% (4.7% - 6.9%)
Tacoma, WA	6.3% (5.2% - 7.5%)	3.7% (3% - 4.4%)	3.7% (3% - 4.4%)	3.7% (3% - 4.4%)	3.7% (3% - 4.4%)	2% (1.6% - 2.4%)	0.3% (0.2% - 0.3%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-25. Percent Reduction from the Current Standards: Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -12%)	0% (0% - 0%)	10% (10% - 10%)	21% (20% - 21%)	31% (31% - 31%)	21% (20% - 21%)	33% (32% - 33%)
Baltimore, MD	-8% (-8% - -8%)	0% (0% - 0%)	8% (8% - 8%)	18% (18% - 19%)	29% (29% - 29%)	21% (21% - 22%)	43% (43% - 44%)
Birmingham, AL	-40% (-39% - -41%)	0% (0% - 0%)	11% (11% - 11%)	23% (22% - 23%)	34% (34% - 34%)	23% (22% - 23%)	45% (45% - 45%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-35% (-35% - -36%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 13%)	25% (25% - 25%)	23% (23% - 23%)	47% (46% - 47%)
Fresno, CA	-174% (-171% - -177%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 34%)	68% (67% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 23%)	34% (34% - 35%)	23% (23% - 23%)	34% (34% - 35%)
Los Angeles, CA	-116% (-114% - -118%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	62% (62% - 62%)
New York, NY	-33% (-33% - -34%)	0% (0% - 0%)	0% (0% - 0%)	4% (4% - 4%)	18% (18% - 18%)	25% (25% - 25%)	50% (50% - 50%)
Philadelphia, PA	-14% (-14% - -14%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	23% (22% - 23%)	23% (23% - 24%)	48% (47% - 48%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 45%)
Pittsburgh, PA	-50% (-49% - -51%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	17% (17% - 17%)	25% (24% - 25%)	50% (50% - 50%)
Salt Lake City, UT	-247% (-245% - -249%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-17% (-16% - -17%)	0% (0% - 0%)	9% (9% - 9%)	20% (19% - 20%)	30% (30% - 31%)	22% (21% - 22%)	44% (44% - 44%)
Tacoma, WA	-51% (-51% - -52%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-26. Percent Reduction from the Current Standards: Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -12%)	0% (0% - 0%)	10% (10% - 10%)	21% (20% - 21%)	31% (31% - 31%)	21% (20% - 21%)	33% (32% - 33%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 21%)	32% (32% - 32%)	24% (23% - 24%)	48% (47% - 48%)
Birmingham, AL	-42% (-41% - -42%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 36%)	23% (23% - 24%)	47% (46% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (12% - 13%)	0% (0% - 0%)	13% (12% - 13%)
Detroit, MI	-43% (-42% - -43%)	0% (0% - 0%)	1% (1% - 1%)	16% (15% - 16%)	30% (30% - 30%)	28% (27% - 28%)	56% (56% - 56%)
Fresno, CA	-170% (-167% - -173%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (32% - 33%)	66% (66% - 66%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 36%)	23% (23% - 24%)	35% (35% - 36%)
Los Angeles, CA	-131% (-129% - -133%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	35% (34% - 35%)	70% (70% - 70%)
New York, NY	-39% (-39% - -40%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	29% (29% - 29%)	59% (59% - 59%)
Philadelphia, PA	-14% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 24%)	25% (24% - 25%)	50% (50% - 50%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	12% (12% - 13%)	44% (44% - 45%)
Pittsburgh, PA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	28% (28% - 29%)	58% (58% - 58%)
Salt Lake City, UT	-427% (-425% - -430%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-19% (-19% - -20%)	0% (0% - 0%)	10% (10% - 10%)	23% (22% - 23%)	35% (35% - 35%)	25% (25% - 25%)	51% (50% - 51%)
Tacoma, WA	-74% (-74% - -75%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	47% (47% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-27. Percent Reduction from the Current Standards: Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -13%)	0% (0% - 0%)	10% (10% - 11%)	21% (21% - 21%)	32% (32% - 32%)	21% (21% - 21%)	34% (33% - 34%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 21%)	32% (32% - 32%)	24% (23% - 24%)	48% (47% - 48%)
Birmingham, AL	-41% (-40% - -42%)	0% (0% - 0%)	11% (11% - 12%)	23% (23% - 23%)	35% (34% - 35%)	23% (23% - 23%)	46% (46% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-41% (-41% - -42%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	29% (29% - 29%)	27% (26% - 27%)	54% (54% - 54%)
Fresno, CA	-164% (-161% - -167%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	31% (31% - 32%)	64% (64% - 64%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	35% (35% - 35%)
Los Angeles, CA	-127% (-125% - -129%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (33% - 34%)	68% (68% - 68%)
New York, NY	-36% (-35% - -36%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	19% (19% - 19%)	26% (26% - 27%)	54% (53% - 54%)
Philadelphia, PA	-15% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 24%)	25% (25% - 25%)	50% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (49% - 50%)
Pittsburgh, PA	-53% (-52% - -53%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	18% (18% - 19%)	26% (26% - 26%)	53% (53% - 53%)
Salt Lake City, UT	-210% (-209% - -212%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-19% (-18% - -19%)	0% (0% - 0%)	10% (10% - 10%)	22% (21% - 22%)	33% (33% - 34%)	24% (24% - 24%)	48% (48% - 49%)
Tacoma, WA	-72% (-71% - -72%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-28. Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1999 - 2000[1]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	312 (257 - 364)	279 (229 - 327)	251 (206 - 295)	222 (182 - 262)	193 (158 - 228)	222 (182 - 262)	189 (154 - 223)
Baltimore, MD	497 (409 - 581)	460 (378 - 538)	423 (348 - 497)	376 (308 - 442)	328 (268 - 386)	363 (298 - 427)	263 (214 - 310)
Birmingham, AL	233 (192 - 273)	168 (137 - 197)	149 (122 - 176)	130 (106 - 154)	111 (90 - 131)	130 (106 - 154)	93 (75 - 110)
Dallas, TX	292 (239 - 344)	292 (239 - 344)	292 (239 - 344)	292 (239 - 344)	261 (213 - 307)	292 (239 - 344)	261 (213 - 307)
Detroit, MI	862 (711 - 1007)	642 (526 - 754)	635 (520 - 746)	561 (459 - 660)	485 (396 - 572)	497 (406 - 586)	346 (282 - 410)
Fresno, CA	234 (193 - 273)	87 (71 - 103)	87 (71 - 103)	87 (71 - 103)	87 (71 - 103)	58 (47 - 69)	28 (23 - 34)
Houston, TX	467 (383 - 548)	429 (351 - 505)	382 (312 - 449)	333 (272 - 393)	284 (231 - 335)	333 (272 - 393)	284 (231 - 335)
Los Angeles, CA	2664 (2192 - 3117)	1249 (1017 - 1477)	1249 (1017 - 1477)	1249 (1017 - 1477)	1103 (897 - 1306)	869 (705 - 1030)	477 (386 - 567)
New York, NY	3285 (2700 - 3849)	2475 (2024 - 2914)	2475 (2024 - 2914)	2369 (1936 - 2790)	2040 (1665 - 2408)	1871 (1525 - 2210)	1243 (1010 - 1474)
Philadelphia, PA	419 (344 - 492)	369 (303 - 434)	369 (303 - 434)	332 (271 - 391)	287 (234 - 338)	284 (232 - 335)	195 (159 - 231)
Phoenix, AZ	445 (363 - 526)	445 (363 - 526)	445 (363 - 526)	445 (363 - 526)	401 (327 - 475)	389 (317 - 461)	247 (200 - 293)
Pittsburgh, PA	547 (450 - 639)	368 (301 - 433)	368 (301 - 433)	346 (283 - 408)	305 (249 - 361)	278 (227 - 329)	185 (151 - 220)
Salt Lake City, UT	51 (42 - 60)	15 (12 - 18)	15 (12 - 18)	15 (12 - 18)	15 (12 - 18)	5 (4 - 6)	0 (0 - 0)
St. Louis, MO	796 (656 - 930)	684 (562 - 802)	624 (512 - 733)	553 (453 - 650)	480 (392 - 566)	539 (441 - 635)	388 (316 - 458)
Tacoma, WA	117 (96 - 138)	78 (63 - 92)	78 (63 - 92)	78 (63 - 92)	78 (63 - 92)	52 (42 - 62)	26 (21 - 31)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-29. Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	321 (264 - 375)	287 (236 - 336)	258 (212 - 303)	229 (187 - 269)	199 (163 - 235)	229 (187 - 269)	194 (159 - 229)
Baltimore, MD	409 (335 - 480)	375 (307 - 441)	342 (280 - 403)	300 (245 - 353)	256 (209 - 303)	288 (235 - 340)	198 (161 - 234)
Birmingham, AL	221 (181 - 258)	157 (128 - 184)	139 (113 - 164)	120 (98 - 142)	102 (83 - 120)	120 (98 - 142)	84 (68 - 100)
Dallas, TX	222 (181 - 262)	222 (181 - 262)	222 (181 - 262)	222 (181 - 262)	195 (158 - 230)	222 (181 - 262)	195 (158 - 230)
Detroit, MI	638 (523 - 749)	449 (367 - 530)	443 (361 - 523)	380 (310 - 450)	316 (257 - 375)	327 (266 - 387)	200 (162 - 237)
Fresno, CA	243 (201 - 284)	92 (75 - 108)	92 (75 - 108)	92 (75 - 108)	92 (75 - 108)	62 (50 - 74)	32 (26 - 38)
Houston, TX	453 (371 - 533)	416 (340 - 490)	368 (301 - 434)	320 (261 - 378)	270 (220 - 320)	320 (261 - 378)	270 (220 - 320)
Los Angeles, CA	2370 (1945 - 2779)	1038 (843 - 1229)	1038 (843 - 1229)	1038 (843 - 1229)	901 (731 - 1068)	682 (553 - 809)	316 (255 - 376)
New York, NY	2588 (2118 - 3046)	1865 (1520 - 2203)	1865 (1520 - 2203)	1770 (1442 - 2092)	1478 (1202 - 1750)	1328 (1079 - 1573)	774 (627 - 920)
Philadelphia, PA	381 (313 - 448)	334 (273 - 393)	334 (273 - 393)	298 (244 - 352)	255 (208 - 302)	253 (206 - 298)	168 (137 - 199)
Phoenix, AZ	471 (384 - 557)	471 (384 - 557)	471 (384 - 557)	471 (384 - 557)	426 (347 - 503)	413 (336 - 488)	264 (214 - 313)
Pittsburgh, PA	439 (360 - 516)	279 (228 - 330)	279 (228 - 330)	260 (212 - 308)	225 (183 - 266)	200 (163 - 237)	119 (96 - 141)
Salt Lake City, UT	42 (34 - 50)	8 (6 - 10)	8 (6 - 10)	8 (6 - 10)	8 (6 - 10)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	610 (500 - 716)	512 (419 - 603)	460 (375 - 542)	398 (324 - 470)	335 (272 - 396)	386 (314 - 456)	255 (207 - 302)
Tacoma, WA	80 (65 - 95)	46 (37 - 55)	46 (37 - 55)	46 (37 - 55)	46 (37 - 55)	24 (20 - 29)	2 (2 - 2)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-30. Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	310 (255 - 363)	277 (227 - 324)	248 (203 - 291)	219 (179 - 258)	189 (154 - 223)	219 (179 - 258)	185 (151 - 218)
Baltimore, MD	408 (335 - 479)	374 (307 - 440)	342 (280 - 402)	299 (244 - 353)	256 (209 - 302)	288 (235 - 339)	197 (160 - 234)
Birmingham, AL	231 (190 - 270)	165 (135 - 194)	146 (120 - 173)	128 (104 - 151)	108 (88 - 128)	128 (104 - 151)	90 (73 - 107)
Dallas, TX	247 (202 - 291)	247 (202 - 291)	247 (202 - 291)	247 (202 - 291)	218 (178 - 257)	247 (202 - 291)	218 (178 - 257)
Detroit, MI	670 (549 - 786)	478 (390 - 563)	471 (385 - 556)	407 (332 - 481)	341 (278 - 404)	352 (286 - 416)	222 (180 - 264)
Fresno, CA	255 (211 - 298)	98 (80 - 116)	98 (80 - 116)	98 (80 - 116)	98 (80 - 116)	68 (55 - 80)	36 (29 - 43)
Houston, TX	473 (387 - 556)	434 (355 - 511)	385 (314 - 453)	335 (273 - 395)	284 (231 - 335)	335 (273 - 395)	284 (231 - 335)
Los Angeles, CA	2456 (2017 - 2879)	1094 (890 - 1296)	1094 (890 - 1296)	1094 (890 - 1296)	954 (775 - 1131)	730 (592 - 866)	355 (287 - 423)
New York, NY	3003 (2462 - 3525)	2222 (1814 - 2620)	2222 (1814 - 2620)	2120 (1730 - 2501)	1804 (1469 - 2132)	1641 (1336 - 1941)	1040 (843 - 1234)
Philadelphia, PA	378 (309 - 444)	330 (270 - 389)	330 (270 - 389)	295 (241 - 347)	252 (205 - 298)	249 (203 - 295)	165 (134 - 196)
Phoenix, AZ	402 (327 - 476)	402 (327 - 476)	402 (327 - 476)	402 (327 - 476)	359 (291 - 425)	347 (282 - 410)	204 (165 - 242)
Pittsburgh, PA	490 (403 - 574)	324 (264 - 382)	324 (264 - 382)	303 (248 - 358)	265 (216 - 313)	240 (195 - 284)	153 (124 - 181)
Salt Lake City, UT	59 (48 - 70)	19 (16 - 23)	19 (16 - 23)	19 (16 - 23)	19 (16 - 23)	9 (7 - 10)	0 (0 - 0)
St. Louis, MO	665 (546 - 780)	563 (461 - 662)	508 (415 - 599)	443 (362 - 523)	377 (307 - 446)	431 (351 - 509)	294 (239 - 348)
Tacoma, WA	84 (68 - 99)	49 (40 - 58)	49 (40 - 58)	49 (40 - 58)	49 (40 - 58)	27 (21 - 32)	4 (3 - 4)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-31. Estimated Percent of Total Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2001

Risk Assessment Location	Percent of Total Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	19.9% (16.4% - 23.2%)	17.8% (14.6% - 20.8%)	16% (13.1% - 18.8%)	14.2% (11.6% - 16.7%)	12.3% (10.1% - 14.5%)	14.2% (11.6% - 16.7%)	12% (9.8% - 14.2%)
Baltimore, MD	19.5% (16.1% - 22.8%)	18.1% (14.8% - 21.2%)	16.6% (13.7% - 19.5%)	14.8% (12.1% - 17.4%)	12.9% (10.5% - 15.2%)	14.3% (11.7% - 16.8%)	10.3% (8.4% - 12.2%)
Birmingham, AL	19.9% (16.4% - 23.3%)	14.3% (11.7% - 16.8%)	12.7% (10.4% - 15%)	11.1% (9.1% - 13.1%)	9.5% (7.7% - 11.2%)	11.1% (9.1% - 13.1%)	7.9% (6.4% - 9.4%)
Dallas, TX	14% (11.5% - 16.5%)	14% (11.5% - 16.5%)	14% (11.5% - 16.5%)	14% (11.5% - 16.5%)	12.5% (10.2% - 14.7%)	14% (11.5% - 16.5%)	12.5% (10.2% - 14.7%)
Detroit, MI	20.6% (17% - 24%)	15.3% (12.6% - 18%)	15.1% (12.4% - 17.8%)	13.4% (10.9% - 15.7%)	11.6% (9.4% - 13.6%)	11.9% (9.7% - 14%)	8.3% (6.7% - 9.8%)
Fresno, CA	21% (17.3% - 24.5%)	7.8% (6.3% - 9.2%)	7.8% (6.3% - 9.2%)	7.8% (6.3% - 9.2%)	7.8% (6.3% - 9.2%)	5.2% (4.2% - 6.2%)	2.5% (2.1% - 3%)
Houston, TX	15.4% (12.6% - 18.1%)	14.2% (11.6% - 16.6%)	12.6% (10.3% - 14.8%)	11% (9% - 13%)	9.4% (7.6% - 11.1%)	11% (9% - 13%)	9.4% (7.6% - 11.1%)
Los Angeles, CA	19% (15.7% - 22.3%)	8.9% (7.3% - 10.6%)	8.9% (7.3% - 10.6%)	8.9% (7.3% - 10.6%)	7.9% (6.4% - 9.3%)	6.2% (5% - 7.4%)	3.4% (2.8% - 4.1%)
New York, NY	17.7% (14.5% - 20.7%)	13.3% (10.9% - 15.7%)	13.3% (10.9% - 15.7%)	12.8% (10.4% - 15%)	11% (9% - 13%)	10.1% (8.2% - 11.9%)	6.7% (5.4% - 7.9%)
Philadelphia, PA	16.8% (13.8% - 19.7%)	14.8% (12.1% - 17.4%)	14.8% (12.1% - 17.4%)	13.3% (10.8% - 15.6%)	11.5% (9.4% - 13.5%)	11.4% (9.3% - 13.4%)	7.8% (6.3% - 9.2%)
Phoenix, AZ	10.1% (8.2% - 11.9%)	10.1% (8.2% - 11.9%)	10.1% (8.2% - 11.9%)	10.1% (8.2% - 11.9%)	9.1% (7.4% - 10.8%)	8.8% (7.2% - 10.5%)	5.6% (4.5% - 6.6%)
Pittsburgh, PA	19.7% (16.2% - 23%)	13.2% (10.8% - 15.6%)	13.2% (10.8% - 15.6%)	12.5% (10.2% - 14.7%)	11% (9% - 13%)	10% (8.2% - 11.8%)	6.7% (5.4% - 7.9%)
Salt Lake City, UT	10.4% (8.5% - 12.3%)	3% (2.4% - 3.6%)	3% (2.4% - 3.6%)	3% (2.4% - 3.6%)	3% (2.4% - 3.6%)	1.1% (0.9% - 1.3%)	0% (0% - 0%)
St. Louis, MO	20.2% (16.6% - 23.6%)	17.4% (14.3% - 20.4%)	15.8% (13% - 18.6%)	14% (11.5% - 16.5%)	12.2% (10% - 14.4%)	13.7% (11.2% - 16.1%)	9.8% (8% - 11.6%)
Tacoma, WA	11.6% (9.5% - 13.7%)	7.7% (6.3% - 9.1%)	7.7% (6.3% - 9.1%)	7.7% (6.3% - 9.1%)	7.7% (6.3% - 9.1%)	5.2% (4.2% - 6.1%)	2.6% (2.1% - 3.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-32. Estimated Percent of Total Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2001

Risk Assessment Location	Percent of Total Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	19.8% (16.3% - 23.2%)	17.7% (14.6% - 20.8%)	16% (13.1% - 18.7%)	14.2% (11.6% - 16.6%)	12.3% (10% - 14.5%)	14.2% (11.6% - 16.6%)	12% (9.8% - 14.2%)
Baltimore, MD	16% (13.2% - 18.8%)	14.7% (12.1% - 17.3%)	13.4% (11% - 15.8%)	11.8% (9.6% - 13.9%)	10.1% (8.2% - 11.9%)	11.3% (9.2% - 13.3%)	7.8% (6.3% - 9.2%)
Birmingham, AL	18.6% (15.3% - 21.8%)	13.2% (10.8% - 15.6%)	11.7% (9.6% - 13.8%)	10.2% (8.3% - 12%)	8.6% (7% - 10.2%)	10.2% (8.3% - 12%)	7.1% (5.8% - 8.4%)
Dallas, TX	10.4% (8.5% - 12.3%)	10.4% (8.5% - 12.3%)	10.4% (8.5% - 12.3%)	10.4% (8.5% - 12.3%)	9.1% (7.4% - 10.8%)	10.4% (8.5% - 12.3%)	9.1% (7.4% - 10.8%)
Detroit, MI	15.2% (12.5% - 17.9%)	10.7% (8.8% - 12.7%)	10.6% (8.6% - 12.5%)	9.1% (7.4% - 10.7%)	7.6% (6.1% - 8.9%)	7.8% (6.3% - 9.2%)	4.8% (3.9% - 5.7%)
Fresno, CA	21.5% (17.7% - 25.1%)	8.1% (6.6% - 9.6%)	8.1% (6.6% - 9.6%)	8.1% (6.6% - 9.6%)	8.1% (6.6% - 9.6%)	5.5% (4.4% - 6.5%)	2.8% (2.3% - 3.3%)
Houston, TX	14.5% (11.8% - 17%)	13.3% (10.8% - 15.6%)	11.7% (9.6% - 13.8%)	10.2% (8.3% - 12%)	8.6% (7% - 10.2%)	10.2% (8.3% - 12%)	8.6% (7% - 10.2%)
Los Angeles, CA	16.8% (13.8% - 19.7%)	7.4% (6% - 8.7%)	7.4% (6% - 8.7%)	7.4% (6% - 8.7%)	6.4% (5.2% - 7.6%)	4.8% (3.9% - 5.8%)	2.2% (1.8% - 2.7%)
New York, NY	13.8% (11.3% - 16.2%)	9.9% (8.1% - 11.7%)	9.9% (8.1% - 11.7%)	9.4% (7.7% - 11.2%)	7.9% (6.4% - 9.3%)	7.1% (5.8% - 8.4%)	4.1% (3.3% - 4.9%)
Philadelphia, PA	15.3% (12.5% - 18%)	13.4% (10.9% - 15.8%)	13.4% (10.9% - 15.8%)	11.9% (9.8% - 14.1%)	10.2% (8.3% - 12.1%)	10.1% (8.3% - 12%)	6.7% (5.5% - 8%)
Phoenix, AZ	10.3% (8.4% - 12.2%)	10.3% (8.4% - 12.2%)	10.3% (8.4% - 12.2%)	10.3% (8.4% - 12.2%)	9.3% (7.6% - 11%)	9% (7.3% - 10.7%)	5.8% (4.7% - 6.8%)
Pittsburgh, PA	15.9% (13% - 18.7%)	10.1% (8.2% - 11.9%)	10.1% (8.2% - 11.9%)	9.4% (7.7% - 11.1%)	8.1% (6.6% - 9.6%)	7.3% (5.9% - 8.6%)	4.3% (3.5% - 5.1%)
Salt Lake City, UT	8.3% (6.7% - 9.8%)	1.6% (1.3% - 1.9%)	1.6% (1.3% - 1.9%)	1.6% (1.3% - 1.9%)	1.6% (1.3% - 1.9%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	15.4% (12.6% - 18.1%)	12.9% (10.6% - 15.2%)	11.6% (9.5% - 13.7%)	10% (8.2% - 11.9%)	8.5% (6.9% - 10%)	9.7% (7.9% - 11.5%)	6.4% (5.2% - 7.6%)
Tacoma, WA	7.8% (6.3% - 9.2%)	4.5% (3.6% - 5.3%)	4.5% (3.6% - 5.3%)	4.5% (3.6% - 5.3%)	4.5% (3.6% - 5.3%)	2.4% (1.9% - 2.8%)	0.2% (0.2% - 0.2%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-33. Estimated Percent of Total Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	18.7% (15.4% - 21.8%)	16.7% (13.7% - 19.5%)	14.9% (12.2% - 17.6%)	13.2% (10.8% - 15.5%)	11.4% (9.3% - 13.4%)	13.2% (10.8% - 15.5%)	11.1% (9.1% - 13.1%)
Baltimore, MD	16.1% (13.2% - 18.8%)	14.7% (12.1% - 17.3%)	13.4% (11% - 15.8%)	11.8% (9.6% - 13.9%)	10.1% (8.2% - 11.9%)	11.3% (9.2% - 13.3%)	7.8% (6.3% - 9.2%)
Birmingham, AL	19.3% (15.9% - 22.6%)	13.8% (11.3% - 16.2%)	12.2% (10% - 14.4%)	10.7% (8.7% - 12.6%)	9.1% (7.4% - 10.7%)	10.7% (8.7% - 12.6%)	7.5% (6.1% - 8.9%)
Dallas, TX	11.4% (9.3% - 13.4%)	11.4% (9.3% - 13.4%)	11.4% (9.3% - 13.4%)	11.4% (9.3% - 13.4%)	10% (8.2% - 11.9%)	11.4% (9.3% - 13.4%)	10% (8.2% - 11.9%)
Detroit, MI	16.1% (13.2% - 18.9%)	11.5% (9.4% - 13.5%)	11.3% (9.3% - 13.4%)	9.8% (8% - 11.6%)	8.2% (6.7% - 9.7%)	8.5% (6.9% - 10%)	5.3% (4.3% - 6.3%)
Fresno, CA	22.2% (18.3% - 25.9%)	8.5% (7% - 10.1%)	8.5% (7% - 10.1%)	8.5% (7% - 10.1%)	8.5% (7% - 10.1%)	5.9% (4.8% - 7%)	3.1% (2.5% - 3.7%)
Houston, TX	14.8% (12.1% - 17.4%)	13.6% (11.1% - 16%)	12% (9.8% - 14.2%)	10.5% (8.5% - 12.3%)	8.9% (7.2% - 10.5%)	10.5% (8.5% - 12.3%)	8.9% (7.2% - 10.5%)
Los Angeles, CA	17.3% (14.2% - 20.3%)	7.7% (6.3% - 9.1%)	7.7% (6.3% - 9.1%)	7.7% (6.3% - 9.1%)	6.7% (5.5% - 8%)	5.2% (4.2% - 6.1%)	2.5% (2% - 3%)
New York, NY	15.9% (13% - 18.7%)	11.8% (9.6% - 13.9%)	11.8% (9.6% - 13.9%)	11.2% (9.2% - 13.2%)	9.6% (7.8% - 11.3%)	8.7% (7.1% - 10.3%)	5.5% (4.5% - 6.5%)
Philadelphia, PA	15.1% (12.4% - 17.8%)	13.2% (10.8% - 15.6%)	13.2% (10.8% - 15.6%)	11.8% (9.6% - 13.9%)	10.1% (8.2% - 11.9%)	10% (8.1% - 11.8%)	6.6% (5.4% - 7.8%)
Phoenix, AZ	8.5% (6.9% - 10.1%)	8.5% (6.9% - 10.1%)	8.5% (6.9% - 10.1%)	8.5% (6.9% - 10.1%)	7.6% (6.2% - 9%)	7.3% (6% - 8.7%)	4.3% (3.5% - 5.1%)
Pittsburgh, PA	17.8% (14.7% - 20.9%)	11.8% (9.6% - 13.9%)	11.8% (9.6% - 13.9%)	11% (9% - 13%)	9.6% (7.8% - 11.4%)	8.7% (7.1% - 10.3%)	5.6% (4.5% - 6.6%)
Salt Lake City, UT	11.4% (9.3% - 13.4%)	3.7% (3% - 4.4%)	3.7% (3% - 4.4%)	3.7% (3% - 4.4%)	3.7% (3% - 4.4%)	1.7% (1.4% - 2%)	0% (0% - 0%)
St. Louis, MO	16.8% (13.8% - 19.7%)	14.2% (11.6% - 16.7%)	12.8% (10.5% - 15.1%)	11.2% (9.1% - 13.2%)	9.5% (7.7% - 11.2%)	10.9% (8.9% - 12.8%)	7.4% (6% - 8.8%)
Tacoma, WA	8% (6.5% - 9.5%)	4.7% (3.8% - 5.6%)	4.7% (3.8% - 5.6%)	4.7% (3.8% - 5.6%)	4.7% (3.8% - 5.6%)	2.5% (2.1% - 3%)	0.3% (0.3% - 0.4%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-34. Percent Reduction from the Current Standards: Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-11% - -12%)	0% (0% - 0%)	10% (10% - 10%)	20% (20% - 21%)	31% (30% - 31%)	20% (20% - 21%)	32% (32% - 33%)
Baltimore, MD	-8% (-8% - -8%)	0% (0% - 0%)	8% (8% - 8%)	18% (18% - 18%)	29% (28% - 29%)	21% (21% - 21%)	43% (42% - 43%)
Birmingham, AL	-39% (-38% - -40%)	0% (0% - 0%)	11% (11% - 11%)	22% (22% - 23%)	34% (33% - 34%)	22% (22% - 23%)	45% (44% - 45%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-34% (-34% - -35%)	0% (0% - 0%)	1% (1% - 1%)	13% (12% - 13%)	24% (24% - 25%)	23% (22% - 23%)	46% (46% - 46%)
Fresno, CA	-170% (-166% - -174%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	67% (67% - 67%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	11% (11% - 11%)	22% (22% - 23%)	34% (34% - 34%)	22% (22% - 23%)	34% (34% - 34%)
Los Angeles, CA	-113% (-111% - -116%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	30% (30% - 31%)	62% (62% - 62%)
New York, NY	-33% (-32% - -33%)	0% (0% - 0%)	0% (0% - 0%)	4% (4% - 4%)	18% (17% - 18%)	24% (24% - 25%)	50% (49% - 50%)
Philadelphia, PA	-13% (-13% - -14%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 23%)	23% (23% - 23%)	47% (47% - 48%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	12% (12% - 13%)	45% (44% - 45%)
Pittsburgh, PA	-49% (-48% - -50%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	17% (17% - 17%)	24% (24% - 25%)	50% (49% - 50%)
Salt Lake City, UT	-244% (-242% - -247%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-16% (-16% - -17%)	0% (0% - 0%)	9% (9% - 9%)	19% (19% - 19%)	30% (29% - 30%)	21% (21% - 22%)	43% (43% - 44%)
Tacoma, WA	-51% (-50% - -51%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	67% (66% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-35. Percent Reduction from the Current Standards: Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-11% - -12%)	0% (0% - 0%)	10% (10% - 10%)	20% (20% - 21%)	31% (30% - 31%)	20% (20% - 21%)	32% (32% - 33%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 20%)	32% (31% - 32%)	23% (23% - 23%)	47% (47% - 48%)
Birmingham, AL	-41% (-40% - -42%)	0% (0% - 0%)	11% (11% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	46% (46% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 13%)	0% (0% - 0%)	12% (12% - 13%)
Detroit, MI	-42% (-41% - -43%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 16%)	30% (29% - 30%)	27% (27% - 28%)	56% (55% - 56%)
Fresno, CA	-165% (-162% - -169%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (32% - 33%)	66% (65% - 66%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	11% (11% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	35% (35% - 35%)
Los Angeles, CA	-128% (-126% - -131%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (34% - 34%)	70% (69% - 70%)
New York, NY	-39% (-38% - -39%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	29% (29% - 29%)	58% (58% - 59%)
Philadelphia, PA	-14% (-14% - -14%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (23% - 24%)	24% (24% - 25%)	50% (49% - 50%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	12% (12% - 12%)	44% (44% - 44%)
Pittsburgh, PA	-57% (-56% - -58%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (19% - 20%)	28% (28% - 28%)	57% (57% - 58%)
Salt Lake City, UT	-423% (-420% - -427%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-19% (-19% - -19%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 23%)	35% (34% - 35%)	25% (24% - 25%)	50% (50% - 51%)
Tacoma, WA	-74% (-73% - -74%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	47% (47% - 47%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-36. Percent Reduction from the Current Standards: Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -12%)	0% (0% - 0%)	10% (10% - 10%)	21% (21% - 21%)	32% (31% - 32%)	21% (21% - 21%)	33% (33% - 34%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 20%)	32% (31% - 32%)	23% (23% - 23%)	47% (47% - 48%)
Birmingham, AL	-40% (-39% - -41%)	0% (0% - 0%)	11% (11% - 11%)	23% (22% - 23%)	34% (34% - 35%)	23% (22% - 23%)	45% (45% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-40% (-40% - -41%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	28% (28% - 29%)	26% (26% - 27%)	53% (53% - 54%)
Fresno, CA	-159% (-156% - -163%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	31% (31% - 31%)	63% (63% - 64%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 23%)	35% (34% - 35%)	23% (23% - 23%)	35% (34% - 35%)
Los Angeles, CA	-124% (-122% - -127%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	33% (33% - 33%)	68% (67% - 68%)
New York, NY	-35% (-35% - -36%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	19% (19% - 19%)	26% (26% - 26%)	53% (53% - 54%)
Philadelphia, PA	-14% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (23% - 24%)	25% (24% - 25%)	50% (50% - 50%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	49% (49% - 50%)
Pittsburgh, PA	-51% (-51% - -52%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	18% (18% - 18%)	26% (26% - 26%)	53% (52% - 53%)
Salt Lake City, UT	-208% (-205% - -210%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-18% (-18% - -18%)	0% (0% - 0%)	10% (10% - 10%)	21% (21% - 22%)	33% (33% - 33%)	23% (23% - 24%)	48% (47% - 48%)
Tacoma, WA	-71% (-71% - -72%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-37. Estimated Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	512 (391 - 630)	455 (347 - 561)	407 (310 - 502)	359 (273 - 443)	310 (236 - 383)	359 (273 - 443)	302 (230 - 374)
Baltimore, MD	507 (387 - 624)	467 (356 - 575)	428 (326 - 528)	378 (288 - 466)	327 (249 - 405)	364 (278 - 450)	260 (198 - 322)
Birmingham, AL	365 (279 - 450)	258 (196 - 318)	228 (174 - 282)	198 (151 - 245)	168 (128 - 208)	198 (151 - 245)	140 (106 - 173)
Dallas, TX	321 (244 - 396)	321 (244 - 396)	321 (244 - 396)	321 (244 - 396)	285 (217 - 352)	321 (244 - 396)	285 (217 - 352)
Detroit, MI	748 (572 - 920)	547 (417 - 675)	540 (412 - 667)	474 (361 - 586)	408 (310 - 505)	419 (318 - 518)	288 (219 - 357)
Fresno, CA	240 (184 - 295)	85 (65 - 105)	85 (65 - 105)	85 (65 - 105)	85 (65 - 105)	56 (43 - 70)	27 (21 - 34)
Houston, TX	499 (380 - 616)	457 (348 - 564)	404 (307 - 499)	351 (267 - 434)	297 (226 - 368)	351 (267 - 434)	297 (226 - 368)
Los Angeles, CA	2357 (1800 - 2902)	1069 (812 - 1324)	1069 (812 - 1324)	1069 (812 - 1324)	941 (714 - 1166)	737 (559 - 915)	401 (304 - 499)
New York, NY	2205 (1683 - 2717)	1637 (1246 - 2022)	1637 (1246 - 2022)	1564 (1190 - 1933)	1339 (1018 - 1657)	1224 (930 - 1515)	805 (611 - 998)
Philadelphia, PA	439 (335 - 541)	384 (293 - 474)	384 (293 - 474)	343 (261 - 424)	295 (224 - 365)	292 (222 - 361)	198 (151 - 246)
Phoenix, AZ	406 (309 - 503)	406 (309 - 503)	406 (309 - 503)	406 (309 - 503)	365 (278 - 453)	354 (269 - 439)	222 (169 - 276)
Pittsburgh, PA	529 (405 - 652)	349 (265 - 431)	349 (265 - 431)	328 (249 - 405)	287 (219 - 356)	261 (198 - 323)	172 (131 - 213)
Salt Lake City, UT	76 (58 - 94)	22 (16 - 27)	22 (16 - 27)	22 (16 - 27)	22 (16 - 27)	8 (6 - 10)	0 (0 - 0)
St. Louis, MO	758 (580 - 933)	646 (493 - 796)	586 (447 - 723)	516 (393 - 637)	445 (339 - 550)	503 (383 - 621)	357 (271 - 442)
Tacoma, WA	110 (84 - 136)	72 (55 - 89)	72 (55 - 89)	72 (55 - 89)	72 (55 - 89)	48 (36 - 60)	24 (18 - 29)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-38. Estimated Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	527 (403 - 649)	469 (358 - 577)	419 (320 - 517)	369 (281 - 456)	319 (243 - 394)	369 (281 - 456)	311 (237 - 385)
Baltimore, MD	412 (314 - 509)	377 (287 - 465)	342 (261 - 423)	298 (227 - 369)	253 (193 - 314)	286 (218 - 354)	194 (147 - 241)
Birmingham, AL	344 (263 - 424)	240 (183 - 297)	211 (161 - 261)	183 (139 - 226)	154 (117 - 190)	183 (139 - 226)	127 (96 - 157)
Dallas, TX	241 (183 - 298)	241 (183 - 298)	241 (183 - 298)	241 (183 - 298)	210 (160 - 260)	241 (183 - 298)	210 (160 - 260)
Detroit, MI	543 (414 - 670)	377 (287 - 466)	372 (283 - 460)	317 (241 - 393)	263 (199 - 326)	272 (206 - 336)	165 (125 - 204)
Fresno, CA	250 (191 - 307)	90 (68 - 112)	90 (68 - 112)	90 (68 - 112)	90 (68 - 112)	60 (46 - 75)	30 (23 - 38)
Houston, TX	483 (368 - 597)	441 (336 - 545)	389 (296 - 481)	336 (255 - 416)	283 (215 - 350)	336 (255 - 416)	283 (215 - 350)
Los Angeles, CA	2081 (1587 - 2566)	884 (671 - 1095)	884 (671 - 1095)	884 (671 - 1095)	765 (580 - 948)	576 (436 - 715)	265 (200 - 329)
New York, NY	1715 (1306 - 2118)	1220 (927 - 1510)	1220 (927 - 1510)	1156 (878 - 1431)	961 (729 - 1191)	861 (653 - 1067)	497 (377 - 618)
Philadelphia, PA	398 (303 - 491)	346 (263 - 427)	346 (263 - 427)	307 (234 - 380)	262 (199 - 324)	259 (197 - 320)	171 (129 - 211)
Phoenix, AZ	431 (327 - 533)	431 (327 - 533)	431 (327 - 533)	431 (327 - 533)	388 (294 - 480)	376 (286 - 466)	238 (180 - 295)
Pittsburgh, PA	420 (320 - 518)	262 (199 - 324)	262 (199 - 324)	244 (185 - 302)	209 (159 - 259)	186 (141 - 231)	110 (83 - 136)
Salt Lake City, UT	62 (47 - 77)	12 (9 - 15)	12 (9 - 15)	12 (9 - 15)	12 (9 - 15)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	572 (436 - 705)	476 (362 - 588)	426 (324 - 526)	366 (278 - 453)	307 (233 - 380)	355 (270 - 440)	232 (176 - 288)
Tacoma, WA	74 (56 - 92)	42 (32 - 53)	42 (32 - 53)	42 (32 - 53)	42 (32 - 53)	22 (17 - 28)	2 (1 - 2)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-39. Estimated Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	507 (387 - 625)	449 (343 - 554)	401 (305 - 495)	352 (268 - 435)	302 (230 - 374)	352 (268 - 435)	295 (224 - 365)
Baltimore, MD	412 (314 - 508)	376 (286 - 464)	342 (260 - 422)	298 (226 - 368)	253 (192 - 313)	286 (217 - 353)	194 (147 - 240)
Birmingham, AL	361 (276 - 444)	253 (193 - 313)	224 (170 - 276)	194 (147 - 240)	164 (124 - 203)	194 (147 - 240)	136 (103 - 168)
Dallas, TX	269 (205 - 333)	269 (205 - 333)	269 (205 - 333)	269 (205 - 333)	236 (179 - 292)	269 (205 - 333)	236 (179 - 292)
Detroit, MI	572 (436 - 705)	402 (305 - 497)	396 (301 - 490)	340 (259 - 421)	284 (216 - 352)	293 (223 - 363)	183 (139 - 227)
Fresno, CA	263 (201 - 323)	97 (74 - 120)	97 (74 - 120)	97 (74 - 120)	97 (74 - 120)	66 (50 - 82)	35 (26 - 43)
Houston, TX	504 (384 - 622)	461 (351 - 569)	407 (309 - 503)	352 (268 - 436)	297 (225 - 368)	352 (268 - 436)	297 (225 - 368)
Los Angeles, CA	2160 (1648 - 2663)	933 (708 - 1156)	933 (708 - 1156)	933 (708 - 1156)	811 (615 - 1006)	617 (468 - 766)	298 (226 - 370)
New York, NY	2003 (1527 - 2470)	1462 (1112 - 1808)	1462 (1112 - 1808)	1392 (1059 - 1722)	1179 (895 - 1459)	1069 (812 - 1324)	671 (508 - 832)
Philadelphia, PA	393 (300 - 485)	342 (260 - 423)	342 (260 - 423)	304 (231 - 375)	258 (196 - 320)	255 (194 - 316)	168 (127 - 208)
Phoenix, AZ	366 (278 - 453)	366 (278 - 453)	366 (278 - 453)	366 (278 - 453)	325 (247 - 403)	314 (238 - 389)	183 (139 - 227)
Pittsburgh, PA	472 (360 - 581)	305 (232 - 378)	305 (232 - 378)	286 (217 - 353)	248 (188 - 307)	224 (170 - 277)	141 (107 - 175)
Salt Lake City, UT	89 (68 - 110)	28 (21 - 35)	28 (21 - 35)	28 (21 - 35)	28 (21 - 35)	13 (10 - 16)	0 (0 - 0)
St. Louis, MO	626 (478 - 772)	526 (400 - 649)	472 (359 - 584)	410 (312 - 507)	347 (264 - 430)	398 (302 - 492)	268 (203 - 332)
Tacoma, WA	78 (59 - 97)	45 (34 - 56)	45 (34 - 56)	45 (34 - 56)	45 (34 - 56)	24 (18 - 30)	3 (2 - 4)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-40. Estimated Percent of Total Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	8.8% (6.7% - 10.8%)	7.8% (5.9% - 9.6%)	7% (5.3% - 8.6%)	6.1% (4.7% - 7.6%)	5.3% (4% - 6.6%)	6.1% (4.7% - 7.6%)	5.2% (3.9% - 6.4%)
Baltimore, MD	8.6% (6.6% - 10.6%)	7.9% (6% - 9.8%)	7.3% (5.5% - 9%)	6.4% (4.9% - 7.9%)	5.6% (4.2% - 6.9%)	6.2% (4.7% - 7.6%)	4.4% (3.4% - 5.5%)
Birmingham, AL	8.8% (6.7% - 10.8%)	6.2% (4.7% - 7.7%)	5.5% (4.2% - 6.8%)	4.8% (3.6% - 5.9%)	4% (3.1% - 5%)	4.8% (3.6% - 5.9%)	3.4% (2.6% - 4.2%)
Dallas, TX	6.1% (4.6% - 7.5%)	6.1% (4.6% - 7.5%)	6.1% (4.6% - 7.5%)	6.1% (4.6% - 7.5%)	5.4% (4.1% - 6.7%)	6.1% (4.6% - 7.5%)	5.4% (4.1% - 6.7%)
Detroit, MI	9.1% (7% - 11.2%)	6.7% (5.1% - 8.2%)	6.6% (5% - 8.1%)	5.8% (4.4% - 7.1%)	5% (3.8% - 6.1%)	5.1% (3.9% - 6.3%)	3.5% (2.7% - 4.3%)
Fresno, CA	9.3% (7.1% - 11.4%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	2.2% (1.7% - 2.7%)	1.1% (0.8% - 1.3%)
Houston, TX	6.7% (5.1% - 8.3%)	6.1% (4.7% - 7.6%)	5.4% (4.1% - 6.7%)	4.7% (3.6% - 5.8%)	4% (3% - 4.9%)	4.7% (3.6% - 5.8%)	4% (3% - 4.9%)
Los Angeles, CA	8.4% (6.4% - 10.3%)	3.8% (2.9% - 4.7%)	3.8% (2.9% - 4.7%)	3.8% (2.9% - 4.7%)	3.3% (2.5% - 4.1%)	2.6% (2% - 3.3%)	1.4% (1.1% - 1.8%)
New York, NY	7.8% (5.9% - 9.6%)	5.8% (4.4% - 7.1%)	5.8% (4.4% - 7.1%)	5.5% (4.2% - 6.8%)	4.7% (3.6% - 5.8%)	4.3% (3.3% - 5.3%)	2.8% (2.1% - 3.5%)
Philadelphia, PA	7.3% (5.6% - 9%)	6.4% (4.9% - 7.9%)	6.4% (4.9% - 7.9%)	5.7% (4.4% - 7.1%)	4.9% (3.7% - 6.1%)	4.9% (3.7% - 6%)	3.3% (2.5% - 4.1%)
Phoenix, AZ	4.3% (3.3% - 5.3%)	4.3% (3.3% - 5.3%)	4.3% (3.3% - 5.3%)	4.3% (3.3% - 5.3%)	3.9% (2.9% - 4.8%)	3.8% (2.9% - 4.7%)	2.4% (1.8% - 2.9%)
Pittsburgh, PA	8.7% (6.6% - 10.7%)	5.7% (4.4% - 7.1%)	5.7% (4.4% - 7.1%)	5.4% (4.1% - 6.6%)	4.7% (3.6% - 5.8%)	4.3% (3.3% - 5.3%)	2.8% (2.1% - 3.5%)
Salt Lake City, UT	4.5% (3.4% - 5.5%)	1.3% (1% - 1.6%)	1.3% (1% - 1.6%)	1.3% (1% - 1.6%)	1.3% (1% - 1.6%)	0.5% (0.3% - 0.6%)	0% (0% - 0%)
St. Louis, MO	8.9% (6.8% - 11%)	7.6% (5.8% - 9.4%)	6.9% (5.3% - 8.5%)	6.1% (4.6% - 7.5%)	5.2% (4% - 6.5%)	5.9% (4.5% - 7.3%)	4.2% (3.2% - 5.2%)
Tacoma, WA	5% (3.8% - 6.2%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	2.2% (1.7% - 2.7%)	1.1% (0.8% - 1.3%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-41. Estimated Percent of Total Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	8.8% (6.7% - 10.8%)	7.8% (5.9% - 9.6%)	7% (5.3% - 8.6%)	6.1% (4.7% - 7.6%)	5.3% (4% - 6.5%)	6.1% (4.7% - 7.6%)	5.2% (3.9% - 6.4%)
Baltimore, MD	7% (5.3% - 8.6%)	6.4% (4.9% - 7.9%)	5.8% (4.4% - 7.2%)	5.1% (3.8% - 6.2%)	4.3% (3.3% - 5.3%)	4.9% (3.7% - 6%)	3.3% (2.5% - 4.1%)
Birmingham, AL	8.2% (6.3% - 10.1%)	5.7% (4.3% - 7.1%)	5% (3.8% - 6.2%)	4.3% (3.3% - 5.4%)	3.7% (2.8% - 4.5%)	4.3% (3.3% - 5.4%)	3% (2.3% - 3.7%)
Dallas, TX	4.5% (3.4% - 5.5%)	4.5% (3.4% - 5.5%)	4.5% (3.4% - 5.5%)	4.5% (3.4% - 5.5%)	3.9% (3% - 4.8%)	4.5% (3.4% - 5.5%)	3.9% (3% - 4.8%)
Detroit, MI	6.6% (5% - 8.2%)	4.6% (3.5% - 5.7%)	4.5% (3.4% - 5.6%)	3.9% (2.9% - 4.8%)	3.2% (2.4% - 4%)	3.3% (2.5% - 4.1%)	2% (1.5% - 2.5%)
Fresno, CA	9.5% (7.3% - 11.7%)	3.4% (2.6% - 4.3%)	3.4% (2.6% - 4.3%)	3.4% (2.6% - 4.3%)	3.4% (2.6% - 4.3%)	2.3% (1.7% - 2.9%)	1.2% (0.9% - 1.4%)
Houston, TX	6.3% (4.8% - 7.7%)	5.7% (4.4% - 7.1%)	5% (3.8% - 6.2%)	4.4% (3.3% - 5.4%)	3.7% (2.8% - 4.5%)	4.4% (3.3% - 5.4%)	3.7% (2.8% - 4.5%)
Los Angeles, CA	7.4% (5.6% - 9.1%)	3.1% (2.4% - 3.9%)	3.1% (2.4% - 3.9%)	3.1% (2.4% - 3.9%)	2.7% (2.1% - 3.4%)	2% (1.5% - 2.5%)	0.9% (0.7% - 1.2%)
New York, NY	6% (4.5% - 7.4%)	4.2% (3.2% - 5.3%)	4.2% (3.2% - 5.3%)	4% (3.1% - 5%)	3.3% (2.5% - 4.1%)	3% (2.3% - 3.7%)	1.7% (1.3% - 2.2%)
Philadelphia, PA	6.6% (5.1% - 8.2%)	5.8% (4.4% - 7.1%)	5.8% (4.4% - 7.1%)	5.1% (3.9% - 6.4%)	4.4% (3.3% - 5.4%)	4.3% (3.3% - 5.4%)	2.9% (2.2% - 3.5%)
Phoenix, AZ	4.4% (3.3% - 5.4%)	4.4% (3.3% - 5.4%)	4.4% (3.3% - 5.4%)	4.4% (3.3% - 5.4%)	4% (3% - 4.9%)	3.8% (2.9% - 4.8%)	2.4% (1.8% - 3%)
Pittsburgh, PA	6.9% (5.3% - 8.5%)	4.3% (3.3% - 5.4%)	4.3% (3.3% - 5.4%)	4% (3.1% - 5%)	3.5% (2.6% - 4.3%)	3.1% (2.3% - 3.8%)	1.8% (1.4% - 2.2%)
Salt Lake City, UT	3.5% (2.7% - 4.4%)	0.7% (0.5% - 0.8%)	0.7% (0.5% - 0.8%)	0.7% (0.5% - 0.8%)	0.7% (0.5% - 0.8%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	6.7% (5.1% - 8.3%)	5.6% (4.2% - 6.9%)	5% (3.8% - 6.2%)	4.3% (3.3% - 5.3%)	3.6% (2.7% - 4.5%)	4.2% (3.2% - 5.1%)	2.7% (2.1% - 3.4%)
Tacoma, WA	3.3% (2.5% - 4.1%)	1.9% (1.4% - 2.3%)	1.9% (1.4% - 2.3%)	1.9% (1.4% - 2.3%)	1.9% (1.4% - 2.3%)	1% (0.7% - 1.2%)	0.1% (0.1% - 0.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-42. Estimated Percent of Total Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	8.2% (6.3% - 10.1%)	7.3% (5.5% - 9%)	6.5% (4.9% - 8%)	5.7% (4.3% - 7%)	4.9% (3.7% - 6.1%)	5.7% (4.3% - 7%)	4.8% (3.6% - 5.9%)
Baltimore, MD	7% (5.3% - 8.6%)	6.4% (4.9% - 7.9%)	5.8% (4.4% - 7.2%)	5.1% (3.8% - 6.3%)	4.3% (3.3% - 5.3%)	4.9% (3.7% - 6%)	3.3% (2.5% - 4.1%)
Birmingham, AL	8.5% (6.5% - 10.5%)	6% (4.5% - 7.4%)	5.3% (4% - 6.5%)	4.6% (3.5% - 5.7%)	3.9% (2.9% - 4.8%)	4.6% (3.5% - 5.7%)	3.2% (2.4% - 4%)
Dallas, TX	4.9% (3.7% - 6%)	4.9% (3.7% - 6%)	4.9% (3.7% - 6%)	4.9% (3.7% - 6%)	4.3% (3.3% - 5.3%)	4.9% (3.7% - 6%)	4.3% (3.3% - 5.3%)
Detroit, MI	7% (5.4% - 8.7%)	4.9% (3.8% - 6.1%)	4.9% (3.7% - 6%)	4.2% (3.2% - 5.2%)	3.5% (2.6% - 4.3%)	3.6% (2.7% - 4.5%)	2.3% (1.7% - 2.8%)
Fresno, CA	9.9% (7.6% - 12.1%)	3.6% (2.8% - 4.5%)	3.6% (2.8% - 4.5%)	3.6% (2.8% - 4.5%)	3.6% (2.8% - 4.5%)	2.5% (1.9% - 3.1%)	1.3% (1% - 1.6%)
Houston, TX	6.4% (4.9% - 7.9%)	5.9% (4.5% - 7.2%)	5.2% (3.9% - 6.4%)	4.5% (3.4% - 5.5%)	3.8% (2.9% - 4.7%)	4.5% (3.4% - 5.5%)	3.8% (2.9% - 4.7%)
Los Angeles, CA	7.6% (5.8% - 9.4%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	3.3% (2.5% - 4.1%)	2.8% (2.2% - 3.5%)	2.2% (1.6% - 2.7%)	1% (0.8% - 1.3%)
New York, NY	6.9% (5.3% - 8.5%)	5.1% (3.8% - 6.3%)	5.1% (3.8% - 6.3%)	4.8% (3.7% - 6%)	4.1% (3.1% - 5%)	3.7% (2.8% - 4.6%)	2.3% (1.8% - 2.9%)
Philadelphia, PA	6.6% (5% - 8.1%)	5.7% (4.3% - 7.1%)	5.7% (4.3% - 7.1%)	5.1% (3.9% - 6.3%)	4.3% (3.3% - 5.3%)	4.3% (3.2% - 5.3%)	2.8% (2.1% - 3.5%)
Phoenix, AZ	3.6% (2.8% - 4.5%)	3.6% (2.8% - 4.5%)	3.6% (2.8% - 4.5%)	3.6% (2.8% - 4.5%)	3.2% (2.4% - 4%)	3.1% (2.4% - 3.9%)	1.8% (1.4% - 2.3%)
Pittsburgh, PA	7.8% (6% - 9.6%)	5.1% (3.8% - 6.3%)	5.1% (3.8% - 6.3%)	4.7% (3.6% - 5.9%)	4.1% (3.1% - 5.1%)	3.7% (2.8% - 4.6%)	2.3% (1.8% - 2.9%)
Salt Lake City, UT	4.9% (3.7% - 6.1%)	1.6% (1.2% - 1.9%)	1.6% (1.2% - 1.9%)	1.6% (1.2% - 1.9%)	1.6% (1.2% - 1.9%)	0.7% (0.5% - 0.9%)	0% (0% - 0%)
St. Louis, MO	7.3% (5.6% - 9%)	6.1% (4.7% - 7.6%)	5.5% (4.2% - 6.8%)	4.8% (3.6% - 5.9%)	4.1% (3.1% - 5%)	4.7% (3.5% - 5.8%)	3.1% (2.4% - 3.9%)
Tacoma, WA	3.4% (2.6% - 4.2%)	2% (1.5% - 2.5%)	2% (1.5% - 2.5%)	2% (1.5% - 2.5%)	2% (1.5% - 2.5%)	1.1% (0.8% - 1.3%)	0.1% (0.1% - 0.2%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-43. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-12% - -13%)	0% (0% - 0%)	11% (10% - 11%)	21% (21% - 21%)	32% (32% - 32%)	21% (21% - 21%)	34% (33% - 34%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	8% (8% - 8%)	19% (19% - 19%)	30% (30% - 30%)	22% (22% - 22%)	44% (44% - 44%)
Birmingham, AL	-42% (-41% - -42%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	46% (46% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-37% (-36% - -37%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 13%)	25% (25% - 26%)	23% (23% - 24%)	47% (47% - 47%)
Fresno, CA	-182% (-180% - -184%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (34% - 34%)	68% (68% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	35% (35% - 35%)
Los Angeles, CA	-120% (-119% - -122%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	62% (62% - 63%)
New York, NY	-35% (-34% - -35%)	0% (0% - 0%)	0% (0% - 0%)	4% (4% - 5%)	18% (18% - 18%)	25% (25% - 25%)	51% (51% - 51%)
Philadelphia, PA	-14% (-14% - -14%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 23%)	24% (24% - 24%)	48% (48% - 49%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 45%)
Pittsburgh, PA	-52% (-51% - -52%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	18% (17% - 18%)	25% (25% - 25%)	51% (50% - 51%)
Salt Lake City, UT	-252% (-251% - -254%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-17% (-17% - -18%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 20%)	31% (31% - 31%)	22% (22% - 22%)	45% (45% - 45%)
Tacoma, WA	-53% (-52% - -53%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-44. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -12%)	0% (0% - 0%)	10% (10% - 11%)	21% (21% - 21%)	32% (31% - 32%)	21% (21% - 21%)	33% (33% - 33%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	21% (20% - 21%)	32% (32% - 33%)	24% (24% - 24%)	48% (48% - 48%)
Birmingham, AL	-43% (-42% - -43%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	47% (47% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	0% (0% - 0%)	13% (13% - 13%)
Detroit, MI	-43% (-43% - -44%)	0% (0% - 0%)	1% (1% - 1%)	16% (16% - 16%)	30% (30% - 30%)	28% (28% - 28%)	56% (56% - 56%)
Fresno, CA	-173% (-171% - -176%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	66% (66% - 66%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	36% (35% - 36%)
Los Angeles, CA	-133% (-132% - -135%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	35% (35% - 35%)	70% (70% - 70%)
New York, NY	-40% (-40% - -40%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	29% (29% - 29%)	59% (59% - 59%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 24%)	25% (25% - 25%)	50% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (44% - 45%)
Pittsburgh, PA	-59% (-59% - -60%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	29% (29% - 29%)	58% (58% - 58%)
Salt Lake City, UT	-431% (-428% - -433%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-20% (-20% - -20%)	0% (0% - 0%)	10% (10% - 11%)	23% (23% - 23%)	35% (35% - 35%)	25% (25% - 25%)	51% (51% - 51%)
Tacoma, WA	-75% (-74% - -75%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	48% (47% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-45. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	22% (22% - 22%)	33% (33% - 33%)	22% (22% - 22%)	34% (34% - 35%)
Baltimore, MD	-10% (-9% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (33% - 33%)	24% (24% - 24%)	48% (48% - 49%)
Birmingham, AL	-43% (-42% - -43%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 36%)	23% (23% - 24%)	46% (46% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-42% (-42% - -43%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	29% (29% - 29%)	27% (27% - 27%)	54% (54% - 55%)
Fresno, CA	-171% (-169% - -174%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (32% - 32%)	64% (64% - 64%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (35% - 36%)	24% (24% - 24%)	36% (35% - 36%)
Los Angeles, CA	-132% (-130% - -133%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (34% - 34%)	68% (68% - 68%)
New York, NY	-37% (-37% - -37%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	19% (19% - 19%)	27% (27% - 27%)	54% (54% - 54%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 25%)	25% (25% - 25%)	51% (51% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (50% - 50%)
Pittsburgh, PA	-55% (-54% - -55%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	19% (19% - 19%)	27% (27% - 27%)	54% (54% - 54%)
Salt Lake City, UT	-215% (-214% - -216%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-19% (-19% - -19%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 22%)	34% (34% - 34%)	24% (24% - 24%)	49% (49% - 49%)
Tacoma, WA	-73% (-73% - -73%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-46. Estimated Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1999 - 2000[1]

Risk Assessment Location	Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	722 (569 - 872)	643 (506 - 778)	577 (453 - 698)	509 (399 - 617)	441 (345 - 535)	509 (399 - 617)	430 (337 - 522)
Baltimore, MD	715 (563 - 863)	660 (518 - 797)	606 (476 - 733)	536 (420 - 649)	465 (364 - 564)	517 (405 - 627)	371 (290 - 451)
Birmingham, AL	516 (406 - 622)	366 (287 - 443)	324 (254 - 393)	282 (221 - 343)	240 (187 - 291)	282 (221 - 343)	200 (156 - 243)
Dallas, TX	455 (357 - 552)	455 (357 - 552)	455 (357 - 552)	455 (357 - 552)	405 (317 - 492)	455 (357 - 552)	405 (317 - 492)
Detroit, MI	1054 (830 - 1271)	775 (608 - 939)	766 (601 - 928)	674 (528 - 817)	581 (454 - 705)	596 (466 - 723)	412 (321 - 501)
Fresno, CA	338 (266 - 408)	122 (95 - 148)	122 (95 - 148)	122 (95 - 148)	122 (95 - 148)	81 (63 - 99)	39 (31 - 48)
Houston, TX	707 (555 - 856)	649 (508 - 786)	574 (450 - 697)	500 (391 - 607)	424 (331 - 516)	500 (391 - 607)	424 (331 - 516)
Los Angeles, CA	3328 (2618 - 4019)	1526 (1191 - 1856)	1526 (1191 - 1856)	1526 (1191 - 1856)	1344 (1048 - 1636)	1055 (822 - 1286)	576 (448 - 703)
New York, NY	3117 (2450 - 3768)	2326 (1821 - 2820)	2326 (1821 - 2820)	2223 (1740 - 2697)	1907 (1491 - 2317)	1745 (1363 - 2121)	1151 (897 - 1403)
Philadelphia, PA	621 (488 - 752)	545 (427 - 660)	545 (427 - 660)	488 (382 - 592)	420 (328 - 510)	416 (325 - 505)	283 (221 - 345)
Phoenix, AZ	579 (453 - 704)	579 (453 - 704)	579 (453 - 704)	579 (453 - 704)	521 (407 - 634)	506 (395 - 615)	318 (248 - 388)
Pittsburgh, PA	747 (588 - 902)	495 (388 - 601)	495 (388 - 601)	466 (364 - 565)	409 (320 - 497)	372 (291 - 452)	246 (192 - 300)
Salt Lake City, UT	109 (85 - 132)	31 (24 - 38)	31 (24 - 38)	31 (24 - 38)	31 (24 - 38)	11 (9 - 14)	0 (0 - 0)
St. Louis, MO	1069 (842 - 1290)	913 (718 - 1104)	830 (651 - 1005)	732 (574 - 888)	633 (496 - 769)	714 (559 - 865)	509 (397 - 618)
Tacoma, WA	156 (122 - 190)	103 (80 - 125)	103 (80 - 125)	103 (80 - 125)	103 (80 - 125)	69 (54 - 84)	34 (26 - 42)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-47. Estimated Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1999 - 2000[1]

Risk Assessment Location	Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	744 (586 - 898)	662 (521 - 801)	594 (466 - 719)	524 (411 - 635)	454 (355 - 550)	524 (411 - 635)	443 (346 - 538)
Baltimore, MD	584 (459 - 707)	534 (419 - 647)	486 (381 - 590)	424 (332 - 515)	361 (282 - 439)	407 (319 - 495)	277 (216 - 338)
Birmingham, AL	486 (382 - 587)	341 (267 - 414)	301 (235 - 365)	260 (203 - 316)	219 (171 - 267)	260 (203 - 316)	181 (141 - 220)
Dallas, TX	344 (268 - 417)	344 (268 - 417)	344 (268 - 417)	344 (268 - 417)	300 (234 - 365)	344 (268 - 417)	300 (234 - 365)
Detroit, MI	770 (604 - 932)	537 (420 - 652)	530 (414 - 643)	453 (354 - 551)	375 (293 - 457)	388 (303 - 472)	236 (184 - 288)
Fresno, CA	352 (277 - 424)	129 (100 - 157)	129 (100 - 157)	129 (100 - 157)	129 (100 - 157)	87 (67 - 106)	44 (34 - 53)
Houston, TX	686 (537 - 831)	627 (491 - 761)	553 (433 - 672)	479 (374 - 582)	404 (315 - 491)	479 (374 - 582)	404 (315 - 491)
Los Angeles, CA	2945 (2313 - 3562)	1263 (985 - 1538)	1263 (985 - 1538)	1263 (985 - 1538)	1094 (852 - 1333)	825 (642 - 1007)	380 (296 - 465)
New York, NY	2435 (1907 - 2951)	1739 (1358 - 2114)	1739 (1358 - 2114)	1649 (1288 - 2005)	1373 (1071 - 1671)	1231 (960 - 1499)	713 (555 - 870)
Philadelphia, PA	564 (442 - 683)	491 (385 - 596)	491 (385 - 596)	437 (342 - 531)	373 (291 - 453)	369 (288 - 449)	244 (190 - 297)
Phoenix, AZ	614 (480 - 746)	614 (480 - 746)	614 (480 - 746)	614 (480 - 746)	553 (432 - 673)	536 (419 - 653)	340 (265 - 415)
Pittsburgh, PA	595 (467 - 720)	373 (292 - 454)	373 (292 - 454)	348 (271 - 423)	299 (233 - 364)	266 (208 - 324)	157 (122 - 192)
Salt Lake City, UT	89 (69 - 108)	17 (13 - 21)	17 (13 - 21)	17 (13 - 21)	17 (13 - 21)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	810 (636 - 981)	677 (530 - 821)	606 (474 - 735)	522 (408 - 635)	438 (342 - 533)	506 (395 - 616)	332 (259 - 405)
Tacoma, WA	106 (83 - 129)	61 (47 - 74)	61 (47 - 74)	61 (47 - 74)	61 (47 - 74)	32 (25 - 39)	3 (2 - 3)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-48. Estimated Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	717 (563 - 865)	636 (500 - 770)	568 (446 - 689)	500 (391 - 606)	430 (337 - 523)	500 (391 - 606)	420 (328 - 510)
Baltimore, MD	583 (458 - 706)	533 (418 - 646)	485 (380 - 589)	423 (331 - 514)	361 (282 - 438)	407 (318 - 494)	277 (216 - 337)
Birmingham, AL	509 (401 - 615)	359 (282 - 436)	318 (249 - 386)	276 (216 - 335)	234 (182 - 284)	276 (216 - 335)	194 (151 - 236)
Dallas, TX	383 (299 - 465)	383 (299 - 465)	383 (299 - 465)	383 (299 - 465)	337 (263 - 409)	383 (299 - 465)	337 (263 - 409)
Detroit, MI	810 (636 - 980)	572 (447 - 694)	564 (441 - 685)	485 (379 - 590)	406 (317 - 494)	419 (327 - 509)	262 (204 - 320)
Fresno, CA	370 (292 - 446)	138 (108 - 168)	138 (108 - 168)	138 (108 - 168)	138 (108 - 168)	95 (74 - 115)	50 (39 - 61)
Houston, TX	715 (561 - 866)	655 (513 - 794)	579 (453 - 702)	501 (392 - 609)	424 (331 - 515)	501 (392 - 609)	424 (331 - 515)
Los Angeles, CA	3056 (2401 - 3695)	1333 (1040 - 1623)	1333 (1040 - 1623)	1333 (1040 - 1623)	1160 (904 - 1413)	884 (688 - 1079)	428 (333 - 523)
New York, NY	2837 (2227 - 3434)	2080 (1627 - 2526)	2080 (1627 - 2526)	1982 (1550 - 2408)	1681 (1313 - 2044)	1526 (1191 - 1857)	960 (748 - 1171)
Philadelphia, PA	558 (437 - 675)	486 (381 - 589)	486 (381 - 589)	432 (338 - 525)	368 (288 - 447)	364 (284 - 443)	240 (187 - 292)
Phoenix, AZ	522 (407 - 635)	522 (407 - 635)	522 (407 - 635)	522 (407 - 635)	464 (362 - 565)	448 (350 - 546)	262 (204 - 320)
Pittsburgh, PA	667 (524 - 806)	434 (340 - 527)	434 (340 - 527)	407 (318 - 494)	354 (276 - 430)	320 (249 - 389)	202 (158 - 247)
Salt Lake City, UT	127 (99 - 154)	41 (32 - 50)	41 (32 - 50)	41 (32 - 50)	41 (32 - 50)	18 (14 - 22)	0 (0 - 0)
St. Louis, MO	887 (696 - 1072)	746 (585 - 904)	671 (526 - 814)	584 (456 - 709)	495 (386 - 602)	567 (443 - 688)	383 (299 - 467)
Tacoma, WA	111 (87 - 135)	65 (50 - 79)	65 (50 - 79)	65 (50 - 79)	65 (50 - 79)	35 (27 - 43)	5 (4 - 6)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-49. Estimated Percent of Total Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 20001

Risk Assessment Location	Percent of Total Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	12.4% (9.7% - 14.9%)	11% (8.7% - 13.3%)	9.9% (7.7% - 11.9%)	8.7% (6.8% - 10.6%)	7.5% (5.9% - 9.2%)	8.7% (6.8% - 10.6%)	7.4% (5.8% - 8.9%)
Baltimore, MD	12.2% (9.6% - 14.7%)	11.2% (8.8% - 13.5%)	10.3% (8.1% - 12.4%)	9.1% (7.1% - 11%)	7.9% (6.2% - 9.6%)	8.8% (6.9% - 10.6%)	6.3% (4.9% - 7.7%)
Birmingham, AL	12.4% (9.8% - 15%)	8.8% (6.9% - 10.7%)	7.8% (6.1% - 9.5%)	6.8% (5.3% - 8.3%)	5.8% (4.5% - 7%)	6.8% (5.3% - 8.3%)	4.8% (3.8% - 5.9%)
Dallas, TX	8.6% (6.7% - 10.4%)	8.6% (6.7% - 10.4%)	8.6% (6.7% - 10.4%)	8.6% (6.7% - 10.4%)	7.7% (6% - 9.3%)	8.6% (6.7% - 10.4%)	7.7% (6% - 9.3%)
Detroit, MI	12.8% (10.1% - 15.5%)	9.4% (7.4% - 11.4%)	9.3% (7.3% - 11.3%)	8.2% (6.4% - 10%)	7.1% (5.5% - 8.6%)	7.3% (5.7% - 8.8%)	5% (3.9% - 6.1%)
Fresno, CA	13.1% (10.3% - 15.8%)	4.7% (3.7% - 5.7%)	4.7% (3.7% - 5.7%)	4.7% (3.7% - 5.7%)	4.7% (3.7% - 5.7%)	3.1% (2.4% - 3.8%)	1.5% (1.2% - 1.9%)
Houston, TX	9.5% (7.4% - 11.5%)	8.7% (6.8% - 10.5%)	7.7% (6% - 9.4%)	6.7% (5.2% - 8.1%)	5.7% (4.4% - 6.9%)	6.7% (5.2% - 8.1%)	5.7% (4.4% - 6.9%)
Los Angeles, CA	11.8% (9.3% - 14.3%)	5.4% (4.2% - 6.6%)	5.4% (4.2% - 6.6%)	5.4% (4.2% - 6.6%)	4.8% (3.7% - 5.8%)	3.8% (2.9% - 4.6%)	2% (1.6% - 2.5%)
New York, NY	11% (8.6% - 13.3%)	8.2% (6.4% - 9.9%)	8.2% (6.4% - 9.9%)	7.8% (6.1% - 9.5%)	6.7% (5.2% - 8.1%)	6.1% (4.8% - 7.5%)	4% (3.2% - 4.9%)
Philadelphia, PA	10.4% (8.1% - 12.5%)	9.1% (7.1% - 11%)	9.1% (7.1% - 11%)	8.1% (6.4% - 9.9%)	7% (5.5% - 8.5%)	6.9% (5.4% - 8.4%)	4.7% (3.7% - 5.8%)
Phoenix, AZ	6.2% (4.8% - 7.5%)	6.2% (4.8% - 7.5%)	6.2% (4.8% - 7.5%)	6.2% (4.8% - 7.5%)	5.5% (4.3% - 6.7%)	5.4% (4.2% - 6.5%)	3.4% (2.6% - 4.1%)
Pittsburgh, PA	12.3% (9.6% - 14.8%)	8.1% (6.4% - 9.9%)	8.1% (6.4% - 9.9%)	7.6% (6% - 9.3%)	6.7% (5.2% - 8.2%)	6.1% (4.8% - 7.4%)	4% (3.1% - 4.9%)
Salt Lake City, UT	6.3% (5% - 7.7%)	1.8% (1.4% - 2.2%)	1.8% (1.4% - 2.2%)	1.8% (1.4% - 2.2%)	1.8% (1.4% - 2.2%)	0.6% (0.5% - 0.8%)	0% (0% - 0%)
St. Louis, MO	12.6% (9.9% - 15.2%)	10.8% (8.4% - 13%)	9.8% (7.7% - 11.8%)	8.6% (6.8% - 10.5%)	7.5% (5.8% - 9%)	8.4% (6.6% - 10.2%)	6% (4.7% - 7.3%)
Tacoma, WA	7.1% (5.6% - 8.6%)	4.7% (3.6% - 5.7%)	4.7% (3.6% - 5.7%)	4.7% (3.6% - 5.7%)	4.7% (3.6% - 5.7%)	3.1% (2.4% - 3.8%)	1.5% (1.2% - 1.9%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-50. Estimated Percent of Total Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 20001

Risk Assessment Location	Percent of Total Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	12.4% (9.7% - 14.9%)	11% (8.6% - 13.3%)	9.9% (7.7% - 11.9%)	8.7% (6.8% - 10.5%)	7.5% (5.9% - 9.1%)	8.7% (6.8% - 10.5%)	7.4% (5.8% - 8.9%)
Baltimore, MD	9.9% (7.8% - 12%)	9.1% (7.1% - 11%)	8.2% (6.5% - 10%)	7.2% (5.6% - 8.7%)	6.1% (4.8% - 7.4%)	6.9% (5.4% - 8.4%)	4.7% (3.7% - 5.7%)
Birmingham, AL	11.6% (9.1% - 14%)	8.1% (6.4% - 9.8%)	7.2% (5.6% - 8.7%)	6.2% (4.8% - 7.5%)	5.2% (4.1% - 6.4%)	6.2% (4.8% - 7.5%)	4.3% (3.4% - 5.2%)
Dallas, TX	6.4% (5% - 7.7%)	6.4% (5% - 7.7%)	6.4% (5% - 7.7%)	6.4% (5% - 7.7%)	5.5% (4.3% - 6.7%)	6.4% (5% - 7.7%)	5.5% (4.3% - 6.7%)
Detroit, MI	9.4% (7.4% - 11.4%)	6.5% (5.1% - 8%)	6.5% (5% - 7.8%)	5.5% (4.3% - 6.7%)	4.6% (3.6% - 5.6%)	4.7% (3.7% - 5.8%)	2.9% (2.2% - 3.5%)
Fresno, CA	13.4% (10.6% - 16.2%)	4.9% (3.8% - 6%)	4.9% (3.8% - 6%)	4.9% (3.8% - 6%)	4.9% (3.8% - 6%)	3.3% (2.6% - 4%)	1.7% (1.3% - 2%)
Houston, TX	8.9% (7% - 10.8%)	8.1% (6.4% - 9.9%)	7.2% (5.6% - 8.7%)	6.2% (4.9% - 7.6%)	5.2% (4.1% - 6.4%)	6.2% (4.9% - 7.6%)	5.2% (4.1% - 6.4%)
Los Angeles, CA	10.4% (8.2% - 12.6%)	4.5% (3.5% - 5.4%)	4.5% (3.5% - 5.4%)	4.5% (3.5% - 5.4%)	3.9% (3% - 4.7%)	2.9% (2.3% - 3.6%)	1.3% (1% - 1.6%)
New York, NY	8.5% (6.6% - 10.3%)	6.1% (4.7% - 7.4%)	6.1% (4.7% - 7.4%)	5.7% (4.5% - 7%)	4.8% (3.7% - 5.8%)	4.3% (3.3% - 5.2%)	2.5% (1.9% - 3%)
Philadelphia, PA	9.4% (7.4% - 11.4%)	8.2% (6.4% - 10%)	8.2% (6.4% - 10%)	7.3% (5.7% - 8.9%)	6.2% (4.9% - 7.6%)	6.2% (4.8% - 7.5%)	4.1% (3.2% - 5%)
Phoenix, AZ	6.3% (4.9% - 7.6%)	6.3% (4.9% - 7.6%)	6.3% (4.9% - 7.6%)	6.3% (4.9% - 7.6%)	5.7% (4.4% - 6.9%)	5.5% (4.3% - 6.7%)	3.5% (2.7% - 4.2%)
Pittsburgh, PA	9.8% (7.7% - 11.9%)	6.2% (4.8% - 7.5%)	6.2% (4.8% - 7.5%)	5.7% (4.5% - 7%)	4.9% (3.8% - 6%)	4.4% (3.4% - 5.4%)	2.6% (2% - 3.2%)
Salt Lake City, UT	5% (3.9% - 6.1%)	0.9% (0.7% - 1.2%)	0.9% (0.7% - 1.2%)	0.9% (0.7% - 1.2%)	0.9% (0.7% - 1.2%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	9.5% (7.4% - 11.5%)	7.9% (6.2% - 9.6%)	7.1% (5.5% - 8.6%)	6.1% (4.8% - 7.4%)	5.1% (4% - 6.2%)	5.9% (4.6% - 7.2%)	3.9% (3% - 4.7%)
Tacoma, WA	4.7% (3.7% - 5.8%)	2.7% (2.1% - 3.3%)	2.7% (2.1% - 3.3%)	2.7% (2.1% - 3.3%)	2.7% (2.1% - 3.3%)	1.4% (1.1% - 1.7%)	0.1% (0.1% - 0.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-51. Estimated Percent of Total Annual Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2001

Risk Assessment Location	Percent of Total Incidence of Cardiopulmonary Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	11.6% (9.1% - 14%)	10.3% (8.1% - 12.5%)	9.2% (7.2% - 11.1%)	8.1% (6.3% - 9.8%)	7% (5.4% - 8.5%)	8.1% (6.3% - 9.8%)	6.8% (5.3% - 8.3%)
Baltimore, MD	9.9% (7.8% - 12%)	9.1% (7.1% - 11%)	8.2% (6.5% - 10%)	7.2% (5.6% - 8.7%)	6.1% (4.8% - 7.5%)	6.9% (5.4% - 8.4%)	4.7% (3.7% - 5.7%)
Birmingham, AL	12% (9.5% - 14.5%)	8.5% (6.6% - 10.3%)	7.5% (5.9% - 9.1%)	6.5% (5.1% - 7.9%)	5.5% (4.3% - 6.7%)	6.5% (5.1% - 7.9%)	4.6% (3.6% - 5.6%)
Dallas, TX	7% (5.4% - 8.4%)	7% (5.4% - 8.4%)	7% (5.4% - 8.4%)	7% (5.4% - 8.4%)	6.1% (4.8% - 7.4%)	7% (5.4% - 8.4%)	6.1% (4.8% - 7.4%)
Detroit, MI	9.9% (7.8% - 12%)	7% (5.5% - 8.5%)	6.9% (5.4% - 8.4%)	6% (4.7% - 7.2%)	5% (3.9% - 6.1%)	5.1% (4% - 6.3%)	3.2% (2.5% - 3.9%)
Fresno, CA	13.9% (11% - 16.7%)	5.2% (4.1% - 6.3%)	5.2% (4.1% - 6.3%)	5.2% (4.1% - 6.3%)	5.2% (4.1% - 6.3%)	3.5% (2.8% - 4.3%)	1.9% (1.5% - 2.3%)
Houston, TX	9.1% (7.1% - 11%)	8.3% (6.5% - 10.1%)	7.4% (5.8% - 8.9%)	6.4% (5% - 7.8%)	5.4% (4.2% - 6.6%)	6.4% (5% - 7.8%)	5.4% (4.2% - 6.6%)
Los Angeles, CA	10.7% (8.4% - 13%)	4.7% (3.7% - 5.7%)	4.7% (3.7% - 5.7%)	4.7% (3.7% - 5.7%)	4.1% (3.2% - 5%)	3.1% (2.4% - 3.8%)	1.5% (1.2% - 1.8%)
New York, NY	9.8% (7.7% - 11.9%)	7.2% (5.6% - 8.7%)	7.2% (5.6% - 8.7%)	6.9% (5.4% - 8.3%)	5.8% (4.5% - 7.1%)	5.3% (4.1% - 6.4%)	3.3% (2.6% - 4.1%)
Philadelphia, PA	9.3% (7.3% - 11.3%)	8.1% (6.4% - 9.8%)	8.1% (6.4% - 9.8%)	7.2% (5.6% - 8.8%)	6.2% (4.8% - 7.5%)	6.1% (4.8% - 7.4%)	4% (3.1% - 4.9%)
Phoenix, AZ	5.2% (4% - 6.3%)	5.2% (4% - 6.3%)	5.2% (4% - 6.3%)	5.2% (4% - 6.3%)	4.6% (3.6% - 5.6%)	4.4% (3.5% - 5.4%)	2.6% (2% - 3.2%)
Pittsburgh, PA	11.1% (8.7% - 13.4%)	7.2% (5.6% - 8.7%)	7.2% (5.6% - 8.7%)	6.7% (5.3% - 8.2%)	5.9% (4.6% - 7.1%)	5.3% (4.1% - 6.4%)	3.4% (2.6% - 4.1%)
Salt Lake City, UT	7% (5.4% - 8.5%)	2.2% (1.7% - 2.7%)	2.2% (1.7% - 2.7%)	2.2% (1.7% - 2.7%)	2.2% (1.7% - 2.7%)	1% (0.8% - 1.2%)	0% (0% - 0%)
St. Louis, MO	10.4% (8.1% - 12.5%)	8.7% (6.8% - 10.6%)	7.9% (6.1% - 9.5%)	6.8% (5.3% - 8.3%)	5.8% (4.5% - 7%)	6.6% (5.2% - 8.1%)	4.5% (3.5% - 5.5%)
Tacoma, WA	4.9% (3.8% - 5.9%)	2.8% (2.2% - 3.5%)	2.8% (2.2% - 3.5%)	2.8% (2.2% - 3.5%)	2.8% (2.2% - 3.5%)	1.5% (1.2% - 1.9%)	0.2% (0.2% - 0.2%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-52. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -12%)	0% (0% - 0%)	10% (10% - 10%)	21% (21% - 21%)	32% (31% - 32%)	21% (21% - 21%)	33% (33% - 33%)
Baltimore, MD	-8% (-8% - -9%)	0% (0% - 0%)	8% (8% - 8%)	19% (19% - 19%)	29% (29% - 30%)	22% (21% - 22%)	44% (43% - 44%)
Birmingham, AL	-41% (-40% - -42%)	0% (0% - 0%)	11% (11% - 11%)	23% (23% - 23%)	34% (34% - 35%)	23% (23% - 23%)	45% (45% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-36% (-35% - -37%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 13%)	25% (25% - 25%)	23% (23% - 23%)	47% (47% - 47%)
Fresno, CA	-178% (-175% - -181%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (33% - 34%)	68% (68% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	11% (11% - 12%)	23% (23% - 23%)	35% (34% - 35%)	23% (23% - 23%)	35% (34% - 35%)
Los Angeles, CA	-118% (-116% - -120%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	62% (62% - 62%)
New York, NY	-34% (-34% - -34%)	0% (0% - 0%)	0% (0% - 0%)	4% (4% - 4%)	18% (18% - 18%)	25% (25% - 25%)	50% (50% - 51%)
Philadelphia, PA	-14% (-14% - -14%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 11%)	23% (23% - 23%)	24% (24% - 24%)	48% (48% - 48%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 45%)
Pittsburgh, PA	-51% (-50% - -52%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	17% (17% - 18%)	25% (25% - 25%)	50% (50% - 51%)
Salt Lake City, UT	-250% (-248% - -251%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-17% (-17% - -17%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 20%)	31% (30% - 31%)	22% (22% - 22%)	44% (44% - 45%)
Tacoma, WA	-52% (-52% - -52%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-53. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -12%)	0% (0% - 0%)	10% (10% - 11%)	21% (21% - 21%)	32% (31% - 32%)	21% (21% - 21%)	33% (33% - 33%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	21% (20% - 21%)	32% (32% - 33%)	24% (24% - 24%)	48% (48% - 48%)
Birmingham, AL	-43% (-42% - -43%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	47% (47% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	0% (0% - 0%)	13% (13% - 13%)
Detroit, MI	-43% (-43% - -44%)	0% (0% - 0%)	1% (1% - 1%)	16% (16% - 16%)	30% (30% - 30%)	28% (28% - 28%)	56% (56% - 56%)
Fresno, CA	-173% (-171% - -176%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	66% (66% - 66%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	36% (35% - 36%)
Los Angeles, CA	-133% (-132% - -135%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	35% (35% - 35%)	70% (70% - 70%)
New York, NY	-40% (-40% - -40%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	29% (29% - 29%)	59% (59% - 59%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 24%)	25% (25% - 25%)	50% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (44% - 45%)
Pittsburgh, PA	-59% (-59% - -60%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	29% (29% - 29%)	58% (58% - 58%)
Salt Lake City, UT	-431% (-428% - -433%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-20% (-20% - -20%)	0% (0% - 0%)	10% (10% - 11%)	23% (23% - 23%)	35% (35% - 35%)	25% (25% - 25%)	51% (51% - 51%)
Tacoma, WA	-75% (-74% - -75%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	48% (47% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-54. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiopulmonary Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-12% - -13%)	0% (0% - 0%)	11% (11% - 11%)	21% (21% - 22%)	32% (32% - 33%)	21% (21% - 22%)	34% (34% - 34%)
Baltimore, MD	-9% (-9% - -9%)	0% (0% - 0%)	9% (9% - 9%)	21% (20% - 21%)	32% (32% - 33%)	24% (24% - 24%)	48% (48% - 48%)
Birmingham, AL	-42% (-41% - -42%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 23%)	35% (35% - 35%)	23% (23% - 23%)	46% (46% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-42% (-41% - -42%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	29% (29% - 29%)	27% (27% - 27%)	54% (54% - 54%)
Fresno, CA	-168% (-165% - -170%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (32% - 32%)	64% (64% - 64%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 36%)	23% (23% - 24%)	35% (35% - 36%)
Los Angeles, CA	-129% (-128% - -131%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (34% - 34%)	68% (68% - 68%)
New York, NY	-36% (-36% - -37%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	19% (19% - 19%)	27% (26% - 27%)	54% (54% - 54%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 24%)	25% (25% - 25%)	51% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (50% - 50%)
Pittsburgh, PA	-54% (-53% - -54%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	19% (18% - 19%)	26% (26% - 27%)	53% (53% - 54%)
Salt Lake City, UT	-213% (-211% - -215%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-19% (-19% - -19%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 22%)	34% (33% - 34%)	24% (24% - 24%)	49% (48% - 49%)
Tacoma, WA	-72% (-72% - -73%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-55. Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	77 (29 - 122)	68 (26 - 108)	61 (23 - 97)	54 (20 - 86)	46 (17 - 74)	54 (20 - 86)	45 (17 - 73)
Baltimore, MD	81 (31 - 128)	74 (28 - 118)	68 (26 - 109)	60 (23 - 96)	52 (20 - 84)	58 (22 - 93)	42 (16 - 67)
Birmingham, AL	55 (21 - 87)	39 (15 - 62)	34 (13 - 55)	30 (11 - 48)	25 (10 - 41)	30 (11 - 48)	21 (8 - 34)
Dallas, TX	50 (19 - 79)	50 (19 - 79)	50 (19 - 79)	50 (19 - 79)	44 (17 - 71)	50 (19 - 79)	44 (17 - 71)
Detroit, MI	112 (43 - 178)	82 (31 - 131)	81 (31 - 129)	71 (27 - 114)	61 (23 - 98)	63 (24 - 101)	43 (16 - 70)
Fresno, CA	26 (10 - 41)	9 (3 - 15)	9 (3 - 15)	9 (3 - 15)	9 (3 - 15)	6 (2 - 10)	3 (1 - 5)
Houston, TX	76 (29 - 122)	70 (26 - 112)	62 (23 - 99)	54 (20 - 86)	46 (17 - 73)	54 (20 - 86)	46 (17 - 73)
Los Angeles, CA	248 (94 - 393)	112 (42 - 181)	112 (42 - 181)	112 (42 - 181)	99 (37 - 160)	78 (29 - 125)	42 (16 - 68)
New York, NY	208 (79 - 331)	155 (58 - 247)	155 (58 - 247)	148 (56 - 236)	126 (48 - 203)	116 (43 - 186)	76 (28 - 123)
Philadelphia, PA	70 (26 - 111)	61 (23 - 98)	61 (23 - 98)	55 (21 - 87)	47 (18 - 75)	46 (17 - 75)	32 (12 - 51)
Phoenix, AZ	58 (22 - 94)	58 (22 - 94)	58 (22 - 94)	58 (22 - 94)	53 (20 - 85)	51 (19 - 82)	32 (12 - 52)
Pittsburgh, PA	80 (31 - 127)	53 (20 - 84)	53 (20 - 84)	50 (19 - 79)	44 (16 - 70)	40 (15 - 64)	26 (10 - 42)
Salt Lake City, UT	8 (3 - 13)	2 (1 - 4)	2 (1 - 4)	2 (1 - 4)	2 (1 - 4)	1 (0 - 1)	0 (0 - 0)
St. Louis, MO	116 (44 - 184)	99 (37 - 157)	90 (34 - 143)	79 (30 - 126)	68 (26 - 109)	77 (29 - 123)	54 (20 - 88)
Tacoma, WA	19 (7 - 30)	12 (5 - 20)	12 (5 - 20)	12 (5 - 20)	12 (5 - 20)	8 (3 - 13)	4 (1 - 6)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-56. Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	79 (30 - 125)	70 (27 - 112)	63 (24 - 100)	55 (21 - 88)	48 (18 - 77)	55 (21 - 88)	47 (18 - 75)
Baltimore, MD	66 (25 - 105)	60 (23 - 96)	55 (21 - 87)	48 (18 - 76)	40 (15 - 65)	46 (17 - 73)	31 (12 - 50)
Birmingham, AL	52 (20 - 82)	36 (14 - 58)	32 (12 - 51)	28 (10 - 44)	23 (9 - 37)	28 (10 - 44)	19 (7 - 31)
Dallas, TX	37 (14 - 60)	37 (14 - 60)	37 (14 - 60)	37 (14 - 60)	33 (12 - 52)	37 (14 - 60)	33 (12 - 52)
Detroit, MI	82 (31 - 130)	57 (21 - 91)	56 (21 - 90)	48 (18 - 77)	39 (15 - 64)	41 (15 - 66)	25 (9 - 40)
Fresno, CA	27 (10 - 43)	10 (4 - 16)	10 (4 - 16)	10 (4 - 16)	10 (4 - 16)	7 (2 - 11)	3 (1 - 5)
Houston, TX	74 (28 - 118)	68 (26 - 108)	60 (22 - 96)	52 (19 - 83)	43 (16 - 70)	52 (19 - 83)	43 (16 - 70)
Los Angeles, CA	219 (83 - 348)	93 (35 - 150)	93 (35 - 150)	93 (35 - 150)	80 (30 - 130)	61 (23 - 98)	28 (10 - 45)
New York, NY	162 (61 - 259)	115 (43 - 185)	115 (43 - 185)	109 (41 - 176)	91 (34 - 146)	81 (30 - 131)	47 (17 - 76)
Philadelphia, PA	63 (24 - 101)	55 (21 - 88)	55 (21 - 88)	49 (18 - 78)	42 (16 - 67)	41 (15 - 66)	27 (10 - 44)
Phoenix, AZ	62 (23 - 100)	62 (23 - 100)	62 (23 - 100)	62 (23 - 100)	56 (21 - 90)	54 (20 - 87)	34 (13 - 55)
Pittsburgh, PA	64 (24 - 101)	40 (15 - 64)	40 (15 - 64)	37 (14 - 59)	32 (12 - 51)	28 (11 - 45)	17 (6 - 27)
Salt Lake City, UT	6 (2 - 10)	1 (0 - 2)	1 (0 - 2)	1 (0 - 2)	1 (0 - 2)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	87 (33 - 139)	73 (27 - 116)	65 (24 - 104)	56 (21 - 90)	47 (18 - 75)	54 (20 - 87)	35 (13 - 57)
Tacoma, WA	13 (5 - 20)	7 (3 - 12)	7 (3 - 12)	7 (3 - 12)	7 (3 - 12)	4 (1 - 6)	0 (0 - 0)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-57. Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	76 (29 - 121)	67 (26 - 107)	60 (23 - 96)	53 (20 - 84)	45 (17 - 73)	53 (20 - 84)	44 (17 - 71)
Baltimore, MD	66 (25 - 105)	60 (23 - 96)	55 (21 - 87)	47 (18 - 76)	40 (15 - 65)	46 (17 - 73)	31 (12 - 50)
Birmingham, AL	54 (21 - 86)	38 (14 - 61)	34 (13 - 54)	29 (11 - 47)	25 (9 - 40)	29 (11 - 47)	20 (8 - 33)
Dallas, TX	42 (16 - 67)	42 (16 - 67)	42 (16 - 67)	42 (16 - 67)	37 (14 - 59)	42 (16 - 67)	37 (14 - 59)
Detroit, MI	86 (33 - 137)	60 (23 - 97)	59 (22 - 95)	51 (19 - 82)	43 (16 - 69)	44 (16 - 71)	28 (10 - 44)
Fresno, CA	29 (11 - 45)	11 (4 - 17)	11 (4 - 17)	11 (4 - 17)	11 (4 - 17)	7 (3 - 12)	4 (1 - 6)
Houston, TX	77 (29 - 123)	71 (27 - 113)	62 (23 - 100)	54 (20 - 87)	46 (17 - 73)	54 (20 - 87)	46 (17 - 73)
Los Angeles, CA	227 (86 - 361)	98 (37 - 158)	98 (37 - 158)	98 (37 - 158)	85 (32 - 138)	65 (24 - 105)	31 (12 - 51)
New York, NY	189 (72 - 301)	138 (52 - 221)	138 (52 - 221)	131 (49 - 211)	111 (42 - 179)	101 (38 - 163)	63 (24 - 102)
Philadelphia, PA	63 (24 - 100)	54 (21 - 87)	54 (21 - 87)	48 (18 - 77)	41 (15 - 66)	41 (15 - 65)	27 (10 - 43)
Phoenix, AZ	53 (20 - 85)	53 (20 - 85)	53 (20 - 85)	53 (20 - 85)	47 (17 - 75)	45 (17 - 73)	26 (10 - 43)
Pittsburgh, PA	71 (27 - 114)	46 (17 - 74)	46 (17 - 74)	43 (16 - 69)	38 (14 - 60)	34 (13 - 55)	21 (8 - 35)
Salt Lake City, UT	9 (3 - 15)	3 (1 - 5)	3 (1 - 5)	3 (1 - 5)	3 (1 - 5)	1 (0 - 2)	0 (0 - 0)
St. Louis, MO	96 (36 - 152)	80 (30 - 128)	72 (27 - 116)	63 (24 - 100)	53 (20 - 85)	61 (23 - 98)	41 (15 - 66)
Tacoma, WA	13 (5 - 21)	8 (3 - 12)	8 (3 - 12)	8 (3 - 12)	8 (3 - 12)	4 (2 - 7)	1 (0 - 1)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-58. Estimated Percent of Total Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	8.6% (3.3% - 13.6%)	7.6% (2.9% - 12.1%)	6.8% (2.6% - 10.9%)	6% (2.3% - 9.6%)	5.2% (2% - 8.3%)	6% (2.3% - 9.6%)	5.1% (1.9% - 8.1%)
Baltimore, MD	8.4% (3.2% - 13.4%)	7.8% (3% - 12.3%)	7.1% (2.7% - 11.3%)	6.3% (2.4% - 10%)	5.5% (2.1% - 8.7%)	6.1% (2.3% - 9.7%)	4.3% (1.6% - 7%)
Birmingham, AL	8.6% (3.3% - 13.7%)	6.1% (2.3% - 9.7%)	5.4% (2% - 8.6%)	4.7% (1.8% - 7.5%)	4% (1.5% - 6.4%)	4.7% (1.8% - 7.5%)	3.3% (1.2% - 5.3%)
Dallas, TX	5.9% (2.2% - 9.5%)	5.9% (2.2% - 9.5%)	5.9% (2.2% - 9.5%)	5.9% (2.2% - 9.5%)	5.3% (2% - 8.5%)	5.9% (2.2% - 9.5%)	5.3% (2% - 8.5%)
Detroit, MI	8.9% (3.4% - 14.1%)	6.5% (2.5% - 10.4%)	6.5% (2.4% - 10.3%)	5.7% (2.1% - 9.1%)	4.9% (1.8% - 7.8%)	5% (1.9% - 8%)	3.4% (1.3% - 5.5%)
Fresno, CA	9.1% (3.5% - 14.4%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	2.1% (0.8% - 3.5%)	1% (0.4% - 1.7%)
Houston, TX	6.6% (2.5% - 10.5%)	6% (2.3% - 9.6%)	5.3% (2% - 8.5%)	4.6% (1.7% - 7.4%)	3.9% (1.5% - 6.3%)	4.6% (1.7% - 7.4%)	3.9% (1.5% - 6.3%)
Los Angeles, CA	8.2% (3.1% - 13%)	3.7% (1.4% - 6%)	3.7% (1.4% - 6%)	3.7% (1.4% - 6%)	3.3% (1.2% - 5.3%)	2.6% (1% - 4.2%)	1.4% (0.5% - 2.3%)
New York, NY	7.6% (2.9% - 12.1%)	5.6% (2.1% - 9%)	5.6% (2.1% - 9%)	5.4% (2% - 8.6%)	4.6% (1.7% - 7.4%)	4.2% (1.6% - 6.8%)	2.8% (1% - 4.5%)
Philadelphia, PA	7.2% (2.7% - 11.4%)	6.3% (2.4% - 10%)	6.3% (2.4% - 10%)	5.6% (2.1% - 9%)	4.8% (1.8% - 7.7%)	4.8% (1.8% - 7.7%)	3.2% (1.2% - 5.2%)
Phoenix, AZ	4.2% (1.6% - 6.8%)	4.2% (1.6% - 6.8%)	4.2% (1.6% - 6.8%)	4.2% (1.6% - 6.8%)	3.8% (1.4% - 6.1%)	3.7% (1.4% - 5.9%)	2.3% (0.9% - 3.7%)
Pittsburgh, PA	8.5% (3.2% - 13.5%)	5.6% (2.1% - 9%)	5.6% (2.1% - 9%)	5.3% (2% - 8.4%)	4.6% (1.7% - 7.4%)	4.2% (1.6% - 6.7%)	2.8% (1% - 4.5%)
Salt Lake City, UT	4.4% (1.6% - 7%)	1.2% (0.5% - 2%)	1.2% (0.5% - 2%)	1.2% (0.5% - 2%)	1.2% (0.5% - 2%)	0.4% (0.2% - 0.7%)	0% (0% - 0%)
St. Louis, MO	8.8% (3.3% - 13.9%)	7.5% (2.8% - 11.9%)	6.8% (2.6% - 10.8%)	6% (2.3% - 9.5%)	5.1% (1.9% - 8.2%)	5.8% (2.2% - 9.3%)	4.1% (1.5% - 6.6%)
Tacoma, WA	4.9% (1.8% - 7.8%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	2.1% (0.8% - 3.5%)	1.1% (0.4% - 1.7%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-59. Estimated Percent of Total Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	8.6% (3.3% - 13.6%)	7.6% (2.9% - 12.1%)	6.8% (2.6% - 10.9%)	6% (2.3% - 9.6%)	5.2% (2% - 8.3%)	6% (2.3% - 9.6%)	5.1% (1.9% - 8.1%)
Baltimore, MD	6.9% (2.6% - 10.9%)	6.3% (2.4% - 10%)	5.7% (2.1% - 9.1%)	5% (1.9% - 7.9%)	4.2% (1.6% - 6.8%)	4.8% (1.8% - 7.6%)	3.2% (1.2% - 5.2%)
Birmingham, AL	8% (3.1% - 12.7%)	5.6% (2.1% - 9%)	4.9% (1.9% - 7.9%)	4.3% (1.6% - 6.8%)	3.6% (1.3% - 5.8%)	4.3% (1.6% - 6.8%)	3% (1.1% - 4.8%)
Dallas, TX	4.4% (1.6% - 7%)	4.4% (1.6% - 7%)	4.4% (1.6% - 7%)	4.4% (1.6% - 7%)	3.8% (1.4% - 6.1%)	4.4% (1.6% - 7%)	3.8% (1.4% - 6.1%)
Detroit, MI	6.5% (2.5% - 10.4%)	4.5% (1.7% - 7.2%)	4.4% (1.7% - 7.1%)	3.8% (1.4% - 6.1%)	3.1% (1.2% - 5.1%)	3.2% (1.2% - 5.2%)	2% (0.7% - 3.2%)
Fresno, CA	9.3% (3.6% - 14.8%)	3.4% (1.3% - 5.4%)	3.4% (1.3% - 5.4%)	3.4% (1.3% - 5.4%)	3.4% (1.3% - 5.4%)	2.3% (0.8% - 3.7%)	1.1% (0.4% - 1.9%)
Houston, TX	6.1% (2.3% - 9.8%)	5.6% (2.1% - 9%)	4.9% (1.9% - 7.9%)	4.3% (1.6% - 6.9%)	3.6% (1.3% - 5.8%)	4.3% (1.6% - 6.9%)	3.6% (1.3% - 5.8%)
Los Angeles, CA	7.2% (2.7% - 11.5%)	3.1% (1.1% - 4.9%)	3.1% (1.1% - 4.9%)	3.1% (1.1% - 4.9%)	2.6% (1% - 4.3%)	2% (0.7% - 3.2%)	0.9% (0.3% - 1.5%)
New York, NY	5.9% (2.2% - 9.4%)	4.2% (1.6% - 6.7%)	4.2% (1.6% - 6.7%)	3.9% (1.5% - 6.4%)	3.3% (1.2% - 5.3%)	2.9% (1.1% - 4.7%)	1.7% (0.6% - 2.8%)
Philadelphia, PA	6.5% (2.5% - 10.4%)	5.7% (2.1% - 9.1%)	5.7% (2.1% - 9.1%)	5% (1.9% - 8.1%)	4.3% (1.6% - 6.9%)	4.2% (1.6% - 6.8%)	2.8% (1% - 4.5%)
Phoenix, AZ	4.3% (1.6% - 6.9%)	4.3% (1.6% - 6.9%)	4.3% (1.6% - 6.9%)	4.3% (1.6% - 6.9%)	3.9% (1.5% - 6.3%)	3.8% (1.4% - 6.1%)	2.4% (0.9% - 3.9%)
Pittsburgh, PA	6.8% (2.6% - 10.8%)	4.2% (1.6% - 6.8%)	4.2% (1.6% - 6.8%)	3.9% (1.5% - 6.3%)	3.4% (1.3% - 5.5%)	3% (1.1% - 4.9%)	1.8% (0.7% - 2.9%)
Salt Lake City, UT	3.4% (1.3% - 5.6%)	0.6% (0.2% - 1%)	0.6% (0.2% - 1%)	0.6% (0.2% - 1%)	0.6% (0.2% - 1%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	6.6% (2.5% - 10.5%)	5.5% (2.1% - 8.8%)	4.9% (1.8% - 7.8%)	4.2% (1.6% - 6.8%)	3.5% (1.3% - 5.7%)	4.1% (1.5% - 6.6%)	2.7% (1% - 4.3%)
Tacoma, WA	3.2% (1.2% - 5.2%)	1.9% (0.7% - 3%)	1.9% (0.7% - 3%)	1.9% (0.7% - 3%)	1.9% (0.7% - 3%)	1% (0.4% - 1.6%)	0.1% (0% - 0.1%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-60. Estimated Percent of Total Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient PM2.5 Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent of Total Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	8% (3.1% - 12.8%)	7.1% (2.7% - 11.4%)	6.4% (2.4% - 10.1%)	5.6% (2.1% - 8.9%)	4.8% (1.8% - 7.7%)	5.6% (2.1% - 8.9%)	4.7% (1.8% - 7.5%)
Baltimore, MD	6.9% (2.6% - 10.9%)	6.3% (2.4% - 10%)	5.7% (2.1% - 9.1%)	5% (1.9% - 7.9%)	4.2% (1.6% - 6.8%)	4.8% (1.8% - 7.6%)	3.2% (1.2% - 5.2%)
Birmingham, AL	8.3% (3.2% - 13.2%)	5.9% (2.2% - 9.4%)	5.2% (1.9% - 8.3%)	4.5% (1.7% - 7.2%)	3.8% (1.4% - 6.1%)	4.5% (1.7% - 7.2%)	3.1% (1.2% - 5.1%)
Dallas, TX	4.8% (1.8% - 7.7%)	4.8% (1.8% - 7.7%)	4.8% (1.8% - 7.7%)	4.8% (1.8% - 7.7%)	4.2% (1.6% - 6.8%)	4.8% (1.8% - 7.7%)	4.2% (1.6% - 6.8%)
Detroit, MI	6.9% (2.6% - 11%)	4.8% (1.8% - 7.8%)	4.8% (1.8% - 7.7%)	4.1% (1.5% - 6.6%)	3.4% (1.3% - 5.5%)	3.5% (1.3% - 5.7%)	2.2% (0.8% - 3.6%)
Fresno, CA	9.7% (3.7% - 15.3%)	3.6% (1.3% - 5.7%)	3.6% (1.3% - 5.7%)	3.6% (1.3% - 5.7%)	3.6% (1.3% - 5.7%)	2.4% (0.9% - 3.9%)	1.3% (0.5% - 2.1%)
Houston, TX	6.3% (2.4% - 10%)	5.7% (2.2% - 9.2%)	5.1% (1.9% - 8.1%)	4.4% (1.6% - 7%)	3.7% (1.4% - 6%)	4.4% (1.6% - 7%)	3.7% (1.4% - 6%)
Los Angeles, CA	7.4% (2.8% - 11.8%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	3.2% (1.2% - 5.2%)	2.8% (1% - 4.5%)	2.1% (0.8% - 3.4%)	1% (0.4% - 1.7%)
New York, NY	6.8% (2.6% - 10.8%)	5% (1.9% - 7.9%)	5% (1.9% - 7.9%)	4.7% (1.8% - 7.6%)	4% (1.5% - 6.4%)	3.6% (1.4% - 5.8%)	2.3% (0.8% - 3.7%)
Philadelphia, PA	6.4% (2.4% - 10.3%)	5.6% (2.1% - 9%)	5.6% (2.1% - 9%)	5% (1.9% - 8%)	4.2% (1.6% - 6.8%)	4.2% (1.6% - 6.7%)	2.7% (1% - 4.4%)
Phoenix, AZ	3.6% (1.3% - 5.7%)	3.6% (1.3% - 5.7%)	3.6% (1.3% - 5.7%)	3.6% (1.3% - 5.7%)	3.2% (1.2% - 5.1%)	3.1% (1.1% - 4.9%)	1.8% (0.7% - 2.9%)
Pittsburgh, PA	7.7% (2.9% - 12.2%)	5% (1.9% - 8%)	5% (1.9% - 8%)	4.6% (1.7% - 7.4%)	4% (1.5% - 6.5%)	3.6% (1.4% - 5.9%)	2.3% (0.9% - 3.7%)
Salt Lake City, UT	4.8% (1.8% - 7.7%)	1.5% (0.6% - 2.5%)	1.5% (0.6% - 2.5%)	1.5% (0.6% - 2.5%)	1.5% (0.6% - 2.5%)	0.7% (0.3% - 1.1%)	0% (0% - 0%)
St. Louis, MO	7.2% (2.7% - 11.4%)	6% (2.3% - 9.6%)	5.4% (2% - 8.7%)	4.7% (1.8% - 7.5%)	4% (1.5% - 6.4%)	4.6% (1.7% - 7.3%)	3.1% (1.2% - 5%)
Tacoma, WA	3.3% (1.3% - 5.4%)	1.9% (0.7% - 3.1%)	1.9% (0.7% - 3.1%)	1.9% (0.7% - 3.1%)	1.9% (0.7% - 3.1%)	1% (0.4% - 1.7%)	0.1% (0.1% - 0.2%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-61. Percent Reduction from the Current Standards: Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	1435	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-12% - -13%)	0% (0% - 0%)	11% (10% - 11%)	21% (21% - 22%)	32% (31% - 32%)	21% (21% - 22%)	34% (33% - 34%)
Baltimore, MD	-9% (-8% - -9%)	0% (0% - 0%)	8% (8% - 9%)	19% (19% - 19%)	30% (29% - 30%)	22% (21% - 22%)	44% (44% - 45%)
Birmingham, AL	-42% (-41% - -43%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 23%)	35% (34% - 35%)	23% (23% - 23%)	46% (45% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-37% (-36% - -38%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 13%)	25% (25% - 26%)	23% (23% - 24%)	47% (47% - 48%)
Fresno, CA	-182% (-177% - -188%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (33% - 34%)	68% (68% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 24%)	35% (35% - 35%)	23% (23% - 24%)	35% (35% - 35%)
Los Angeles, CA	-121% (-117% - -124%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	62% (62% - 63%)
New York, NY	-35% (-34% - -36%)	0% (0% - 0%)	0% (0% - 0%)	4% (4% - 5%)	18% (18% - 18%)	25% (25% - 26%)	51% (50% - 51%)
Philadelphia, PA	-14% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (10% - 11%)	23% (23% - 24%)	24% (24% - 24%)	48% (48% - 49%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 46%)
Pittsburgh, PA	-52% (-50% - -53%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	18% (17% - 18%)	25% (25% - 25%)	51% (50% - 51%)
Salt Lake City, UT	-252% (-249% - -256%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-17% (-17% - -18%)	0% (0% - 0%)	9% (9% - 9%)	20% (20% - 21%)	31% (31% - 32%)	22% (22% - 23%)	45% (44% - 45%)
Tacoma, WA	-53% (-52% - -54%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 34%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-62. Percent Reduction from the Current Standards: Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	1435	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-12% - -13%)	0% (0% - 0%)	11% (10% - 11%)	21% (21% - 22%)	32% (31% - 32%)	21% (21% - 22%)	34% (33% - 34%)
Baltimore, MD	-10% (-9% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (32% - 33%)	24% (24% - 24%)	48% (48% - 49%)
Birmingham, AL	-43% (-42% - -45%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	47% (47% - 48%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	0% (0% - 0%)	13% (13% - 13%)
Detroit, MI	-44% (-43% - -45%)	0% (0% - 0%)	1% (1% - 1%)	16% (16% - 16%)	30% (30% - 31%)	28% (28% - 28%)	56% (56% - 57%)
Fresno, CA	-177% (-172% - -183%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 33%)	66% (66% - 66%)
Houston, TX	-9% (-9% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (24% - 24%)	36% (36% - 36%)	24% (24% - 24%)	36% (36% - 36%)
Los Angeles, CA	-136% (-132% - -139%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 14%)	35% (35% - 35%)	70% (70% - 70%)
New York, NY	-41% (-40% - -41%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	29% (29% - 30%)	59% (59% - 60%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 25%)	25% (25% - 26%)	51% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (44% - 45%)
Pittsburgh, PA	-60% (-59% - -62%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	29% (29% - 29%)	58% (58% - 59%)
Salt Lake City, UT	-434% (-430% - -439%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-20% (-20% - -21%)	0% (0% - 0%)	11% (10% - 11%)	23% (23% - 23%)	36% (35% - 36%)	25% (25% - 26%)	51% (51% - 52%)
Tacoma, WA	-75% (-75% - -76%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	48% (48% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-63. Percent Reduction from the Current Standards: Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1979 - 1983[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	1435	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-13% - -13%)	0% (0% - 0%)	11% (11% - 11%)	22% (21% - 22%)	33% (32% - 33%)	22% (21% - 22%)	34% (34% - 35%)
Baltimore, MD	-10% (-9% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (21% - 21%)	33% (32% - 33%)	24% (24% - 24%)	48% (48% - 49%)
Birmingham, AL	-43% (-41% - -44%)	0% (0% - 0%)	12% (12% - 12%)	23% (23% - 24%)	35% (35% - 36%)	23% (23% - 24%)	46% (46% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-42% (-42% - -43%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	29% (29% - 30%)	27% (27% - 27%)	54% (54% - 55%)
Fresno, CA	-172% (-166% - -177%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (32% - 32%)	64% (64% - 64%)
Houston, TX	-9% (-9% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	36% (35% - 36%)
Los Angeles, CA	-132% (-128% - -135%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (34% - 34%)	68% (68% - 68%)
New York, NY	-37% (-36% - -38%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	19% (19% - 20%)	27% (27% - 27%)	54% (54% - 55%)
Philadelphia, PA	-15% (-15% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 25%)	25% (25% - 26%)	51% (51% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (50% - 50%)
Pittsburgh, PA	-55% (-53% - -56%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	19% (19% - 19%)	27% (26% - 27%)	54% (53% - 54%)
Salt Lake City, UT	-215% (-212% - -219%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-19% (-19% - -20%)	0% (0% - 0%)	10% (10% - 10%)	22% (22% - 22%)	34% (34% - 34%)	24% (24% - 25%)	49% (49% - 49%)
Tacoma, WA	-73% (-72% - -74%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-64. Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1999 - 2000[1]

Risk Assessment Location	Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	110 (49 - 167)	98 (44 - 149)	88 (39 - 134)	78 (34 - 119)	67 (30 - 103)	78 (34 - 119)	66 (29 - 101)
Baltimore, MD	116 (52 - 176)	107 (48 - 163)	99 (44 - 150)	87 (38 - 133)	76 (33 - 116)	84 (37 - 129)	60 (26 - 93)
Birmingham, AL	79 (35 - 120)	56 (25 - 86)	50 (22 - 77)	43 (19 - 67)	37 (16 - 57)	43 (19 - 67)	31 (13 - 48)
Dallas, TX	72 (32 - 110)	72 (32 - 110)	72 (32 - 110)	72 (32 - 110)	64 (28 - 98)	72 (32 - 110)	64 (28 - 98)
Detroit, MI	161 (72 - 244)	119 (52 - 181)	117 (52 - 179)	103 (45 - 158)	89 (39 - 137)	91 (40 - 140)	63 (27 - 98)
Fresno, CA	38 (17 - 57)	14 (6 - 21)	14 (6 - 21)	14 (6 - 21)	14 (6 - 21)	9 (4 - 14)	4 (2 - 7)
Houston, TX	111 (49 - 169)	101 (45 - 155)	90 (39 - 138)	78 (34 - 120)	66 (29 - 102)	78 (34 - 120)	66 (29 - 102)
Los Angeles, CA	357 (159 - 541)	164 (71 - 253)	164 (71 - 253)	164 (71 - 253)	144 (63 - 223)	113 (49 - 176)	62 (27 - 96)
New York, NY	300 (133 - 457)	224 (99 - 343)	224 (99 - 343)	214 (94 - 329)	184 (80 - 283)	168 (73 - 259)	111 (48 - 172)
Philadelphia, PA	101 (45 - 154)	88 (39 - 135)	88 (39 - 135)	79 (35 - 121)	68 (30 - 105)	67 (30 - 104)	46 (20 - 71)
Phoenix, AZ	85 (37 - 131)	85 (37 - 131)	85 (37 - 131)	85 (37 - 131)	76 (33 - 118)	74 (32 - 115)	47 (20 - 73)
Pittsburgh, PA	115 (51 - 175)	76 (34 - 117)	76 (34 - 117)	72 (32 - 110)	63 (28 - 97)	57 (25 - 89)	38 (17 - 59)
Salt Lake City, UT	11 (5 - 18)	3 (1 - 5)	3 (1 - 5)	3 (1 - 5)	3 (1 - 5)	1 (1 - 2)	0 (0 - 0)
St. Louis, MO	167 (74 - 252)	142 (63 - 217)	129 (57 - 197)	114 (50 - 175)	99 (43 - 152)	111 (49 - 170)	79 (35 - 122)
Tacoma, WA	27 (12 - 41)	18 (8 - 27)	18 (8 - 27)	18 (8 - 27)	18 (8 - 27)	12 (5 - 18)	6 (3 - 9)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-65. Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1999 - 2000[1]

Risk Assessment Location	Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	114 (51 - 172)	101 (45 - 154)	91 (40 - 138)	80 (35 - 123)	69 (30 - 106)	80 (35 - 123)	68 (30 - 104)
Baltimore, MD	95 (42 - 145)	87 (38 - 133)	79 (35 - 121)	69 (30 - 106)	59 (26 - 91)	66 (29 - 102)	45 (20 - 70)
Birmingham, AL	75 (33 - 113)	52 (23 - 80)	46 (20 - 71)	40 (18 - 62)	34 (15 - 52)	40 (18 - 62)	28 (12 - 43)
Dallas, TX	54 (24 - 84)	54 (24 - 84)	54 (24 - 84)	54 (24 - 84)	47 (21 - 73)	54 (24 - 84)	47 (21 - 73)
Detroit, MI	118 (52 - 180)	82 (36 - 127)	81 (35 - 125)	69 (30 - 107)	58 (25 - 89)	59 (26 - 92)	36 (16 - 56)
Fresno, CA	39 (18 - 59)	14 (6 - 22)	14 (6 - 22)	14 (6 - 22)	14 (6 - 22)	10 (4 - 15)	5 (2 - 8)
Houston, TX	107 (47 - 164)	98 (43 - 150)	87 (38 - 133)	75 (33 - 116)	63 (28 - 98)	75 (33 - 116)	63 (28 - 98)
Los Angeles, CA	316 (140 - 481)	135 (59 - 210)	135 (59 - 210)	135 (59 - 210)	117 (51 - 182)	89 (38 - 138)	41 (18 - 64)
New York, NY	234 (103 - 359)	167 (73 - 258)	167 (73 - 258)	159 (69 - 245)	132 (58 - 205)	119 (52 - 184)	69 (30 - 107)
Philadelphia, PA	91 (40 - 140)	80 (35 - 122)	80 (35 - 122)	71 (31 - 109)	61 (26 - 93)	60 (26 - 92)	40 (17 - 61)
Phoenix, AZ	90 (39 - 139)	90 (39 - 139)	90 (39 - 139)	90 (39 - 139)	81 (35 - 125)	79 (34 - 122)	50 (22 - 78)
Pittsburgh, PA	92 (41 - 140)	58 (25 - 89)	58 (25 - 89)	54 (23 - 83)	46 (20 - 71)	41 (18 - 64)	24 (10 - 38)
Salt Lake City, UT	9 (4 - 14)	2 (1 - 3)	2 (1 - 3)	2 (1 - 3)	2 (1 - 3)	0 (0 - 0)	0 (0 - 0)
St. Louis, MO	126 (56 - 193)	105 (46 - 162)	94 (41 - 145)	81 (36 - 126)	68 (30 - 106)	79 (34 - 122)	52 (22 - 80)
Tacoma, WA	18 (8 - 28)	10 (5 - 16)	10 (5 - 16)	10 (5 - 16)	10 (5 - 16)	5 (2 - 9)	0 (0 - 1)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-66. Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient PM2.5 from 1999 - 2000[1]

Risk Assessment Location	Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	109 (49 - 166)	97 (43 - 148)	87 (38 - 133)	76 (34 - 117)	66 (29 - 101)	76 (34 - 117)	64 (28 - 99)
Baltimore, MD	95 (42 - 145)	87 (38 - 133)	79 (35 - 121)	69 (30 - 106)	59 (26 - 91)	66 (29 - 102)	45 (20 - 70)
Birmingham, AL	78 (35 - 119)	55 (24 - 85)	49 (21 - 75)	42 (19 - 65)	36 (16 - 56)	42 (19 - 65)	30 (13 - 46)
Dallas, TX	60 (27 - 93)	60 (27 - 93)	60 (27 - 93)	60 (27 - 93)	53 (23 - 82)	60 (27 - 93)	53 (23 - 82)
Detroit, MI	124 (55 - 189)	88 (38 - 135)	86 (38 - 133)	74 (32 - 115)	62 (27 - 96)	64 (28 - 99)	40 (17 - 63)
Fresno, CA	41 (18 - 62)	15 (7 - 24)	15 (7 - 24)	15 (7 - 24)	15 (7 - 24)	11 (5 - 16)	6 (2 - 9)
Houston, TX	112 (49 - 171)	102 (45 - 157)	90 (40 - 139)	78 (34 - 121)	66 (29 - 102)	78 (34 - 121)	66 (29 - 102)
Los Angeles, CA	328 (145 - 499)	143 (62 - 222)	143 (62 - 222)	143 (62 - 222)	124 (54 - 193)	95 (41 - 148)	46 (20 - 72)
New York, NY	273 (121 - 417)	200 (88 - 308)	200 (88 - 308)	191 (84 - 294)	162 (71 - 250)	147 (64 - 227)	92 (40 - 144)
Philadelphia, PA	91 (40 - 138)	79 (35 - 121)	79 (35 - 121)	70 (31 - 108)	60 (26 - 92)	59 (26 - 91)	39 (17 - 60)
Phoenix, AZ	77 (33 - 118)	77 (33 - 118)	77 (33 - 118)	77 (33 - 118)	68 (30 - 106)	66 (29 - 102)	38 (17 - 60)
Pittsburgh, PA	103 (46 - 157)	67 (29 - 103)	67 (29 - 103)	63 (28 - 97)	55 (24 - 84)	49 (22 - 76)	31 (14 - 49)
Salt Lake City, UT	13 (6 - 21)	4 (2 - 7)	4 (2 - 7)	4 (2 - 7)	4 (2 - 7)	2 (1 - 3)	0 (0 - 0)
St. Louis, MO	138 (61 - 210)	116 (51 - 178)	105 (46 - 161)	91 (40 - 140)	77 (34 - 119)	88 (39 - 136)	60 (26 - 93)
Tacoma, WA	19 (8 - 30)	11 (5 - 17)	11 (5 - 17)	11 (5 - 17)	11 (5 - 17)	6 (3 - 9)	1 (0 - 1)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-67. Estimated Percent of Total Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	12.4% (5.5% - 18.7%)	11% (4.9% - 16.7%)	9.9% (4.4% - 15.1%)	8.7% (3.8% - 13.3%)	7.5% (3.3% - 11.6%)	8.7% (3.8% - 13.3%)	7.4% (3.2% - 11.3%)
Baltimore, MD	12.2% (5.4% - 18.4%)	11.2% (5% - 17%)	10.3% (4.6% - 15.7%)	9.1% (4% - 13.9%)	7.9% (3.5% - 12.1%)	8.8% (3.9% - 13.4%)	6.3% (2.8% - 9.7%)
Birmingham, AL	12.4% (5.5% - 18.8%)	8.8% (3.9% - 13.5%)	7.8% (3.4% - 12%)	6.8% (3% - 10.5%)	5.8% (2.5% - 8.9%)	6.8% (3% - 10.5%)	4.8% (2.1% - 7.4%)
Dallas, TX	8.6% (3.8% - 13.2%)	8.6% (3.8% - 13.2%)	8.6% (3.8% - 13.2%)	8.6% (3.8% - 13.2%)	7.7% (3.4% - 11.8%)	8.6% (3.8% - 13.2%)	7.7% (3.4% - 11.8%)
Detroit, MI	12.8% (5.7% - 19.4%)	9.4% (4.2% - 14.4%)	9.3% (4.1% - 14.3%)	8.2% (3.6% - 12.6%)	7.1% (3.1% - 10.9%)	7.3% (3.2% - 11.2%)	5% (2.2% - 7.8%)
Fresno, CA	13.1% (5.8% - 19.8%)	4.7% (2.1% - 7.3%)	4.7% (2.1% - 7.3%)	4.7% (2.1% - 7.3%)	4.7% (2.1% - 7.3%)	3.1% (1.4% - 4.9%)	1.5% (0.7% - 2.4%)
Houston, TX	9.5% (4.2% - 14.5%)	8.7% (3.8% - 13.3%)	7.7% (3.4% - 11.8%)	6.7% (2.9% - 10.3%)	5.7% (2.5% - 8.8%)	6.7% (2.9% - 10.3%)	5.7% (2.5% - 8.8%)
Los Angeles, CA	11.8% (5.3% - 18%)	5.4% (2.4% - 8.4%)	5.4% (2.4% - 8.4%)	5.4% (2.4% - 8.4%)	4.8% (2.1% - 7.4%)	3.8% (1.6% - 5.8%)	2% (0.9% - 3.2%)
New York, NY	11% (4.9% - 16.7%)	8.2% (3.6% - 12.5%)	8.2% (3.6% - 12.5%)	7.8% (3.4% - 12%)	6.7% (2.9% - 10.3%)	6.1% (2.7% - 9.5%)	4% (1.8% - 6.3%)
Philadelphia, PA	10.4% (4.6% - 15.8%)	9.1% (4% - 13.9%)	9.1% (4% - 13.9%)	8.1% (3.6% - 12.5%)	7% (3.1% - 10.8%)	6.9% (3% - 10.7%)	4.7% (2.1% - 7.3%)
Phoenix, AZ	6.2% (2.7% - 9.5%)	6.2% (2.7% - 9.5%)	6.2% (2.7% - 9.5%)	6.2% (2.7% - 9.5%)	5.5% (2.4% - 8.6%)	5.4% (2.3% - 8.3%)	3.4% (1.5% - 5.3%)
Pittsburgh, PA	12.3% (5.5% - 18.6%)	8.1% (3.6% - 12.5%)	8.1% (3.6% - 12.5%)	7.6% (3.4% - 11.7%)	6.7% (2.9% - 10.3%)	6.1% (2.7% - 9.4%)	4% (1.8% - 6.3%)
Salt Lake City, UT	6.3% (2.8% - 9.8%)	1.8% (0.8% - 2.8%)	1.8% (0.8% - 2.8%)	1.8% (0.8% - 2.8%)	1.8% (0.8% - 2.8%)	0.6% (0.3% - 1%)	0% (0% - 0%)
St. Louis, MO	12.6% (5.6% - 19.1%)	10.8% (4.8% - 16.4%)	9.8% (4.3% - 14.9%)	8.6% (3.8% - 13.2%)	7.5% (3.3% - 11.5%)	8.4% (3.7% - 12.9%)	6% (2.6% - 9.2%)
Tacoma, WA	7.1% (3.1% - 10.9%)	4.7% (2% - 7.2%)	4.7% (2% - 7.2%)	4.7% (2% - 7.2%)	4.7% (2% - 7.2%)	3.1% (1.4% - 4.9%)	1.5% (0.7% - 2.4%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-68. Estimated Percent of Total Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	12.4% (5.5% - 18.7%)	11% (4.9% - 16.7%)	9.9% (4.4% - 15%)	8.7% (3.8% - 13.3%)	7.5% (3.3% - 11.6%)	8.7% (3.8% - 13.3%)	7.4% (3.2% - 11.3%)
Baltimore, MD	9.9% (4.4% - 15.1%)	9.1% (4% - 13.9%)	8.2% (3.6% - 12.6%)	7.2% (3.2% - 11.1%)	6.1% (2.7% - 9.5%)	6.9% (3% - 10.6%)	4.7% (2% - 7.3%)
Birmingham, AL	11.6% (5.1% - 17.6%)	8.1% (3.6% - 12.4%)	7.2% (3.1% - 11%)	6.2% (2.7% - 9.6%)	5.2% (2.3% - 8.1%)	6.2% (2.7% - 9.6%)	4.3% (1.9% - 6.7%)
Dallas, TX	6.4% (2.8% - 9.8%)	6.4% (2.8% - 9.8%)	6.4% (2.8% - 9.8%)	6.4% (2.8% - 9.8%)	5.5% (2.4% - 8.6%)	6.4% (2.8% - 9.8%)	5.5% (2.4% - 8.6%)
Detroit, MI	9.4% (4.1% - 14.3%)	6.5% (2.9% - 10.1%)	6.5% (2.8% - 10%)	5.5% (2.4% - 8.5%)	4.6% (2% - 7.1%)	4.7% (2.1% - 7.3%)	2.9% (1.2% - 4.5%)
Fresno, CA	13.4% (6% - 20.3%)	4.9% (2.1% - 7.6%)	4.9% (2.1% - 7.6%)	4.9% (2.1% - 7.6%)	4.9% (2.1% - 7.6%)	3.3% (1.4% - 5.1%)	1.7% (0.7% - 2.6%)
Houston, TX	8.9% (3.9% - 13.6%)	8.1% (3.6% - 12.5%)	7.2% (3.1% - 11%)	6.2% (2.7% - 9.6%)	5.2% (2.3% - 8.1%)	6.2% (2.7% - 9.6%)	5.2% (2.3% - 8.1%)
Los Angeles, CA	10.4% (4.6% - 15.9%)	4.5% (1.9% - 6.9%)	4.5% (1.9% - 6.9%)	4.5% (1.9% - 6.9%)	3.9% (1.7% - 6%)	2.9% (1.3% - 4.5%)	1.3% (0.6% - 2.1%)
New York, NY	8.5% (3.7% - 13%)	6.1% (2.6% - 9.3%)	6.1% (2.6% - 9.3%)	5.7% (2.5% - 8.9%)	4.8% (2.1% - 7.4%)	4.3% (1.9% - 6.7%)	2.5% (1.1% - 3.9%)
Philadelphia, PA	9.4% (4.2% - 14.4%)	8.2% (3.6% - 12.6%)	8.2% (3.6% - 12.6%)	7.3% (3.2% - 11.2%)	6.2% (2.7% - 9.6%)	6.2% (2.7% - 9.5%)	4.1% (1.8% - 6.3%)
Phoenix, AZ	6.3% (2.7% - 9.7%)	6.3% (2.7% - 9.7%)	6.3% (2.7% - 9.7%)	6.3% (2.7% - 9.7%)	5.7% (2.5% - 8.7%)	5.5% (2.4% - 8.5%)	3.5% (1.5% - 5.4%)
Pittsburgh, PA	9.8% (4.3% - 15%)	6.2% (2.7% - 9.5%)	6.2% (2.7% - 9.5%)	5.7% (2.5% - 8.9%)	4.9% (2.1% - 7.6%)	4.4% (1.9% - 6.8%)	2.6% (1.1% - 4%)
Salt Lake City, UT	5% (2.2% - 7.8%)	0.9% (0.4% - 1.5%)	0.9% (0.4% - 1.5%)	0.9% (0.4% - 1.5%)	0.9% (0.4% - 1.5%)	0% (0% - 0%)	0% (0% - 0%)
St. Louis, MO	9.5% (4.2% - 14.5%)	7.9% (3.5% - 12.2%)	7.1% (3.1% - 10.9%)	6.1% (2.7% - 9.4%)	5.1% (2.2% - 7.9%)	5.9% (2.6% - 9.2%)	3.9% (1.7% - 6%)
Tacoma, WA	4.7% (2.1% - 7.3%)	2.7% (1.2% - 4.2%)	2.7% (1.2% - 4.2%)	2.7% (1.2% - 4.2%)	2.7% (1.2% - 4.2%)	1.4% (0.6% - 2.2%)	0.1% (0% - 0.2%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-69. Estimated Percent of Total Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent of Total Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	11.6% (5.2% - 17.6%)	10.3% (4.6% - 15.7%)	9.2% (4.1% - 14.1%)	8.1% (3.6% - 12.4%)	7% (3.1% - 10.7%)	8.1% (3.6% - 12.4%)	6.8% (3% - 10.5%)
Baltimore, MD	9.9% (4.4% - 15.1%)	9.1% (4% - 13.9%)	8.2% (3.6% - 12.6%)	7.2% (3.2% - 11.1%)	6.1% (2.7% - 9.5%)	6.9% (3% - 10.6%)	4.7% (2% - 7.3%)
Birmingham, AL	12% (5.3% - 18.2%)	8.5% (3.7% - 13%)	7.5% (3.3% - 11.5%)	6.5% (2.8% - 10%)	5.5% (2.4% - 8.5%)	6.5% (2.8% - 10%)	4.6% (2% - 7.1%)
Dallas, TX	7% (3% - 10.7%)	7% (3% - 10.7%)	7% (3% - 10.7%)	7% (3% - 10.7%)	6.1% (2.7% - 9.4%)	7% (3% - 10.7%)	6.1% (2.7% - 9.4%)
Detroit, MI	9.9% (4.4% - 15.2%)	7% (3.1% - 10.8%)	6.9% (3% - 10.7%)	6% (2.6% - 9.2%)	5% (2.2% - 7.7%)	5.1% (2.2% - 8%)	3.2% (1.4% - 5%)
Fresno, CA	13.9% (6.2% - 20.9%)	5.2% (2.3% - 8%)	5.2% (2.3% - 8%)	5.2% (2.3% - 8%)	5.2% (2.3% - 8%)	3.5% (1.5% - 5.5%)	1.9% (0.8% - 2.9%)
Houston, TX	9.1% (4% - 13.9%)	8.3% (3.7% - 12.8%)	7.4% (3.2% - 11.3%)	6.4% (2.8% - 9.8%)	5.4% (2.4% - 8.3%)	6.4% (2.8% - 9.8%)	5.4% (2.4% - 8.3%)
Los Angeles, CA	10.7% (4.8% - 16.3%)	4.7% (2% - 7.3%)	4.7% (2% - 7.3%)	4.7% (2% - 7.3%)	4.1% (1.8% - 6.3%)	3.1% (1.3% - 4.8%)	1.5% (0.6% - 2.4%)
New York, NY	9.8% (4.3% - 15%)	7.2% (3.2% - 11.1%)	7.2% (3.2% - 11.1%)	6.9% (3% - 10.6%)	5.8% (2.5% - 9%)	5.3% (2.3% - 8.2%)	3.3% (1.4% - 5.2%)
Philadelphia, PA	9.3% (4.1% - 14.2%)	8.1% (3.6% - 12.5%)	8.1% (3.6% - 12.5%)	7.2% (3.2% - 11.1%)	6.2% (2.7% - 9.5%)	6.1% (2.7% - 9.4%)	4% (1.7% - 6.2%)
Phoenix, AZ	5.2% (2.3% - 8%)	5.2% (2.3% - 8%)	5.2% (2.3% - 8%)	5.2% (2.3% - 8%)	4.6% (2% - 7.1%)	4.4% (1.9% - 6.9%)	2.6% (1.1% - 4.1%)
Pittsburgh, PA	11.1% (4.9% - 16.8%)	7.2% (3.2% - 11.1%)	7.2% (3.2% - 11.1%)	6.7% (3% - 10.4%)	5.9% (2.6% - 9.1%)	5.3% (2.3% - 8.2%)	3.4% (1.5% - 5.2%)
Salt Lake City, UT	7% (3.1% - 10.7%)	2.2% (1% - 3.5%)	2.2% (1% - 3.5%)	2.2% (1% - 3.5%)	2.2% (1% - 3.5%)	1% (0.4% - 1.6%)	0% (0% - 0%)
St. Louis, MO	10.4% (4.6% - 15.8%)	8.7% (3.8% - 13.4%)	7.9% (3.5% - 12.1%)	6.8% (3% - 10.5%)	5.8% (2.5% - 8.9%)	6.6% (2.9% - 10.2%)	4.5% (2% - 6.9%)
Tacoma, WA	4.9% (2.1% - 7.6%)	2.8% (1.2% - 4.4%)	2.8% (1.2% - 4.4%)	2.8% (1.2% - 4.4%)	2.8% (1.2% - 4.4%)	1.5% (0.7% - 2.4%)	0.2% (0.1% - 0.3%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-70. Percent Reduction from the Current Standards: Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations -- Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -13%)	0% (0% - 0%)	10% (10% - 11%)	21% (20% - 21%)	32% (31% - 32%)	21% (20% - 21%)	33% (32% - 34%)
Baltimore, MD	-8% (-8% - -9%)	0% (0% - 0%)	8% (8% - 8%)	19% (18% - 19%)	29% (29% - 30%)	22% (21% - 22%)	44% (43% - 45%)
Birmingham, AL	-41% (-39% - -43%)	0% (0% - 0%)	11% (11% - 12%)	23% (22% - 23%)	34% (34% - 35%)	23% (22% - 23%)	45% (45% - 46%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	0% (0% - 0%)	11% (11% - 11%)
Detroit, MI	-36% (-35% - -37%)	0% (0% - 0%)	1% (1% - 1%)	13% (13% - 13%)	25% (25% - 26%)	23% (23% - 24%)	47% (46% - 48%)
Fresno, CA	-178% (-171% - -185%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	34% (33% - 34%)	68% (67% - 68%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	11% (11% - 12%)	23% (23% - 23%)	35% (34% - 35%)	23% (23% - 23%)	35% (34% - 35%)
Los Angeles, CA	-118% (-114% - -122%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	31% (31% - 31%)	62% (62% - 63%)
New York, NY	-34% (-33% - -35%)	0% (0% - 0%)	0% (0% - 0%)	4% (4% - 5%)	18% (18% - 18%)	25% (25% - 25%)	50% (50% - 51%)
Philadelphia, PA	-14% (-14% - -14%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 11%)	23% (22% - 23%)	24% (23% - 24%)	48% (47% - 49%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (13% - 13%)	45% (45% - 45%)
Pittsburgh, PA	-51% (-49% - -53%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	17% (17% - 18%)	25% (24% - 25%)	50% (50% - 51%)
Salt Lake City, UT	-250% (-245% - -254%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	64% (64% - 64%)	100% (100% - 100%)
St. Louis, MO	-17% (-16% - -18%)	0% (0% - 0%)	9% (9% - 9%)	20% (19% - 20%)	31% (30% - 31%)	22% (21% - 22%)	44% (44% - 45%)
Tacoma, WA	-52% (-51% - -53%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (33% - 34%)	67% (67% - 67%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-71. Percent Reduction from the Current Standards: Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations -- Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-12% (-12% - -13%)	0% (0% - 0%)	10% (10% - 11%)	21% (20% - 21%)	32% (31% - 32%)	21% (20% - 21%)	33% (32% - 34%)
Baltimore, MD	-9% (-9% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (20% - 21%)	32% (32% - 33%)	24% (23% - 24%)	48% (47% - 49%)
Birmingham, AL	-43% (-41% - -44%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	47% (46% - 48%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (12% - 13%)	0% (0% - 0%)	13% (12% - 13%)
Detroit, MI	-43% (-42% - -45%)	0% (0% - 0%)	1% (1% - 1%)	16% (15% - 16%)	30% (30% - 30%)	28% (27% - 28%)	56% (56% - 57%)
Fresno, CA	-173% (-167% - -181%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	33% (32% - 33%)	66% (66% - 66%)
Houston, TX	-9% (-9% - -10%)	0% (0% - 0%)	12% (12% - 12%)	24% (23% - 24%)	36% (35% - 36%)	24% (23% - 24%)	36% (35% - 36%)
Los Angeles, CA	-133% (-129% - -137%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 14%)	35% (34% - 35%)	70% (70% - 70%)
New York, NY	-40% (-39% - -41%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	21% (21% - 21%)	29% (29% - 30%)	59% (59% - 59%)
Philadelphia, PA	-15% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 25%)	25% (24% - 25%)	50% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	10% (10% - 10%)	13% (12% - 13%)	45% (44% - 45%)
Pittsburgh, PA	-59% (-58% - -61%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	20% (20% - 20%)	29% (28% - 29%)	58% (57% - 58%)
Salt Lake City, UT	-431% (-425% - -437%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	100% (100% - 100%)	100% (100% - 100%)
St. Louis, MO	-20% (-19% - -20%)	0% (0% - 0%)	10% (10% - 11%)	23% (22% - 23%)	35% (35% - 36%)	25% (25% - 26%)	51% (50% - 51%)
Tacoma, WA	-75% (-74% - -76%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	48% (47% - 48%)	96% (96% - 96%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-72. Percent Reduction from the Current Standards: Estimated Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations -- Estimates Based on Krewski et al. (2009), Using Ambient $PM_{2.5}$ from 1999 - 2000[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Lung Cancer Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-13% (-12% - -13%)	0% (0% - 0%)	11% (10% - 11%)	21% (21% - 22%)	32% (32% - 33%)	21% (21% - 22%)	34% (33% - 35%)
Baltimore, MD	-9% (-9% - -10%)	0% (0% - 0%)	9% (9% - 9%)	21% (20% - 21%)	32% (32% - 33%)	24% (23% - 24%)	48% (47% - 49%)
Birmingham, AL	-42% (-40% - -43%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 24%)	35% (34% - 36%)	23% (23% - 24%)	46% (45% - 47%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	12% (12% - 12%)	0% (0% - 0%)	12% (12% - 12%)
Detroit, MI	-42% (-41% - -43%)	0% (0% - 0%)	1% (1% - 1%)	15% (15% - 15%)	29% (29% - 29%)	27% (26% - 27%)	54% (54% - 55%)
Fresno, CA	-168% (-161% - -175%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	32% (31% - 32%)	64% (64% - 64%)
Houston, TX	-9% (-9% - -9%)	0% (0% - 0%)	12% (11% - 12%)	23% (23% - 24%)	35% (35% - 36%)	23% (23% - 24%)	35% (35% - 36%)
Los Angeles, CA	-129% (-125% - -134%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	13% (13% - 13%)	34% (33% - 34%)	68% (68% - 68%)
New York, NY	-36% (-35% - -37%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	19% (19% - 20%)	27% (26% - 27%)	54% (53% - 54%)
Philadelphia, PA	-15% (-14% - -15%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	24% (24% - 25%)	25% (25% - 26%)	51% (50% - 51%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	11% (11% - 11%)	14% (14% - 14%)	50% (49% - 50%)
Pittsburgh, PA	-54% (-52% - -55%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	19% (18% - 19%)	26% (26% - 27%)	53% (53% - 54%)
Salt Lake City, UT	-213% (-209% - -217%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	55% (55% - 55%)	100% (100% - 100%)
St. Louis, MO	-19% (-18% - -19%)	0% (0% - 0%)	10% (10% - 10%)	22% (21% - 22%)	34% (33% - 34%)	24% (24% - 25%)	49% (48% - 49%)
Tacoma, WA	-72% (-71% - -74%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	46% (46% - 46%)	93% (93% - 93%)

[1]Based on follow-up through 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-73. Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	193 (37 - 347)	177 (34 - 319)	164 (31 - 295)	151 (29 - 272)	137 (26 - 248)	151 (29 - 272)	135 (26 - 244)
Baltimore, MD	271 (110 - 430)	256 (104 - 406)	242 (98 - 384)	224 (91 - 356)	206 (83 - 327)	219 (89 - 348)	182 (74 - 289)
Birmingham, AL	44 (-68 - 154)	34 (-53 - 121)	32 (-49 - 112)	29 (-45 - 103)	27 (-41 - 94)	29 (-45 - 103)	24 (-38 - 85)
Dallas, TX	156 (37 - 273)	156 (37 - 273)	156 (37 - 273)	156 (37 - 273)	145 (35 - 253)	156 (37 - 273)	145 (35 - 253)
Detroit, MI	181 (-32 - 390)	147 (-26 - 317)	146 (-26 - 315)	135 (-24 - 291)	124 (-22 - 267)	125 (-22 - 271)	104 (-18 - 225)
Fresno, CA	79 (11 - 145)	44 (6 - 81)	44 (6 - 81)	44 (6 - 81)	44 (6 - 81)	37 (5 - 69)	31 (4 - 57)
Houston, TX	227 (46 - 405)	214 (44 - 383)	198 (40 - 354)	182 (37 - 326)	166 (34 - 297)	182 (37 - 326)	166 (34 - 297)
Los Angeles, CA	129 (-185 - 441)	81 (-117 - 278)	81 (-117 - 278)	81 (-117 - 278)	77 (-110 - 263)	69 (-100 - 238)	58 (-82 - 197)
New York, NY	939 (552 - 1323)	781 (459 - 1102)	781 (459 - 1102)	761 (447 - 1073)	700 (411 - 987)	668 (392 - 943)	555 (325 - 783)
Philadelphia, PA	234 (86 - 380)	216 (79 - 350)	216 (79 - 350)	202 (74 - 328)	185 (68 - 301)	184 (68 - 300)	153 (56 - 249)
Phoenix, AZ	242 (40 - 442)	242 (40 - 442)	242 (40 - 442)	242 (40 - 442)	230 (38 - 420)	227 (38 - 414)	188 (31 - 344)
Pittsburgh, PA	224 (66 - 380)	159 (47 - 270)	159 (47 - 270)	155 (45 - 263)	147 (43 - 249)	136 (40 - 231)	112 (33 - 191)
Salt Lake City, UT	48 (10 - 85)	30 (6 - 54)	30 (6 - 54)	30 (6 - 54)	30 (6 - 54)	26 (5 - 46)	21 (4 - 38)
St. Louis, MO	290 (84 - 494)	260 (75 - 443)	244 (71 - 416)	226 (65 - 385)	207 (60 - 354)	222 (64 - 379)	184 (53 - 315)
Tacoma, WA	59 (10 - 107)	48 (8 - 87)	48 (8 - 87)	48 (8 - 87)	48 (8 - 87)	41 (7 - 74)	34 (6 - 62)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-74. Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	196 (37 - 353)	180 (34 - 324)	166 (32 - 300)	153 (29 - 276)	139 (26 - 251)	153 (29 - 276)	137 (26 - 248)
Baltimore, MD	237 (96 - 376)	224 (91 - 356)	212 (86 - 336)	196 (79 - 311)	180 (73 - 286)	192 (78 - 305)	159 (64 - 253)
Birmingham, AL	42 (-66 - 148)	33 (-51 - 116)	30 (-47 - 108)	28 (-44 - 99)	26 (-40 - 90)	28 (-44 - 99)	23 (-36 - 82)
Dallas, TX	130 (31 - 228)	130 (31 - 228)	130 (31 - 228)	130 (31 - 228)	121 (29 - 212)	130 (31 - 228)	121 (29 - 212)
Detroit, MI	145 (-25 - 314)	118 (-21 - 255)	117 (-20 - 253)	108 (-19 - 234)	99 (-17 - 215)	101 (-18 - 218)	83 (-15 - 181)
Fresno, CA	84 (12 - 155)	47 (7 - 86)	47 (7 - 86)	47 (7 - 86)	47 (7 - 86)	40 (6 - 74)	33 (5 - 61)
Houston, TX	221 (45 - 395)	208 (42 - 373)	193 (39 - 345)	177 (36 - 317)	162 (33 - 289)	177 (36 - 317)	162 (33 - 289)
Los Angeles, CA	119 (-171 - 407)	75 (-108 - 257)	75 (-108 - 257)	75 (-108 - 257)	71 (-101 - 242)	64 (-92 - 219)	53 (-76 - 182)
New York, NY	807 (474 - 1137)	671 (394 - 946)	671 (394 - 946)	654 (383 - 922)	601 (352 - 847)	574 (336 - 809)	476 (279 - 672)
Philadelphia, PA	222 (82 - 359)	204 (75 - 331)	204 (75 - 331)	191 (70 - 310)	175 (65 - 285)	174 (64 - 283)	145 (53 - 235)
Phoenix, AZ	254 (42 - 463)	254 (42 - 463)	254 (42 - 463)	254 (42 - 463)	241 (40 - 440)	238 (39 - 434)	198 (33 - 361)
Pittsburgh, PA	194 (57 - 329)	136 (40 - 232)	136 (40 - 232)	133 (39 - 226)	126 (37 - 215)	116 (34 - 198)	96 (28 - 164)
Salt Lake City, UT	44 (9 - 78)	27 (6 - 49)	27 (6 - 49)	27 (6 - 49)	27 (6 - 49)	23 (5 - 42)	19 (4 - 35)
St. Louis, MO	240 (69 - 409)	215 (62 - 367)	202 (58 - 345)	187 (54 - 319)	171 (49 - 293)	184 (53 - 314)	152 (44 - 260)
Tacoma, WA	50 (9 - 90)	40 (7 - 73)	40 (7 - 73)	40 (7 - 73)	40 (7 - 73)	34 (6 - 62)	28 (5 - 52)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-75. Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	193 (37 - 348)	177 (34 - 319)	164 (31 - 296)	151 (29 - 272)	137 (26 - 248)	151 (29 - 272)	135 (26 - 244)
Baltimore, MD	240 (97 - 380)	227 (92 - 360)	214 (87 - 340)	198 (80 - 315)	182 (74 - 289)	194 (79 - 308)	161 (65 - 256)
Birmingham, AL	44 (-68 - 154)	34 (-53 - 120)	32 (-49 - 111)	29 (-45 - 102)	26 (-41 - 93)	29 (-45 - 102)	24 (-37 - 85)
Dallas, TX	139 (33 - 243)	139 (33 - 243)	139 (33 - 243)	139 (33 - 243)	129 (31 - 225)	139 (33 - 243)	129 (31 - 225)
Detroit, MI	150 (-26 - 323)	121 (-21 - 262)	120 (-21 - 261)	111 (-19 - 241)	102 (-18 - 221)	104 (-18 - 224)	86 (-15 - 186)
Fresno, CA	87 (12 - 160)	48 (7 - 89)	48 (7 - 89)	48 (7 - 89)	48 (7 - 89)	41 (6 - 76)	34 (5 - 63)
Houston, TX	224 (46 - 401)	212 (43 - 378)	196 (40 - 350)	180 (37 - 322)	164 (33 - 294)	180 (37 - 322)	164 (33 - 294)
Los Angeles, CA	121 (-174 - 415)	77 (-110 - 262)	77 (-110 - 262)	77 (-110 - 262)	72 (-104 - 247)	65 (-94 - 224)	54 (-78 - 186)
New York, NY	882 (518 - 1243)	734 (431 - 1035)	734 (431 - 1035)	715 (419 - 1008)	657 (385 - 927)	627 (368 - 885)	521 (305 - 735)
Philadelphia, PA	226 (83 - 367)	208 (77 - 338)	208 (77 - 338)	195 (72 - 316)	179 (66 - 291)	178 (66 - 289)	148 (54 - 240)
Phoenix, AZ	242 (40 - 442)	242 (40 - 442)	242 (40 - 442)	242 (40 - 442)	230 (38 - 420)	227 (38 - 414)	188 (31 - 344)
Pittsburgh, PA	204 (60 - 346)	143 (42 - 244)	143 (42 - 244)	140 (41 - 237)	133 (39 - 226)	122 (36 - 208)	102 (30 - 173)
Salt Lake City, UT	54 (11 - 96)	34 (7 - 61)	34 (7 - 61)	34 (7 - 61)	34 (7 - 61)	29 (6 - 52)	24 (5 - 43)
St. Louis, MO	251 (73 - 428)	225 (65 - 384)	211 (61 - 360)	195 (56 - 333)	179 (52 - 306)	192 (55 - 328)	160 (46 - 272)
Tacoma, WA	52 (9 - 94)	42 (7 - 76)	42 (7 - 76)	42 (7 - 76)	42 (7 - 76)	36 (6 - 65)	30 (5 - 54)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-76. Estimated Percent of Total Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	1.3% (0.3% - 2.4%)	1.2% (0.2% - 2.2%)	1.1% (0.2% - 2%)	1% (0.2% - 1.9%)	1% (0.2% - 1.7%)	1% (0.2% - 1.9%)	0.9% (0.2% - 1.7%)
Baltimore, MD	2% (0.8% - 3.2%)	1.9% (0.8% - 3%)	1.8% (0.7% - 2.8%)	1.7% (0.7% - 2.6%)	1.5% (0.6% - 2.4%)	1.6% (0.7% - 2.6%)	1.3% (0.5% - 2.1%)
Birmingham, AL	0.5% (-0.7% - 1.6%)	0.4% (-0.6% - 1.3%)	0.3% (-0.5% - 1.2%)	0.3% (-0.5% - 1.1%)	0.3% (-0.4% - 1%)	0.3% (-0.5% - 1.1%)	0.3% (-0.4% - 0.9%)
Dallas, TX	1.2% (0.3% - 2.2%)	1.2% (0.3% - 2.2%)	1.2% (0.3% - 2.2%)	1.2% (0.3% - 2.2%)	1.2% (0.3% - 2%)	1.2% (0.3% - 2.2%)	1.2% (0.3% - 2%)
Detroit, MI	1% (-0.2% - 2.3%)	0.8% (-0.1% - 1.8%)	0.8% (-0.1% - 1.8%)	0.8% (-0.1% - 1.7%)	0.7% (-0.1% - 1.5%)	0.7% (-0.1% - 1.6%)	0.6% (-0.1% - 1.3%)
Fresno, CA	1.5% (0.2% - 2.7%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.7% (0.1% - 1.3%)	0.6% (0.1% - 1.1%)
Houston, TX	1.3% (0.3% - 2.3%)	1.2% (0.2% - 2.1%)	1.1% (0.2% - 2%)	1% (0.2% - 1.8%)	0.9% (0.2% - 1.7%)	1% (0.2% - 1.8%)	0.9% (0.2% - 1.7%)
Los Angeles, CA	0.2% (-0.3% - 0.8%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.4%)	0.1% (-0.1% - 0.4%)
New York, NY	1.8% (1.1% - 2.6%)	1.5% (0.9% - 2.1%)	1.5% (0.9% - 2.1%)	1.5% (0.9% - 2.1%)	1.4% (0.8% - 1.9%)	1.3% (0.8% - 1.8%)	1.1% (0.6% - 1.5%)
Philadelphia, PA	1.7% (0.6% - 2.7%)	1.5% (0.6% - 2.5%)	1.5% (0.6% - 2.5%)	1.4% (0.5% - 2.3%)	1.3% (0.5% - 2.1%)	1.3% (0.5% - 2.1%)	1.1% (0.4% - 1.8%)
Phoenix, AZ	1.1% (0.2% - 2%)	1.1% (0.2% - 2%)	1.1% (0.2% - 2%)	1.1% (0.2% - 2%)	1.1% (0.2% - 1.9%)	1% (0.2% - 1.9%)	0.9% (0.1% - 1.6%)
Pittsburgh, PA	1.7% (0.5% - 2.8%)	1.2% (0.3% - 2%)	1.2% (0.3% - 2%)	1.1% (0.3% - 1.9%)	1.1% (0.3% - 1.8%)	1% (0.3% - 1.7%)	0.8% (0.2% - 1.4%)
Salt Lake City, UT	1% (0.2% - 1.8%)	0.6% (0.1% - 1.2%)	0.6% (0.1% - 1.2%)	0.6% (0.1% - 1.2%)	0.6% (0.1% - 1.2%)	0.6% (0.1% - 1%)	0.5% (0.1% - 0.8%)
St. Louis, MO	1.6% (0.5% - 2.7%)	1.4% (0.4% - 2.4%)	1.3% (0.4% - 2.3%)	1.2% (0.4% - 2.1%)	1.1% (0.3% - 1.9%)	1.2% (0.4% - 2.1%)	1% (0.3% - 1.7%)
Tacoma, WA	1.2% (0.2% - 2.2%)	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	0.8% (0.1% - 1.5%)	0.7% (0.1% - 1.3%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-77. Estimated Percent of Total Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	1.3% (0.3% - 2.4%)	1.2% (0.2% - 2.2%)	1.1% (0.2% - 2%)	1% (0.2% - 1.9%)	0.9% (0.2% - 1.7%)	1% (0.2% - 1.9%)	0.9% (0.2% - 1.7%)
Baltimore, MD	1.7% (0.7% - 2.8%)	1.6% (0.7% - 2.6%)	1.6% (0.6% - 2.5%)	1.4% (0.6% - 2.3%)	1.3% (0.5% - 2.1%)	1.4% (0.6% - 2.2%)	1.2% (0.5% - 1.9%)
Birmingham, AL	0.4% (-0.7% - 1.6%)	0.3% (-0.5% - 1.2%)	0.3% (-0.5% - 1.1%)	0.3% (-0.5% - 1%)	0.3% (-0.4% - 0.9%)	0.3% (-0.5% - 1%)	0.2% (-0.4% - 0.9%)
Dallas, TX	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	0.9% (0.2% - 1.7%)	1% (0.2% - 1.8%)	0.9% (0.2% - 1.7%)
Detroit, MI	0.8% (-0.1% - 1.8%)	0.7% (-0.1% - 1.5%)	0.7% (-0.1% - 1.5%)	0.6% (-0.1% - 1.4%)	0.6% (-0.1% - 1.3%)	0.6% (-0.1% - 1.3%)	0.5% (-0.1% - 1.1%)
Fresno, CA	1.5% (0.2% - 2.8%)	0.8% (0.1% - 1.6%)	0.8% (0.1% - 1.6%)	0.8% (0.1% - 1.6%)	0.8% (0.1% - 1.6%)	0.7% (0.1% - 1.3%)	0.6% (0.1% - 1.1%)
Houston, TX	1.2% (0.2% - 2.1%)	1.1% (0.2% - 2%)	1% (0.2% - 1.9%)	1% (0.2% - 1.7%)	0.9% (0.2% - 1.6%)	1% (0.2% - 1.7%)	0.9% (0.2% - 1.6%)
Los Angeles, CA	0.2% (-0.3% - 0.7%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.4%)	0.1% (-0.2% - 0.4%)	0.1% (-0.1% - 0.3%)
New York, NY	1.6% (0.9% - 2.2%)	1.3% (0.8% - 1.8%)	1.3% (0.8% - 1.8%)	1.3% (0.7% - 1.8%)	1.2% (0.7% - 1.6%)	1.1% (0.6% - 1.6%)	0.9% (0.5% - 1.3%)
Philadelphia, PA	1.6% (0.6% - 2.6%)	1.5% (0.5% - 2.4%)	1.5% (0.5% - 2.4%)	1.4% (0.5% - 2.2%)	1.2% (0.5% - 2%)	1.2% (0.5% - 2%)	1% (0.4% - 1.7%)
Phoenix, AZ	1.1% (0.2% - 2%)	1.1% (0.2% - 2%)	1.1% (0.2% - 2%)	1.1% (0.2% - 2%)	1.1% (0.2% - 1.9%)	1.1% (0.2% - 1.9%)	0.9% (0.1% - 1.6%)
Pittsburgh, PA	1.4% (0.4% - 2.5%)	1% (0.3% - 1.7%)	1% (0.3% - 1.7%)	1% (0.3% - 1.7%)	0.9% (0.3% - 1.6%)	0.9% (0.3% - 1.5%)	0.7% (0.2% - 1.2%)
Salt Lake City, UT	0.9% (0.2% - 1.6%)	0.6% (0.1% - 1%)	0.6% (0.1% - 1%)	0.6% (0.1% - 1%)	0.6% (0.1% - 1%)	0.5% (0.1% - 0.9%)	0.4% (0.1% - 0.7%)
St. Louis, MO	1.3% (0.4% - 2.2%)	1.2% (0.3% - 2%)	1.1% (0.3% - 1.9%)	1% (0.3% - 1.7%)	0.9% (0.3% - 1.6%)	1% (0.3% - 1.7%)	0.8% (0.2% - 1.4%)
Tacoma, WA	1% (0.2% - 1.8%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.7% (0.1% - 1.2%)	0.6% (0.1% - 1%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-78. Estimated Percent of Total Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	1.3% (0.2% - 2.3%)	1.2% (0.2% - 2.1%)	1.1% (0.2% - 1.9%)	1% (0.2% - 1.8%)	0.9% (0.2% - 1.6%)	1% (0.2% - 1.8%)	0.9% (0.2% - 1.6%)
Baltimore, MD	1.8% (0.7% - 2.8%)	1.7% (0.7% - 2.6%)	1.6% (0.6% - 2.5%)	1.5% (0.6% - 2.3%)	1.3% (0.5% - 2.1%)	1.4% (0.6% - 2.3%)	1.2% (0.5% - 1.9%)
Birmingham, AL	0.5% (-0.7% - 1.6%)	0.4% (-0.6% - 1.2%)	0.3% (-0.5% - 1.2%)	0.3% (-0.5% - 1.1%)	0.3% (-0.4% - 1%)	0.3% (-0.5% - 1.1%)	0.2% (-0.4% - 0.9%)
Dallas, TX	1.1% (0.3% - 1.9%)	1.1% (0.3% - 1.9%)	1.1% (0.3% - 1.9%)	1.1% (0.3% - 1.9%)	1% (0.2% - 1.8%)	1.1% (0.3% - 1.9%)	1% (0.2% - 1.8%)
Detroit, MI	0.9% (-0.2% - 1.9%)	0.7% (-0.1% - 1.6%)	0.7% (-0.1% - 1.5%)	0.7% (-0.1% - 1.4%)	0.6% (-0.1% - 1.3%)	0.6% (-0.1% - 1.3%)	0.5% (-0.1% - 1.1%)
Fresno, CA	1.6% (0.2% - 2.9%)	0.9% (0.1% - 1.6%)	0.9% (0.1% - 1.6%)	0.9% (0.1% - 1.6%)	0.9% (0.1% - 1.6%)	0.7% (0.1% - 1.4%)	0.6% (0.1% - 1.1%)
Houston, TX	1.2% (0.2% - 2.1%)	1.1% (0.2% - 2%)	1% (0.2% - 1.9%)	1% (0.2% - 1.7%)	0.9% (0.2% - 1.6%)	1% (0.2% - 1.7%)	0.9% (0.2% - 1.6%)
Los Angeles, CA	0.2% (-0.3% - 0.7%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.5%)	0.1% (-0.2% - 0.4%)	0.1% (-0.2% - 0.4%)	0.1% (-0.1% - 0.3%)
New York, NY	1.7% (1% - 2.4%)	1.4% (0.8% - 2%)	1.4% (0.8% - 2%)	1.4% (0.8% - 1.9%)	1.3% (0.7% - 1.8%)	1.2% (0.7% - 1.7%)	1% (0.6% - 1.4%)
Philadelphia, PA	1.6% (0.6% - 2.6%)	1.5% (0.5% - 2.4%)	1.5% (0.5% - 2.4%)	1.4% (0.5% - 2.3%)	1.3% (0.5% - 2.1%)	1.3% (0.5% - 2.1%)	1.1% (0.4% - 1.7%)
Phoenix, AZ	1% (0.2% - 1.9%)	1% (0.2% - 1.9%)	1% (0.2% - 1.9%)	1% (0.2% - 1.9%)	1% (0.2% - 1.8%)	1% (0.2% - 1.8%)	0.8% (0.1% - 1.5%)
Pittsburgh, PA	1.5% (0.4% - 2.6%)	1.1% (0.3% - 1.8%)	1.1% (0.3% - 1.8%)	1% (0.3% - 1.8%)	1% (0.3% - 1.7%)	0.9% (0.3% - 1.6%)	0.8% (0.2% - 1.3%)
Salt Lake City, UT	1.1% (0.2% - 2%)	0.7% (0.1% - 1.3%)	0.7% (0.1% - 1.3%)	0.7% (0.1% - 1.3%)	0.7% (0.1% - 1.3%)	0.6% (0.1% - 1.1%)	0.5% (0.1% - 0.9%)
St. Louis, MO	1.4% (0.4% - 2.4%)	1.2% (0.4% - 2.1%)	1.2% (0.3% - 2%)	1.1% (0.3% - 1.8%)	1% (0.3% - 1.7%)	1.1% (0.3% - 1.8%)	0.9% (0.3% - 1.5%)
Tacoma, WA	1% (0.2% - 1.9%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.8% (0.1% - 1.5%)	0.7% (0.1% - 1.3%)	0.6% (0.1% - 1.1%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-79. Percent Reduction from the Current Standards: Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Estimated Percent Reduction From the Current Standards to Several Alternative Standards in Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	5% (5% - 6%)	13% (12% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 10%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-41% (-41% - -41%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	8% (8% - 8%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -23%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-80. Percent Reduction from the Current Standards: Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Estimated Percent Reduction From the Current Standards to Several Alternative Standards in Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (5% - 6%)	13% (12% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 11%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -23%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-81. Percent Reduction from the Current Standards: Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Estimated Percent Reduction From the Current Standards to Several Alternative Standards in Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (5% - 6%)	13% (13% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 11%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -23%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-82. Estimated Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	35 (-36 - 104)	32 (-33 - 95)	30 (-30 - 88)	27 (-28 - 81)	25 (-25 - 74)	27 (-28 - 81)	24 (-25 - 73)
Baltimore, MD	74 (-5 - 151)	70 (-5 - 143)	66 (-4 - 135)	61 (-4 - 125)	56 (-4 - 115)	60 (-4 - 122)	50 (-3 - 102)
Birmingham, AL	-1 (-55 - 52)	-1 (-43 - 40)	-1 (-39 - 37)	-1 (-36 - 34)	-1 (-33 - 31)	-1 (-36 - 34)	0 (-30 - 29)
Dallas, TX	32 (-21 - 85)	32 (-21 - 85)	32 (-21 - 85)	32 (-21 - 85)	30 (-20 - 79)	32 (-21 - 85)	30 (-20 - 79)
Detroit, MI	89 (-11 - 188)	73 (-9 - 153)	72 (-9 - 152)	67 (-8 - 140)	61 (-8 - 129)	62 (-8 - 131)	51 (-6 - 109)
Fresno, CA	20 (-14 - 54)	11 (-8 - 30)	11 (-8 - 30)	11 (-8 - 30)	11 (-8 - 30)	10 (-7 - 26)	8 (-6 - 21)
Houston, TX	50 (-34 - 131)	47 (-32 - 124)	43 (-29 - 114)	40 (-27 - 105)	36 (-25 - 96)	40 (-27 - 105)	36 (-25 - 96)
Los Angeles, CA	-50 (-223 - 121)	-31 (-140 - 76)	-31 (-140 - 76)	-31 (-140 - 76)	-30 (-132 - 72)	-27 (-119 - 65)	-22 (-99 - 54)
New York, NY	605 (353 - 853)	504 (294 - 711)	504 (294 - 711)	491 (286 - 693)	451 (263 - 637)	431 (251 - 609)	358 (208 - 506)
Philadelphia, PA	94 (25 - 163)	87 (23 - 150)	87 (23 - 150)	81 (21 - 140)	75 (19 - 129)	74 (19 - 129)	62 (16 - 107)
Phoenix, AZ	84 (-4 - 170)	84 (-4 - 170)	84 (-4 - 170)	84 (-4 - 170)	80 (-3 - 161)	79 (-3 - 159)	65 (-3 - 132)
Pittsburgh, PA	67 (-13 - 145)	47 (-9 - 103)	47 (-9 - 103)	46 (-9 - 101)	44 (-9 - 96)	41 (-8 - 88)	34 (-7 - 73)
Salt Lake City, UT	13 (-3 - 28)	8 (-2 - 18)	8 (-2 - 18)	8 (-2 - 18)	8 (-2 - 18)	7 (-2 - 15)	6 (-1 - 12)
St. Louis, MO	136 (30 - 240)	122 (27 - 215)	115 (26 - 203)	106 (24 - 187)	98 (22 - 172)	105 (23 - 185)	87 (19 - 153)
Tacoma, WA	15 (-8 - 38)	12 (-7 - 31)	12 (-7 - 31)	12 (-7 - 31)	12 (-7 - 31)	11 (-6 - 27)	9 (-5 - 22)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-83. Estimated Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	35 (-36 - 105)	32 (-33 - 97)	30 (-31 - 90)	28 (-28 - 82)	25 (-26 - 75)	28 (-28 - 82)	25 (-25 - 74)
Baltimore, MD	65 (-4 - 132)	61 (-4 - 125)	58 (-4 - 118)	53 (-4 - 109)	49 (-3 - 101)	52 (-4 - 107)	43 (-3 - 89)
Birmingham, AL	-1 (-52 - 50)	-1 (-41 - 39)	-1 (-38 - 36)	-1 (-35 - 33)	0 (-32 - 30)	-1 (-35 - 33)	0 (-29 - 27)
Dallas, TX	27 (-18 - 71)	27 (-18 - 71)	27 (-18 - 71)	27 (-18 - 71)	25 (-16 - 66)	27 (-18 - 71)	25 (-16 - 66)
Detroit, MI	72 (-9 - 152)	58 (-7 - 123)	58 (-7 - 122)	54 (-7 - 113)	49 (-6 - 104)	50 (-6 - 105)	41 (-5 - 87)
Fresno, CA	22 (-15 - 58)	12 (-8 - 32)	12 (-8 - 32)	12 (-8 - 32)	12 (-8 - 32)	10 (-7 - 27)	9 (-6 - 23)
Houston, TX	48 (-33 - 128)	45 (-31 - 120)	42 (-29 - 112)	39 (-26 - 103)	35 (-24 - 94)	39 (-26 - 103)	35 (-24 - 94)
Los Angeles, CA	-46 (-205 - 112)	-29 (-129 - 70)	-29 (-129 - 70)	-29 (-129 - 70)	-27 (-122 - 66)	-25 (-110 - 60)	-20 (-91 - 50)
New York, NY	519 (303 - 733)	432 (252 - 611)	432 (252 - 611)	421 (246 - 595)	387 (226 - 548)	370 (216 - 523)	307 (179 - 435)
Philadelphia, PA	89 (23 - 154)	82 (21 - 142)	82 (21 - 142)	77 (20 - 133)	71 (18 - 122)	70 (18 - 122)	58 (15 - 101)
Phoenix, AZ	88 (-4 - 178)	88 (-4 - 178)	88 (-4 - 178)	88 (-4 - 178)	84 (-4 - 169)	82 (-4 - 167)	69 (-3 - 139)
Pittsburgh, PA	58 (-12 - 126)	41 (-8 - 89)	41 (-8 - 89)	40 (-8 - 86)	38 (-8 - 82)	35 (-7 - 76)	29 (-6 - 63)
Salt Lake City, UT	11 (-3 - 25)	7 (-2 - 16)	7 (-2 - 16)	7 (-2 - 16)	7 (-2 - 16)	6 (-1 - 14)	5 (-1 - 11)
St. Louis, MO	113 (25 - 199)	101 (23 - 179)	95 (21 - 168)	88 (20 - 155)	81 (18 - 143)	87 (19 - 153)	72 (16 - 127)
Tacoma, WA	13 (-7 - 32)	10 (-6 - 26)	10 (-6 - 26)	10 (-6 - 26)	10 (-6 - 26)	9 (-5 - 22)	7 (-4 - 19)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-84. Estimated Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	35 (-36 - 104)	32 (-33 - 95)	30 (-30 - 88)	27 (-28 - 81)	25 (-25 - 74)	27 (-28 - 81)	24 (-25 - 73)
Baltimore, MD	65 (-4 - 133)	62 (-4 - 126)	58 (-4 - 119)	54 (-4 - 111)	50 (-3 - 102)	53 (-4 - 108)	44 (-3 - 90)
Birmingham, AL	-1 (-54 - 51)	-1 (-42 - 40)	-1 (-39 - 37)	-1 (-36 - 34)	-1 (-33 - 31)	-1 (-36 - 34)	0 (-30 - 28)
Dallas, TX	29 (-19 - 76)	29 (-19 - 76)	29 (-19 - 76)	29 (-19 - 76)	27 (-17 - 70)	29 (-19 - 76)	27 (-17 - 70)
Detroit, MI	74 (-9 - 156)	60 (-8 - 127)	60 (-7 - 126)	55 (-7 - 116)	51 (-6 - 107)	51 (-6 - 108)	43 (-5 - 90)
Fresno, CA	23 (-16 - 59)	12 (-9 - 33)	12 (-9 - 33)	12 (-9 - 33)	12 (-9 - 33)	11 (-7 - 28)	9 (-6 - 24)
Houston, TX	49 (-33 - 130)	46 (-31 - 122)	43 (-29 - 113)	39 (-27 - 104)	36 (-24 - 95)	39 (-27 - 104)	36 (-24 - 95)
Los Angeles, CA	-47 (-209 - 114)	-30 (-132 - 72)	-30 (-132 - 72)	-30 (-132 - 72)	-28 (-124 - 68)	-25 (-112 - 61)	-21 (-93 - 51)
New York, NY	568 (332 - 802)	473 (276 - 668)	473 (276 - 668)	461 (269 - 651)	424 (247 - 599)	405 (236 - 572)	336 (196 - 476)
Philadelphia, PA	91 (24 - 157)	84 (22 - 145)	84 (22 - 145)	79 (20 - 136)	72 (19 - 125)	72 (19 - 124)	60 (15 - 103)
Phoenix, AZ	84 (-4 - 170)	84 (-4 - 170)	84 (-4 - 170)	84 (-4 - 170)	80 (-3 - 162)	79 (-3 - 159)	65 (-3 - 133)
Pittsburgh, PA	61 (-12 - 132)	43 (-9 - 93)	43 (-9 - 93)	42 (-8 - 91)	40 (-8 - 87)	37 (-7 - 80)	30 (-6 - 66)
Salt Lake City, UT	14 (-3 - 31)	9 (-2 - 20)	9 (-2 - 20)	9 (-2 - 20)	9 (-2 - 20)	8 (-2 - 17)	6 (-1 - 14)
St. Louis, MO	118 (26 - 208)	106 (24 - 187)	99 (22 - 176)	92 (20 - 162)	84 (19 - 149)	91 (20 - 160)	75 (17 - 133)
Tacoma, WA	14 (-7 - 34)	11 (-6 - 27)	11 (-6 - 27)	11 (-6 - 27)	11 (-6 - 27)	9 (-5 - 23)	8 (-4 - 19)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-85. Estimated Percent of Total Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.9% (-1% - 2.8%)	0.9% (-0.9% - 2.6%)	0.8% (-0.8% - 2.4%)	0.7% (-0.7% - 2.2%)	0.7% (-0.7% - 2%)	0.7% (-0.7% - 2.2%)	0.7% (-0.7% - 2%)
Baltimore, MD	1.9% (-0.1% - 3.9%)	1.8% (-0.1% - 3.7%)	1.7% (-0.1% - 3.5%)	1.6% (-0.1% - 3.2%)	1.4% (-0.1% - 3%)	1.5% (-0.1% - 3.1%)	1.3% (-0.1% - 2.6%)
Birmingham, AL	0% (-2% - 1.9%)	0% (-1.6% - 1.5%)	0% (-1.5% - 1.4%)	0% (-1.3% - 1.3%)	0% (-1.2% - 1.2%)	0% (-1.3% - 1.3%)	0% (-1.1% - 1.1%)
Dallas, TX	1% (-0.6% - 2.5%)	1% (-0.6% - 2.5%)	1% (-0.6% - 2.5%)	1% (-0.6% - 2.5%)	0.9% (-0.6% - 2.3%)	1% (-0.6% - 2.5%)	0.9% (-0.6% - 2.3%)
Detroit, MI	1.5% (-0.2% - 3.1%)	1.2% (-0.2% - 2.5%)	1.2% (-0.2% - 2.5%)	1.1% (-0.1% - 2.3%)	1% (-0.1% - 2.1%)	1% (-0.1% - 2.2%)	0.9% (-0.1% - 1.8%)
Fresno, CA	1.2% (-0.9% - 3.3%)	0.7% (-0.5% - 1.8%)	0.7% (-0.5% - 1.8%)	0.7% (-0.5% - 1.8%)	0.7% (-0.5% - 1.8%)	0.6% (-0.4% - 1.6%)	0.5% (-0.3% - 1.3%)
Houston, TX	1% (-0.7% - 2.7%)	1% (-0.7% - 2.5%)	0.9% (-0.6% - 2.3%)	0.8% (-0.6% - 2.2%)	0.7% (-0.5% - 2%)	0.8% (-0.6% - 2.2%)	0.7% (-0.5% - 2%)
Los Angeles, CA	-0.3% (-1.2% - 0.6%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.1% (-0.6% - 0.3%)	-0.1% (-0.5% - 0.3%)
New York, NY	2.7% (1.6% - 3.8%)	2.2% (1.3% - 3.2%)	2.2% (1.3% - 3.2%)	2.2% (1.3% - 3.1%)	2% (1.2% - 2.8%)	1.9% (1.1% - 2.7%)	1.6% (0.9% - 2.3%)
Philadelphia, PA	2.3% (0.6% - 4%)	2.2% (0.6% - 3.7%)	2.2% (0.6% - 3.7%)	2% (0.5% - 3.5%)	1.9% (0.5% - 3.2%)	1.8% (0.5% - 3.2%)	1.5% (0.4% - 2.7%)
Phoenix, AZ	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.7%)	1.3% (-0.1% - 2.7%)	1.1% (0% - 2.3%)
Pittsburgh, PA	1.6% (-0.3% - 3.6%)	1.2% (-0.2% - 2.5%)	1.2% (-0.2% - 2.5%)	1.1% (-0.2% - 2.5%)	1.1% (-0.2% - 2.3%)	1% (-0.2% - 2.2%)	0.8% (-0.2% - 1.8%)
Salt Lake City, UT	1.1% (-0.3% - 2.5%)	0.7% (-0.2% - 1.6%)	0.7% (-0.2% - 1.6%)	0.7% (-0.2% - 1.6%)	0.7% (-0.2% - 1.6%)	0.6% (-0.1% - 1.4%)	0.5% (-0.1% - 1.1%)
St. Louis, MO	2.4% (0.5% - 4.2%)	2.2% (0.5% - 3.8%)	2% (0.5% - 3.6%)	1.9% (0.4% - 3.3%)	1.7% (0.4% - 3%)	1.8% (0.4% - 3.2%)	1.5% (0.3% - 2.7%)
Tacoma, WA	1.1% (-0.6% - 2.7%)	0.9% (-0.5% - 2.2%)	0.9% (-0.5% - 2.2%)	0.9% (-0.5% - 2.2%)	0.9% (-0.5% - 2.2%)	0.7% (-0.4% - 1.8%)	0.6% (-0.3% - 1.5%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-86. Estimated Percent of Total Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.9% (-0.9% - 2.8%)	0.8% (-0.9% - 2.5%)	0.8% (-0.8% - 2.3%)	0.7% (-0.7% - 2.2%)	0.7% (-0.7% - 2%)	0.7% (-0.7% - 2.2%)	0.6% (-0.7% - 1.9%)
Baltimore, MD	1.7% (-0.1% - 3.4%)	1.6% (-0.1% - 3.2%)	1.5% (-0.1% - 3%)	1.4% (-0.1% - 2.8%)	1.3% (-0.1% - 2.6%)	1.3% (-0.1% - 2.7%)	1.1% (-0.1% - 2.3%)
Birmingham, AL	0% (-1.9% - 1.8%)	0% (-1.5% - 1.4%)	0% (-1.4% - 1.3%)	0% (-1.3% - 1.2%)	0% (-1.2% - 1.1%)	0% (-1.3% - 1.2%)	0% (-1.1% - 1%)
Dallas, TX	0.8% (-0.5% - 2.1%)	0.8% (-0.5% - 2.1%)	0.8% (-0.5% - 2.1%)	0.8% (-0.5% - 2.1%)	0.7% (-0.5% - 1.9%)	0.8% (-0.5% - 2.1%)	0.7% (-0.5% - 1.9%)
Detroit, MI	1.2% (-0.2% - 2.5%)	1% (-0.1% - 2.1%)	1% (-0.1% - 2.1%)	0.9% (-0.1% - 1.9%)	0.8% (-0.1% - 1.7%)	0.8% (-0.1% - 1.8%)	0.7% (-0.1% - 1.5%)
Fresno, CA	1.3% (-0.9% - 3.5%)	0.7% (-0.5% - 1.9%)	0.7% (-0.5% - 1.9%)	0.7% (-0.5% - 1.9%)	0.7% (-0.5% - 1.9%)	0.6% (-0.4% - 1.6%)	0.5% (-0.4% - 1.4%)
Houston, TX	1% (-0.6% - 2.5%)	0.9% (-0.6% - 2.4%)	0.8% (-0.6% - 2.2%)	0.8% (-0.5% - 2%)	0.7% (-0.5% - 1.9%)	0.8% (-0.5% - 2%)	0.7% (-0.5% - 1.9%)
Los Angeles, CA	-0.2% (-1.1% - 0.6%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.1% (-0.6% - 0.4%)	-0.1% (-0.6% - 0.3%)	-0.1% (-0.5% - 0.3%)
New York, NY	2.3% (1.3% - 3.3%)	1.9% (1.1% - 2.7%)	1.9% (1.1% - 2.7%)	1.9% (1.1% - 2.6%)	1.7% (1% - 2.4%)	1.6% (1% - 2.3%)	1.4% (0.8% - 1.9%)
Philadelphia, PA	2.2% (0.6% - 3.8%)	2.1% (0.5% - 3.5%)	2.1% (0.5% - 3.5%)	1.9% (0.5% - 3.3%)	1.8% (0.5% - 3.1%)	1.8% (0.5% - 3%)	1.5% (0.4% - 2.5%)
Phoenix, AZ	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.9%)	1.4% (-0.1% - 2.8%)	1.4% (-0.1% - 2.7%)	1.1% (0% - 2.3%)
Pittsburgh, PA	1.4% (-0.3% - 3.1%)	1% (-0.2% - 2.2%)	1% (-0.2% - 2.2%)	1% (-0.2% - 2.1%)	0.9% (-0.2% - 2%)	0.9% (-0.2% - 1.9%)	0.7% (-0.1% - 1.6%)
Salt Lake City, UT	1% (-0.2% - 2.2%)	0.6% (-0.1% - 1.4%)	0.6% (-0.1% - 1.4%)	0.6% (-0.1% - 1.4%)	0.6% (-0.1% - 1.4%)	0.5% (-0.1% - 1.2%)	0.5% (-0.1% - 1%)
St. Louis, MO	2% (0.4% - 3.5%)	1.8% (0.4% - 3.1%)	1.7% (0.4% - 3%)	1.5% (0.3% - 2.7%)	1.4% (0.3% - 2.5%)	1.5% (0.3% - 2.7%)	1.3% (0.3% - 2.2%)
Tacoma, WA	0.9% (-0.5% - 2.2%)	0.7% (-0.4% - 1.8%)	0.7% (-0.4% - 1.8%)	0.7% (-0.4% - 1.8%)	0.7% (-0.4% - 1.8%)	0.6% (-0.3% - 1.5%)	0.5% (-0.3% - 1.3%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-87. Estimated Percent of Total Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.9% (-0.9% - 2.7%)	0.8% (-0.8% - 2.4%)	0.8% (-0.8% - 2.3%)	0.7% (-0.7% - 2.1%)	0.6% (-0.6% - 1.9%)	0.7% (-0.7% - 2.1%)	0.6% (-0.6% - 1.9%)
Baltimore, MD	1.7% (-0.1% - 3.4%)	1.6% (-0.1% - 3.2%)	1.5% (-0.1% - 3.1%)	1.4% (-0.1% - 2.8%)	1.3% (-0.1% - 2.6%)	1.4% (-0.1% - 2.8%)	1.1% (-0.1% - 2.3%)
Birmingham, AL	0% (-2% - 1.9%)	0% (-1.5% - 1.5%)	0% (-1.4% - 1.4%)	0% (-1.3% - 1.2%)	0% (-1.2% - 1.1%)	0% (-1.3% - 1.2%)	0% (-1.1% - 1%)
Dallas, TX	0.8% (-0.5% - 2.2%)	0.8% (-0.5% - 2.2%)	0.8% (-0.5% - 2.2%)	0.8% (-0.5% - 2.2%)	0.8% (-0.5% - 2%)	0.8% (-0.5% - 2.2%)	0.8% (-0.5% - 2%)
Detroit, MI	1.3% (-0.2% - 2.7%)	1% (-0.1% - 2.2%)	1% (-0.1% - 2.1%)	0.9% (-0.1% - 2%)	0.9% (-0.1% - 1.8%)	0.9% (-0.1% - 1.8%)	0.7% (-0.1% - 1.5%)
Fresno, CA	1.3% (-0.9% - 3.5%)	0.7% (-0.5% - 2%)	0.7% (-0.5% - 2%)	0.7% (-0.5% - 2%)	0.7% (-0.5% - 2%)	0.6% (-0.4% - 1.7%)	0.5% (-0.4% - 1.4%)
Houston, TX	1% (-0.6% - 2.5%)	0.9% (-0.6% - 2.4%)	0.8% (-0.6% - 2.2%)	0.8% (-0.5% - 2%)	0.7% (-0.5% - 1.9%)	0.8% (-0.5% - 2%)	0.7% (-0.5% - 1.9%)
Los Angeles, CA	-0.2% (-1.1% - 0.6%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.2% (-0.7% - 0.4%)	-0.1% (-0.7% - 0.4%)	-0.1% (-0.6% - 0.3%)	-0.1% (-0.5% - 0.3%)
New York, NY	2.5% (1.5% - 3.5%)	2.1% (1.2% - 3%)	2.1% (1.2% - 3%)	2% (1.2% - 2.9%)	1.9% (1.1% - 2.6%)	1.8% (1% - 2.5%)	1.5% (0.9% - 2.1%)
Philadelphia, PA	2.3% (0.6% - 3.9%)	2.1% (0.5% - 3.6%)	2.1% (0.5% - 3.6%)	2% (0.5% - 3.4%)	1.8% (0.5% - 3.1%)	1.8% (0.5% - 3.1%)	1.5% (0.4% - 2.6%)
Phoenix, AZ	1.3% (-0.1% - 2.7%)	1.3% (-0.1% - 2.7%)	1.3% (-0.1% - 2.7%)	1.3% (-0.1% - 2.7%)	1.3% (-0.1% - 2.6%)	1.3% (-0.1% - 2.5%)	1% (0% - 2.1%)
Pittsburgh, PA	1.5% (-0.3% - 3.3%)	1.1% (-0.2% - 2.3%)	1.1% (-0.2% - 2.3%)	1% (-0.2% - 2.3%)	1% (-0.2% - 2.1%)	0.9% (-0.2% - 2%)	0.8% (-0.1% - 1.6%)
Salt Lake City, UT	1.2% (-0.3% - 2.7%)	0.8% (-0.2% - 1.7%)	0.8% (-0.2% - 1.7%)	0.8% (-0.2% - 1.7%)	0.8% (-0.2% - 1.7%)	0.7% (-0.2% - 1.5%)	0.6% (-0.1% - 1.2%)
St. Louis, MO	2.1% (0.5% - 3.7%)	1.9% (0.4% - 3.3%)	1.7% (0.4% - 3.1%)	1.6% (0.4% - 2.9%)	1.5% (0.3% - 2.6%)	1.6% (0.4% - 2.8%)	1.3% (0.3% - 2.3%)
Tacoma, WA	0.9% (-0.5% - 2.3%)	0.7% (-0.4% - 1.8%)	0.7% (-0.4% - 1.8%)	0.7% (-0.4% - 1.8%)	0.7% (-0.4% - 1.8%)	0.6% (-0.3% - 1.6%)	0.5% (-0.3% - 1.3%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-88. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (5% - 6%)	13% (12% - 13%)	20% (19% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -83%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-59% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 10%)	14% (14% - 14%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-41% (-41% - -42%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	8% (8% - 8%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-11% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-89. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (5% - 6%)	13% (12% - 13%)	20% (19% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -83%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	23% (22% - 23%)
Los Angeles, CA	-59% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 10%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-11% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-90. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (5% - 6%)	13% (12% - 13%)	20% (19% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-79% - -83%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	23% (22% - 23%)
Los Angeles, CA	-59% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 10%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-57% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-11% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-91. Estimated Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	21 (-9 - 51)	20 (-8 - 47)	18 (-7 - 43)	17 (-7 - 40)	15 (-6 - 36)	17 (-7 - 40)	15 (-6 - 36)
Baltimore, MD	38 (7 - 67)	36 (7 - 64)	34 (6 - 60)	31 (6 - 56)	29 (5 - 51)	30 (6 - 55)	25 (5 - 45)
Birmingham, AL	12 (-10 - 33)	9 (-7 - 26)	9 (-7 - 24)	8 (-6 - 22)	7 (-6 - 20)	8 (-6 - 22)	7 (-5 - 18)
Dallas, TX	11 (-10 - 32)	11 (-10 - 32)	11 (-10 - 32)	11 (-10 - 32)	10 (-10 - 30)	11 (-10 - 32)	10 (-10 - 30)
Detroit, MI	35 (2 - 67)	28 (1 - 55)	28 (1 - 54)	26 (1 - 50)	24 (1 - 46)	24 (1 - 47)	20 (1 - 39)
Fresno, CA	15 (0 - 30)	9 (0 - 17)	9 (0 - 17)	9 (0 - 17)	9 (0 - 17)	7 (0 - 14)	6 (0 - 12)
Houston, TX	36 (6 - 65)	34 (5 - 61)	31 (5 - 57)	29 (5 - 52)	26 (4 - 48)	29 (5 - 52)	26 (4 - 48)
Los Angeles, CA	90 (9 - 171)	57 (6 - 108)	57 (6 - 108)	57 (6 - 108)	54 (5 - 102)	49 (5 - 93)	41 (4 - 77)
New York, NY	128 (45 - 208)	106 (37 - 174)	106 (37 - 174)	104 (37 - 169)	95 (34 - 156)	91 (32 - 149)	76 (27 - 124)
Philadelphia, PA	25 (-2 - 52)	23 (-2 - 48)	23 (-2 - 48)	22 (-2 - 45)	20 (-2 - 41)	20 (-2 - 41)	16 (-2 - 34)
Phoenix, AZ	47 (4 - 90)	47 (4 - 90)	47 (4 - 90)	47 (4 - 90)	45 (4 - 85)	44 (4 - 84)	37 (3 - 70)
Pittsburgh, PA	28 (-3 - 58)	20 (-2 - 42)	20 (-2 - 42)	20 (-2 - 40)	19 (-2 - 38)	17 (-2 - 36)	14 (-1 - 30)
Salt Lake City, UT	8 (1 - 15)	5 (1 - 10)	5 (1 - 10)	5 (1 - 10)	5 (1 - 10)	4 (1 - 8)	4 (0 - 7)
St. Louis, MO	35 (-9 - 78)	31 (-8 - 70)	29 (-8 - 65)	27 (-7 - 61)	25 (-7 - 56)	27 (-7 - 60)	22 (-6 - 50)
Tacoma, WA	9 (0 - 18)	7 (0 - 15)	7 (0 - 15)	7 (0 - 15)	7 (0 - 15)	6 (0 - 13)	5 (0 - 10)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-92. Estimated Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	22 (-9 - 51)	20 (-8 - 47)	18 (-7 - 44)	17 (-7 - 40)	16 (-6 - 37)	17 (-7 - 40)	15 (-6 - 36)
Baltimore, MD	33 (6 - 59)	31 (6 - 56)	29 (5 - 53)	27 (5 - 49)	25 (5 - 45)	27 (5 - 48)	22 (4 - 40)
Birmingham, AL	11 (-9 - 31)	9 (-7 - 25)	8 (-7 - 23)	8 (-6 - 21)	7 (-6 - 19)	8 (-6 - 21)	6 (-5 - 17)
Dallas, TX	9 (-9 - 27)	9 (-9 - 27)	9 (-9 - 27)	9 (-9 - 27)	9 (-8 - 25)	9 (-9 - 27)	9 (-8 - 25)
Detroit, MI	28 (1 - 54)	23 (1 - 44)	23 (1 - 44)	21 (1 - 41)	19 (1 - 37)	20 (1 - 38)	16 (1 - 31)
Fresno, CA	16 (1 - 32)	9 (0 - 18)	9 (0 - 18)	9 (0 - 18)	9 (0 - 18)	8 (0 - 15)	6 (0 - 13)
Houston, TX	35 (6 - 63)	33 (5 - 60)	30 (5 - 55)	28 (4 - 51)	25 (4 - 46)	28 (4 - 51)	25 (4 - 46)
Los Angeles, CA	84 (8 - 158)	53 (5 - 100)	53 (5 - 100)	53 (5 - 100)	50 (5 - 95)	45 (4 - 86)	37 (4 - 71)
New York, NY	110 (39 - 179)	91 (32 - 149)	91 (32 - 149)	89 (31 - 146)	82 (29 - 134)	78 (27 - 128)	65 (23 - 107)
Philadelphia, PA	24 (-2 - 49)	22 (-2 - 45)	22 (-2 - 45)	20 (-2 - 42)	19 (-2 - 39)	19 (-2 - 39)	15 (-1 - 32)
Phoenix, AZ	50 (4 - 94)	50 (4 - 94)	50 (4 - 94)	50 (4 - 94)	47 (4 - 90)	46 (4 - 88)	39 (3 - 74)
Pittsburgh, PA	24 (-2 - 51)	17 (-2 - 36)	17 (-2 - 36)	17 (-2 - 35)	16 (-2 - 33)	15 (-1 - 31)	12 (-1 - 25)
Salt Lake City, UT	8 (1 - 14)	5 (1 - 9)	5 (1 - 9)	5 (1 - 9)	5 (1 - 9)	4 (1 - 8)	3 (0 - 6)
St. Louis, MO	29 (-8 - 64)	26 (-7 - 58)	24 (-6 - 54)	22 (-6 - 50)	21 (-5 - 46)	22 (-6 - 49)	18 (-5 - 41)
Tacoma, WA	8 (0 - 15)	6 (0 - 12)	6 (0 - 12)	6 (0 - 12)	6 (0 - 12)	5 (0 - 11)	4 (0 - 9)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-93. Estimated Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	21 (-9 - 51)	20 (-8 - 47)	18 (-7 - 43)	17 (-7 - 40)	15 (-6 - 36)	17 (-7 - 40)	15 (-6 - 36)
Baltimore, MD	33 (6 - 60)	31 (6 - 56)	30 (6 - 53)	28 (5 - 49)	25 (5 - 45)	27 (5 - 48)	22 (4 - 40)
Birmingham, AL	12 (-10 - 32)	9 (-7 - 25)	9 (-7 - 24)	8 (-6 - 22)	7 (-6 - 20)	8 (-6 - 22)	7 (-5 - 18)
Dallas, TX	10 (-9 - 29)	10 (-9 - 29)	10 (-9 - 29)	10 (-9 - 29)	9 (-8 - 27)	10 (-9 - 29)	9 (-8 - 27)
Detroit, MI	29 (1 - 56)	24 (1 - 45)	23 (1 - 45)	22 (1 - 42)	20 (1 - 38)	20 (1 - 39)	17 (1 - 32)
Fresno, CA	17 (1 - 33)	9 (0 - 18)	9 (0 - 18)	9 (0 - 18)	9 (0 - 18)	8 (0 - 16)	7 (0 - 13)
Houston, TX	35 (6 - 64)	33 (5 - 61)	31 (5 - 56)	28 (5 - 52)	26 (4 - 47)	28 (5 - 52)	26 (4 - 47)
Los Angeles, CA	85 (8 - 161)	54 (5 - 102)	54 (5 - 102)	54 (5 - 102)	51 (5 - 96)	46 (4 - 87)	38 (4 - 73)
New York, NY	120 (42 - 196)	100 (35 - 163)	100 (35 - 163)	97 (34 - 159)	89 (31 - 147)	85 (30 - 140)	71 (25 - 117)
Philadelphia, PA	24 (-2 - 50)	22 (-2 - 46)	22 (-2 - 46)	21 (-2 - 43)	19 (-2 - 40)	19 (-2 - 39)	16 (-1 - 33)
Phoenix, AZ	47 (4 - 90)	47 (4 - 90)	47 (4 - 90)	47 (4 - 90)	45 (4 - 85)	44 (4 - 84)	37 (3 - 70)
Pittsburgh, PA	26 (-3 - 53)	18 (-2 - 38)	18 (-2 - 38)	18 (-2 - 37)	17 (-2 - 35)	15 (-2 - 32)	13 (-1 - 27)
Salt Lake City, UT	9 (1 - 17)	6 (1 - 11)	6 (1 - 11)	6 (1 - 11)	6 (1 - 11)	5 (1 - 9)	4 (1 - 8)
St. Louis, MO	30 (-8 - 67)	27 (-7 - 60)	25 (-7 - 57)	23 (-6 - 53)	22 (-6 - 48)	23 (-6 - 52)	19 (-5 - 43)
Tacoma, WA	8 (0 - 16)	6 (0 - 13)	6 (0 - 13)	6 (0 - 13)	6 (0 - 13)	5 (0 - 11)	5 (0 - 9)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-94. Estimated Percent of Total Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	1.7% (-0.7% - 4.1%)	1.6% (-0.6% - 3.7%)	1.5% (-0.6% - 3.5%)	1.3% (-0.5% - 3.2%)	1.2% (-0.5% - 2.9%)	1.3% (-0.5% - 3.2%)	1.2% (-0.5% - 2.9%)
Baltimore, MD	3.1% (0.6% - 5.6%)	2.9% (0.5% - 5.3%)	2.8% (0.5% - 5%)	2.6% (0.5% - 4.6%)	2.4% (0.4% - 4.2%)	2.5% (0.5% - 4.5%)	2.1% (0.4% - 3.8%)
Birmingham, AL	1.4% (-1.1% - 3.7%)	1.1% (-0.9% - 2.9%)	1% (-0.8% - 2.7%)	0.9% (-0.7% - 2.5%)	0.8% (-0.7% - 2.3%)	0.9% (-0.7% - 2.5%)	0.8% (-0.6% - 2.1%)
Dallas, TX	1% (-0.9% - 3%)	1% (-0.9% - 3%)	1% (-0.9% - 3%)	1% (-0.9% - 3%)	1% (-0.9% - 2.7%)	1% (-0.9% - 3%)	1% (-0.9% - 2.7%)
Detroit, MI	2.6% (0.1% - 5%)	2.1% (0.1% - 4.1%)	2.1% (0.1% - 4%)	1.9% (0.1% - 3.7%)	1.8% (0.1% - 3.4%)	1.8% (0.1% - 3.5%)	1.5% (0.1% - 2.9%)
Fresno, CA	2.6% (0.1% - 5.1%)	1.5% (0% - 2.8%)	1.5% (0% - 2.8%)	1.5% (0% - 2.8%)	1.5% (0% - 2.8%)	1.2% (0% - 2.4%)	1% (0% - 2%)
Houston, TX	2.5% (0.4% - 4.6%)	2.4% (0.4% - 4.4%)	2.2% (0.4% - 4%)	2% (0.3% - 3.7%)	1.9% (0.3% - 3.4%)	2% (0.3% - 3.7%)	1.9% (0.3% - 3.4%)
Los Angeles, CA	1.6% (0.2% - 3.1%)	1% (0.1% - 1.9%)	1% (0.1% - 1.9%)	1% (0.1% - 1.9%)	1% (0.1% - 1.8%)	0.9% (0.1% - 1.7%)	0.7% (0.1% - 1.4%)
New York, NY	3% (1% - 4.8%)	2.5% (0.9% - 4%)	2.5% (0.9% - 4%)	2.4% (0.8% - 3.9%)	2.2% (0.8% - 3.6%)	2.1% (0.7% - 3.5%)	1.8% (0.6% - 2.9%)
Philadelphia, PA	2.1% (-0.2% - 4.3%)	1.9% (-0.2% - 3.9%)	1.9% (-0.2% - 3.9%)	1.8% (-0.2% - 3.7%)	1.6% (-0.2% - 3.4%)	1.6% (-0.2% - 3.4%)	1.3% (-0.1% - 2.8%)
Phoenix, AZ	1.9% (0.2% - 3.7%)	1.9% (0.2% - 3.7%)	1.9% (0.2% - 3.7%)	1.9% (0.2% - 3.7%)	1.8% (0.1% - 3.5%)	1.8% (0.1% - 3.5%)	1.5% (0.1% - 2.9%)
Pittsburgh, PA	2.4% (-0.2% - 4.9%)	1.7% (-0.2% - 3.5%)	1.7% (-0.2% - 3.5%)	1.6% (-0.2% - 3.4%)	1.6% (-0.2% - 3.2%)	1.4% (-0.1% - 3%)	1.2% (-0.1% - 2.5%)
Salt Lake City, UT	1.9% (0.2% - 3.5%)	1.2% (0.1% - 2.2%)	1.2% (0.1% - 2.2%)	1.2% (0.1% - 2.2%)	1.2% (0.1% - 2.2%)	1% (0.1% - 1.9%)	0.8% (0.1% - 1.6%)
St. Louis, MO	2% (-0.5% - 4.5%)	1.8% (-0.5% - 4%)	1.7% (-0.4% - 3.8%)	1.6% (-0.4% - 3.5%)	1.4% (-0.4% - 3.2%)	1.5% (-0.4% - 3.4%)	1.3% (-0.3% - 2.9%)
Tacoma, WA	1.8% (0% - 3.6%)	1.5% (0% - 3%)	1.5% (0% - 3%)	1.5% (0% - 3%)	1.5% (0% - 3%)	1.3% (0% - 2.5%)	1.1% (0% - 2.1%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-95. Estimated Percent of Total Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	1.7% (-0.7% - 4%)	1.6% (-0.6% - 3.7%)	1.4% (-0.6% - 3.4%)	1.3% (-0.5% - 3.1%)	1.2% (-0.5% - 2.9%)	1.3% (-0.5% - 3.1%)	1.2% (-0.5% - 2.8%)
Baltimore, MD	2.7% (0.5% - 4.9%)	2.6% (0.5% - 4.6%)	2.4% (0.4% - 4.3%)	2.2% (0.4% - 4%)	2.1% (0.4% - 3.7%)	2.2% (0.4% - 3.9%)	1.8% (0.3% - 3.3%)
Birmingham, AL	1.3% (-1% - 3.6%)	1% (-0.8% - 2.8%)	0.9% (-0.8% - 2.6%)	0.9% (-0.7% - 2.4%)	0.8% (-0.6% - 2.2%)	0.9% (-0.7% - 2.4%)	0.7% (-0.6% - 2%)
Dallas, TX	0.8% (-0.8% - 2.4%)	0.8% (-0.8% - 2.4%)	0.8% (-0.8% - 2.4%)	0.8% (-0.8% - 2.4%)	0.8% (-0.7% - 2.3%)	0.8% (-0.8% - 2.4%)	0.8% (-0.7% - 2.3%)
Detroit, MI	2.1% (0.1% - 4.1%)	1.7% (0.1% - 3.3%)	1.7% (0.1% - 3.3%)	1.6% (0.1% - 3%)	1.4% (0.1% - 2.8%)	1.5% (0.1% - 2.8%)	1.2% (0.1% - 2.3%)
Fresno, CA	2.8% (0.1% - 5.3%)	1.5% (0% - 3%)	1.5% (0% - 3%)	1.5% (0% - 3%)	1.5% (0% - 3%)	1.3% (0% - 2.6%)	1.1% (0% - 2.1%)
Houston, TX	2.4% (0.4% - 4.4%)	2.3% (0.4% - 4.1%)	2.1% (0.3% - 3.8%)	1.9% (0.3% - 3.5%)	1.8% (0.3% - 3.2%)	1.9% (0.3% - 3.5%)	1.8% (0.3% - 3.2%)
Los Angeles, CA	1.5% (0.1% - 2.8%)	0.9% (0.1% - 1.8%)	0.9% (0.1% - 1.8%)	0.9% (0.1% - 1.8%)	0.9% (0.1% - 1.7%)	0.8% (0.1% - 1.5%)	0.7% (0.1% - 1.3%)
New York, NY	2.5% (0.9% - 4.1%)	2.1% (0.7% - 3.5%)	2.1% (0.7% - 3.5%)	2.1% (0.7% - 3.4%)	1.9% (0.7% - 3.1%)	1.8% (0.6% - 3%)	1.5% (0.5% - 2.5%)
Philadelphia, PA	2% (-0.2% - 4%)	1.8% (-0.2% - 3.7%)	1.8% (-0.2% - 3.7%)	1.7% (-0.2% - 3.5%)	1.6% (-0.1% - 3.2%)	1.5% (-0.1% - 3.2%)	1.3% (-0.1% - 2.7%)
Phoenix, AZ	2% (0.2% - 3.7%)	2% (0.2% - 3.7%)	2% (0.2% - 3.7%)	2% (0.2% - 3.7%)	1.9% (0.1% - 3.6%)	1.8% (0.1% - 3.5%)	1.5% (0.1% - 2.9%)
Pittsburgh, PA	2.1% (-0.2% - 4.3%)	1.5% (-0.1% - 3%)	1.5% (-0.1% - 3%)	1.4% (-0.1% - 3%)	1.4% (-0.1% - 2.8%)	1.2% (-0.1% - 2.6%)	1% (-0.1% - 2.2%)
Salt Lake City, UT	1.7% (0.2% - 3.1%)	1.1% (0.1% - 2%)	1.1% (0.1% - 2%)	1.1% (0.1% - 2%)	1.1% (0.1% - 2%)	0.9% (0.1% - 1.7%)	0.8% (0.1% - 1.4%)
St. Louis, MO	1.7% (-0.4% - 3.7%)	1.5% (-0.4% - 3.3%)	1.4% (-0.4% - 3.1%)	1.3% (-0.3% - 2.9%)	1.2% (-0.3% - 2.7%)	1.3% (-0.3% - 2.8%)	1.1% (-0.3% - 2.4%)
Tacoma, WA	1.5% (0% - 3%)	1.2% (0% - 2.5%)	1.2% (0% - 2.5%)	1.2% (0% - 2.5%)	1.2% (0% - 2.5%)	1% (0% - 2.1%)	0.9% (0% - 1.7%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-96. Estimated Percent of Total Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	1.6% (-0.7% - 3.9%)	1.5% (-0.6% - 3.6%)	1.4% (-0.6% - 3.3%)	1.3% (-0.5% - 3%)	1.2% (-0.5% - 2.8%)	1.3% (-0.5% - 3%)	1.2% (-0.5% - 2.7%)
Baltimore, MD	2.7% (0.5% - 4.9%)	2.6% (0.5% - 4.7%)	2.5% (0.5% - 4.4%)	2.3% (0.4% - 4.1%)	2.1% (0.4% - 3.8%)	2.2% (0.4% - 4%)	1.8% (0.3% - 3.3%)
Birmingham, AL	1.3% (-1.1% - 3.7%)	1% (-0.8% - 2.9%)	1% (-0.8% - 2.7%)	0.9% (-0.7% - 2.5%)	0.8% (-0.7% - 2.2%)	0.9% (-0.7% - 2.5%)	0.7% (-0.6% - 2%)
Dallas, TX	0.9% (-0.8% - 2.6%)	0.9% (-0.8% - 2.6%)	0.9% (-0.8% - 2.6%)	0.9% (-0.8% - 2.6%)	0.8% (-0.8% - 2.4%)	0.9% (-0.8% - 2.6%)	0.8% (-0.8% - 2.4%)
Detroit, MI	2.2% (0.1% - 4.2%)	1.8% (0.1% - 3.4%)	1.8% (0.1% - 3.4%)	1.6% (0.1% - 3.2%)	1.5% (0.1% - 2.9%)	1.5% (0.1% - 2.9%)	1.3% (0.1% - 2.4%)
Fresno, CA	2.8% (0.1% - 5.4%)	1.6% (0.1% - 3%)	1.6% (0.1% - 3%)	1.6% (0.1% - 3%)	1.6% (0.1% - 3%)	1.3% (0% - 2.6%)	1.1% (0% - 2.2%)
Houston, TX	2.4% (0.4% - 4.4%)	2.3% (0.4% - 4.1%)	2.1% (0.3% - 3.8%)	1.9% (0.3% - 3.5%)	1.8% (0.3% - 3.2%)	1.9% (0.3% - 3.5%)	1.8% (0.3% - 3.2%)
Los Angeles, CA	1.5% (0.1% - 2.9%)	1% (0.1% - 1.8%)	1% (0.1% - 1.8%)	1% (0.1% - 1.8%)	0.9% (0.1% - 1.7%)	0.8% (0.1% - 1.6%)	0.7% (0.1% - 1.3%)
New York, NY	2.8% (1% - 4.5%)	2.3% (0.8% - 3.8%)	2.3% (0.8% - 3.8%)	2.2% (0.8% - 3.7%)	2.1% (0.7% - 3.4%)	2% (0.7% - 3.2%)	1.6% (0.6% - 2.7%)
Philadelphia, PA	2% (-0.2% - 4.1%)	1.8% (-0.2% - 3.8%)	1.8% (-0.2% - 3.8%)	1.7% (-0.2% - 3.6%)	1.6% (-0.1% - 3.3%)	1.6% (-0.1% - 3.3%)	1.3% (-0.1% - 2.7%)
Phoenix, AZ	1.8% (0.1% - 3.5%)	1.8% (0.1% - 3.5%)	1.8% (0.1% - 3.5%)	1.8% (0.1% - 3.5%)	1.7% (0.1% - 3.3%)	1.7% (0.1% - 3.3%)	1.4% (0.1% - 2.7%)
Pittsburgh, PA	2.2% (-0.2% - 4.5%)	1.5% (-0.2% - 3.2%)	1.5% (-0.2% - 3.2%)	1.5% (-0.1% - 3.1%)	1.4% (-0.1% - 3%)	1.3% (-0.1% - 2.7%)	1.1% (-0.1% - 2.3%)
Salt Lake City, UT	2% (0.3% - 3.8%)	1.3% (0.2% - 2.4%)	1.3% (0.2% - 2.4%)	1.3% (0.2% - 2.4%)	1.3% (0.2% - 2.4%)	1.1% (0.1% - 2%)	0.9% (0.1% - 1.7%)
St. Louis, MO	1.7% (-0.5% - 3.9%)	1.6% (-0.4% - 3.5%)	1.5% (-0.4% - 3.3%)	1.3% (-0.4% - 3%)	1.2% (-0.3% - 2.8%)	1.3% (-0.3% - 3%)	1.1% (-0.3% - 2.5%)
Tacoma, WA	1.6% (0% - 3.1%)	1.3% (0% - 2.5%)	1.3% (0% - 2.5%)	1.3% (0% - 2.5%)	1.3% (0% - 2.5%)	1.1% (0% - 2.2%)	0.9% (0% - 1.8%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-97. Percent Reduction from the Current Standards: Estimated Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	5% (5% - 6%)	12% (12% - 13%)	20% (19% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-27% - -28%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	29% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (15% - 16%)	14% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-80% (-78% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	14% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-58% (-57% - -58%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (14% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 10%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-41% (-40% - -42%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	8% (8% - 8%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-57% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-11% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-98. Percent Reduction from the Current Standards: Estimated Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	5% (5% - 6%)	12% (12% - 13%)	20% (19% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-27% - -28%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	29% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-80% (-79% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	14% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-58% (-58% - -58%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 11%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-11% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-99. Percent Reduction from the Current Standards: Estimated Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	24% (23% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	5% (5% - 6%)	13% (12% - 13%)	20% (19% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-27% - -28%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	29% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (14% - 15%)	29% (29% - 29%)
Fresno, CA	-80% (-78% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	14% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	7% (7% - 8%)	15% (15% - 15%)	22% (22% - 23%)	15% (15% - 15%)	22% (22% - 23%)
Los Angeles, CA	-58% (-57% - -58%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (14% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 11%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (14% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-57% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-11% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (14% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-100. Estimated Annual Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Total Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	43 (-28 - 115)	40 (-26 - 105)	37 (-24 - 98)	34 (-22 - 90)	31 (-20 - 82)	34 (-22 - 90)	30 (-20 - 81)
Baltimore, MD	262 (192 - 331)	247 (182 - 313)	234 (172 - 295)	216 (159 - 273)	199 (146 - 251)	212 (155 - 267)	176 (129 - 222)
Birmingham, AL	21 (-14 - 56)	17 (-11 - 44)	15 (-10 - 41)	14 (-9 - 37)	13 (-8 - 34)	14 (-9 - 37)	12 (-8 - 31)
Dallas, TX	31 (-20 - 81)	31 (-20 - 81)	31 (-20 - 81)	31 (-20 - 81)	28 (-19 - 75)	31 (-20 - 81)	28 (-19 - 75)
Detroit, MI	345 (253 - 435)	280 (206 - 354)	278 (204 - 351)	257 (189 - 325)	236 (173 - 298)	239 (176 - 302)	198 (146 - 251)
Fresno, CA	38 (0 - 75)	21 (0 - 41)	21 (0 - 41)	21 (0 - 41)	21 (0 - 41)	18 (0 - 35)	15 (0 - 29)
Houston, TX	60 (-39 - 158)	56 (-37 - 149)	52 (-34 - 138)	48 (-31 - 127)	44 (-29 - 115)	48 (-31 - 127)	44 (-29 - 115)
Los Angeles, CA	418 (5 - 827)	264 (3 - 523)	264 (3 - 523)	264 (3 - 523)	249 (3 - 494)	225 (3 - 447)	187 (2 - 371)
New York, NY	952 (700 - 1204)	792 (582 - 1002)	792 (582 - 1002)	772 (567 - 976)	709 (521 - 897)	677 (497 - 857)	562 (413 - 711)
Philadelphia, PA	233 (171 - 294)	214 (157 - 271)	214 (157 - 271)	200 (147 - 253)	184 (135 - 233)	183 (134 - 232)	152 (112 - 192)
Phoenix, AZ	108 (1 - 213)	108 (1 - 213)	108 (1 - 213)	108 (1 - 213)	102 (1 - 203)	101 (1 - 200)	84 (1 - 166)
Pittsburgh, PA	222 (163 - 280)	157 (115 - 199)	157 (115 - 199)	153 (112 - 193)	145 (106 - 183)	134 (98 - 170)	111 (82 - 141)
Salt Lake City, UT	13 (0 - 25)	8 (0 - 16)	8 (0 - 16)	8 (0 - 16)	8 (0 - 16)	7 (0 - 13)	6 (0 - 11)
St. Louis, MO	231 (170 - 293)	207 (152 - 262)	195 (143 - 246)	180 (132 - 228)	165 (121 - 209)	177 (130 - 224)	147 (108 - 186)
Tacoma, WA	26 (-65 - 113)	21 (-52 - 92)	21 (-52 - 92)	21 (-52 - 92)	21 (-52 - 92)	18 (-44 - 79)	15 (-37 - 65)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-101. Estimated Annual Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Total Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	44 (-29 - 117)	41 (-27 - 108)	38 (-25 - 99)	35 (-23 - 91)	31 (-21 - 83)	35 (-23 - 91)	31 (-20 - 82)
Baltimore, MD	227 (167 - 287)	214 (157 - 271)	203 (149 - 256)	187 (138 - 237)	172 (126 - 218)	183 (135 - 232)	152 (112 - 192)
Birmingham, AL	20 (-13 - 53)	16 (-10 - 42)	15 (-10 - 38)	13 (-9 - 35)	12 (-8 - 32)	13 (-9 - 35)	11 (-7 - 29)
Dallas, TX	26 (-17 - 68)	26 (-17 - 68)	26 (-17 - 68)	26 (-17 - 68)	24 (-16 - 63)	26 (-17 - 68)	24 (-16 - 63)
Detroit, MI	278 (204 - 351)	225 (165 - 285)	224 (164 - 283)	207 (152 - 261)	190 (139 - 240)	192 (141 - 243)	160 (117 - 202)
Fresno, CA	40 (0 - 80)	22 (0 - 44)	22 (0 - 44)	22 (0 - 44)	22 (0 - 44)	19 (0 - 38)	16 (0 - 31)
Houston, TX	58 (-38 - 154)	55 (-36 - 145)	51 (-33 - 134)	47 (-31 - 123)	43 (-28 - 113)	47 (-31 - 123)	43 (-28 - 113)
Los Angeles, CA	392 (5 - 776)	248 (3 - 491)	248 (3 - 491)	248 (3 - 491)	234 (3 - 463)	211 (3 - 419)	175 (2 - 348)
New York, NY	822 (604 - 1040)	684 (502 - 865)	684 (502 - 865)	666 (489 - 843)	612 (449 - 774)	585 (429 - 740)	485 (356 - 614)
Philadelphia, PA	218 (160 - 276)	201 (147 - 254)	201 (147 - 254)	188 (138 - 237)	173 (127 - 218)	172 (126 - 217)	142 (105 - 180)
Phoenix, AZ	113 (1 - 224)	113 (1 - 224)	113 (1 - 224)	113 (1 - 224)	107 (1 - 212)	106 (1 - 209)	88 (1 - 174)
Pittsburgh, PA	190 (140 - 240)	134 (98 - 169)	134 (98 - 169)	130 (96 - 165)	124 (91 - 157)	114 (84 - 144)	95 (69 - 120)
Salt Lake City, UT	12 (0 - 23)	7 (0 - 15)	7 (0 - 15)	7 (0 - 15)	7 (0 - 15)	6 (0 - 12)	5 (0 - 10)
St. Louis, MO	191 (140 - 241)	171 (126 - 216)	160 (118 - 203)	148 (109 - 188)	136 (100 - 172)	146 (107 - 185)	121 (89 - 153)
Tacoma, WA	22 (-54 - 95)	18 (-44 - 78)	18 (-44 - 78)	18 (-44 - 78)	18 (-44 - 78)	15 (-37 - 66)	13 (-31 - 55)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-102. Estimated Annual Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Total Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent Ambient $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	45 (-29 - 119)	41 (-27 - 109)	38 (-25 - 101)	35 (-23 - 92)	32 (-21 - 84)	35 (-23 - 92)	31 (-21 - 83)
Baltimore, MD	229 (168 - 289)	216 (159 - 273)	204 (150 - 258)	189 (139 - 239)	174 (127 - 220)	185 (136 - 234)	153 (113 - 194)
Birmingham, AL	21 (-14 - 54)	16 (-11 - 43)	15 (-10 - 39)	14 (-9 - 36)	12 (-8 - 33)	14 (-9 - 36)	11 (-7 - 30)
Dallas, TX	28 (-18 - 73)	28 (-18 - 73)	28 (-18 - 73)	28 (-18 - 73)	26 (-17 - 68)	28 (-18 - 73)	26 (-17 - 68)
Detroit, MI	288 (211 - 364)	233 (171 - 295)	232 (170 - 293)	214 (157 - 271)	197 (144 - 249)	199 (146 - 252)	165 (121 - 209)
Fresno, CA	42 (1 - 83)	23 (0 - 46)	23 (0 - 46)	23 (0 - 46)	23 (0 - 46)	20 (0 - 39)	16 (0 - 32)
Houston, TX	60 (-39 - 158)	56 (-37 - 149)	52 (-34 - 138)	48 (-31 - 127)	44 (-29 - 116)	48 (-31 - 127)	44 (-29 - 116)
Los Angeles, CA	408 (5 - 807)	258 (3 - 511)	258 (3 - 511)	258 (3 - 511)	243 (3 - 482)	220 (3 - 436)	182 (2 - 362)
New York, NY	905 (665 - 1144)	752 (552 - 951)	752 (552 - 951)	733 (538 - 927)	673 (494 - 852)	643 (472 - 814)	534 (392 - 676)
Philadelphia, PA	221 (162 - 279)	203 (149 - 257)	203 (149 - 257)	190 (140 - 240)	175 (128 - 221)	174 (128 - 220)	144 (106 - 183)
Phoenix, AZ	108 (1 - 215)	108 (1 - 215)	108 (1 - 215)	108 (1 - 215)	103 (1 - 204)	102 (1 - 201)	84 (1 - 167)
Pittsburgh, PA	199 (146 - 251)	140 (103 - 177)	140 (103 - 177)	136 (100 - 172)	129 (95 - 164)	119 (88 - 151)	99 (73 - 125)
Salt Lake City, UT	15 (0 - 29)	9 (0 - 18)	9 (0 - 18)	9 (0 - 18)	9 (0 - 18)	8 (0 - 16)	7 (0 - 13)
St. Louis, MO	199 (146 - 251)	178 (131 - 225)	167 (123 - 212)	155 (114 - 196)	142 (104 - 180)	152 (112 - 193)	126 (93 - 160)
Tacoma, WA	23 (-57 - 101)	19 (-46 - 82)	19 (-46 - 82)	19 (-46 - 82)	19 (-46 - 82)	16 (-39 - 70)	13 (-33 - 58)

[1] Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-103. Estimated Percent of Total Annual Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standard						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.41% (-0.27% - 1.09%)	0.4% (-0.2% - 1%)	0.35% (-0.23% - 0.93%)	0.32% (-0.21% - 0.85%)	0.29% (-0.19% - 0.78%)	0.32% (-0.21% - 0.85%)	0.29% (-0.19% - 0.77%)
Baltimore, MD	1.59% (1.17% - 2.01%)	1.5% (1.1% - 1.9%)	1.42% (1.05% - 1.8%)	1.32% (0.97% - 1.67%)	1.21% (0.89% - 1.53%)	1.29% (0.95% - 1.63%)	1.07% (0.79% - 1.35%)
Birmingham, AL	0.42% (-0.28% - 1.12%)	0.3% (-0.2% - 0.9%)	0.31% (-0.2% - 0.81%)	0.28% (-0.18% - 0.75%)	0.26% (-0.17% - 0.68%)	0.28% (-0.18% - 0.75%)	0.23% (-0.15% - 0.62%)
Dallas, TX	0.32% (-0.21% - 0.85%)	0.3% (-0.2% - 0.9%)	0.32% (-0.21% - 0.85%)	0.32% (-0.21% - 0.85%)	0.3% (-0.2% - 0.79%)	0.32% (-0.21% - 0.85%)	0.3% (-0.2% - 0.79%)
Detroit, MI	1.65% (1.22% - 2.09%)	1.3% (1% - 1.7%)	1.33% (0.98% - 1.68%)	1.23% (0.91% - 1.56%)	1.13% (0.83% - 1.43%)	1.15% (0.84% - 1.45%)	0.95% (0.7% - 1.2%)
Fresno, CA	0.81% (0.01% - 1.59%)	0.4% (0% - 0.9%)	0.44% (0.01% - 0.88%)	0.44% (0.01% - 0.88%)	0.44% (0.01% - 0.88%)	0.38% (0% - 0.75%)	0.31% (0% - 0.62%)
Houston, TX	0.35% (-0.23% - 0.93%)	0.3% (-0.2% - 0.9%)	0.31% (-0.2% - 0.82%)	0.28% (-0.19% - 0.75%)	0.26% (-0.17% - 0.68%)	0.28% (-0.19% - 0.75%)	0.26% (-0.17% - 0.68%)
Los Angeles, CA	0.77% (0.01% - 1.52%)	0.5% (0% - 1%)	0.49% (0.01% - 0.96%)	0.49% (0.01% - 0.96%)	0.46% (0.01% - 0.91%)	0.41% (0% - 0.82%)	0.34% (0% - 0.68%)
New York, NY	1.49% (1.09% - 1.88%)	1.2% (0.9% - 1.6%)	1.24% (0.91% - 1.57%)	1.21% (0.89% - 1.53%)	1.11% (0.81% - 1.4%)	1.06% (0.78% - 1.34%)	0.88% (0.65% - 1.11%)
Philadelphia, PA	1.41% (1.04% - 1.79%)	1.3% (1% - 1.6%)	1.3% (0.96% - 1.64%)	1.22% (0.89% - 1.54%)	1.12% (0.82% - 1.41%)	1.11% (0.82% - 1.41%)	0.92% (0.68% - 1.17%)
Phoenix, AZ	0.53% (0.01% - 1.05%)	0.5% (0% - 1.1%)	0.53% (0.01% - 1.05%)	0.53% (0.01% - 1.05%)	0.51% (0.01% - 1%)	0.5% (0.01% - 0.99%)	0.41% (0% - 0.82%)
Pittsburgh, PA	1.72% (1.26% - 2.17%)	1.2% (0.9% - 1.5%)	1.22% (0.89% - 1.54%)	1.19% (0.87% - 1.5%)	1.13% (0.83% - 1.42%)	1.04% (0.76% - 1.32%)	0.86% (0.63% - 1.09%)
Salt Lake City, UT	0.52% (0.01% - 1.03%)	0.3% (0% - 0.7%)	0.33% (0% - 0.65%)	0.33% (0% - 0.65%)	0.33% (0% - 0.65%)	0.28% (0% - 0.56%)	0.23% (0% - 0.46%)
St. Louis, MO	1.64% (1.21% - 2.08%)	1.5% (1.1% - 1.9%)	1.38% (1.02% - 1.75%)	1.28% (0.94% - 1.62%)	1.17% (0.86% - 1.48%)	1.26% (0.92% - 1.59%)	1.04% (0.77% - 1.32%)
Tacoma, WA	0.76% (-1.86% - 3.26%)	0.6% (-1.5% - 2.7%)	0.62% (-1.5% - 2.65%)	0.62% (-1.5% - 2.65%)	0.62% (-1.5% - 2.65%)	0.53% (-1.28% - 2.27%)	0.44% (-1.05% - 1.89%)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Percents rounded to the nearest hundredth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-104. Estimated Percent of Total Annual Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standard						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.41% (-0.27% - 1.08%)	0.4% (-0.2% - 1%)	0.35% (-0.23% - 0.92%)	0.32% (-0.21% - 0.84%)	0.29% (-0.19% - 0.77%)	0.32% (-0.21% - 0.84%)	0.29% (-0.19% - 0.76%)
Baltimore, MD	1.39% (1.02% - 1.75%)	1.3% (1% - 1.7%)	1.24% (0.91% - 1.57%)	1.15% (0.84% - 1.45%)	1.05% (0.77% - 1.33%)	1.12% (0.82% - 1.42%)	0.93% (0.68% - 1.18%)
Birmingham, AL	0.4% (-0.26% - 1.06%)	0.3% (-0.2% - 0.8%)	0.29% (-0.19% - 0.77%)	0.27% (-0.17% - 0.71%)	0.24% (-0.16% - 0.64%)	0.27% (-0.17% - 0.71%)	0.22% (-0.14% - 0.59%)
Dallas, TX	0.27% (-0.17% - 0.7%)	0.3% (-0.2% - 0.7%)	0.27% (-0.17% - 0.7%)	0.27% (-0.17% - 0.7%)	0.25% (-0.16% - 0.65%)	0.27% (-0.17% - 0.7%)	0.25% (-0.16% - 0.65%)
Detroit, MI	1.34% (0.98% - 1.69%)	1.1% (0.8% - 1.4%)	1.08% (0.79% - 1.37%)	1% (0.73% - 1.26%)	0.92% (0.67% - 1.16%)	0.93% (0.68% - 1.18%)	0.77% (0.57% - 0.97%)
Fresno, CA	0.85% (0.01% - 1.68%)	0.5% (0% - 0.9%)	0.47% (0.01% - 0.93%)	0.47% (0.01% - 0.93%)	0.47% (0.01% - 0.93%)	0.4% (0% - 0.79%)	0.33% (0% - 0.66%)
Houston, TX	0.33% (-0.22% - 0.88%)	0.3% (-0.2% - 0.8%)	0.29% (-0.19% - 0.77%)	0.27% (-0.17% - 0.71%)	0.24% (-0.16% - 0.64%)	0.27% (-0.17% - 0.71%)	0.24% (-0.16% - 0.64%)
Los Angeles, CA	0.71% (0.01% - 1.41%)	0.4% (0% - 0.9%)	0.45% (0.01% - 0.89%)	0.45% (0.01% - 0.89%)	0.42% (0.01% - 0.84%)	0.38% (0% - 0.76%)	0.32% (0% - 0.63%)
New York, NY	1.27% (0.93% - 1.61%)	1.1% (0.8% - 1.3%)	1.06% (0.78% - 1.34%)	1.03% (0.76% - 1.3%)	0.95% (0.7% - 1.2%)	0.9% (0.66% - 1.14%)	0.75% (0.55% - 0.95%)
Philadelphia, PA	1.34% (0.99% - 1.7%)	1.2% (0.9% - 1.6%)	1.24% (0.91% - 1.56%)	1.16% (0.85% - 1.46%)	1.06% (0.78% - 1.34%)	1.06% (0.78% - 1.34%)	0.88% (0.64% - 1.11%)
Phoenix, AZ	0.54% (0.01% - 1.07%)	0.5% (0% - 1.1%)	0.54% (0.01% - 1.07%)	0.54% (0.01% - 1.07%)	0.51% (0.01% - 1.02%)	0.5% (0.01% - 1%)	0.42% (0.01% - 0.83%)
Pittsburgh, PA	1.5% (1.1% - 1.89%)	1.1% (0.8% - 1.3%)	1.05% (0.77% - 1.33%)	1.03% (0.75% - 1.3%)	0.98% (0.72% - 1.23%)	0.9% (0.66% - 1.14%)	0.75% (0.55% - 0.94%)
Salt Lake City, UT	0.46% (0.01% - 0.92%)	0.3% (0% - 0.6%)	0.29% (0% - 0.58%)	0.29% (0% - 0.58%)	0.29% (0% - 0.58%)	0.25% (0% - 0.49%)	0.21% (0% - 0.41%)
St. Louis, MO	1.36% (1% - 1.72%)	1.2% (0.9% - 1.5%)	1.14% (0.84% - 1.45%)	1.06% (0.78% - 1.34%)	0.97% (0.71% - 1.23%)	1.04% (0.76% - 1.32%)	0.86% (0.63% - 1.09%)
Tacoma, WA	0.63% (-1.53% - 2.69%)	0.5% (-1.2% - 2.2%)	0.51% (-1.23% - 2.19%)	0.51% (-1.23% - 2.19%)	0.51% (-1.23% - 2.19%)	0.43% (-1.05% - 1.87%)	0.36% (-0.87% - 1.56%)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Percents rounded to the nearest hundredth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-105. Estimated Percent of Total Annual Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standard						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.4% (-0.26% - 1.06%)	0.4% (-0.2% - 1%)	0.34% (-0.22% - 0.9%)	0.31% (-0.2% - 0.83%)	0.28% (-0.19% - 0.75%)	0.31% (-0.2% - 0.83%)	0.28% (-0.18% - 0.74%)
Baltimore, MD	1.41% (1.03% - 1.78%)	1.3% (1% - 1.7%)	1.26% (0.92% - 1.59%)	1.16% (0.85% - 1.47%)	1.07% (0.78% - 1.35%)	1.14% (0.83% - 1.44%)	0.94% (0.69% - 1.19%)
Birmingham, AL	0.41% (-0.27% - 1.09%)	0.3% (-0.2% - 0.9%)	0.3% (-0.19% - 0.79%)	0.27% (-0.18% - 0.72%)	0.25% (-0.16% - 0.66%)	0.27% (-0.18% - 0.72%)	0.23% (-0.15% - 0.6%)
Dallas, TX	0.28% (-0.18% - 0.74%)	0.3% (-0.2% - 0.7%)	0.28% (-0.18% - 0.74%)	0.28% (-0.18% - 0.74%)	0.26% (-0.17% - 0.68%)	0.28% (-0.18% - 0.74%)	0.26% (-0.17% - 0.68%)
Detroit, MI	1.4% (1.03% - 1.77%)	1.1% (0.8% - 1.4%)	1.13% (0.83% - 1.42%)	1.04% (0.76% - 1.32%)	0.96% (0.7% - 1.21%)	0.97% (0.71% - 1.23%)	0.8% (0.59% - 1.02%)
Fresno, CA	0.86% (0.01% - 1.7%)	0.5% (0% - 0.9%)	0.48% (0.01% - 0.94%)	0.48% (0.01% - 0.94%)	0.48% (0.01% - 0.94%)	0.41% (0% - 0.81%)	0.34% (0% - 0.67%)
Houston, TX	0.33% (-0.22% - 0.88%)	0.3% (-0.2% - 0.8%)	0.29% (-0.19% - 0.77%)	0.27% (-0.17% - 0.71%)	0.24% (-0.16% - 0.64%)	0.27% (-0.17% - 0.71%)	0.24% (-0.16% - 0.64%)
Los Angeles, CA	0.72% (0.01% - 1.43%)	0.5% (0% - 0.9%)	0.46% (0.01% - 0.91%)	0.46% (0.01% - 0.91%)	0.43% (0.01% - 0.86%)	0.39% (0% - 0.78%)	0.32% (0% - 0.64%)
New York, NY	1.39% (1.02% - 1.75%)	1.2% (0.8% - 1.5%)	1.15% (0.85% - 1.46%)	1.12% (0.83% - 1.42%)	1.03% (0.76% - 1.31%)	0.99% (0.72% - 1.25%)	0.82% (0.6% - 1.04%)
Philadelphia, PA	1.38% (1.01% - 1.74%)	1.3% (0.9% - 1.6%)	1.27% (0.93% - 1.6%)	1.18% (0.87% - 1.5%)	1.09% (0.8% - 1.38%)	1.08% (0.79% - 1.37%)	0.9% (0.66% - 1.14%)
Phoenix, AZ	0.5% (0.01% - 0.99%)	0.5% (0% - 1%)	0.5% (0.01% - 0.99%)	0.5% (0.01% - 0.99%)	0.47% (0.01% - 0.94%)	0.47% (0.01% - 0.93%)	0.39% (0% - 0.77%)
Pittsburgh, PA	1.58% (1.16% - 2%)	1.1% (0.8% - 1.4%)	1.11% (0.82% - 1.41%)	1.08% (0.8% - 1.37%)	1.03% (0.76% - 1.3%)	0.95% (0.7% - 1.2%)	0.79% (0.58% - 1%)
Salt Lake City, UT	0.56% (0.01% - 1.11%)	0.4% (0% - 0.7%)	0.36% (0% - 0.7%)	0.36% (0% - 0.7%)	0.36% (0% - 0.7%)	0.3% (0% - 0.6%)	0.25% (0% - 0.5%)
St. Louis, MO	1.42% (1.04% - 1.79%)	1.3% (0.9% - 1.6%)	1.19% (0.88% - 1.51%)	1.1% (0.81% - 1.4%)	1.01% (0.74% - 1.28%)	1.09% (0.8% - 1.37%)	0.9% (0.66% - 1.14%)
Tacoma, WA	0.65% (-1.58% - 2.77%)	0.5% (-1.3% - 2.3%)	0.52% (-1.28% - 2.26%)	0.52% (-1.28% - 2.26%)	0.52% (-1.28% - 2.26%)	0.45% (-1.09% - 1.93%)	0.37% (-0.9% - 1.6%)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Percents rounded to the nearest hundredth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-106. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiovascular Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (24% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (5% - 6%)	13% (13% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-81% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (23% - 23%)	15% (15% - 15%)	23% (23% - 23%)
Los Angeles, CA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 10%)	14% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-41% (-41% - -41%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	8% (8% - 8%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-59% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-107. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiovascular Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (24% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (23% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-81% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (23% - 23%)	15% (15% - 15%)	23% (23% - 23%)
Los Angeles, CA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 11%)	15% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -42%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-59% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-108. Percent Reduction from the Current Standards: Estimated Annual Incidence of Cardiovascular Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (24% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	14% (14% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-81% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (23% - 23%)	15% (15% - 15%)	23% (23% - 23%)
Los Angeles, CA	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	10% (10% - 11%)	15% (14% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	14% (14% - 14%)	14% (14% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-42% (-42% - -42%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-59% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-109. Estimated Annual Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	19 (-23 - 60)	17 (-22 - 55)	16 (-20 - 51)	15 (-18 - 47)	13 (-17 - 43)	15 (-18 - 47)	13 (-16 - 42)
Baltimore, MD	21 (-12 - 54)	20 (-12 - 51)	19 (-11 - 48)	17 (-10 - 45)	16 (-9 - 41)	17 (-10 - 44)	14 (-8 - 36)
Birmingham, AL	9 (-11 - 29)	7 (-9 - 23)	7 (-8 - 21)	6 (-8 - 20)	6 (-7 - 18)	6 (-8 - 20)	5 (-6 - 16)
Dallas, TX	15 (-18 - 47)	15 (-18 - 47)	15 (-18 - 47)	15 (-18 - 47)	14 (-17 - 44)	15 (-18 - 47)	14 (-17 - 44)
Detroit, MI	31 (-18 - 79)	25 (-15 - 64)	25 (-15 - 64)	23 (-13 - 59)	21 (-12 - 54)	21 (-13 - 55)	18 (-10 - 46)
Fresno, CA	25 (6 - 44)	14 (3 - 25)	14 (3 - 25)	14 (3 - 25)	14 (3 - 25)	12 (3 - 21)	10 (2 - 17)
Houston, TX	27 (-34 - 86)	25 (-32 - 81)	23 (-29 - 75)	21 (-27 - 69)	19 (-24 - 63)	21 (-27 - 69)	19 (-24 - 63)
Los Angeles, CA	269 (63 - 473)	170 (40 - 300)	170 (40 - 300)	170 (40 - 300)	161 (37 - 283)	145 (34 - 256)	121 (28 - 213)
New York, NY	79 (-46 - 203)	65 (-38 - 169)	65 (-38 - 169)	64 (-37 - 164)	58 (-34 - 151)	56 (-33 - 144)	46 (-27 - 120)
Philadelphia, PA	19 (-11 - 48)	17 (-10 - 44)	17 (-10 - 44)	16 (-9 - 41)	15 (-9 - 38)	15 (-9 - 38)	12 (-7 - 31)
Phoenix, AZ	61 (14 - 107)	61 (14 - 107)	61 (14 - 107)	61 (14 - 107)	58 (14 - 102)	57 (13 - 101)	47 (11 - 84)
Pittsburgh, PA	18 (-11 - 47)	13 (-8 - 33)	13 (-8 - 33)	12 (-7 - 32)	12 (-7 - 30)	11 (-6 - 28)	9 (-5 - 23)
Salt Lake City, UT	9 (2 - 16)	6 (1 - 10)	6 (1 - 10)	6 (1 - 10)	6 (1 - 10)	5 (1 - 9)	4 (1 - 7)
St. Louis, MO	28 (-16 - 72)	25 (-15 - 64)	23 (-14 - 60)	22 (-13 - 56)	20 (-12 - 51)	21 (-13 - 55)	18 (-10 - 46)
Tacoma, WA	2 (-34 - 37)	2 (-27 - 30)	2 (-27 - 30)	2 (-27 - 30)	2 (-27 - 30)	2 (-23 - 26)	1 (-19 - 21)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-110. Estimated Annual Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	19 (-24 - 61)	17 (-22 - 56)	16 (-20 - 52)	15 (-19 - 48)	13 (-17 - 44)	15 (-19 - 48)	13 (-17 - 43)
Baltimore, MD	18 (-11 - 47)	17 (-10 - 44)	16 (-10 - 42)	15 (-9 - 39)	14 (-8 - 36)	15 (-9 - 38)	12 (-7 - 31)
Birmingham, AL	9 (-11 - 28)	7 (-8 - 22)	6 (-8 - 20)	6 (-7 - 19)	5 (-7 - 17)	6 (-7 - 19)	5 (-6 - 15)
Dallas, TX	12 (-15 - 40)	12 (-15 - 40)	12 (-15 - 40)	12 (-15 - 40)	11 (-14 - 37)	12 (-15 - 40)	11 (-14 - 37)
Detroit, MI	25 (-15 - 64)	20 (-12 - 52)	20 (-12 - 51)	18 (-11 - 47)	17 (-10 - 44)	17 (-10 - 44)	14 (-8 - 37)
Fresno, CA	27 (6 - 47)	15 (3 - 26)	15 (3 - 26)	15 (3 - 26)	15 (3 - 26)	13 (3 - 22)	11 (2 - 19)
Houston, TX	26 (-33 - 84)	25 (-31 - 79)	23 (-29 - 73)	21 (-26 - 68)	19 (-24 - 62)	21 (-26 - 68)	19 (-24 - 62)
Los Angeles, CA	253 (59 - 444)	160 (37 - 281)	160 (37 - 281)	160 (37 - 281)	151 (35 - 265)	136 (32 - 240)	113 (26 - 199)
New York, NY	68 (-40 - 175)	56 (-33 - 145)	56 (-33 - 145)	55 (-32 - 142)	50 (-30 - 130)	48 (-28 - 124)	40 (-24 - 103)
Philadelphia, PA	17 (-10 - 45)	16 (-9 - 41)	16 (-9 - 41)	15 (-9 - 39)	14 (-8 - 36)	14 (-8 - 35)	11 (-7 - 29)
Phoenix, AZ	64 (15 - 112)	64 (15 - 112)	64 (15 - 112)	64 (15 - 112)	61 (14 - 107)	60 (14 - 105)	50 (12 - 87)
Pittsburgh, PA	16 (-9 - 40)	11 (-6 - 28)	11 (-6 - 28)	11 (-6 - 27)	10 (-6 - 26)	9 (-5 - 24)	8 (-5 - 20)
Salt Lake City, UT	8 (2 - 15)	5 (1 - 9)	5 (1 - 9)	5 (1 - 9)	5 (1 - 9)	5 (1 - 8)	4 (1 - 7)
St. Louis, MO	23 (-14 - 59)	21 (-12 - 53)	19 (-11 - 50)	18 (-10 - 46)	16 (-10 - 42)	18 (-10 - 45)	15 (-9 - 38)
Tacoma, WA	2 (-28 - 31)	2 (-23 - 25)	2 (-23 - 25)	2 (-23 - 25)	2 (-23 - 25)	1 (-19 - 22)	1 (-16 - 18)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-111. Estimated Annual Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	19 (-24 - 62)	18 (-22 - 57)	16 (-21 - 53)	15 (-19 - 48)	14 (-17 - 44)	15 (-19 - 48)	13 (-17 - 44)
Baltimore, MD	18 (-11 - 47)	17 (-10 - 45)	16 (-10 - 42)	15 (-9 - 39)	14 (-8 - 36)	15 (-9 - 38)	12 (-7 - 32)
Birmingham, AL	9 (-11 - 29)	7 (-9 - 22)	6 (-8 - 21)	6 (-7 - 19)	5 (-7 - 17)	6 (-7 - 19)	5 (-6 - 16)
Dallas, TX	13 (-17 - 43)	13 (-17 - 43)	13 (-17 - 43)	13 (-17 - 43)	12 (-15 - 40)	13 (-17 - 43)	12 (-15 - 40)
Detroit, MI	26 (-15 - 66)	21 (-12 - 54)	21 (-12 - 53)	19 (-11 - 49)	18 (-10 - 45)	18 (-10 - 46)	15 (-9 - 38)
Fresno, CA	28 (7 - 49)	15 (4 - 27)	15 (4 - 27)	15 (4 - 27)	15 (4 - 27)	13 (3 - 23)	11 (3 - 19)
Houston, TX	27 (-34 - 87)	25 (-32 - 82)	23 (-29 - 76)	21 (-27 - 69)	20 (-25 - 63)	21 (-27 - 69)	20 (-25 - 63)
Los Angeles, CA	263 (61 - 461)	166 (39 - 293)	166 (39 - 293)	166 (39 - 293)	157 (37 - 276)	142 (33 - 250)	118 (27 - 207)
New York, NY	75 (-44 - 193)	62 (-37 - 160)	62 (-37 - 160)	60 (-36 - 156)	56 (-33 - 143)	53 (-31 - 137)	44 (-26 - 113)
Philadelphia, PA	18 (-10 - 46)	16 (-10 - 42)	16 (-10 - 42)	15 (-9 - 39)	14 (-8 - 36)	14 (-8 - 36)	12 (-7 - 30)
Phoenix, AZ	61 (14 - 108)	61 (14 - 108)	61 (14 - 108)	61 (14 - 108)	58 (14 - 103)	57 (13 - 101)	48 (11 - 84)
Pittsburgh, PA	16 (-10 - 42)	11 (-7 - 29)	11 (-7 - 29)	11 (-7 - 29)	11 (-6 - 27)	10 (-6 - 25)	8 (-5 - 21)
Salt Lake City, UT	11 (2 - 19)	7 (2 - 12)	7 (2 - 12)	7 (2 - 12)	7 (2 - 12)	6 (1 - 10)	5 (1 - 8)
St. Louis, MO	24 (-14 - 62)	21 (-13 - 55)	20 (-12 - 52)	19 (-11 - 48)	17 (-10 - 44)	18 (-11 - 47)	15 (-9 - 39)
Tacoma, WA	2 (-30 - 33)	2 (-24 - 27)	2 (-24 - 27)	2 (-24 - 27)	2 (-24 - 27)	2 (-21 - 23)	1 (-17 - 19)

[1]Incidence estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-112. Estimated Percent of Total Annual Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.5% (-0.63% - 1.61%)	0.46% (-0.58% - 1.48%)	0.42% (-0.53% - 1.37%)	0.39% (-0.49% - 1.26%)	0.35% (-0.45% - 1.15%)	0.39% (-0.49% - 1.26%)	0.35% (-0.44% - 1.13%)
Baltimore, MD	0.42% (-0.25% - 1.08%)	0.39% (-0.23% - 1.02%)	0.37% (-0.22% - 0.96%)	0.34% (-0.2% - 0.89%)	0.32% (-0.19% - 0.82%)	0.34% (-0.2% - 0.87%)	0.28% (-0.16% - 0.72%)
Birmingham, AL	0.51% (-0.65% - 1.65%)	0.4% (-0.51% - 1.3%)	0.37% (-0.47% - 1.2%)	0.34% (-0.43% - 1.1%)	0.31% (-0.39% - 1.01%)	0.34% (-0.43% - 1.1%)	0.28% (-0.36% - 0.92%)
Dallas, TX	0.39% (-0.49% - 1.26%)	0.39% (-0.49% - 1.26%)	0.39% (-0.49% - 1.26%)	0.39% (-0.49% - 1.26%)	0.36% (-0.45% - 1.17%)	0.39% (-0.49% - 1.26%)	0.36% (-0.45% - 1.17%)
Detroit, MI	0.43% (-0.26% - 1.12%)	0.35% (-0.21% - 0.91%)	0.35% (-0.21% - 0.9%)	0.32% (-0.19% - 0.83%)	0.3% (-0.17% - 0.76%)	0.3% (-0.18% - 0.77%)	0.25% (-0.15% - 0.64%)
Fresno, CA	1.42% (0.33% - 2.49%)	0.78% (0.18% - 1.38%)	0.78% (0.18% - 1.38%)	0.78% (0.18% - 1.38%)	0.78% (0.18% - 1.38%)	0.67% (0.16% - 1.18%)	0.56% (0.13% - 0.98%)
Houston, TX	0.43% (-0.54% - 1.38%)	0.4% (-0.51% - 1.3%)	0.37% (-0.47% - 1.2%)	0.34% (-0.43% - 1.11%)	0.31% (-0.39% - 1.01%)	0.34% (-0.43% - 1.11%)	0.31% (-0.39% - 1.01%)
Los Angeles, CA	1.36% (0.32% - 2.38%)	0.86% (0.2% - 1.51%)	0.86% (0.2% - 1.51%)	0.86% (0.2% - 1.51%)	0.81% (0.19% - 1.42%)	0.73% (0.17% - 1.29%)	0.61% (0.14% - 1.07%)
New York, NY	0.39% (-0.23% - 1.01%)	0.32% (-0.19% - 0.84%)	0.32% (-0.19% - 0.84%)	0.32% (-0.19% - 0.81%)	0.29% (-0.17% - 0.75%)	0.28% (-0.16% - 0.71%)	0.23% (-0.14% - 0.59%)
Philadelphia, PA	0.37% (-0.22% - 0.95%)	0.34% (-0.2% - 0.88%)	0.34% (-0.2% - 0.88%)	0.32% (-0.19% - 0.82%)	0.29% (-0.17% - 0.75%)	0.29% (-0.17% - 0.75%)	0.24% (-0.14% - 0.62%)
Phoenix, AZ	0.94% (0.22% - 1.65%)	0.94% (0.22% - 1.65%)	0.94% (0.22% - 1.65%)	0.94% (0.22% - 1.65%)	0.89% (0.21% - 1.57%)	0.88% (0.21% - 1.55%)	0.73% (0.17% - 1.29%)
Pittsburgh, PA	0.45% (-0.27% - 1.16%)	0.32% (-0.19% - 0.82%)	0.32% (-0.19% - 0.82%)	0.31% (-0.18% - 0.8%)	0.29% (-0.17% - 0.76%)	0.27% (-0.16% - 0.7%)	0.23% (-0.13% - 0.58%)
Salt Lake City, UT	0.92% (0.21% - 1.61%)	0.58% (0.14% - 1.02%)	0.58% (0.14% - 1.02%)	0.58% (0.14% - 1.02%)	0.58% (0.14% - 1.02%)	0.49% (0.12% - 0.87%)	0.41% (0.1% - 0.72%)
St. Louis, MO	0.43% (-0.25% - 1.11%)	0.39% (-0.23% - 0.99%)	0.36% (-0.21% - 0.93%)	0.33% (-0.2% - 0.86%)	0.31% (-0.18% - 0.79%)	0.33% (-0.19% - 0.85%)	0.27% (-0.16% - 0.7%)
Tacoma, WA	0.2% (-2.72% - 2.96%)	0.16% (-2.19% - 2.41%)	0.16% (-2.19% - 2.41%)	0.16% (-2.19% - 2.41%)	0.16% (-2.19% - 2.41%)	0.14% (-1.87% - 2.06%)	0.11% (-1.54% - 1.71%)

[1]Estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Percents rounded to the nearest hundredth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-113. Estimated Percent of Total Annual Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.49% (-0.62% - 1.59%)	0.45% (-0.57% - 1.46%)	0.42% (-0.53% - 1.35%)	0.38% (-0.48% - 1.24%)	0.35% (-0.44% - 1.13%)	0.38% (-0.48% - 1.24%)	0.34% (-0.43% - 1.12%)
Baltimore, MD	0.36% (-0.21% - 0.94%)	0.34% (-0.2% - 0.89%)	0.32% (-0.19% - 0.84%)	0.3% (-0.18% - 0.77%)	0.28% (-0.16% - 0.71%)	0.29% (-0.17% - 0.76%)	0.24% (-0.14% - 0.63%)
Birmingham, AL	0.48% (-0.61% - 1.57%)	0.38% (-0.48% - 1.23%)	0.35% (-0.44% - 1.14%)	0.32% (-0.41% - 1.04%)	0.29% (-0.37% - 0.95%)	0.32% (-0.41% - 1.04%)	0.27% (-0.34% - 0.87%)
Dallas, TX	0.32% (-0.4% - 1.04%)	0.32% (-0.4% - 1.04%)	0.32% (-0.4% - 1.04%)	0.32% (-0.4% - 1.04%)	0.3% (-0.37% - 0.96%)	0.32% (-0.4% - 1.04%)	0.3% (-0.37% - 0.96%)
Detroit, MI	0.35% (-0.21% - 0.9%)	0.28% (-0.17% - 0.73%)	0.28% (-0.17% - 0.73%)	0.26% (-0.15% - 0.67%)	0.24% (-0.14% - 0.62%)	0.24% (-0.14% - 0.63%)	0.2% (-0.12% - 0.52%)
Fresno, CA	1.49% (0.35% - 2.62%)	0.83% (0.19% - 1.45%)	0.83% (0.19% - 1.45%)	0.83% (0.19% - 1.45%)	0.83% (0.19% - 1.45%)	0.71% (0.16% - 1.24%)	0.58% (0.14% - 1.03%)
Houston, TX	0.4% (-0.51% - 1.3%)	0.38% (-0.48% - 1.23%)	0.35% (-0.44% - 1.13%)	0.32% (-0.4% - 1.04%)	0.29% (-0.37% - 0.95%)	0.32% (-0.4% - 1.04%)	0.29% (-0.37% - 0.95%)
Los Angeles, CA	1.25% (0.29% - 2.2%)	0.79% (0.18% - 1.4%)	0.79% (0.18% - 1.4%)	0.79% (0.18% - 1.4%)	0.75% (0.17% - 1.32%)	0.68% (0.16% - 1.19%)	0.56% (0.13% - 0.99%)
New York, NY	0.33% (-0.2% - 0.86%)	0.28% (-0.16% - 0.71%)	0.28% (-0.16% - 0.71%)	0.27% (-0.16% - 0.7%)	0.25% (-0.15% - 0.64%)	0.24% (-0.14% - 0.61%)	0.2% (-0.12% - 0.51%)
Philadelphia, PA	0.35% (-0.21% - 0.91%)	0.32% (-0.19% - 0.83%)	0.32% (-0.19% - 0.83%)	0.3% (-0.18% - 0.78%)	0.28% (-0.16% - 0.72%)	0.28% (-0.16% - 0.71%)	0.23% (-0.14% - 0.59%)
Phoenix, AZ	0.95% (0.22% - 1.67%)	0.95% (0.22% - 1.67%)	0.95% (0.22% - 1.67%)	0.95% (0.22% - 1.67%)	0.9% (0.21% - 1.59%)	0.89% (0.21% - 1.57%)	0.74% (0.17% - 1.3%)
Pittsburgh, PA	0.39% (-0.23% - 1.01%)	0.28% (-0.16% - 0.71%)	0.28% (-0.16% - 0.71%)	0.27% (-0.16% - 0.69%)	0.26% (-0.15% - 0.66%)	0.24% (-0.14% - 0.61%)	0.19% (-0.11% - 0.5%)
Salt Lake City, UT	0.82% (0.19% - 1.43%)	0.51% (0.12% - 0.91%)	0.51% (0.12% - 0.91%)	0.51% (0.12% - 0.91%)	0.51% (0.12% - 0.91%)	0.44% (0.1% - 0.77%)	0.36% (0.08% - 0.64%)
St. Louis, MO	0.36% (-0.21% - 0.92%)	0.32% (-0.19% - 0.82%)	0.3% (-0.18% - 0.77%)	0.28% (-0.16% - 0.71%)	0.25% (-0.15% - 0.65%)	0.27% (-0.16% - 0.7%)	0.23% (-0.13% - 0.58%)
Tacoma, WA	0.16% (-2.23% - 2.45%)	0.13% (-1.8% - 1.99%)	0.13% (-1.8% - 1.99%)	0.13% (-1.8% - 1.99%)	0.13% (-1.8% - 1.99%)	0.11% (-1.53% - 1.7%)	0.09% (-1.26% - 1.41%)

[1]Estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Percents rounded to the nearest hundredth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-114. Estimated Percent of Total Annual Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent of Total Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	0.48% (-0.61% - 1.56%)	0.44% (-0.56% - 1.43%)	0.41% (-0.52% - 1.32%)	0.38% (-0.47% - 1.22%)	0.34% (-0.43% - 1.11%)	0.38% (-0.47% - 1.22%)	0.34% (-0.43% - 1.09%)
Baltimore, MD	0.37% (-0.22% - 0.95%)	0.35% (-0.2% - 0.9%)	0.33% (-0.19% - 0.85%)	0.3% (-0.18% - 0.78%)	0.28% (-0.16% - 0.72%)	0.3% (-0.18% - 0.77%)	0.25% (-0.15% - 0.64%)
Birmingham, AL	0.5% (-0.63% - 1.6%)	0.39% (-0.49% - 1.26%)	0.36% (-0.45% - 1.16%)	0.33% (-0.42% - 1.07%)	0.3% (-0.38% - 0.97%)	0.33% (-0.42% - 1.07%)	0.27% (-0.34% - 0.89%)
Dallas, TX	0.34% (-0.42% - 1.09%)	0.34% (-0.42% - 1.09%)	0.34% (-0.42% - 1.09%)	0.34% (-0.42% - 1.09%)	0.31% (-0.39% - 1.01%)	0.34% (-0.42% - 1.09%)	0.31% (-0.39% - 1.01%)
Detroit, MI	0.37% (-0.22% - 0.94%)	0.3% (-0.17% - 0.77%)	0.29% (-0.17% - 0.76%)	0.27% (-0.16% - 0.7%)	0.25% (-0.15% - 0.64%)	0.25% (-0.15% - 0.65%)	0.21% (-0.12% - 0.54%)
Fresno, CA	1.52% (0.36% - 2.66%)	0.84% (0.2% - 1.48%)	0.84% (0.2% - 1.48%)	0.84% (0.2% - 1.48%)	0.84% (0.2% - 1.48%)	0.72% (0.17% - 1.26%)	0.6% (0.14% - 1.05%)
Houston, TX	0.4% (-0.51% - 1.3%)	0.38% (-0.48% - 1.23%)	0.35% (-0.44% - 1.13%)	0.32% (-0.41% - 1.04%)	0.29% (-0.37% - 0.95%)	0.32% (-0.41% - 1.04%)	0.29% (-0.37% - 0.95%)
Los Angeles, CA	1.28% (0.3% - 2.25%)	0.81% (0.19% - 1.42%)	0.81% (0.19% - 1.42%)	0.81% (0.19% - 1.42%)	0.76% (0.18% - 1.34%)	0.69% (0.16% - 1.22%)	0.57% (0.13% - 1.01%)
New York, NY	0.36% (-0.21% - 0.94%)	0.3% (-0.18% - 0.78%)	0.3% (-0.18% - 0.78%)	0.29% (-0.17% - 0.76%)	0.27% (-0.16% - 0.7%)	0.26% (-0.15% - 0.67%)	0.21% (-0.13% - 0.55%)
Philadelphia, PA	0.36% (-0.21% - 0.93%)	0.33% (-0.2% - 0.85%)	0.33% (-0.2% - 0.85%)	0.31% (-0.18% - 0.8%)	0.28% (-0.17% - 0.73%)	0.28% (-0.17% - 0.73%)	0.23% (-0.14% - 0.61%)
Phoenix, AZ	0.88% (0.21% - 1.55%)	0.88% (0.21% - 1.55%)	0.88% (0.21% - 1.55%)	0.88% (0.21% - 1.55%)	0.84% (0.2% - 1.48%)	0.83% (0.19% - 1.46%)	0.69% (0.16% - 1.21%)
Pittsburgh, PA	0.42% (-0.24% - 1.07%)	0.29% (-0.17% - 0.75%)	0.29% (-0.17% - 0.75%)	0.28% (-0.17% - 0.73%)	0.27% (-0.16% - 0.7%)	0.25% (-0.15% - 0.64%)	0.21% (-0.12% - 0.53%)
Salt Lake City, UT	0.99% (0.23% - 1.74%)	0.63% (0.15% - 1.1%)	0.63% (0.15% - 1.1%)	0.63% (0.15% - 1.1%)	0.63% (0.15% - 1.1%)	0.54% (0.12% - 0.94%)	0.44% (0.1% - 0.78%)
St. Louis, MO	0.37% (-0.22% - 0.96%)	0.33% (-0.2% - 0.86%)	0.31% (-0.18% - 0.81%)	0.29% (-0.17% - 0.74%)	0.26% (-0.16% - 0.68%)	0.28% (-0.17% - 0.73%)	0.24% (-0.14% - 0.61%)
Tacoma, WA	0.17% (-2.31% - 2.52%)	0.14% (-1.86% - 2.05%)	0.14% (-1.86% - 2.05%)	0.14% (-1.86% - 2.05%)	0.14% (-1.86% - 2.05%)	0.12% (-1.59% - 1.76%)	0.1% (-1.31% - 1.46%)

[1]Estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2] Percents rounded to the nearest hundredth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-115. Percent Reduction from the Current Standards: Estimated Annual Incidence of Respiratory Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:					
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (24% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	23% (22% - 23%)
Los Angeles, CA	-58% (-58% - -58%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	11% (11% - 11%)	15% (15% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	14% (14% - 14%)	15% (15% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-41% (-41% - -42%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	8% (8% - 8%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-116. Percent Reduction from the Current Standards: Estimated Annual Incidence of Respiratory Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (24% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	23% (22% - 23%)
Los Angeles, CA	-58% (-58% - -58%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	11% (11% - 11%)	15% (15% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	14% (14% - 14%)	15% (15% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-43% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-117. Percent Reduction from the Current Standards: Estimated Annual Incidence of Respiratory Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Risk Assessment Location	Percent Reduction from the Current Standards: Annual Incidence of Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m)[2]:						
	Recent $PM_{2.5}$ Concentrations	15/35[3]	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	-9% (-9% - -9%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	24% (24% - 24%)
Baltimore, MD	-6% (-6% - -6%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Birmingham, AL	-28% (-28% - -28%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	30% (29% - 30%)
Dallas, TX	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	7% (7% - 7%)	0% (0% - 0%)	7% (7% - 7%)
Detroit, MI	-23% (-23% - -23%)	0% (0% - 0%)	1% (1% - 1%)	8% (8% - 8%)	16% (16% - 16%)	15% (15% - 15%)	29% (29% - 29%)
Fresno, CA	-81% (-80% - -82%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 29%)
Houston, TX	-6% (-6% - -6%)	0% (0% - 0%)	8% (7% - 8%)	15% (15% - 15%)	23% (22% - 23%)	15% (15% - 15%)	23% (22% - 23%)
Los Angeles, CA	-58% (-58% - -58%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 6%)	15% (15% - 15%)	29% (29% - 29%)
New York, NY	-20% (-20% - -20%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	11% (11% - 11%)	15% (15% - 15%)	29% (29% - 29%)
Philadelphia, PA	-9% (-9% - -9%)	0% (0% - 0%)	0% (0% - 0%)	6% (6% - 7%)	14% (14% - 14%)	15% (15% - 15%)	29% (29% - 29%)
Phoenix, AZ	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	5% (5% - 5%)	6% (6% - 6%)	22% (22% - 22%)
Pittsburgh, PA	-43% (-42% - -43%)	0% (0% - 0%)	0% (0% - 0%)	3% (3% - 3%)	7% (7% - 7%)	15% (15% - 15%)	29% (29% - 29%)
Salt Lake City, UT	-58% (-58% - -59%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (15% - 15%)	29% (29% - 29%)
St. Louis, MO	-12% (-12% - -12%)	0% (0% - 0%)	6% (6% - 6%)	13% (13% - 13%)	20% (20% - 20%)	15% (15% - 15%)	29% (29% - 29%)
Tacoma, WA	-23% (-23% - -24%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	0% (0% - 0%)	15% (14% - 15%)	29% (29% - 30%)

[1]Estimates were calculated using the appropriate regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

[2]Numbers rounded to the nearest percent. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-118. Estimated Annual Incidence of Emergency Room (ER) Visits Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Study	Location	ER Visit for:	Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
			Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Tolbert et al. (2007)	Atlanta, GA	Cardiovascular illness	216 (-304 - 727)	198 (-279 - 668)	183 (-258 - 618)	169 (-237 - 568)	154 (-216 - 518)	169 (-237 - 568)	151 (-212 - 511)
Tolbert et al. (2007)	Atlanta, GA	Respiratory illness	814 (-816 - 2419)	746 (-748 - 2220)	690 (-691 - 2055)	634 (-635 - 1889)	578 (-578 - 1723)	634 (-635 - 1889)	570 (-570 - 1698)
Ito et al. (2007)	New York, NY	Asthma	5235 (3346 - 7071)	4375 (2790 - 5923)	4375 (2790 - 5923)	4265 (2719 - 5776)	3927 (2501 - 5323)	3754 (2390 - 5091)	3127 (1987 - 4248)

[1]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-119. Estimated Annual Incidence of Emergency Room (ER) Visits Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Study	Location	ER Visit for:	Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
			Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Tolbert et al. (2007)	Atlanta, GA	Cardiovascular illness	220 (-310 - 741)	202 (-284 - 681)	187 (-263 - 630)	172 (-241 - 579)	157 (-220 - 528)	172 (-241 - 579)	154 (-216 - 521)
Tolbert et al. (2007)	Atlanta, GA	Respiratory illness	829 (-831 - 2465)	761 (-762 - 2263)	704 (-705 - 2094)	647 (-647 - 1925)	589 (-590 - 1756)	647 (-647 - 1925)	581 (-581 - 1730)
Ito et al. (2007)	New York, NY	Asthma	4506 (2876 - 6095)	3764 (2397 - 5102)	3764 (2397 - 5102)	3669 (2336 - 4974)	3377 (2149 - 4582)	3228 (2053 - 4382)	2688 (1707 - 3654)

[1]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.
[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-120. Estimated Annual Incidence of Emergency Room (ER) Visits Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Study	Location	ER Visit for:	Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
			Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Tolbert et al. (2007)	Atlanta, GA	Cardiovascular illness	219 (-308 - 738)	201 (-283 - 677)	186 (-261 - 627)	171 (-240 - 576)	156 (-219 - 526)	171 (-240 - 576)	154 (-215 - 518)
Tolbert et al. (2007)	Atlanta, GA	Respiratory illness	825 (-827 - 2453)	757 (-758 - 2251)	700 (-701 - 2084)	643 (-644 - 1915)	586 (-587 - 1747)	643 (-644 - 1915)	578 (-578 - 1721)
Ito et al. (2007)	New York, NY	Asthma	4926 (3145 - 6660)	4115 (2622 - 5575)	4115 (2622 - 5575)	4011 (2555 - 5436)	3692 (2350 - 5008)	3529 (2245 - 4790)	2939 (1867 - 3995)

[1]Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-121. Estimated Percent of Total Annual Incidence of Emergency Room (ER) Visits Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Study	Location	ER Visit for:	Percent of Total Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
			Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Tolbert et al. (2007)	Atlanta, GA	Cardiovascular illness	0.6% (-0.9% - 2.2%)	0.6% (-0.8% - 2%)	0.5% (-0.8% - 1.9%)	0.5% (-0.7% - 1.7%)	0.5% (-0.6% - 1.6%)	0.5% (-0.7% - 1.7%)	0.5% (-0.6% - 1.5%)
Tolbert et al. (2007)	Atlanta, GA	Respiratory illness	0.6% (-0.6% - 1.9%)	0.6% (-0.6% - 1.8%)	0.5% (-0.6% - 1.6%)	0.5% (-0.5% - 1.5%)	0.5% (-0.5% - 1.4%)	0.5% (-0.5% - 1.5%)	0.5% (-0.5% - 1.4%)
Ito et al. (2007)	New York, NY	Asthma	6.1% (3.9% - 8.2%)	5.1% (3.3% - 6.9%)	5.1% (3.3% - 6.9%)	5% (3.2% - 6.7%)	4.6% (2.9% - 6.2%)	4.4% (2.8% - 5.9%)	3.6% (2.3% - 5%)

[1]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-122. Estimated Percent of Total Annual Incidence of Emergency Room (ER) Visits Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Study	Location	ER Visit for:	Percent of Total Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
			Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Tolbert et al. (2007)	Atlanta, GA	Cardiovascular illness	0.6% (-0.9% - 2.1%)	0.6% (-0.8% - 2%)	0.5% (-0.8% - 1.8%)	0.5% (-0.7% - 1.7%)	0.5% (-0.6% - 1.5%)	0.5% (-0.7% - 1.7%)	0.4% (-0.6% - 1.5%)
Tolbert et al. (2007)	Atlanta, GA	Respiratory illness	0.6% (-0.6% - 1.9%)	0.6% (-0.6% - 1.7%)	0.5% (-0.5% - 1.6%)	0.5% (-0.5% - 1.5%)	0.5% (-0.5% - 1.4%)	0.5% (-0.5% - 1.5%)	0.4% (-0.4% - 1.3%)
Ito et al. (2007)	New York, NY	Asthma	5.2% (3.3% - 7.1%)	4.4% (2.8% - 5.9%)	4.4% (2.8% - 5.9%)	4.3% (2.7% - 5.8%)	3.9% (2.5% - 5.3%)	3.7% (2.4% - 5.1%)	3.1% (2% - 4.2%)

[1]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table E-123. Estimated Percent of Total Annual Incidence of Emergency Room (ER) Visits Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Study	Location	ER Visit for:	Percent of Total Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
			Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Tolbert et al. (2007)	Atlanta, GA	Cardiovascular illness	0.6% (-0.9% - 2.1%)	0.6% (-0.8% - 1.9%)	0.5% (-0.7% - 1.8%)	0.5% (-0.7% - 1.6%)	0.4% (-0.6% - 1.5%)	0.5% (-0.7% - 1.6%)	0.4% (-0.6% - 1.5%)
Tolbert et al. (2007)	Atlanta, GA	Respiratory illness	0.6% (-0.6% - 1.8%)	0.6% (-0.6% - 1.7%)	0.5% (-0.5% - 1.6%)	0.5% (-0.5% - 1.4%)	0.4% (-0.4% - 1.3%)	0.5% (-0.5% - 1.4%)	0.4% (-0.4% - 1.3%)
Ito et al. (2007)	New York, NY	Asthma	5.7% (3.6% - 7.7%)	4.8% (3% - 6.5%)	4.8% (3% - 6.5%)	4.6% (3% - 6.3%)	4.3% (2.7% - 5.8%)	4.1% (2.6% - 5.5%)	3.4% (2.2% - 4.6%)

[1]Percents rounded to the nearest tenth. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

APPENDIX F: SENSITIVITY ANALYSIS RESULTS

Appendix F. Sensitivity Analysis Results

This Appendix provides detailed results of the single- and multi-factor sensitivity analyses completed as part of this risk analysis. For additional detail on the sensitivity analysis results completed for this analysis, as well as the types of results generated, see section 4.3.

Table F-1. Sensitivity Analysis: Impact of Using Different Model Choices to Estimate the Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Health Endpoint	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]			Percent Difference [6]	
	Standard Fixed Effects Log-Linear (Cox Proportional Hazard) Model[3]	Random Effects Log-Linear Model [4]	Random Effects Log-Log Model [5]	Fixed Effects vs. Random Effects Log-Linear Models	Fixed Effects vs. Random Effects Log-Log Models
Los Angeles, CA					
All Cause Mortality	1342 (854 - 1827)	1656 (772 - 2527)	3360 (2075 - 4615)	23%	150%
Cardiopulmonary Mortality	1526 (1191 - 1856)	--- [7]	2569 (1709 - 3400)	---	68%
Ischemic Heart Disease Mortality	1249 (1017 - 1477)	1397 (847 - 1924)	2535 (1793 - 3232)	12%	103%
Lung Cancer Mortality	164 (71 - 253)	---	307 (160 - 446)	---	87%
Philadelphia, PA					
All Cause Mortality	584 (372 - 792)	719 (337 - 1090)	1254 (779 - 1713)	23%	115%
Cardiopulmonary Mortality	545 (427 - 660)	---	790 (530 - 1038)	---	45%
Ischemic Heart Disease Mortality	369 (303 - 434)	411 (253 - 558)	639 (458 - 803)	11%	73%
Lung Cancer Mortality	88 (39 - 135)	---	142 (75 - 204)	---	61%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Mortality incidence was estimated for $PM_{2.5}$ concentrations down to the lowest measured level in the study (5.8 ug/m^3). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[4]Estimates based on Table 9. Autocorrelation at MSA and ZCA levels; MSA & DIFF, in Krewski et al. (2009) – exposure period from 1999 - 2000.

[5]Estimates based on Table 11, "MSA and DIFF" rows, in Krewski et al. (2009) -- exposure period from 1999 - 2000.

[6]Calculated as (core analysis model estimate - alternative model estimate)/(core analysis model estimate.)

[7]Estimates for cardiopulmonary mortality and lung cancer mortality were not available for the random effects log-linear model.

Table F-2. Sensitivity Analysis: Impact of Using Different Model Choices to Estimate the Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Health Endpoint	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]			Percent Difference [6]	
	Standard Fixed Effects Log-Linear (Cox Proportional Hazard) Model[3]	Random Effects Log-Linear Model [4]	Random Effects Log-Log Model [5]	Fixed Effects vs. Random Effects Log-Linear Models	Fixed Effects vs. Random Effects Log-Log Models
Los Angeles, CA					
All Cause Mortality	1108 (704 - 1509)	1368 (637 - 2090)	2904 (1790 - 3995)	23%	162%
Cardiopulmonary Mortality	1263 (985 - 1538)	--- [7]	2225 (1477 - 2953)	---	76%
Ischemic Heart Disease Mortality	1038 (843 - 1229)	1162 (702 - 1605)	2212 (1558 - 2833)	12%	113%
Lung Cancer Mortality	135 (59 - 210)	---	266 (138 - 388)	---	97%
Philadelphia, PA					
All Cause Mortality	525 (335 - 713)	647 (303 - 982)	1166 (723 - 1595)	23%	122%
Cardiopulmonary Mortality	491 (385 - 596)	---	736 (493 - 969)	---	50%
Ischemic Heart Disease Mortality	334 (273 - 393)	372 (228 - 507)	598 (428 - 755)	11%	79%
Lung Cancer Mortality	80 (35 - 122)	---	133 (70 - 191)	---	66%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Mortality incidence was estimated for $PM_{2.5}$ concentrations down to the lowest measured level in the study (5.8 ug/m^3). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[4]Estimates based on Table 9. Autocorrelation at MSA and ZCA levels; MSA & DIFF, in Krewski et al. (2009) – exposure period from 1999 - 2000.

[5]Estimates based on Table 11, "MSA and DIFF" rows, in Krewski et al. (2009) -- exposure period from 1999 - 2000.

[6]Calculated as (core analysis model estimate - alternative model estimate)/(core analysis model estimate.)

[7]Estimates for cardiopulmonary mortality and lung cancer mortality were not available for the random effects log-linear model.

Table F-3. Sensitivity Analysis: Impact of Using Different Model Choices to Estimate the Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Health Endpoint	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]			Percent Difference [6]	
	Standard Fixed Effects Log-Linear (Cox Proportional Hazard) Model[3]	Random Effects Log-Linear Model [4]	Random Effects Log-Log Model [5]	Fixed Effects vs. Random Effects Log-Linear Models	Fixed Effects vs. Random Effects Log-Log Models
Los Angeles, CA					
All Cause Mortality	1170 (744 - 1593)	1444 (672 - 2206)	3034 (1871 - 4173)	23%	159%
Cardiopulmonary Mortality	1333 (1040 - 1623)	--- [7]	2324 (1544 - 3082)	---	74%
Ischemic Heart Disease Mortality	1094 (890 - 1296)	1225 (741 - 1691)	2306 (1626 - 2950)	12%	111%
Lung Cancer Mortality	143 (62 - 222)	---	278 (145 - 405)	---	94%
Philadelphia, PA					
All Cause Mortality	519 (331 - 704)	639 (299 - 971)	1157 (718 - 1583)	23%	123%
Cardiopulmonary Mortality	486 (381 - 589)	---	731 (489 - 962)	---	50%
Ischemic Heart Disease Mortality	330 (270 - 389)	368 (226 - 502)	594 (424 - 750)	12%	80%
Lung Cancer Mortality	79 (35 - 121)	---	132 (69 - 190)	---	67%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Mortality incidence was estimated for $PM_{2.5}$ concentrations down to the lowest measured level in the study (5.8 ug/m^3). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[4]Estimates based on Table 9. Autocorrelation at MSA and ZCA levels; MSA & DIFF, in Krewski et al. (2009) – exposure period from 1999 - 2000.

[5]Estimates based on Table 11, "MSA and DIFF" rows, in Krewski et al. (2009) -- exposure period from 1999 - 2000.

[6]Calculated as (core analysis model estimate - alternative model estimate)/(core analysis model estimate.)

[7]Estimates for cardiopulmonary mortality and lung cancer mortality were not available for the random effects log-linear model.

Table F-4. Sensitivity Analysis: Impact of Limiting Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards to the Lowest Measured Level in the Study vs. to PRB, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1, 2]

Risk Assessment Location	Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Measured Down to:		Percent Difference[3]
	Lowest Measured Level in Study (5.8 ug/m3)	Estimated PRB	
Atlanta, GA	736 (470 - 997)	1057 (678 - 1426)	44%
Baltimore, MD	702 (448 - 950)	1073 (689 - 1446)	53%
Birmingham, AL	380 (243 - 516)	592 (379 - 800)	56%
Dallas, TX	486 (310 - 659)	762 (488 - 1030)	57%
Detroit, MI	743 (474 - 1008)	1205 (773 - 1626)	62%
Fresno, CA	114 (72 - 155)	262 (167 - 355)	130%
Houston, TX	713 (455 - 968)	1114 (713 - 1506)	56%
Los Angeles, CA	1342 (854 - 1827)	2845 (1819 - 3853)	112%
New York, NY	1893 (1207 - 2571)	3299 (2113 - 4456)	74%
Philadelphia, PA	584 (372 - 792)	971 (622 - 1310)	66%
Phoenix, AZ	620 (394 - 843)	1255 (803 - 1698)	102%
Pittsburgh, PA	497 (317 - 674)	859 (550 - 1161)	73%
Salt Lake City, UT	37 (24 - 51)	161 (102 - 218)	335%
St. Louis, MO	897 (573 - 1215)	1381 (887 - 1862)	54%
Tacoma, WA	103 (66 - 141)	234 (149 - 317)	127%

[1]Estimates based on Table 33 in Krewski et al. (2009) -- exposure period from 1999 - 2000, follow-up through 2000, models with 44 individual and 7 ecological covariates. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality estimated down to PRB - mortality estimated down to LML)/(mortality estimated down to LML).

Table F-5. Sensitivity Analysis: Impact of Limiting Estimated Annual Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards to the Lowest Measured Level in the Study vs. to PRB, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1, 2]

Risk Assessment Location	Incidence of Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Measured Down to:		Percent Difference[3]
	Lowest Measured Level in Study (5.8 ug/m^3)	Estimated PRB	
Atlanta, GA	287 (236 - 336)	400 (331 - 465)	39%
Baltimore, MD	375 (307 - 441)	601 (497 - 699)	60%
Birmingham, AL	157 (128 - 184)	244 (201 - 285)	55%
Dallas, TX	222 (181 - 262)	384 (315 - 450)	73%
Detroit, MI	449 (367 - 530)	829 (683 - 969)	85%
Fresno, CA	92 (75 - 108)	198 (162 - 232)	115%
Houston, TX	416 (340 - 490)	646 (533 - 755)	55%
Los Angeles, CA	1038 (843 - 1229)	2366 (1943 - 2775)	128%
New York, NY	1865 (1520 - 2203)	3618 (2979 - 4232)	94%
Philadelphia, PA	334 (273 - 393)	559 (461 - 651)	67%
Phoenix, AZ	471 (384 - 557)	907 (747 - 1061)	93%
Pittsburgh, PA	279 (228 - 330)	531 (437 - 621)	90%
Salt Lake City, UT	8 (6 - 10)	57 (47 - 67)	613%
St. Louis, MO	512 (419 - 603)	862 (712 - 1006)	68%
Tacoma, WA	46 (37 - 55)	143 (117 - 168)	211%

[1]Estimates based on Table 33 in Krewski et al. (2009) -- exposure period from 1999 - 2000, follow-up through 2000, models with 44 individual and 7 ecological covariates. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (IHD mortality estimated down to PRB - IHD mortality estimated down to LML)/(IHD mortality estimated down to LML).

Table F-6. Sensitivity Analysis: Impact of Limiting Estimated Annual Incidence of All-Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards to the Lowest Measured Level in the Study vs. to PRB, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1, 2]

Risk Assessment Location	Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Measured Down to:		Percent Difference[3]
	Lowest Measured Level in Study (5.8 ug/m3)	Estimated PRB	
Atlanta, GA	726 (464 - 984)	1067 (684 - 1440)	47%
Baltimore, MD	564 (360 - 765)	938 (602 - 1267)	66%
Birmingham, AL	374 (238 - 507)	590 (377 - 797)	58%
Dallas, TX	407 (259 - 553)	696 (445 - 942)	71%
Detroit, MI	544 (346 - 739)	1007 (644 - 1362)	85%
Fresno, CA	130 (82 - 177)	282 (180 - 382)	117%
Houston, TX	719 (459 - 977)	1143 (732 - 1545)	59%
Los Angeles, CA	1170 (744 - 1593)	2697 (1723 - 3654)	131%
New York, NY	1689 (1076 - 2295)	3124 (2000 - 4224)	85%
Philadelphia, PA	519 (331 - 704)	907 (581 - 1225)	75%
Phoenix, AZ	556 (354 - 757)	1240 (792 - 1678)	123%
Pittsburgh, PA	434 (277 - 590)	795 (509 - 1074)	83%
Salt Lake City, UT	48 (31 - 66)	179 (114 - 244)	273%
St. Louis, MO	728 (464 - 988)	1220 (782 - 1648)	68%
Tacoma, WA	64 (41 - 88)	201 (128 - 272)	214%

[1]Estimates based on Table 33 in Krewski et al. (2009) -- exposure period from 1999 - 2000, follow-up through 2000, models with 44 individual and 7 ecological covariates. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality estimated down to PRB - mortality estimated down to LML)/(mortality estimated down to LML).

Table F-7. Sensitivity Analysis: Impact of Using a Different Study to Estimate the Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Health Endpoint	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]		Percent Difference[5]
	Krewski et al. (2009)[3]	Krewski et al. (2000)[4]	
Los Angeles, CA			
All Cause Mortality	1342 (854 - 1827)	2965 (1005 - 4855)	121%
Cardiopulmonary Mortality	1526 (1191 - 1856)	1981 (693 - 3207)	30%
Lung Cancer Mortality	164 (71 - 253)	212 (-152 - 535)	29%
Philadelphia, PA			
All Cause Mortality	584 (372 - 792)	1276 (438 - 2064)	118%
Cardiopulmonary Mortality	545 (427 - 660)	704 (250 - 1121)	29%
Lung Cancer Mortality	88 (39 - 135)	114 (-85 - 276)	30%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Mortality incidence was estimated for $PM_{2.5}$ concentrations down to the lowest measured level in Krewski et al., 2009 (5.8 ug/m^3). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty

[3]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[4]Estimates based on Table 21b in Krewski et al. (2000) [reanalysis of Six Cities Study].

[5]Calculated as (Krewski et al. (2000) estimate - Krewski et al. (2009) estimate)/(Krewski et al. (2009) estimate).

Table F-8. Sensitivity Analysis: Impact of Using a Different Study to Estimate the Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Health Endpoint	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]		Percent Difference[5]
	Krewski et al. (2009)[3]	Krewski et al. (2000)[4]	
Los Angeles, CA			
All Cause Mortality	1108 (704 - 1509)	2454 (829 - 4031)	121%
Cardiopulmonary Mortality	1263 (985 - 1538)	1642 (572 - 2671)	30%
Lung Cancer Mortality	135 (59 - 210)	176 (-124 - 448)	30%
Philadelphia, PA			
All Cause Mortality	525 (335 - 713)	1150 (394 - 1866)	119%
Cardiopulmonary Mortality	491 (385 - 596)	635 (225 - 1016)	29%
Lung Cancer Mortality	80 (35 - 122)	103 (-76 - 251)	29%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.
[2]Mortality incidence was estimated for $PM_{2.5}$ concentrations down to the lowest measured level in Krewski et al., 2009 (5.8 ug/m^3). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty
[3]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).
[4]Estimates based on Table 21b in Krewski et al. (2000) [reanalysis of Six Cities Study].
[5]Calculated as (Krewski et al. (2000) estimate - Krewski et al. (2009) estimate)/(Krewski et al. (2009) estimate).

Table F-9. Sensitivity Analysis: Impact of Using a Different Study to Estimate the Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Health Endpoint	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]		Percent Difference[5]
	Krewski et al. (2009)[3]	Krewski et al. (2000)[4]	
Los Angeles, CA			
All Cause Mortality	1170 (744 - 1593)	2590 (876 - 4252)	121%
Cardiopulmonary Mortality	1333 (1040 - 1623)	1732 (604 - 2815)	30%
Lung Cancer Mortality	143 (62 - 222)	186 (-131 - 472)	30%
Philadelphia, PA			
All Cause Mortality	519 (331 - 704)	1137 (389 - 1846)	119%
Cardiopulmonary Mortality	486 (381 - 589)	628 (223 - 1005)	29%
Lung Cancer Mortality	79 (35 - 121)	102 (-75 - 249)	29%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Mortality incidence was estimated for $PM_{2.5}$ concentrations down to the lowest measured level in Krewski et al., 2009 (5.8 ug/m^3). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009).

[4]Estimates based on Table 21b in Krewski et al. (2000) [reanalysis of Six Cities Study].

[5]Calculated as (Krewski et al. (2000) estimate - Krewski et al. (2009) estimate)/(Krewski et al. (2009) estimate).

Table F-10. Sensitivity Analysis: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Comparison of Proportional and Hybrid Rollback Methods[1]

Risk Assessment Location	Type of Rollback	Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Combinations of Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
		15/35 [2]	14/35	13/35	12/35	13/30	12/25
Baltimore, MD	Proportional	702 (448 - 950)	643 (410 - 871)	566 (361 - 768)	490 (312 - 665)	546 (348 - 741)	388 (247 - 528)
	Hybrid	691 (442 - 936)	667 (426 - 904)	589 (376 - 799)	511 (326 - 694)	537 (342 - 729)	381 (242 - 518)
	Percent Difference [3]	-2%	4%	4%	4%	-2%	-2%
Birmingham, AL	Proportional	380 (243 - 516)	336 (214 - 457)	292 (186 - 397)	247 (157 - 336)	292 (186 - 397)	205 (130 - 280)
	Hybrid	461 (294 - 624)	411 (262 - 557)	360 (230 - 489)	310 (197 - 421)	360 (230 - 489)	274 (174 - 372)
	Percent Difference	21%	22%	23%	26%	23%	34%
Detroit, MI	Proportional	743 (474 - 1008)	734 (468 - 996)	643 (410 - 874)	552 (352 - 751)	567 (361 - 770)	389 (247 - 530)
	Hybrid	773 (493 - 1048)	773 (493 - 1048)	750 (479 - 1018)	651 (415 - 884)	593 (378 - 805)	411 (261 - 559)
	Percent Difference	4%	5%	17%	18%	5%	6%
Los Angeles, CA	Proportional	1342 (854 - 1827)	1342 (854 - 1827)	1342 (854 - 1827)	1180 (750 - 1607)	924 (587 - 1258)	502 (318 - 684)
	Hybrid	1675 (1066 - 2276)	1675 (1066 - 2276)	1599 (1018 - 2175)	1344 (855 - 1830)	1209 (769 - 1647)	740 (470 - 1010)
	Percent Difference	25%	25%	19%	14%	31%	47%
New York, NY	Proportional	1893 (1207 - 2571)	1893 (1207 - 2571)	1808 (1152 - 2455)	1546 (984 - 2101)	1412 (898 - 1920)	926 (588 - 1261)
	Hybrid	1950 (1244 - 2648)	1950 (1244 - 2648)	1806 (1151 - 2452)	1544 (983 - 2099)	1461 (930 - 1987)	967 (614 - 1317)
	Percent Difference	3%	3%	0%	0%	3%	4%
St. Louis, MO	Proportional	897 (573 - 1215)	813 (519 - 1102)	714 (456 - 970)	616 (392 - 836)	696 (443 - 944)	492 (313 - 669)
	Hybrid	956 (611 - 1294)	855 (546 - 1159)	754 (481 - 1022)	652 (415 - 885)	754 (481 - 1022)	548 (349 - 745)
	Percent Difference	7%	5%	6%	6%	8%	11%

[1]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality based on hybrid rollbacks - mortality based on proportional rollbacks)/(mortality based on proportional rollbacks).

Table F-11. Sensitivity Analysis: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Comparison of Proportional and Hybrid Rollback Methods[1]

Risk Assessment Location	Type of Rollback	Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Combinations of Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
		15/35 [2]	14/35	13/35	12/35	13/30	12/25
Baltimore, MD	Proportional	565 (360 - 766)	513 (327 - 696)	446 (284 - 606)	378 (241 - 515)	428 (272 - 581)	289 (184 - 394)
	Hybrid	554 (354 - 752)	533 (340 - 724)	465 (296 - 632)	396 (252 - 539)	419 (267 - 569)	282 (179 - 384)
	Percent Difference [3]	-2%	4%	4%	5%	-2%	-2%
Birmingham, AL	Proportional	354 (226 - 481)	312 (198 - 423)	269 (171 - 365)	226 (144 - 307)	269 (171 - 365)	186 (118 - 253)
	Hybrid	430 (275 - 584)	382 (244 - 519)	334 (213 - 454)	286 (182 - 388)	334 (213 - 454)	251 (159 - 341)
	Percent Difference	21%	22%	24%	27%	24%	35%
Detroit, MI	Proportional	510 (325 - 694)	503 (320 - 684)	429 (273 - 584)	355 (225 - 483)	366 (233 - 499)	222 (141 - 302)
	Hybrid	534 (340 - 725)	534 (340 - 725)	515 (328 - 700)	434 (276 - 591)	387 (246 - 526)	238 (151 - 325)
	Percent Difference	5%	6%	20%	22%	6%	7%
Los Angeles, CA	Proportional	1108 (704 - 1509)	1108 (704 - 1509)	1108 (704 - 1509)	958 (608 - 1305)	721 (457 - 983)	331 (210 - 451)
	Hybrid	1414 (899 - 1923)	1414 (899 - 1923)	1344 (855 - 1829)	1108 (704 - 1510)	984 (625 - 1340)	550 (349 - 750)
	Percent Difference	28%	28%	21%	16%	36%	66%
New York, NY	Proportional	1407 (895 - 1913)	1407 (895 - 1913)	1333 (848 - 1813)	1106 (703 - 1506)	990 (629 - 1349)	571 (362 - 779)
	Hybrid	1453 (924 - 1975)	1453 (924 - 1975)	1327 (844 - 1806)	1101 (700 - 1499)	1030 (654 - 1403)	604 (383 - 823)
	Percent Difference	3%	3%	0%	0%	4%	6%
St. Louis, MO	Proportional	659 (420 - 894)	588 (374 - 799)	506 (322 - 688)	423 (269 - 575)	490 (312 - 666)	319 (203 - 435)
	Hybrid	704 (449 - 956)	620 (395 - 842)	535 (341 - 727)	450 (286 - 612)	535 (341 - 727)	363 (231 - 495)
	Percent Difference	7%	5%	6%	6%	9%	14%

[1]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality based on hybrid rollbacks - mortality based on proportional rollbacks)/(mortality based on proportional rollbacks).

Table F-12. Sensitivity Analysis: Estimated Annual Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Comparison of Proportional and Hybrid Rollback Methods[1]

Risk Assessment Location	Type of Rollback	Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Combinations of Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
		15/35 [2]	14/35	13/35	12/35	13/30	12/25
Baltimore, MD	Proportional	564 (360 - 765)	512 (326 - 695)	445 (283 - 605)	378 (240 - 514)	427 (272 - 580)	289 (184 - 393)
	Hybrid	553 (353 - 751)	532 (339 - 722)	464 (296 - 630)	395 (252 - 537)	418 (266 - 568)	281 (179 - 383)
	Percent Difference [3]	-2%	4%	4%	4%	-2%	-3%
Birmingham, AL	Proportional	374 (238 - 507)	330 (210 - 448)	285 (182 - 388)	241 (153 - 327)	285 (182 - 388)	199 (126 - 271)
	Hybrid	454 (290 - 615)	404 (258 - 548)	354 (226 - 481)	304 (193 - 413)	354 (226 - 481)	268 (170 - 364)
	Percent Difference	21%	22%	24%	26%	24%	35%
Detroit, MI	Proportional	544 (346 - 739)	536 (341 - 729)	460 (293 - 626)	384 (244 - 522)	396 (252 - 539)	247 (157 - 336)
	Hybrid	568 (362 - 772)	568 (362 - 772)	549 (350 - 747)	466 (297 - 634)	417 (265 - 568)	265 (168 - 361)
	Percent Difference	4%	6%	19%	21%	5%	7%
Los Angeles, CA	Proportional	1170 (744 - 1593)	1170 (744 - 1593)	1170 (744 - 1593)	1016 (645 - 1384)	773 (490 - 1053)	372 (236 - 508)
	Hybrid	1484 (944 - 2019)	1484 (944 - 2019)	1413 (899 - 1922)	1171 (744 - 1594)	1043 (662 - 1420)	598 (379 - 815)
	Percent Difference	27%	27%	21%	15%	35%	61%
New York, NY	Proportional	1689 (1076 - 2295)	1689 (1076 - 2295)	1607 (1023 - 2185)	1359 (864 - 1848)	1232 (783 - 1676)	771 (489 - 1051)
	Hybrid	1741 (1109 - 2366)	1741 (1109 - 2366)	1604 (1021 - 2180)	1355 (862 - 1844)	1277 (812 - 1738)	809 (513 - 1102)
	Percent Difference	3%	3%	0%	0%	4%	5%
St. Louis, MO	Proportional	728 (464 - 988)	653 (416 - 887)	566 (360 - 769)	478 (304 - 651)	549 (350 - 747)	369 (235 - 503)
	Hybrid	787 (503 - 1068)	698 (445 - 947)	607 (387 - 825)	516 (329 - 702)	607 (387 - 825)	424 (269 - 577)
	Percent Difference	8%	7%	7%	8%	11%	15%

[1]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000, using models with 44 individual and 7 ecological covariates (see Table 33 in Krewski et al., 2009). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality based on hybrid rollbacks - mortality based on proportional rollbacks)/(mortality based on proportional rollbacks).

Table F-13. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	55 (8 - 102)	53 (3 - 101)	43 (-15 - 99)	33 (-17 - 83)	184 --- [4]	177 (34 - 319)	4%
Baltimore, MD	66 (9 - 122)	46 (1 - 91)	60 (-7 - 126)	50 (7 - 92)	222 ---	256 (104 - 406)	-13%
Birmingham, AL	18 (-4 - 41)	25 (-3 - 51)	17 (-21 - 55)	10 (-21 - 40)	70 ---	34 (-53 - 121)	106%
Dallas, TX	30 (-5 - 64)	30 (-9 - 68)	43 (-3 - 88)	46 (6 - 84)	149 ---	156 (37 - 273)	-4%
Detroit, MI	-6 (-83 - 69)	77 (19 - 134)	54 (-32 - 137)	34 (-31 - 98)	159 ---	147 (-26 - 317)	8%
Fresno, CA	0 (-33 - 33)	16 (-1 - 32)	3 (-14 - 20)	11 (-12 - 34)	30 ---	44 (6 - 81)	-32%
Houston, TX	45 (-5 - 94)	61 (5 - 116)	51 (-13 - 113)	55 (-9 - 117)	212 ---	214 (44 - 383)	-1%
Los Angeles, CA	17 (-84 - 117)	66 (-35 - 166)	-104 (-257 - 48)	-2 (-90 - 85)	-23 ---	81 (-117 - 278)	-128%
New York, NY	279 (102 - 453)	159 (1 - 315)	136 (-55 - 323)	206 (89 - 321)	780 ---	781 (459 - 1102)	0%
Philadelphia, PA	93 (20 - 165)	28 (-33 - 89)	34 (-48 - 114)	65 (16 - 112)	220 ---	216 (79 - 350)	2%
Phoenix, AZ [5]	--- ---	--- ---	--- ---	--- ---	--- ---	242 (40 - 442)	---
Pittsburgh, PA	43 (-4 - 90)	65 (12 - 117)	44 (-23 - 109)	23 (-28 - 73)	175 ---	159 (47 - 270)	10%
Salt Lake City, UT	16 (-2 - 32)	6 (-2 - 14)	6 (-5 - 17)	8 (-3 - 19)	36 ---	30 (6 - 54)	20%
St. Louis, MO	37 (-37 - 109)	75 (14 - 136)	66 (-6 - 136)	73 (13 - 133)	251 ---	260 (75 - 443)	-3%
Tacoma, WA	1 (-53 - 53)	9 (-7 - 25)	4 (-9 - 17)	14 (-10 - 37)	28 ---	48 (8 - 87)	-42%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

[5] Season-specific coefficient estimates were not available from Zanobetti and Schwartz (2009) for this location.

Table F-14. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	48 (7 - 89)	57 (3 - 109)	51 (-18 - 119)	29 (-15 - 72)	185 --- [4]	180 (34 - 324)	3%
Baltimore, MD	54 (7 - 101)	41 (1 - 81)	52 (-6 - 109)	46 (6 - 86)	193 ---	224 (91 - 356)	-14%
Birmingham, AL	16 (-4 - 36)	27 (-3 - 56)	18 (-23 - 58)	8 (-16 - 32)	69 ---	33 (-51 - 116)	109%
Dallas, TX	24 (-4 - 52)	28 (-8 - 64)	36 (-3 - 75)	34 (5 - 63)	122 ---	130 (31 - 228)	-6%
Detroit, MI	-5 (-64 - 54)	77 (19 - 134)	39 (-23 - 100)	26 (-24 - 75)	137 ---	118 (-21 - 255)	16%
Fresno, CA	1 (-36 - 36)	14 (-1 - 30)	4 (-16 - 24)	12 (-12 - 35)	31 ---	47 (7 - 86)	-34%
Houston, TX	40 (-4 - 84)	68 (5 - 130)	51 (-13 - 115)	48 (-8 - 102)	207 ---	208 (42 - 373)	0%
Los Angeles, CA	17 (-86 - 120)	57 (-30 - 143)	-97 (-239 - 45)	-2 (-78 - 74)	-25 ---	75 (-108 - 257)	-133%
New York, NY	242 (89 - 394)	141 (1 - 279)	111 (-44 - 263)	183 (79 - 286)	677 ---	671 (394 - 946)	1%
Philadelphia, PA	79 (17 - 140)	26 (-31 - 83)	33 (-46 - 109)	70 (18 - 121)	208 ---	204 (75 - 331)	2%
Phoenix, AZ [5]	--- ---	--- ---	--- ---	--- ---	--- ---	254 (42 - 463)	---
Pittsburgh, PA	39 (-4 - 81)	58 (10 - 104)	40 (-21 - 100)	17 (-20 - 53)	154 ---	136 (40 - 232)	13%
Salt Lake City, UT	12 (-1 - 25)	7 (-2 - 15)	7 (-6 - 19)	7 (-3 - 17)	33 ---	27 (6 - 49)	22%
St. Louis, MO	26 (-27 - 79)	67 (12 - 120)	58 (-5 - 120)	60 (10 - 110)	211 ---	215 (62 - 367)	-2%
Tacoma, WA	1 (-38 - 38)	10 (-8 - 26)	4 (-10 - 19)	12 (-8 - 30)	27 ---	40 (7 - 73)	-33%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

[5] Season-specific coefficient estimates were not available from Zanobetti and Schwartz (2009) for this location.

Table F-15. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	48 (7 - 88)	70 (4 - 134)	53 (-18 - 122)	30 (-16 - 76)	201 --- [4]	177 (34 - 319)	14%
Baltimore, MD	56 (7 - 104)	46 (1 - 90)	56 (-6 - 118)	49 (7 - 91)	207 ---	227 (92 - 360)	-9%
Birmingham, AL	20 (-5 - 45)	44 (-5 - 92)	21 (-27 - 67)	10 (-21 - 39)	95 ---	34 (-53 - 120)	179%
Dallas, TX	28 (-5 - 60)	25 (-8 - 58)	39 (-3 - 80)	39 (5 - 73)	131 ---	139 (33 - 243)	-6%
Detroit, MI	-6 (-79 - 66)	84 (21 - 145)	46 (-28 - 119)	42 (-39 - 121)	166 ---	121 (-21 - 262)	37%
Fresno, CA	1 (-78 - 76)	25 (-2 - 53)	6 (-23 - 33)	22 (-23 - 64)	54 ---	48 (7 - 89)	13%
Houston, TX	49 (-5 - 102)	63 (5 - 120)	57 (-14 - 127)	52 (-9 - 112)	221 ---	212 (43 - 378)	4%
Los Angeles, CA	23 (-115 - 160)	112 (-59 - 280)	-144 (-359 - 66)	-3 (-140 - 131)	-12 ---	77 (-110 - 262)	-116%
New York, NY	319 (117 - 517)	177 (1 - 350)	150 (-60 - 355)	241 (105 - 376)	887 ---	734 (431 - 1035)	21%
Philadelphia, PA	88 (19 - 156)	32 (-37 - 99)	34 (-48 - 114)	78 (20 - 134)	232 ---	208 (77 - 338)	12%
Phoenix, AZ [5]	--- ---	--- ---	--- ---	--- ---	--- ---	242 (40 - 442)	---
Pittsburgh, PA	54 (-5 - 113)	84 (15 - 152)	57 (-30 - 140)	30 (-35 - 93)	225 ---	143 (42 - 244)	57%
Salt Lake City, UT	28 (-3 - 57)	11 (-4 - 26)	11 (-10 - 32)	13 (-5 - 32)	63 ---	34 (7 - 61)	85%
St. Louis, MO	32 (-32 - 95)	83 (15 - 150)	63 (-6 - 130)	70 (12 - 127)	248 ---	225 (65 - 384)	10%
Tacoma, WA	1 (-47 - 47)	12 (-9 - 32)	4 (-9 - 16)	20 (-14 - 52)	37 ---	42 (7 - 76)	-12%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

[5] Season-specific coefficient estimates were not available from Zanobetti and Schwartz (2009) for this location.

Table F-16. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	14 (-21 - 49)	9 (-32 - 48)	9 (-31 - 46)	-2 (-37 - 31)	30 --- [4]	32 (-33 - 95)	-6%
Baltimore, MD	16 (-30 - 59)	10 (-31 - 48)	11 (-45 - 64)	32 (-2 - 65)	69 ---	70 (-5 - 143)	-1%
Birmingham, AL	4 (-16 - 24)	1 (-23 - 25)	0 (-29 - 27)	-15 (-40 - 8)	-10 ---	-1 (-43 - 40)	900%
Dallas, TX	10 (-18 - 36)	11 (-21 - 42)	13 (-25 - 49)	-2 (-33 - 27)	32 ---	32 (-21 - 85)	0%
Detroit, MI	-1 (-48 - 43)	25 (-7 - 57)	28 (-21 - 74)	36 (0 - 72)	88 ---	73 (-9 - 153)	21%
Fresno, CA	-2 (-13 - 8)	1 (-3 - 5)	0 (-3 - 4)	3 (-4 - 9)	2 ---	11 (-8 - 30)	-82%
Houston, TX	8 (-34 - 49)	2 (-46 - 47)	27 (-21 - 73)	7 (-41 - 54)	44 ---	47 (-32 - 124)	-6%
Los Angeles, CA	-7 (-54 - 39)	3 (-45 - 49)	-43 (-105 - 17)	0 (-43 - 43)	-47 ---	-31 (-140 - 76)	52%
New York, NY	149 (35 - 261)	130 (29 - 228)	160 (30 - 286)	100 (23 - 174)	539 ---	504 (294 - 711)	7%
Philadelphia, PA	28 (-6 - 60)	16 (-14 - 46)	27 (-13 - 65)	27 (4 - 50)	98 ---	87 (23 - 150)	13%
Phoenix, AZ [5]	--- ---	--- ---	--- ---	--- ---	--- ---	84 (-4 - 170)	---
Pittsburgh, PA	14 (-10 - 38)	30 (3 - 56)	13 (-23 - 47)	5 (-20 - 29)	62 ---	47 (-9 - 103)	32%
Salt Lake City, UT [5]	--- ---	--- ---	--- ---	--- ---	--- ---	8 (-2 - 18)	---
St. Louis, MO	-3 (-68 - 59)	48 (-2 - 95)	38 (-17 - 90)	43 (-4 - 88)	126 ---	122 (27 - 215)	3%
Tacoma, WA	0 (-12 - 13)	0 (-3 - 4)	0 (-2 - 3)	2 (-4 - 7)	2 ---	12 (-7 - 31)	-83%

[1] Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

[5] Season-specific coefficient estimates were not available from Zanobetti and Schwartz (2009) for this location.

Table F-17. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	13 (-18 - 42)	9 (-35 - 52)	10 (-38 - 56)	-2 (-32 - 27)	30 --- [4]	32 (-33 - 97)	-6%
Baltimore, MD	13 (-25 - 49)	8 (-28 - 43)	10 (-39 - 56)	30 (-2 - 61)	61 ---	61 (-4 - 125)	0%
Birmingham, AL	4 (-14 - 21)	1 (-25 - 27)	0 (-31 - 29)	-12 (-31 - 7)	-7 ---	-1 (-41 - 39)	600%
Dallas, TX	8 (-14 - 29)	11 (-19 - 40)	11 (-21 - 41)	-1 (-24 - 21)	29 ---	27 (-18 - 71)	7%
Detroit, MI	-1 (-37 - 34)	25 (-7 - 57)	20 (-15 - 55)	28 (0 - 55)	72 ---	58 (-7 - 123)	24%
Fresno, CA	-2 (-14 - 9)	1 (-3 - 5)	0 (-4 - 5)	3 (-4 - 9)	2 ---	12 (-8 - 32)	-83%
Houston, TX	7 (-30 - 44)	2 (-51 - 53)	27 (-22 - 75)	6 (-35 - 47)	42 ---	45 (-31 - 120)	-7%
Los Angeles, CA	-7 (-56 - 40)	2 (-38 - 42)	-41 (-98 - 16)	0 (-38 - 37)	-46 ---	-29 (-129 - 70)	59%
New York, NY	130 (31 - 227)	115 (25 - 202)	130 (25 - 233)	88 (21 - 155)	463 ---	432 (252 - 611)	7%
Philadelphia, PA	24 (-5 - 51)	15 (-13 - 42)	26 (-12 - 62)	30 (4 - 54)	95 ---	82 (21 - 142)	16%
Phoenix, AZ [5]	--- ---	--- ---	--- ---	--- ---	--- ---	88 (-4 - 178)	---
Pittsburgh, PA	13 (-9 - 35)	27 (2 - 50)	12 (-21 - 43)	4 (-14 - 21)	56 ---	41 (-8 - 89)	37%
Salt Lake City, UT [5]	--- ---	--- ---	--- ---	--- ---	--- ---	7 (-2 - 16)	---
St. Louis, MO	-2 (-49 - 43)	42 (-2 - 85)	33 (-15 - 80)	36 (-3 - 73)	109 ---	101 (23 - 179)	8%
Tacoma, WA	0 (-9 - 9)	0 (-3 - 4)	0 (-2 - 3)	1 (-3 - 6)	1 ---	10 (-6 - 26)	-90%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

[5] Season-specific coefficient estimates were not available from Zanobetti and Schwartz (2009) for this location.

Table F-18. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	11 (-17 - 39)	11 (-40 - 58)	10 (-35 - 52)	-2 (-31 - 26)	30 --- [4]	32 (-33 - 95)	-6%
Baltimore, MD	13 (-24 - 48)	9 (-29 - 45)	10 (-39 - 57)	30 (-2 - 61)	62 ---	62 (-4 - 126)	0%
Birmingham, AL	4 (-14 - 21)	2 (-33 - 35)	0 (-28 - 26)	-12 (-31 - 6)	-6 ---	-1 (-42 - 40)	500%
Dallas, TX	9 (-16 - 34)	10 (-18 - 36)	11 (-23 - 44)	-2 (-28 - 24)	28 ---	29 (-19 - 76)	-3%
Detroit, MI	-1 (-37 - 34)	22 (-6 - 50)	19 (-14 - 52)	36 (0 - 72)	76 ---	60 (-8 - 127)	27%
Fresno, CA	-3 (-16 - 11)	1 (-3 - 5)	0 (-3 - 4)	3 (-4 - 9)	1 ---	12 (-9 - 33)	-92%
Houston, TX	8 (-35 - 50)	2 (-45 - 46)	29 (-23 - 78)	7 (-37 - 48)	46 ---	46 (-31 - 122)	0%
Los Angeles, CA	-6 (-47 - 34)	3 (-48 - 53)	-38 (-92 - 15)	0 (-42 - 42)	-41 ---	-30 (-132 - 72)	37%
New York, NY	142 (34 - 248)	120 (26 - 212)	147 (28 - 262)	97 (23 - 170)	506 ---	473 (276 - 668)	7%
Philadelphia, PA	24 (-5 - 52)	16 (-15 - 47)	25 (-12 - 60)	30 (5 - 55)	95 ---	84 (22 - 145)	13%
Phoenix, AZ [5]	--- ---	--- ---	--- ---	--- ---	--- ---	84 (-4 - 170)	---
Pittsburgh, PA	13 (-9 - 34)	27 (2 - 51)	12 (-21 - 43)	4 (-18 - 26)	56 ---	43 (-9 - 93)	30%
Salt Lake City, UT [5]	--- ---	--- ---	--- ---	--- ---	--- ---	9 (-2 - 20)	---
St. Louis, MO	-2 (-53 - 46)	47 (-2 - 94)	32 (-15 - 78)	37 (-3 - 76)	114 ---	106 (24 - 187)	8%
Tacoma, WA	0 (-9 - 9)	0 (-3 - 4)	0 (-2 - 2)	2 (-5 - 8)	2 ---	11 (-6 - 27)	-82%

[1] Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

[5] Season-specific coefficient estimates were not available from Zanobetti and Schwartz (2009) for this location.

Table F-19. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	4 (-6 - 14)	1 (-8 - 11)	3 (-7 - 13)	3 (-5 - 11)	11 --- [4]	20 (-8 - 47)	-45%
Baltimore, MD	5 (-6 - 15)	6 (-4 - 15)	6 (-6 - 17)	3 (-4 - 11)	20 ---	36 (7 - 64)	-44%
Birmingham, AL	1 (-4 - 5)	2 (-4 - 7)	-1 (-8 - 7)	3 (-2 - 9)	5 ---	9 (-7 - 26)	-44%
Dallas, TX	1 (-6 - 9)	3 (-4 - 10)	2 (-6 - 9)	1 (-6 - 7)	7 ---	11 (-10 - 32)	-36%
Detroit, MI	5 (-7 - 16)	9 (-1 - 18)	10 (0 - 19)	9 (0 - 18)	33 ---	28 (1 - 55)	18%
Fresno, CA	-1 (-11 - 9)	4 (-1 - 9)	1 (-2 - 4)	1 (-6 - 8)	5 ---	9 (0 - 17)	-44%
Houston, TX	5 (-4 - 14)	5 (-4 - 13)	4 (-5 - 13)	4 (-7 - 15)	18 ---	34 (5 - 61)	-47%
Los Angeles, CA	27 (-3 - 56)	27 (-2 - 56)	-15 (-58 - 26)	0 (-23 - 21)	39 ---	57 (6 - 108)	-32%
New York, NY	51 (19 - 82)	18 (-6 - 41)	22 (-10 - 53)	22 (1 - 42)	113 ---	106 (37 - 174)	7%
Philadelphia, PA	10 (-1 - 21)	7 (-1 - 15)	7 (-3 - 16)	5 (-2 - 11)	29 ---	23 (-2 - 48)	26%
Phoenix, AZ	27 (-29 - 79)	30 (-8 - 66)	21 (-3 - 45)	41 (14 - 67)	119 ---	47 (4 - 90)	153%
Pittsburgh, PA	4 (-3 - 11)	7 (-1 - 15)	8 (-2 - 17)	7 (0 - 14)	26 ---	20 (-2 - 42)	30%
Salt Lake City, UT	4 (-1 - 9)	2 (-2 - 6)	-2 (-6 - 3)	-1 (-5 - 3)	3 ---	5 (1 - 10)	-40%
St. Louis, MO	1 (-15 - 17)	7 (-6 - 20)	4 (-10 - 17)	7 (-6 - 18)	19 ---	31 (-8 - 70)	-39%
Tacoma, WA	0 (-15 - 13)	2 (-2 - 6)	1 (-2 - 3)	1 (-4 - 6)	4 ---	7 (0 - 15)	-43%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-20. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	3 (-5 - 12)	2 (-9 - 12)	4 (-8 - 16)	3 (-4 - 10)	12 --- [4]	20 (-8 - 47)	-40%
Baltimore, MD	4 (-5 - 13)	5 (-3 - 13)	5 (-5 - 15)	3 (-4 - 10)	17 ---	31 (6 - 56)	-45%
Birmingham, AL	1 (-3 - 5)	2 (-4 - 8)	-1 (-9 - 7)	3 (-2 - 7)	5 ---	9 (-7 - 25)	-44%
Dallas, TX	1 (-5 - 7)	3 (-4 - 10)	2 (-5 - 8)	1 (-4 - 6)	7 ---	9 (-9 - 27)	-22%
Detroit, MI	4 (-5 - 13)	9 (-1 - 18)	7 (0 - 14)	7 (0 - 14)	27 ---	23 (1 - 44)	17%
Fresno, CA	-1 (-11 - 10)	4 (-1 - 9)	1 (-2 - 5)	1 (-6 - 8)	5 ---	9 (0 - 18)	-44%
Houston, TX	5 (-4 - 13)	5 (-5 - 15)	4 (-5 - 13)	4 (-6 - 13)	18 ---	33 (5 - 60)	-45%
Los Angeles, CA	28 (-3 - 57)	24 (-2 - 48)	-14 (-54 - 24)	0 (-19 - 18)	38 ---	53 (5 - 100)	-28%
New York, NY	44 (16 - 72)	16 (-5 - 37)	18 (-8 - 43)	20 (1 - 37)	98 ---	91 (32 - 149)	8%
Philadelphia, PA	9 (-1 - 18)	7 (-1 - 14)	7 (-3 - 16)	5 (-2 - 12)	28 ---	22 (-2 - 45)	27%
Phoenix, AZ	31 (-33 - 90)	30 (-8 - 65)	22 (-3 - 46)	41 (14 - 66)	124 ---	50 (4 - 94)	148%
Pittsburgh, PA	4 (-3 - 10)	6 (-1 - 13)	7 (-2 - 15)	5 (0 - 10)	22 ---	17 (-2 - 36)	29%
Salt Lake City, UT	3 (-1 - 7)	2 (-2 - 6)	-2 (-7 - 3)	-1 (-5 - 3)	2 ---	5 (1 - 9)	-60%
St. Louis, MO	1 (-10 - 12)	6 (-6 - 18)	3 (-9 - 15)	5 (-5 - 15)	15 ---	26 (-7 - 58)	-42%
Tacoma, WA	0 (-11 - 10)	2 (-2 - 6)	1 (-2 - 4)	1 (-3 - 5)	4 ---	6 (0 - 12)	-33%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-21. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	3 (-5 - 11)	2 (-10 - 13)	4 (-8 - 15)	3 (-4 - 9)	12 --- [4]	20 (-8 - 47)	-40%
Baltimore, MD	4 (-5 - 12)	5 (-4 - 14)	5 (-5 - 15)	3 (-4 - 10)	17 ---	31 (6 - 56)	-45%
Birmingham, AL	1 (-3 - 4)	2 (-5 - 10)	-1 (-8 - 7)	3 (-2 - 7)	5 ---	9 (-7 - 25)	-44%
Dallas, TX	1 (-6 - 8)	3 (-3 - 9)	2 (-5 - 8)	1 (-5 - 6)	7 ---	10 (-9 - 29)	-30%
Detroit, MI	4 (-5 - 13)	8 (-1 - 16)	7 (0 - 14)	9 (0 - 18)	28 ---	24 (1 - 45)	17%
Fresno, CA	-1 (-14 - 11)	4 (-1 - 8)	1 (-2 - 4)	1 (-6 - 8)	5 ---	9 (0 - 18)	-44%
Houston, TX	5 (-4 - 15)	4 (-4 - 13)	4 (-6 - 14)	4 (-6 - 13)	17 ---	33 (5 - 61)	-48%
Los Angeles, CA	23 (-2 - 48)	29 (-2 - 60)	-13 (-51 - 23)	0 (-22 - 21)	39 ---	54 (5 - 102)	-28%
New York, NY	49 (18 - 79)	17 (-6 - 38)	20 (-9 - 48)	21 (1 - 41)	107 ---	100 (35 - 163)	7%
Philadelphia, PA	9 (-1 - 19)	7 (-1 - 15)	7 (-3 - 15)	5 (-2 - 12)	28 ---	22 (-2 - 46)	27%
Phoenix, AZ	24 (-24 - 68)	29 (-8 - 63)	25 (-4 - 51)	45 (15 - 73)	123 ---	47 (4 - 90)	162%
Pittsburgh, PA	4 (-3 - 10)	6 (-1 - 13)	7 (-2 - 15)	6 (0 - 13)	23 ---	18 (-2 - 38)	28%
Salt Lake City, UT	5 (-1 - 10)	2 (-2 - 6)	-2 (-7 - 3)	-1 (-5 - 4)	4 ---	6 (1 - 11)	-33%
St. Louis, MO	1 (-11 - 13)	7 (-6 - 20)	3 (-9 - 14)	6 (-5 - 16)	17 ---	27 (-7 - 60)	-37%
Tacoma, WA	0 (-11 - 10)	2 (-2 - 6)	1 (-1 - 3)	1 (-5 - 7)	4 ---	6 (0 - 13)	-33%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons mortality - all-year mortality)/(all-year mortality).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-22. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	29 (-2 - 60)	24 (-9 - 57)	-28 (-68 - 11)	6 (-27 - 39)	31 --- [4]	40 (-26 - 105)	-23%
Baltimore, MD	129 (90 - 168)	45 (16 - 75)	40 (6 - 74)	48 (23 - 73)	262 ---	247 (182 - 313)	6%
Birmingham, AL	10 (-1 - 21)	10 (-3 - 23)	-13 (-32 - 5)	3 (-12 - 17)	10 ---	17 (-11 - 44)	-41%
Dallas, TX	24 (-2 - 50)	19 (-7 - 45)	-21 (-50 - 8)	5 (-19 - 28)	27 ---	31 (-20 - 81)	-13%
Detroit, MI	153 (107 - 198)	54 (18 - 89)	40 (6 - 74)	57 (27 - 87)	304 ---	280 (206 - 354)	9%
Fresno, CA	14 (-5 - 31)	11 (-6 - 27)	-7 (-28 - 14)	3 (-11 - 17)	21 ---	21 (0 - 41)	0%
Houston, TX	44 (-3 - 91)	34 (-12 - 80)	-35 (-84 - 14)	10 (-41 - 59)	53 ---	56 (-37 - 149)	-5%
Los Angeles, CA	104 (-35 - 241)	194 (-98 - 479)	-144 (-613 - 307)	42 (-138 - 218)	196 ---	264 (3 - 523)	-26%
New York, NY	391 (273 - 509)	161 (55 - 266)	131 (19 - 241)	145 (68 - 221)	828 ---	792 (582 - 1002)	5%
Philadelphia, PA	118 (82 - 153)	39 (13 - 64)	35 (5 - 65)	39 (18 - 59)	231 ---	214 (157 - 271)	8%
Phoenix, AZ	58 (-20 - 135)	81 (-41 - 200)	-47 (-198 - 99)	14 (-47 - 75)	106 ---	108 (1 - 213)	-2%
Pittsburgh, PA	59 (41 - 77)	31 (11 - 51)	28 (4 - 51)	36 (17 - 55)	154 ---	157 (115 - 199)	-2%
Salt Lake City, UT	5 (-2 - 13)	4 (-2 - 10)	-3 (-15 - 7)	1 (-3 - 5)	7 ---	8 (0 - 16)	-13%
St. Louis, MO	103 (72 - 134)	44 (15 - 73)	30 (4 - 55)	44 (20 - 66)	221 ---	207 (152 - 262)	7%
Tacoma, WA	12 (-65 - 82)	0 (-61 - 55)	-5 (-56 - 42)	-5 (-53 - 40)	2 ---	21 (-52 - 92)	-90%

[1]Incidence estimates were calculated using the appropriate season-specific or all-year regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons hospital admissions - all-year hospital admissions)/(all-year hospital admissions).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-23. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	27 (-2 - 55)	26 (-9 - 60)	-34 (-81 - 13)	6 (-24 - 35)	25 --- [4]	41 (-27 - 108)	-39%
Baltimore, MD	106 (74 - 137)	40 (14 - 66)	35 (5 - 64)	44 (21 - 68)	225 ---	214 (157 - 271)	5%
Birmingham, AL	9 (-1 - 19)	10 (-4 - 24)	-14 (-33 - 5)	2 (-9 - 13)	7 ---	16 (-10 - 42)	-56%
Dallas, TX	19 (-1 - 40)	18 (-6 - 43)	-18 (-43 - 7)	3 (-15 - 21)	22 ---	26 (-17 - 68)	-15%
Detroit, MI	119 (83 - 155)	54 (19 - 90)	29 (4 - 54)	44 (20 - 66)	246 ---	225 (165 - 285)	9%
Fresno, CA	15 (-5 - 34)	10 (-5 - 25)	-8 (-34 - 17)	3 (-11 - 18)	20 ---	22 (0 - 44)	-9%
Houston, TX	39 (-3 - 81)	38 (-14 - 90)	-36 (-86 - 14)	8 (-36 - 52)	49 ---	55 (-36 - 145)	-11%
Los Angeles, CA	108 (-37 - 252)	170 (-86 - 419)	-137 (-580 - 291)	37 (-121 - 192)	178 ---	248 (3 - 491)	-28%
New York, NY	342 (239 - 445)	143 (49 - 237)	107 (16 - 197)	129 (61 - 198)	721 ---	684 (502 - 865)	5%
Philadelphia, PA	99 (69 - 129)	35 (12 - 59)	33 (5 - 62)	41 (19 - 63)	208 ---	201 (147 - 254)	3%
Phoenix, AZ	66 (-23 - 154)	80 (-40 - 198)	-48 (-202 - 101)	14 (-47 - 74)	112 ---	113 (1 - 224)	-1%
Pittsburgh, PA	53 (37 - 69)	27 (9 - 45)	25 (4 - 46)	26 (12 - 40)	131 ---	134 (98 - 169)	-2%
Salt Lake City, UT	4 (-1 - 10)	4 (-2 - 11)	-4 (-17 - 9)	1 (-3 - 4)	5 ---	7 (0 - 15)	-29%
St. Louis, MO	74 (52 - 96)	39 (13 - 64)	26 (4 - 48)	36 (17 - 54)	175 ---	171 (126 - 216)	2%
Tacoma, WA	9 (-48 - 60)	0 (-64 - 59)	-6 (-61 - 46)	-4 (-43 - 33)	-1 ---	18 (-44 - 78)	-106%

[1] Incidence estimates were calculated using the appropriate season-specific or all-year regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons hospital admissions - all-year hospital admissions)/(all-year hospital admissions).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-24. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Hospital Admissions for Cardiovascular Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	24 (-2 - 50)	30 (-11 - 70)	-33 (-80 - 13)	5 (-23 - 34)	26 --- [4]	41 (-27 - 109)	-37%
Baltimore, MD	103 (72 - 134)	42 (14 - 70)	35 (5 - 65)	44 (21 - 67)	224 ---	216 (159 - 273)	4%
Birmingham, AL	9 (-1 - 18)	13 (-5 - 31)	-12 (-30 - 5)	2 (-9 - 13)	12 ---	16 (-11 - 43)	-25%
Dallas, TX	23 (-2 - 47)	17 (-6 - 39)	-19 (-46 - 7)	4 (-17 - 25)	25 ---	28 (-18 - 73)	-11%
Detroit, MI	121 (84 - 157)	48 (16 - 79)	28 (4 - 52)	58 (27 - 88)	255 ---	233 (171 - 295)	9%
Fresno, CA	17 (-6 - 40)	10 (-5 - 25)	-6 (-26 - 13)	3 (-11 - 18)	24 ---	23 (0 - 46)	4%
Houston, TX	46 (-3 - 95)	34 (-12 - 79)	-38 (-91 - 15)	9 (-37 - 54)	51 ---	56 (-37 - 149)	-9%
Los Angeles, CA	93 (-31 - 216)	215 (-109 - 531)	-131 (-556 - 279)	42 (-139 - 220)	219 ---	258 (3 - 511)	-15%
New York, NY	377 (263 - 490)	151 (51 - 249)	121 (18 - 223)	143 (67 - 218)	792 ---	752 (552 - 951)	5%
Philadelphia, PA	101 (71 - 131)	39 (13 - 64)	32 (5 - 59)	42 (20 - 64)	214 ---	203 (149 - 257)	5%
Phoenix, AZ	50 (-17 - 117)	78 (-39 - 193)	-54 (-230 - 115)	16 (-52 - 83)	90 ---	108 (1 - 215)	-17%
Pittsburgh, PA	51 (36 - 67)	28 (9 - 46)	25 (4 - 46)	32 (15 - 49)	136 ---	140 (103 - 177)	-3%
Salt Lake City, UT	6 (-2 - 15)	5 (-2 - 12)	-4 (-18 - 9)	1 (-3 - 5)	8 ---	9 (0 - 18)	-11%
St. Louis, MO	80 (56 - 104)	43 (15 - 71)	25 (4 - 47)	37 (17 - 56)	185 ---	178 (131 - 225)	4%
Tacoma, WA	9 (-48 - 60)	0 (-64 - 59)	-4 (-43 - 33)	-6 (-63 - 47)	-1 ---	19 (-46 - 82)	-105%

[1] Incidence estimates were calculated using the appropriate season-specific or all-year regional concentration-response function estimates reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons hospital admissions - all-year hospital admissions)/(all-year hospital admissions).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-25. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	6 (-21 - 31)	9 (-10 - 28)	-6 (-25 - 12)	1 (-13 - 15)	10 --- [4]	17 (-22 - 55)	-41%
Baltimore, MD	18 (-5 - 40)	1 (-14 - 15)	14 (0 - 28)	2 (-12 - 15)	35 ---	20 (-12 - 51)	75%
Birmingham, AL	2 (-7 - 11)	4 (-4 - 11)	-3 (-12 - 6)	1 (-5 - 6)	4 ---	7 (-9 - 23)	-43%
Dallas, TX	4 (-17 - 25)	7 (-8 - 23)	-5 (-21 - 10)	1 (-13 - 16)	7 ---	15 (-18 - 47)	-53%
Detroit, MI	24 (-6 - 53)	1 (-18 - 20)	17 (0 - 35)	2 (-14 - 18)	44 ---	25 (-15 - 64)	76%
Fresno, CA	10 (-1 - 20)	3 (-6 - 11)	4 (-4 - 11)	3 (-5 - 11)	20 ---	14 (3 - 25)	43%
Houston, TX	7 (-27 - 42)	12 (-14 - 38)	-8 (-33 - 16)	3 (-27 - 32)	14 ---	25 (-32 - 81)	-44%
Los Angeles, CA	71 (-6 - 148)	45 (-97 - 183)	86 (-98 - 261)	42 (-60 - 140)	244 ---	170 (40 - 300)	44%
New York, NY	57 (-15 - 129)	2 (-52 - 56)	49 (-1 - 99)	5 (-33 - 42)	113 ---	65 (-38 - 169)	74%
Philadelphia, PA	16 (-4 - 37)	1 (-12 - 12)	12 (0 - 25)	1 (-9 - 12)	30 ---	17 (-10 - 44)	76%
Phoenix, AZ	35 (-3 - 72)	17 (-36 - 68)	23 (-26 - 70)	13 (-18 - 43)	88 ---	61 (14 - 107)	44%
Pittsburgh, PA	8 (-2 - 18)	0 (-10 - 11)	9 (0 - 19)	1 (-9 - 12)	18 ---	13 (-8 - 33)	38%
Salt Lake City, UT	4 (0 - 8)	1 (-2 - 5)	2 (-3 - 7)	1 (-2 - 4)	8 ---	6 (1 - 10)	33%
St. Louis, MO	23 (-6 - 53)	1 (-20 - 21)	15 (0 - 29)	2 (-15 - 19)	41 ---	25 (-15 - 64)	64%
Tacoma, WA	0 (-50 - 43)	4 (-27 - 32)	1 (-19 - 19)	-2 (-24 - 18)	3 ---	2 (-27 - 30)	50%

[1]Incidence estimates were calculated using the appropriate season-specific or all-year regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons hospital admissions - all-year hospital admissions)/(all-year hospital admissions).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-26. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	5 (-19 - 28)	10 (-11 - 30)	-7 (-30 - 14)	1 (-11 - 13)	9 --- [4]	17 (-22 - 56)	-47%
Baltimore, MD	15 (-4 - 33)	1 (-12 - 13)	12 (0 - 24)	2 (-11 - 14)	30 ---	17 (-10 - 44)	76%
Birmingham, AL	2 (-6 - 10)	4 (-4 - 12)	-3 (-12 - 6)	0 (-4 - 5)	3 ---	7 (-8 - 22)	-57%
Dallas, TX	4 (-13 - 20)	7 (-8 - 22)	-4 (-18 - 9)	1 (-10 - 12)	8 ---	12 (-15 - 40)	-33%
Detroit, MI	18 (-5 - 41)	1 (-19 - 20)	13 (0 - 25)	2 (-11 - 13)	34 ---	20 (-12 - 52)	70%
Fresno, CA	11 (-1 - 22)	3 (-5 - 10)	5 (-5 - 14)	3 (-5 - 12)	22 ---	15 (3 - 26)	47%
Houston, TX	7 (-24 - 37)	14 (-15 - 42)	-8 (-34 - 17)	3 (-24 - 28)	16 ---	25 (-31 - 79)	-36%
Los Angeles, CA	75 (-6 - 155)	40 (-85 - 160)	82 (-93 - 248)	37 (-53 - 124)	234 ---	160 (37 - 281)	46%
New York, NY	50 (-13 - 113)	2 (-46 - 50)	40 (-1 - 81)	4 (-30 - 38)	96 ---	56 (-33 - 145)	71%
Philadelphia, PA	14 (-4 - 31)	0 (-11 - 12)	12 (0 - 23)	1 (-10 - 13)	27 ---	16 (-9 - 41)	69%
Phoenix, AZ	40 (-3 - 82)	17 (-35 - 67)	24 (-27 - 72)	13 (-18 - 43)	94 ---	64 (15 - 112)	47%
Pittsburgh, PA	7 (-2 - 16)	0 (-9 - 10)	8 (0 - 17)	1 (-7 - 8)	16 ---	11 (-6 - 28)	45%
Salt Lake City, UT	3 (0 - 6)	1 (-3 - 5)	3 (-3 - 8)	1 (-1 - 3)	8 ---	5 (1 - 9)	60%
St. Louis, MO	17 (-5 - 38)	1 (-17 - 18)	13 (0 - 26)	2 (-13 - 16)	33 ---	21 (-12 - 53)	57%
Tacoma, WA	0 (-37 - 31)	4 (-29 - 34)	1 (-21 - 20)	-1 (-20 - 15)	4 ---	2 (-23 - 25)	100%

[1]Incidence estimates were calculated using the appropriate season-specific or all-year regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons hospital admissions - all-year hospital admissions)/(all-year hospital admissions).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-27. Sensitivity Analysis: Impact of Using Season-Specific Concentration-Response Functions vs. an Annual Concentration-Response Function to Estimate the Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1, 2]

Risk Assessment Location	Estimated Incidence of Hospital Admissions for Respiratory Illness Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards						Percent Difference [3]
	Winter	Spring	Summer	Fall	Sum of Four Seasons	All Year	
Atlanta, GA	5 (-17 - 26)	11 (-13 - 35)	-7 (-29 - 14)	1 (-11 - 13)	10 --- [4]	18 (-22 - 57)	-44%
Baltimore, MD	14 (-4 - 32)	1 (-13 - 14)	12 (0 - 25)	2 (-11 - 14)	29 ---	17 (-10 - 45)	71%
Birmingham, AL	2 (-6 - 9)	5 (-6 - 16)	-3 (-11 - 5)	0 (-4 - 5)	4 ---	7 (-9 - 22)	-43%
Dallas, TX	4 (-16 - 24)	6 (-7 - 20)	-5 (-19 - 10)	1 (-12 - 14)	6 ---	13 (-17 - 43)	-54%
Detroit, MI	19 (-5 - 42)	1 (-16 - 18)	12 (0 - 25)	2 (-14 - 18)	34 ---	21 (-12 - 54)	62%
Fresno, CA	13 (-1 - 26)	2 (-5 - 10)	3 (-4 - 11)	4 (-5 - 12)	22 ---	15 (4 - 27)	47%
Houston, TX	8 (-28 - 43)	12 (-14 - 38)	-9 (-36 - 18)	3 (-25 - 29)	14 ---	25 (-32 - 82)	-44%
Los Angeles, CA	64 (-5 - 133)	50 (-108 - 203)	78 (-89 - 239)	42 (-61 - 142)	234 ---	166 (39 - 293)	41%
New York, NY	55 (-15 - 124)	2 (-48 - 52)	46 (-1 - 91)	5 (-33 - 42)	108 ---	62 (-37 - 160)	74%
Philadelphia, PA	14 (-4 - 32)	1 (-12 - 13)	11 (0 - 22)	1 (-10 - 13)	27 ---	16 (-10 - 42)	69%
Phoenix, AZ	30 (-3 - 63)	16 (-34 - 65)	27 (-31 - 82)	14 (-20 - 48)	87 ---	61 (14 - 108)	43%
Pittsburgh, PA	7 (-2 - 16)	0 (-9 - 10)	8 (0 - 17)	1 (-8 - 10)	16 ---	11 (-7 - 29)	45%
Salt Lake City, UT	5 (0 - 9)	1 (-3 - 5)	3 (-3 - 9)	1 (-2 - 4)	10 ---	7 (2 - 12)	43%
St. Louis, MO	18 (-5 - 41)	1 (-19 - 21)	12 (0 - 25)	2 (-13 - 17)	33 ---	21 (-13 - 55)	57%
Tacoma, WA	0 (-37 - 31)	4 (-29 - 34)	1 (-15 - 15)	-2 (-29 - 22)	3 ---	2 (-24 - 27)	50%

[1]Incidence estimates were calculated using the appropriate season-specific or all-year regional concentration-response function estimates from models with a 2-day lag for respiratory hospital admissions reported in Table 2 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (sum-of-4-seasons hospital admissions - all-year hospital admissions)/(all-year hospital admissions).

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-28. Sensitivity Analysis: Impact of Using an Annual Concentration-Response Function vs. a Seasonal Function (for April - August) Applied Only to that Period to Estimate the Incidence of Emergency Room Visits for Asthma Associated with Short-Term Exposure to Concentrations in a Recent Year (2005) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards in New York City, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Concentration-Response (C-R) Function and Period to Which Applied:	Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
	Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Annual C-R Function Applied to the Whole Year	5235 (3346 - 7071)	4375 (2790 - 5923)	4375 (2790 - 5923)	4265 (2719 - 5776)	3927 (2501 - 5323)	3754 (2390 - 5091)	3127 (1987 - 4248)
Seasonal C-R Function for April - August Applied Only to that Period:	3136 (2058 - 4162)	2634 (1722 - 3509)	2634 (1722 - 3509)	2569 (1678 - 3425)	2370 (1546 - 3164)	2268 (1478 - 3031)	1896 (1232 - 2541)

[1]Based on Ito et al. (2007). New York City in this study consisted only of Manhattan. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table F-29. Sensitivity Analysis: Impact of Using an Annual Concentration-Response Function vs. a Seasonal Function (for April - August) Applied Only to that Period to Estimate the Incidence of Emergency Room Visits for Asthma Associated with Short-Term Exposure to Concentrations in a Recent Year (2006) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards in New York City, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Concentration-Response (C-R) Function and Period to Which Applied:	Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and PM Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
	Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Annual C-R Function Applied to the Whole Year	4506 (2876 - 6095)	3764 (2397 - 5102)	3764 (2397 - 5102)	3669 (2336 - 4974)	3377 (2149 - 4582)	3228 (2053 - 4382)	2688 (1707 - 365
Seasonal C-R Function for April - August Applied Only to that Period:	2732 (1791 - 3631)	2293 (1497 - 3059)	2293 (1497 - 3059)	2237 (1460 - 2985)	2063 (1344 - 2757)	1974 (1285 - 2640)	1649 (1071 - 22

[1]Based on Ito et al. (2007). New York City in this study consisted only of Manhattan. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table F-30. Sensitivity Analysis: Impact of Using an Annual Concentration-Response Function vs. a Seasonal Function (for April - August) Applied Only to that Period to Estimate the Incidence of Emergency Room Visits for Asthma Associated with Short-Term Exposure to Concentrations in a Recent Year (2007) and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards in New York City, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Concentration-Response (C-R) Function and Period to Which Applied:	Incidence of ER Visits Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations in a Recent Year and $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):						
	Recent $PM_{2.5}$ Concentrations	15/35[2]	14/35	13/35	12/35	13/30	12/25
Annual C-R Function Applied to the Whole Year	4926 (3145 - 6660)	4115 (2622 - 5575)	4115 (2622 - 5575)	4011 (2555 - 5436)	3692 (2350 - 5008)	3529 (2245 - 4790)	2939 (1867 - 3995)
Seasonal C-R Function for April - August Applied Only to that Period:	2908 (1906 - 3864)	2441 (1593 - 3256)	2441 (1593 - 3256)	2380 (1553 - 3177)	2195 (1431 - 2934)	2101 (1368 - 2810)	1755 (1140 - 2354)

[1]Based on Ito et al. (2007). New York City in this study consisted only of Manhattan. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

Table F-31. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Lag Structure:							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	0 day	none	275 (-35 - 584)	Max. positive est. = 301	81 (-117 - 278)	240%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	none	301 (0 - 600)	Min. positive est. = 194		272%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	2 day	none	194 (-97 - 483)	**Percent diff. = 55%**		140%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	3 day	none	-77 (-373 - 218)			-195%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	4 day	none	-46 (-329 - 235)			-157%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	5 day	none	-287 (-592 - 15)			-454%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	0 day	none	275 (-35 - 584)	Max. positive est. = 275	81 (-117 - 278)	240%
Mortality, short-term non-accidental	log-linear, GLM, 30 df	0 day	none	204 (-174 - 579)	Min. positive est. = 153		152%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	0 day	none	163 (-115 - 441)	**Percent diff. = 80%**		101%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	0 day	none	153 (-218 - 522)			89%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	none	301 (0 - 600)	Max. positive est. = 301	81 (-117 - 278)	272%
Mortality, short-term non-accidental	log-linear, GLM, 30 df	1 day	none	281 (-86 - 644)	Min. positive est. = 51		247%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	1 day	none	51 (-236 - 336)	**Percent diff. = 490%**		-37%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	1 day	none	-5 (-509 - 494)			-106%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	CO	-272 (-676 - 128)		81 (-117 - 278)	-436%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	1 day	CO	-169 (-540 - 198)			-309%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	1 day	CO	-169 (-603 - 260)			-309%

Table F-31 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 30 df	0 day	none	171 (17 - 324)	Max. positive est. = 171	-31 (-140 - 76)	111%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	0 day	none	168 (24 - 310)	Min. positive est. = 168		107%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	0 day	none	168 (-4 - 337)	**Percent diff. = 2%**		107%
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 30 df	1 day	none	178 (26 - 328)	Max. positive est. = 178	-31 (-140 - 76)	120%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	1 day	none	139 (-6 - 282)	Min. positive est. = 120		72%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	1 day	none	120 (-56 - 293)	**Percent diff. = 48%**		48%
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	0 day	CO	307 (130 - 481)	Max. positive est. = 324	-31 (-140 - 76)	279%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	0 day	CO	324 (116 - 529)	Min. positive est. = 158		300%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	1 day	CO	158 (-22 - 335)	**Percent diff. = 105%**		95%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	1 day	CO	158 (-60 - 372)			95%
Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 30 df	0 day	none	-15 (-80 - 49)		--- [5]	---
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	none	-37 (-102 - 25)			---
Mortality, short-term respiratory (COPD+)	log-linear, GLM, 100 df	0 day	none	-32 (-109 - 43)			---
Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 30 df	1 day	none	10 (-56 - 74)	Max. positive est. = 22	---	---
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	none	22 (-42 - 85)	Min. positive est. = 5		---
Mortality, short-term respiratory (COPD+)	log-linear, GLM, 100 df	1 day	none	5 (-75 - 83)	**Percent diff. = 340%**		---

Table F-31 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
HA, cardiovascular	log-linear, GAM (stringent), 30 df	0 day	none	794 (457 - 1128)	Max. positive est. = 794	35 (-60 - 130)	880%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	0 day	none	584 (254 - 912)	Min. positive est. = 584		621%
HA, cardiovascular	log-linear, GLM, 100 df	0 day	none	634 (226 - 1038)	**Percent diff. = 36%**		683%
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
HA, cardiovascular	log-linear, GAM (stringent), 30 df	1 day	none	699 (347 - 1048)	Max. positive est. = 699	35 (-60 - 130)	763%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	1 day	none	569 (234 - 902)	Min. positive est. = 569		602%
HA, cardiovascular	log-linear, GLM, 100 df	1 day	none	604 (194 - 1011)	**Percent diff. = 23%**		646%
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
HA, cardiovascular	log-linear, GAM (stringent), 100 df	0 day	CO	197 (-224 - 615)	Max. positive est. = 293	35 (-60 - 130)	143%
HA, cardiovascular	log-linear, GLM, 100 df	0 day	CO	293 (-208 - 788)	Min. positive est. = 122		262%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	1 day	CO	122 (-330 - 568)	**Percent diff. = 140%**		51%
HA, cardiovascular	log-linear, GLM, 100 df	1 day	CO	137 (-381 - 648)			69%
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	0 day	none	336 (138 - 531)	Max. positive est. = 336	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	none	278 (104 - 450)	Min. positive est. = 278		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	0 day	none	300 (83 - 514)	**Percent diff. = 21%**		---
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	1 day	none	240 (45 - 432)	Max. positive est. = 240	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	none	152 (-22 - 324)	Min. positive est. = 152		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	1 day	none	156 (-55 - 364)	**Percent diff. = 58%**		---

Table F-31 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 2-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	2 day	none	371 (166 - 574)	Max. positive est. = 371	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	2 day	none	230 (43 - 414)	Min. positive est. = 208		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	2 day	none	208 (-24 - 436)	**Percent diff. = 78%**		---
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Lag Structure, with a Copollutant Model							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	NO2	85 (-185 - 351)	Max. positive est. = 85	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	NO2	-8 (-329 - 307)	Min. positive est. = 71		---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	2 day	NO2	71 (-209 - 346)	**Percent diff. = 20%**		---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	3 day	NO2	-223 (-491 - 41)			---

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3. Results are based on Moolgavkar (2003) [reanalysis of Moolgavkar (2000a, 2000b, and 2000c)]. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The core analysis estimates for non-accidental mortality and cardiovascular mortality associated with short-term exposure to PM2.5 are from Zanobetti and Schwartz (2009). The core analysis estimates for cardiovascular hospital admissions associated with short-term exposure to PM2.5 are from Bell et al. (2008).

[3]Calculated as (maximum positive estimate - minimum positive estimate)/(minimum positive estimate).

[4]Calculated as (Moolgavkar (2003) estimate - core analysis estimate)/(core analysis estimate).

[5]Because "respiratory illness" was much more broadly defined in both Zanobetti and Schwartz (2009) and Bell et al. (2008) than in Moolgavkar (2003), a comparison between the Moolgavkar (2003) estimates and the corresponding core analysis estimates is not shown.

Table F-32. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Lag Structure:							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	0 day	none	254 (-32 - 539)	Max. positive est. = 278 Min. positive est. = 179 **Percent diff. = 55%**	75 (-108 - 257)	239%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	none	278 (0 - 554)			271%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	2 day	none	179 (-89 - 445)			139%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	3 day	none	-71 (-344 - 201)			-195%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	4 day	none	-42 (-304 - 217)			-156%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	5 day	none	-265 (-546 - 14)			-453%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	0 day	none	254 (-32 - 539)	Max. positive est. = 254 Min. positive est. = 141 **Percent diff. = 80%**	75 (-108 - 257)	239%
Mortality, short-term non-accidental	log-linear, GLM, 30 df	0 day	none	188 (-161 - 535)			151%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	0 day	none	151 (-106 - 407)			101%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	0 day	none	141 (-201 - 482)			88%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	none	278 (0 - 554)	Max. positive est. = 278 Min. positive est. = 47 **Percent diff. = 491%**	75 (-108 - 257)	271%
Mortality, short-term non-accidental	log-linear, GLM, 30 df	1 day	none	259 (-80 - 595)			245%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	1 day	none	47 (-218 - 310)			-37%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	1 day	none	-5 (-469 - 455)			-107%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	CO	-251 (-623 - 118)		75 (-108 - 257)	-435%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	1 day	CO	-156 (-497 - 183)			-308%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	1 day	CO	-156 (-555 - 240)			-308%

Table F-32 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 30 df	0 day	none	158 (15 - 299)	Max. positive est. = 158	-29 (-129 - 70)	111%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	0 day	none	155 (22 - 286)	Min. positive est. = 155		107%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	0 day	none	155 (-3 - 311)	**Percent diff. = 2%**		107%
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 30 df	1 day	none	164 (24 - 303)	Max. positive est. = 164	-29 (-129 - 70)	119%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	1 day	none	128 (-5 - 260)	Min. positive est. = 110		71%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	1 day	none	110 (-51 - 270)	**Percent diff. = 49%**		47%
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	0 day	CO	283 (120 - 444)	Max. positive est. = 299	-29 (-129 - 70)	277%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	0 day	CO	299 (107 - 489)	Min. positive est. = 145		299%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	1 day	CO	145 (-20 - 309)	**Percent diff. = 106%**		93%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	1 day	CO	145 (-56 - 344)			93%
Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 30 df	0 day	none	-14 (-74 - 45)		---[5]	---
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	none	-35 (-94 - 23)			---
Mortality, short-term respiratory (COPD+)	log-linear, GLM, 100 df	0 day	none	-29 (-100 - 39)			---
Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 30 df	1 day	none	9 (-51 - 68)	Max. positive est. = 21	---	---
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	none	21 (-39 - 78)	Min. positive est. = 5		---
Mortality, short-term respiratory (COPD+)	log-linear, GLM, 100 df	1 day	none	5 (-69 - 76)	**Percent diff. = 320%**		---

Table F-32 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
HA, cardiovascular	log-linear, GAM (stringent), 30 df	0 day	none	745 (428 - 1060)	Max. positive est. = 745	248 (3 - 491)	893%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	0 day	none	548 (238 - 856)	Min. positive est. = 548		631%
HA, cardiovascular	log-linear, GLM, 100 df	0 day	none	595 (212 - 975)	**Percent diff. = 36%**		693%
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
HA, cardiovascular	log-linear, GAM (stringent), 30 df	1 day	none	656 (326 - 984)	Max. positive est. = 656	248 (3 - 491)	775%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	1 day	none	534 (220 - 847)	Min. positive est. = 534		612%
HA, cardiovascular	log-linear, GLM, 100 df	1 day	none	567 (182 - 949)	**Percent diff. = 23%**		656%
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
HA, cardiovascular	log-linear, GAM (stringent), 100 df	0 day	CO	185 (-210 - 577)	Max. positive est. = 275	248 (3 - 491)	147%
HA, cardiovascular	log-linear, GLM, 100 df	0 day	CO	275 (-195 - 740)	Min. positive est. = 114		267%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	1 day	CO	114 (-309 - 533)	**Percent diff. = 141%**		52%
HA, cardiovascular	log-linear, GLM, 100 df	1 day	CO	128 (-357 - 608)			71%
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	0 day	none	310 (127 - 491)	Max. positive est. = 310	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	none	256 (96 - 415)	Min. positive est. = 256		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	0 day	none	277 (76 - 475)	**Percent diff. = 21%**		---
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	1 day	none	221 (42 - 399)	Max. positive est. = 221	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	none	140 (-21 - 299)	Min. positive est. = 140		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	1 day	none	144 (-51 - 336)	**Percent diff. = 58%**		---

Table F-32 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 2-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	2 day	none	343 (153 - 531)	Max. positive est. = 343	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	2 day	none	212 (40 - 383)	Min. positive est. = 192		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	2 day	none	192 (-22 - 403)	**Percent diff. = 79%**		---
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Lag Structure, with a Copollutant Model							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	NO2	78 (-171 - 324)	Max. positive est. = 78	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	NO2	-7 (-303 - 284)	Min. positive est. = 65		---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	2 day	NO2	65 (-192 - 319)	**Percent diff. = 20%**		---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	3 day	NO2	-205 (-452 - 38)			---

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3. Results are based on Moolgavkar (2003) [reanalysis of Moolgavkar (2000a, 2000b, and 2000c)].

[2]The core analysis estimates for non-accidental mortality and cardiovascular mortality associated with short-term exposure to PM2.5 are from Zanobetti and Schwartz (2009). The core analysis estimates for cardiovascular hospital admissions associated with short-term exposure to PM2.5 are from Bell et al. (2008). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Calculated as (maximum positive estimate - minimum positive estimate)/(minimum positive estimate).

[4]Calculated as (Moolgavkar (2003) estimate - core analysis estimate)/(core analysis estimate).

[5]Because "respiratory illness" was much more broadly defined in both Zanobetti and Schwartz (2009) and Bell et al. (2008) than in Moolgavkar (2003), a comparison between the Moolgavkar (2003) estimates and the corresponding core analysis estimates is not shown.

Table F-33. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Lag Structure:							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	0 day	none	259 (-33 - 550)	Max. positive est. = 283	77 (-110 - 262)	236%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	none	283 (0 - 565)	Min. positive est. = 183		268%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	2 day	none	183 (-91 - 455)	**Percent diff. = 55%**		138%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	3 day	none	-72 (-351 - 205)			-194%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	4 day	none	-43 (-310 - 222)			-156%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	5 day	none	-271 (-558 - 14)			-452%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	0 day	none	259 (-33 - 550)	Max. positive est. = 259	77 (-110 - 262)	236%
Mortality, short-term non-accidental	log-linear, GLM, 30 df	0 day	none	192 (-164 - 546)	Min. positive est. = 144		149%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	0 day	none	154 (-109 - 415)	**Percent diff. = 80%**		100%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	0 day	none	144 (-206 - 492)			87%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	none	283 (0 - 565)	Max. positive est. = 283	77 (-110 - 262)	268%
Mortality, short-term non-accidental	log-linear, GLM, 30 df	1 day	none	264 (-81 - 607)	Min. positive est. = 48		243%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	1 day	none	48 (-222 - 317)	**Percent diff. = 490%**		-38%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	1 day	none	-5 (-480 - 465)			-106%
Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
Mortality, short-term non-accidental	log-linear, GAM (stringent), 30 df	1 day	CO	-256 (-636 - 121)		77 (-110 - 262)	-432%
Mortality, short-term non-accidental	log-linear, GAM (stringent), 100 df	1 day	CO	-159 (-508 - 187)			-306%
Mortality, short-term non-accidental	log-linear, GLM, 100 df	1 day	CO	-159 (-567 - 245)			-306%

Table F-33 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 30 df	0 day	none	161 (16 - 306)	Max. positive est. = 161	-30 (-132 - 72)	109%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	0 day	none	158 (23 - 292)	Min. positive est. = 158		105%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	0 day	none	158 (-3 - 318)	**Percent diff. = 2%**		105%
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 30 df	1 day	none	168 (25 - 309)	Max. positive est. = 168	-30 (-132 - 72)	118%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	1 day	none	130 (-6 - 265)	Min. positive est. = 113		69%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	1 day	none	113 (-52 - 276)	**Percent diff. = 49%**		47%
Cardiovascular Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	0 day	CO	289 (123 - 453)	Max. positive est. = 305	-30 (-132 - 72)	275%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	0 day	CO	305 (109 - 498)	Min. positive est. = 148		296%
Mortality, short-term cardiovascular	log-linear, GAM (stringent), 100 df	1 day	CO	148 (-21 - 316)	**Percent diff. = 106%**		92%
Mortality, short-term cardiovascular	log-linear, GLM, 100 df	1 day	CO	148 (-57 - 351)			92%
Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 30 df	0 day	none	-14 (-75 - 46)		--- [5]	---
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	none	-35 (-96 - 24)			---
Mortality, short-term respiratory (COPD+)	log-linear, GLM, 100 df	0 day	none	-30 (-103 - 40)			---
Respiratory Mortality Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 30 df	1 day	none	9 (-52 - 70)	Max. positive est. = 21	---	---
Mortality, short-term respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	none	21 (-39 - 80)	Min. positive est. = 5		---
Mortality, short-term respiratory (COPD+)	log-linear, GLM, 100 df	1 day	none	5 (-71 - 78)	**Percent diff. = 320%**		---

Table F-33 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
HA, cardiovascular	log-linear, GAM (stringent), 30 df	0 day	none	775 (446 - 1102)	Max. positive est. = 775	258 (3 - 511)	906%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	0 day	none	570 (248 - 890)	Min. positive est. = 570		640%
HA, cardiovascular	log-linear, GLM, 100 df	0 day	none	619 (221 - 1014)	**Percent diff. = 36%**		704%
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
HA, cardiovascular	log-linear, GAM (stringent), 30 df	1 day	none	682 (339 - 1023)	Max. positive est. = 682	258 (3 - 511)	786%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	1 day	none	556 (228 - 880)	Min. positive est. = 556		622%
HA, cardiovascular	log-linear, GLM, 100 df	1 day	none	590 (189 - 987)	**Percent diff. = 23%**		666%
Cardiovascular Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of a Copollutant Model							
HA, cardiovascular	log-linear, GAM (stringent), 100 df	0 day	CO	193 (-219 - 600)	Max. positive est. = 286	258 (3 - 511)	151%
HA, cardiovascular	log-linear, GLM, 100 df	0 day	CO	286 (-203 - 769)	Min. positive est. = 119		271%
HA, cardiovascular	log-linear, GAM (stringent), 100 df	1 day	CO	119 (-321 - 554)	**Percent diff. = 140%**		55%
HA, cardiovascular	log-linear, GLM, 100 df	1 day	CO	133 (-371 - 633)			73%
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 0-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	0 day	none	316 (130 - 501)	Max. positive est. = 316	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	none	262 (98 - 424)	Min. positive est. = 262		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	0 day	none	282 (78 - 485)	**Percent diff. = 21%**		---
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 1-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	1 day	none	226 (42 - 407)	Max. positive est. = 226	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	none	143 (-21 - 305)	Min. positive est. = 143		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	1 day	none	146 (-52 - 343)	**Percent diff. = 58%**		---

Table F-33 cont'd. Sensitivity Analysis: Estimated Annual Incidence and Percent of Total Incidence of Mortality in Los Angeles, CA Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Health Effects	Model	Lag	Other Pollutants in Model	Incidence Associated with $PM_{2.5}$ Above Policy Relevant Background	Range of Positive Estimates and Percent Difference Between Maximum and Minimum [2]	Incidence Estimate Using Core Analysis Model [3]	Percent Difference (Compared to Core Analysis Model) [4]
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Type of Model, with a 2-Day Lag							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 30 df	2 day	none	350 (156 - 541)	Max. positive est. = 350	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	2 day	none	216 (41 - 391)	Min. positive est. = 196		---
HA, respiratory (COPD+)	log-linear, GLM, 100 df	2 day	none	196 (-22 - 411)	**Percent diff. = 79%**		---
Respiratory Hospital Admissions Associated with Short-Term Exposure to $PM_{2.5}$ -- Impact of Changing the Lag Structure, with a Copollutant Model							
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	0 day	NO2	80 (-174 - 331)	Max. positive est. = 80	---	---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	1 day	NO2	-8 (-310 - 290)	Min. positive est. = 67		---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	2 day	NO2	67 (-196 - 326)	**Percent diff. = 19%**		---
HA, respiratory (COPD+)	log-linear, GAM (stringent), 100 df	3 day	NO2	-209 (-462 - 39)			---

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3. Results are based on Moolgavkar (2003) [reanalysis of Moolgavkar (2000a, 2000b, and 2000c)]. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The core analysis estimates for non-accidental mortality and cardiovascular mortality associated with short-term exposure to PM2.5 are from Zanobetti and Schwartz (2009). The core analysis estimates for cardiovascular hospital admissions associated with short-term exposure to PM2.5 are from Bell et al. (2008).

[3]Calculated as (maximum positive estimate - minimum positive estimate)/(minimum positive estimate).

[4]Calculated as (Moolgavkar (2003) estimate - core analysis estimate)/(core analysis estimate).

[5]Because "respiratory illness" was much more broadly defined in both Zanobetti and Schwartz (2009) and Bell et al. (2008) than in Moolgavkar (2003), a comparison between the Moolgavkar (2003) estimates and the corresponding core analysis estimates is not shown.

Table F-34. Sensitivity Analysis: Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations: Comparison of Proportional and Hybrid Rollback Methods[1]

Risk Assessment Location	Type of Rollback	Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Combinations of Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
		15/35 [2]	14/35	13/35	12/35	13/30	12/25
Baltimore, MD	Proportional	256 (104 - 406)	242 (98 - 384)	224 (91 - 356)	206 (83 - 327)	219 (89 - 348)	182 (74 - 289)
	Hybrid	254 (103 - 402)	248 (101 - 393)	229 (93 - 364)	211 (86 - 335)	217 (88 - 344)	180 (73 - 286)
	Percent Difference [3]	-1%	2%	2%	2%	-1%	-1%
Birmingham, AL	Proportional	34 (-53 - 121)	32 (-49 - 112)	29 (-45 - 103)	27 (-41 - 94)	29 (-45 - 103)	24 (-38 - 85)
	Hybrid	39 (-61 - 137)	36 (-56 - 127)	33 (-52 - 117)	30 (-47 - 107)	33 (-52 - 117)	28 (-44 - 99)
	Percent Difference	15%	13%	14%	11%	14%	17%
Detroit, MI	Proportional	147 (-26 - 317)	146 (-26 - 315)	135 (-24 - 291)	124 (-22 - 267)	125 (-22 - 271)	104 (-18 - 225)
	Hybrid	151 (-26 - 325)	151 (-26 - 325)	148 (-26 - 319)	136 (-24 - 293)	129 (-23 - 278)	107 (-19 - 231)
	Percent Difference	3%	3%	10%	10%	3%	3%
Los Angeles, CA	Proportional	81 (-117 - 278)	81 (-117 - 278)	81 (-117 - 278)	77 (-110 - 263)	69 (-100 - 238)	58 (-82 - 197)
	Hybrid	91 (-130 - 311)	91 (-130 - 311)	89 (-127 - 304)	81 (-117 - 279)	78 (-111 - 266)	64 (-92 - 220)
	Percent Difference	12%	12%	10%	5%	13%	10%
New York, NY	Proportional	781 (459 - 1102)	781 (459 - 1102)	761 (447 - 1073)	700 (411 - 987)	668 (392 - 943)	555 (325 - 783)
	Hybrid	795 (467 - 1121)	795 (467 - 1121)	761 (446 - 1073)	699 (410 - 986)	680 (399 - 959)	564 (331 - 797)
	Percent Difference	2%	2%	0%	0%	2%	2%
St. Louis, MO	Proportional	260 (75 - 443)	244 (71 - 416)	226 (65 - 385)	207 (60 - 354)	222 (64 - 379)	184 (53 - 315)
	Hybrid	271 (78 - 462)	252 (73 - 429)	233 (67 - 397)	214 (62 - 365)	233 (67 - 397)	195 (56 - 332)
	Percent Difference	4%	3%	3%	3%	5%	6%

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality based on hybrid rollbacks - mortality based on proportional rollbacks)/(mortality based on proportional rollbacks).

Table F-35. Sensitivity Analysis: Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations: Comparison of Proportional and Hybrid Rollback Methods[1]

Risk Assessment Location	Type of Rollback	Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Combinations of Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
		15/35 [2]	14/35	13/35	12/35	13/30	12/25
Baltimore, MD	Proportional	224 (91 - 356)	212 (86 - 336)	196 (79 - 311)	180 (73 - 286)	192 (78 - 305)	159 (64 - 253)
	Hybrid	222 (90 - 352)	217 (88 - 344)	200 (81 - 318)	184 (75 - 293)	190 (77 - 301)	157 (64 - 250)
	Percent Difference [3]	-1%	2%	2%	2%	-1%	-1%
Birmingham, AL	Proportional	33 (-51 - 116)	30 (-47 - 108)	28 (-44 - 99)	26 (-40 - 90)	28 (-44 - 99)	23 (-36 - 82)
	Hybrid	37 (-58 - 132)	35 (-54 - 122)	32 (-49 - 112)	29 (-45 - 102)	32 (-49 - 112)	27 (-42 - 95)
	Percent Difference	12%	17%	14%	12%	14%	17%
Detroit, MI	Proportional	118 (-21 - 255)	117 (-20 - 253)	108 (-19 - 234)	99 (-17 - 215)	101 (-18 - 218)	83 (-15 - 181)
	Hybrid	121 (-21 - 261)	121 (-21 - 261)	118 (-21 - 256)	109 (-19 - 235)	103 (-18 - 223)	85 (-15 - 185)
	Percent Difference	3%	3%	9%	10%	2%	2%
Los Angeles, CA	Proportional	75 (-108 - 257)	75 (-108 - 257)	75 (-108 - 257)	71 (-101 - 242)	64 (-92 - 219)	53 (-76 - 182)
	Hybrid	84 (-120 - 287)	84 (-120 - 287)	82 (-117 - 280)	75 (-108 - 257)	72 (-102 - 245)	59 (-85 - 203)
	Percent Difference	12%	12%	9%	6%	13%	11%
New York, NY	Proportional	671 (394 - 946)	671 (394 - 946)	654 (383 - 922)	601 (352 - 847)	574 (336 - 809)	476 (279 - 672)
	Hybrid	682 (400 - 961)	682 (400 - 961)	652 (383 - 920)	599 (352 - 846)	583 (342 - 822)	484 (284 - 683)
	Percent Difference	2%	2%	0%	0%	2%	2%
St. Louis, MO	Proportional	215 (62 - 367)	202 (58 - 345)	187 (54 - 319)	171 (49 - 293)	184 (53 - 314)	152 (44 - 260)
	Hybrid	224 (64 - 381)	208 (60 - 354)	192 (55 - 328)	176 (51 - 301)	192 (55 - 328)	160 (46 - 274)
	Percent Difference	4%	3%	3%	3%	4%	5%

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality based on hybrid rollbacks - mortality based on proportional rollbacks)/(mortality based on proportional rollbacks).

Table F-36. Sensitivity Analysis: Estimated Annual Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations: Comparison of Proportional and Hybrid Rollback Methods[1]

Risk Assessment Location	Type of Rollback	Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current and Alternative Combinations of Annual (n) and Daily (m) Standards (Standard Combination Denoted n/m):					
		15/35 [2]	14/35	13/35	12/35	13/30	12/25
Baltimore, MD	Proportional	227 (92 - 360)	214 (87 - 340)	198 (80 - 315)	182 (74 - 289)	194 (79 - 308)	161 (65 - 256)
	Hybrid	224 (91 - 356)	219 (89 - 348)	203 (82 - 322)	186 (75 - 296)	192 (78 - 304)	159 (64 - 253)
	Percent Difference [3]	-1%	2%	3%	2%	-1%	-1%
Birmingham, AL	Proportional	34 (-53 - 120)	32 (-49 - 111)	29 (-45 - 102)	26 (-41 - 93)	29 (-45 - 102)	24 (-37 - 85)
	Hybrid	39 (-60 - 137)	36 (-56 - 127)	33 (-51 - 116)	30 (-47 - 106)	33 (-51 - 116)	28 (-43 - 99)
	Percent Difference	15%	13%	14%	15%	14%	17%
Detroit, MI	Proportional	121 (-21 - 262)	120 (-21 - 261)	111 (-19 - 241)	102 (-18 - 221)	104 (-18 - 224)	86 (-15 - 186)
	Hybrid	124 (-22 - 269)	124 (-22 - 269)	122 (-21 - 264)	112 (-20 - 242)	106 (-19 - 230)	88 (-15 - 191)
	Percent Difference	2%	3%	10%	10%	2%	2%
Los Angeles, CA	Proportional	77 (-110 - 262)	77 (-110 - 262)	77 (-110 - 262)	72 (-104 - 247)	65 (-94 - 224)	54 (-78 - 186)
	Hybrid	86 (-123 - 293)	86 (-123 - 293)	83 (-120 - 286)	77 (-110 - 262)	73 (-105 - 250)	61 (-87 - 207)
	Percent Difference	12%	12%	8%	7%	12%	13%
New York, NY	Proportional	734 (431 - 1035)	734 (431 - 1035)	715 (419 - 1008)	657 (385 - 927)	627 (368 - 885)	521 (305 - 735)
	Hybrid	746 (438 - 1052)	746 (438 - 1052)	714 (419 - 1007)	656 (385 - 926)	638 (374 - 900)	530 (310 - 748)
	Percent Difference	2%	2%	0%	0%	2%	2%
St. Louis, MO	Proportional	225 (65 - 384)	211 (61 - 360)	195 (56 - 333)	179 (52 - 306)	192 (55 - 328)	160 (46 - 272)
	Hybrid	236 (68 - 402)	219 (63 - 374)	203 (59 - 346)	186 (54 - 318)	203 (59 - 346)	169 (49 - 289)
	Percent Difference	5%	4%	4%	4%	6%	6%

[1]Based on location-specific single pollutant concentration-response function estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. "Shrunken" coefficient estimates and their standard errors were sent to EPA by A. Zanobetti via email. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Calculated as (mortality based on hybrid rollbacks - mortality based on proportional rollbacks)/(mortality based on proportional rollbacks).

Table F-37. Multi-Factor Sensitivity Analysis: Impact of Using a Log-Linear vs. a Log-Log Model, Estimating Incidence Down to the Lowest Measured Level (LML) in the Study vs. PRB, and Using a Proportional vs. a Hybrid Rollback to Estimate the Incidence of All Cause and Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1]

Modeling Choices:	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]							
Fixed Effects (FE) Log-linear vs. Random Effects (RE) log-log model	FE Log-Linear	FE Log-Linear	FE Log-Linear	FE Log-Linear	RE Log-Log	RE Log-Log	RE Log-Log	RE Log-Log
Down to LML (5.8 ug/m^3) vs. PRB	LML	LML	PRB	PRB	LML	LML	PRB	PRB
Proportional vs. hybrid rollback	Proportional	Hybrid	Proportional	Hybrid	Proportional	Hybrid	Proportional	Hybrid
	Los Angeles, CA							
All Cause Mortality	1342 (854 - 1827)	1675 (1066 - 2276)	2845 (1819 - 3853)	3169 (2027 - 4286)	3360 (2075 - 4615)	3953 (2446 - 5418)	13557 (8709 - 17917)	14037 (9035 - 18516)
Percent Difference: [3]	---	25%	112%	136%	150%	195%	910%	946%
Ischemic Heart Disease Mortality	1249 (1017 - 1477)	1545 (1261 - 1824)	2548 (2095 - 2983)	2813 (2318 - 3288)	2535 (1793 - 3232)	2947 (2095 - 3738)	8269 (6414 - 9670)	8475 (6602 - 9873)
Percent Difference:	---	24%	104%	125%	103%	136%	562%	579%
	Philadelphia, PA							
All Cause Mortality	584 (372 - 792)	--- [4]	859 (550 - 1161)	---	1254 (779 - 1713)	---	3946 (2554 - 5176)	---
Percent Difference:	---	---	47%	---	115%	---	576%	---
Ischemic Heart Disease Mortality	369 (303 - 434)	---	591 (489 - 688)	---	639 (458 - 803)	---	1612 (1271 - 1859)	---
Percent Difference	---	---	60%	---	73%	---	337%	---

[1] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2] Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000. The fixed effects log-linear estimates are from Table 33, using models with 44 individual and 7 ecological covariates; the random effects log-log estimates are from Table 11, "MSA and DIFF" rows. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3] Percent differences are calculated relative to the model selections used in the core analysis (fixed effects log-linear model; LML, and proportional rollbacks). So, for example, the percent difference in estimated all cause mortality in Los Angeles resulting from changing from the core analysis input selections to instead using (1) a fixed effects log-linear model, (2) PRB, and (3) hybrid rollbacks is (3169 - 1342)/1342 = 136%.

[4] Philadelphia was not among the risk assessment urban areas for which hybrid rollbacks were calculated.

Table F-38. Multi-Factor Sensitivity Analysis: Impact of Using a Log-Linear vs. a Log-Log Model, Estimating Incidence Down to the Lowest Measured Level (LML) in the Study vs. PRB, and Using a Proportional vs. a Hybrid Rollback to Estimate the Incidence of All Cause and Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1]

Modeling Choices:	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]							
Fixed Effects (FE) Log-linear vs. Random Effects (RE) log-log model	FE Log-Linear	FE Log-Linear	FE Log-Linear	FE Log-Linear	RE Log-Log	RE Log-Log	RE Log-Log	RE Log-Log
Down to LML (5.8 ug/m^3) vs. PRB	LML	LML	PRB	PRB	LML	LML	PRB	PRB
Proportional vs. hybrid rollback	Proportional	Hybrid	Proportional	Hybrid	Proportional	Hybrid	Proportional	Hybrid
	Los Angeles, CA							
All Cause Mortality	1108 (704 - 1509)	1414 (899 - 1923)	2627 (1678 - 3560)	2924 (1869 - 3959)	2904 (1790 - 3995)	3498 (2161 - 4803)	13255 (8501 - 17544)	13736 (8827 - 18146)
Percent Difference: [3]	---	28%	137%	164%	162%	216%	1096%	1140%
Ischemic Heart Disease Mortality	1038 (843 - 1229)	1314 (1070 - 1553)	2366 (1943 - 2775)	2614 (2150 - 3060)	2212 (1558 - 2833)	2633 (1864 - 3354)	8151 (6301 - 9561)	8361 (6491 - 9770)
Percent Difference:	---	27%	128%	152%	113%	154%	685%	705%
	Philadelphia, PA							
All Cause Mortality	525 (335 - 713)	--- [4]	912 (585 - 1233)	---	1166 (723 - 1595)	---	3869 (2502 - 5082)	---
Percent Difference:	---	---	74%	---	122%	---	637%	---
Ischemic Heart Disease Mortality	334 (273 - 393)	---	559 (461 - 651)	---	598 (428 - 755)	---	1590 (1251 - 1837)	---
Percent Difference	---	---	67%	---	79%	---	376%	---

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000. The fixed effects log-linear estimates are from Table 33, using models with 44 individual and 7 ecological covariates; the random effects log-log estimates are from Table 11, "MSA and DIFF" rows. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3] Percent differences are calculated relative to the model selections used in the core analysis (fixed effects log-linear model; LML, and proportional rollbacks). So, for example, the percent difference in estimated all cause mortality in Los Angeles resulting from changing from the core analysis input selections to instead using (1) a fixed effects log-linear model, (2) PRB, and (3) hybrid rollbacks is (2924 - 1108)/1108 = 164%.

[4] Philadelphia was not among the risk assessment urban areas for which hybrid rollbacks were calculated.

Table F-39. Multi-Factor Sensitivity Analysis: Impact of Using a Log-Linear vs. a Log-Log Model, Estimating Incidence Down to the Lowest Measured Level (LML) in the Study vs. PRB, and Using a Proportional vs. a Hybrid Rollback to Estimate the Incidence of All Cause and Ischemic Heart Disease Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1]

Modeling Choices:	Incidence of Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations Using:[2]							
Fixed Effects (FE) Log-linear vs. Random Effects (RE) log-log model	FE Log-Linear	FE Log-Linear	FE Log-Linear	FE Log-Linear	RE Log-Log	RE Log-Log	RE Log-Log	RE Log-Log
Down to LML (5.8 ug/m^3) vs. PRB	LML	LML	PRB	PRB	LML	LML	PRB	PRB
Proportional vs. hybrid rollback	Proportional	Hybrid	Proportional	Hybrid	Proportional	Hybrid	Proportional	Hybrid
	Los Angeles, CA							
All Cause Mortality	1170 (744 - 1593)	1484 (944 - 2019)	2697 (1723 - 3654)	3003 (1920 - 4064)	3034 (1871 - 4173)	3633 (2245 - 4986)	13430 (8616 - 17770)	13914 (8945 - 18375)
Percent Difference: [3]	---	27%	131%	157%	159%	211%	1048%	1089%
Ischemic Heart Disease Mortality	1094 (890 - 1296)	1377 (1122 - 1627)	2426 (1993 - 2845)	2680 (2205 - 3136)	2306 (1626 - 2950)	2728 (1933 - 3472)	8243 (6377 - 9662)	8454 (6568 - 9871)
Percent Difference:	---	26%	122%	145%	111%	149%	653%	673%
	Philadelphia, PA							
All Cause Mortality	519 (331 - 704)	--- [4] ---	907 (581 - 1225)	--- ---	1157 (718 - 1583)	--- ---	3864 (2498 - 5075)	--- ---
Percent Difference:	---	---	75%	---	123%	---	645%	---
Ischemic Heart Disease Mortality	330 (270 - 389)	--- ---	555 (459 - 647)	--- ---	594 (424 - 750)	--- ---	1589 (1249 - 1836)	--- ---
Percent Difference	---	---	68%	---	80%	---	382%	---

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Estimates Based on Krewski et al. (2009), exposure period from 1999 - 2000. The fixed effects log-linear estimates are from Table 33, using models with 44 individual and 7 ecological covariates; the random effects log-log estimates are from Table 11, "MSA and DIFF" rows. Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3] Percent differences are calculated relative to the model selections used in the core analysis (fixed effects log-linear model; LML, and proportional rollbacks). So, for example, the percent difference in estimated all cause mortality in Los Angeles resulting from changing from the core analysis input selections to instead using (1) a fixed effects log-linear model, (2) PRB, and (3) hybrid rollbacks is (3003 - 1170)/1170 = 157%.

[4] Philadelphia was not among the risk assessment urban areas for which hybrid rollbacks were calculated.

Table F-40. Sensitivity Analysis: Impact of Using Season-Specific vs. Annual Concentration-Response Functions and Proportional vs. Hybrid Rollbacks to Estimate the Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1, 2]

Modeling Choices:	Estimated Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards			
Seasonal C-R Functions vs. an All-Year Function	**All Year**	**All Year**	**Sum of Four Seasons**	**Sum of Four Seasons**
Proportional vs. Hybrid Rollback	**Proportional**	**Hybrid**	**Proportional**	**Hybrid**
Baltimore, MD	256 (104 - 406)	254 (103 - 402)	222 --- [4]	220 ---
Percent Difference [3]	---	-1%	-13%	-14%
Birmingham, AL	34 (-53 - 121)	39 (-61 - 137)	70 ---	79 ---
Percent Difference	---	15%	106%	132%
Detroit, MI	147 (-26 - 317)	151 (-26 - 325)	159 ---	163 ---
Percent Difference	---	3%	8%	11%
Los Angeles, CA	81 (-117 - 278)	91 (-130 - 311)	-23 ---	-25 ---
Percent Difference	---	12%	-128%	-131%
New York, NY	781 (459 - 1102)	795 (467 - 1121)	780 ---	792 ---
Percent Difference	---	2%	0%	1%
Pittsburgh, PA	159 (47 - 270)	163 (48 - 277)	175 ---	182 ---
Percent Difference	---	3%	10%	14%
St. Louis, MO	260 (75 - 443)	271 (78 - 462)	251 ---	261 ---
Percent Difference	---	4%	-3%	0%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Percent differences are calculated relative to the model selections used in the core analysis (all-year C-R function and proportional rollback). So, for example, the percent difference in estimated non-accidental mortality in Baltimore resulting from changing from the core analysis input selections to instead using the sum of four season-specific mortality estimates and hybrid rollbacks is (192 - 225)/225 = -15%.

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-41. Sensitivity Analysis: Impact of Using Season-Specific vs. Annual Concentration-Response Functions and Proportional vs. Hybrid Rollbacks to Estimate the Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1, 2]

Modeling Choices:	Estimated Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards			
Seasonal C-R Functions vs. an All-Year Function	**All Year**	**All Year**	**Sum of Four Seasons**	**Sum of Four Seasons**
Proportional vs. Hybrid Rollback	**Proportional**	**Hybrid**	**Proportional**	**Hybrid**
Baltimore, MD	224 (91 - 356)	222 (90 - 352)	193 --- [4]	193 ---
Percent Difference [3]	---	-1%	-14%	-14%
Birmingham, AL	33 (-51 - 116)	37 (-58 - 132)	69 ---	78 ---
Percent Difference	---	12%	109%	136%
Detroit, MI	118 (-21 - 255)	121 (-21 - 261)	137 ---	140 ---
Percent Difference	---	3%	16%	19%
Los Angeles, CA	75 (-108 - 257)	84 (-120 - 287)	-25 ---	-28 ---
Percent Difference	---	12%	-133%	-137%
New York, NY	671 (394 - 946)	682 (400 - 961)	677 ---	688 ---
Percent Difference	---	2%	1%	3%
Pittsburgh, PA	136 (40 - 232)	147 (43 - 249)	154 ---	164 ---
Percent Difference	---	8%	13%	21%
St. Louis, MO	215 (62 - 367)	224 (64 - 381)	211 ---	219 ---
Percent Difference	---	4%	-2%	2%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Percent differences are calculated relative to the model selections used in the core analysis (all-year C-R function and proportional rollback). So, for example, the percent difference in estimated non-accidental mortality in Baltimore resulting from changing from the core analysis input selections to instead using the sum of four season-specific mortality estimates and hybrid rollbacks is (192 - 225)/225 = -15%.

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-42. Sensitivity Analysis: Impact of Using Season-Specific vs. Annual Concentration-Response Functions and Proportional vs. Hybrid Rollbacks to Estimate the Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1, 2]

Modeling Choices:	Estimated Incidence of Non-Accidental Mortality Associated with Short-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards			
Seasonal C-R Functions vs. an All-Year Function	All Year	All Year	Sum of Four Seasons	Sum of Four Seasons
Proportional vs. Hybrid Rollback	Proportional	Hybrid	Proportional	Hybrid
Baltimore, MD	227 (92 - 360)	224 (91 - 356)	207 --- [4]	194 ---
Percent Difference [3]	---	-1%	-9%	-15%
Birmingham, AL	34 (-53 - 120)	39 (-60 - 137)	95 ---	86 ---
Percent Difference	---	15%	179%	153%
Detroit, MI	121 (-21 - 262)	124 (-22 - 269)	166 ---	137 ---
Percent Difference	---	2%	37%	13%
Los Angeles, CA	77 (-110 - 262)	86 (-123 - 293)	-12 ---	-8 ---
Percent Difference	---	12%	-116%	-110%
New York, NY	734 (431 - 1035)	746 (438 - 1052)	887 ---	750 ---
Percent Difference	---	2%	21%	2%
Pittsburgh, PA	143 (42 - 244)	147 (43 - 250)	225 ---	162 ---
Percent Difference	---	3%	57%	13%
St. Louis, MO	225 (65 - 384)	236 (68 - 402)	248 ---	232 ---
Percent Difference	---	5%	10%	3%

[1]Based on season-specific and all-year location-specific coefficient estimates from Zanobetti and Schwartz (2009) that have been "shrunken" towards the appropriate regional means. Numbers are rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[2]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] Percent differences are calculated relative to the model selections used in the core analysis (all-year C-R function and proportional rollback). So, for example, the percent difference in estimated non-accidental mortality in Baltimore resulting from changing from the core analysis input selections to instead using the sum of four season-specific mortality estimates and hybrid rollbacks is (192 - 225)/225 = -15%.

[4] It was not possible to calculate the 2.5th and 97.5th percentile estimates of the sum of the season-specific incidences because the variance-covariance matrix for the season-specific coefficient estimators was not available.

Table F-43. Sensitivity Analysis: Impact of Copollutant Models in Estimating the Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations[1,2]

Copollutant in Model	Incidence	Percent Difference [3]
Los Angeles, CA		
None	1122 (580 - 1713)	0%
CO	1632 (945 - 2341)	45%
NO_2	1954 (1034 - 2782)	74%
O_3	1632 (945 - 2341)	45%
SO_2	295 (-515 - 1209)	-74%
Philadelphia, PA		
None	489 (253 - 743)	0%
CO	708 (412 - 1012)	45%
NO_2	847 (451 - 1199)	73%
O_3	708 (412 - 1012)	45%
SO_2	129 (-227 - 526)	-74%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Estimates based on Krewski et al. (2000) [reanalysis of the ACS study]. Mortality incidence was estimated for $PM_{2.5}$ concentrations down to 5.8 ug/m^3 (the lowest measured level used for the analyses of long-term exposure). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Calculated as (estimate with copollutant - estimate without copollutant)/(estimate without copollutant).

Table F-44. Sensitivity Analysis: Impact of Copollutant Models in Estimating the Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations[1,2]

Copollutant in Model	Incidence	Percent Difference [3]
Los Angeles, CA		
None	926 (478 - 1415)	0%
CO	1347 (780 - 1936)	45%
NO_2	1615 (853 - 2302)	74%
O_3	1347 (780 - 1936)	45%
SO_2	243 (-424 - 998)	-74%
Philadelphia, PA		
None	439 (228 - 669)	0%
CO	637 (370 - 911)	45%
NO_2	762 (405 - 1080)	74%
O_3	637 (370 - 911)	45%
SO_2	116 (-203 - 473)	-74%

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2]Estimates based on Krewski et al. (2000) [reanalysis of the ACS study]. Mortality incidence was estimated for $PM_{2.5}$ concentrations down to 5.8 ug/m^3 (the lowest measured level used for the analyses of long-term exposure). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3]Calculated as (estimate with copollutant - estimate without copollutant)/(estimate without copollutant).

Table F-45. Sensitivity Analysis: Impact of Copollutant Models in Estimating the Incidence of All Cause Mortality Associated with Long-Term Exposure to $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations[1,2]

Copollutant in Model	Incidence	Percent Difference [3]
Los Angeles, CA		
None	978 (505 - 1494)	0%
CO	1423 (824 - 2043)	46%
NO_2	1705 (901 - 2429)	74%
O_3	1423 (824 - 2043)	46%
SO_2	257 (-448 - 1054)	-74%
Philadelphia, PA		
None	434 (225 - 661)	0%
CO	630 (366 - 901)	45%
NO_2	753 (400 - 1068)	74%
O_3	630 (366 - 901)	45%
SO_2	115 (-201 - 468)	-74%

[1] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2] Estimates based on Krewski et al. (2000) [reanalysis of the ACS study]. Mortality incidence was estimated for $PM_{2.5}$ concentrations down to 5.8 ug/m^3 (the lowest measured level used for the analyses of long-term exposure). Numbers rounded to the nearest whole number. Numbers in parentheses are 95% confidence or credible intervals based on statistical uncertainty surrounding the PM coefficient.

[3] Calculated as (estimate with copollutant - estimate without copollutant)/(estimate without copollutant).

Table F-46. Sensitivity Analysis: Impact of Different Lag Models on Estimated Annual Incidence of Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2005 $PM_{2.5}$ Concentrations [1,2]

Risk Assessment Location	Cardiovascular Hospital Admissions			Respiratory Hospital Admissions		
	0-Day Lag	1-Day Lag	2-Day Lag	0-Day Lag	1-Day Lag	2-Day Lag
Los Angeles, CA	397 (294 - 501)	35 (-60 - 130)	30 (-58 - 118)	40 (-22 - 102)	9 (-53 - 71)	75 (16 - 133)
Philadelphia, PA	159 (118 - 200)	14 (-24 - 52)	12 (-23 - 47)	13 (-7 - 34)	3 (-18 - 24)	25 (5 - 45)

[1] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2] Incidence estimates were calculated using the national concentration-response function estimates reported in Table 1 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

Table F-47. Sensitivity Analysis: Impact of Different Lag Models on Estimated Annual Incidence of Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2006 $PM_{2.5}$ Concentrations [1,2]

Risk Assessment Location	Cardiovascular Hospital Admissions			Respiratory Hospital Admissions		
	0-Day Lag	1-Day Lag	2-Day Lag	0-Day Lag	1-Day Lag	2-Day Lag
Los Angeles, CA	373 (276 - 470)	33 (-56 - 122)	28 (-54 - 110)	38 (-21 - 96)	9 (-50 - 67)	70 (15 - 125)
Philadelphia, PA	149 (110 - 188)	13 (-23 - 49)	11 (-22 - 44)	13 (-7 - 32)	3 (-17 - 22)	24 (5 - 42)

[1]The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2] Incidence estimates were calculated using the national concentration-response function estimates reported in Table 1 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

Table F-48. Sensitivity Analysis: Impact of Different Lag Models on Estimated Annual Incidence of Hospital Admissions Associated with Short-Term Exposure to Ambient $PM_{2.5}$ Concentrations that Just Meet the Current Standards, Based on Adjusting 2007 $PM_{2.5}$ Concentrations [1,2]

Risk Assessment Location	Cardiovascular Hospital Admissions			Respiratory Hospital Admissions		
	0-Day Lag	1-Day Lag	2-Day Lag	0-Day Lag	1-Day Lag	2-Day Lag
Los Angeles, CA	388 (287 - 489)	34 (-59 - 127)	29 (-56 - 115)	39 (-21 - 99)	9 (-52 - 69)	73 (15 - 130)
Philadelphia, PA	151 (112 - 190)	13 (-23 - 49)	11 (-22 - 45)	13 (-7 - 32)	3 (-17 - 23)	24 (5 - 43)

[1] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[2] Incidence estimates were calculated using the national concentration-response function estimates reported in Table 1 of Bell et al. (2008). Location-specific C-R function estimates were not available from this study.

Table F-49 Maximum 3yr Monitor-Specific Average and Annual Composite Monitor Value Given Different Rollback Methods (with comparison of percent reduction in surrogate for long-term mortality risk across rollback methods)

Risk Assessment Location [1]	Rollback Method	Design Value		Recent Air Quality (2007)	Maximum Monitor-Specific Avg. of 2005, 2006, 2007 Annual Avgs. (Max. M-S) and 2007 Annual Average at Composite Monitor (2007CM) (in ug/m^3)												Percent reduction in a surrogate for long-term exposure-related mortality (alternative standard compared with current standard)[6]				
					15/35 [2]		14/35		13/35		12/35		13/30		12/25						
		Annual	24-Hr	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	14/35	13/35	12/35	13/30	12/25
	Proportional				15.0	14.2	14.0	13.3	13.0	12.3	12.0	11.4	13.0	12.3	11.8	11.2	11%	22%	34%	22%	35%
Atlanta, GA	Hybrid [3]	16.2	35.0	15.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving[4]				---	---	---	---	---	---	---	---	---	---	13.6	11.31	---	---	---	---	35%
	Proportional				14.8	13.1	14.0	12.5	13.0	11.6	12.0	10.7	12.7	11.3	10.7	9.5	9%	21%	33%	25%	49%
Baltimore, MD	Hybrid	15.6	37.0	13.9	14.3	13.0	14.0	12.7	13.0	11.8	12.0	10.9	12.3	11.2	10.3	9.4	4%	16%	29%	25%	50%
	Peak Shaving				15.2	13.6	---	---	---	---	---	---	13.0	11.9	10.8	9.8				25%	49%
	Proportional				15.0	12.7	14.0	11.8	13.0	11.0	12.0	10.2	13.0	11.0	11.1	9.4	12%	24%	36%	24%	47%
Birmingham, AL	Hybrid	18.7	44.0	15.7	15.0	14.2	14.0	13.2	13.0	12.3	12.0	11.4	13.0	12.3	11.3	10.7	11%	22%	34%	22%	42%
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	11.9	10.9	---	---	---	---	47%
	Proportional				12.8	11.4	12.8	11.4	12.8	11.4	12.0	10.7	12.8	11.4	12.0	10.7	196%	0%	13%	0%	13%
Dallas, TX	Hybrid	12.8	26.0	11.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Proportional				14.1	11.4	14.0	11.4	13.0	10.6	12.0	9.8	12.2	9.9	10.2	8.3	1%	16%	30%	27%	55%
Detroit, MI	Hybrid	17.2	43.0	13.9	13.2	11.7	13.2	11.7	13.0	11.5	12.0	10.6	11.4	10.1	9.6	8.5	0%	3%	18%	27%	54%
	Peak Shaving				13.9	12.6	---	---	---	---	---	---	11.9	10.8	9.8	8.9	---	---	---	27%	55%
	Proportional				9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	8.6	8.6	7.3	7.3	0%	0%	0%	32%	64%
Fresno, CA	Hybrid	17.4	63.0	17.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				9.8	9.9	9.8	9.9	9.8	9.9	9.8	9.9	8.4	8.5	6.9	7.0	0%	0%	0%	32%	64%
	Proportional				15.0	12.5	14.0	11.7	13.0	10.9	12.0	10.1	13.0	10.9	12.0	10.1	12%	24%	36%	24%	36%
Houston, TX	Hybrid	15.8	31.0	13.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Proportional				12.7	9.5	12.7	9.5	12.7	9.5	12.0	9.0	10.9	8.2	9.2	7.0	0%	0%	13%	34%	68%
Los Angeles, CA	Hybrid	19.6	55.0	14.6	13.3	10.5	13.3	10.5	13.0	10.3	12.0	9.5	11.5	9.1	9.6	7.7	0%	5%	21%	30%	60%
	Peak Shaving				13.9	12.0	13.9	12.0	13.9	12.0	---	---	11.8	10.4	9.8	8.8	0%	0%	---	34%	68%
	Proportional				13.3	11.6	13.3	11.6	13.0	11.3	12.0	10.4	11.5	10.0	9.7	8.4	0%	5%	20%	27%	55%
New York, NY	Hybrid	15.9	42.0	13.8	13.6	11.8	13.6	11.8	13.0	11.3	12.0	10.4	11.7	10.2	9.8	8.5	0%	8%	22%	27%	54%
	Peak Shaving				14.2	13.2	14.2	13.2	---	---	---	---	12.1	11.5	10.1	9.5	0%	---	---	27%	55%
	Proportional				13.9	12.3	13.9	12.3	13.0	11.6	12.0	10.7	11.9	10.7	10.0	9.0	0%	12%	25%	26%	52%
Philadelphia, PA	Hybrid	15.0	38.0	13.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				15.5	12.9	15.5	12.9	---	---	---	---	14.1	11.2	11.7	9.3	0%	---	---	26%	52%
	Proportional				12.6	9.9	12.6	9.9	12.6	9.9	12.0	9.4	11.8	9.3	9.9	7.8	0%	0%	11%	14%	50%
Phoenix, AZ	Hybrid	12.6	32.0	9.9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	10.1	8.9	---	---	---	---	50%

Table F-49 (cont'd) Maximum 3yr Monitor-Specific Average and Annual Composite Monitor Value Given Different Rollback Methods (with comparison of percent reduction in surrogate for long-term mortality risk across rollback methods)

Risk Assessment Location [1]	Rollback Method	Design Value		Recent Air Quality (2007)	Maximum Monitor-Specific Avg. of 2005, 2006, 2007 Annual Avgs. (Max. M-S) and 2007 Annual Average at Composite Monitor (2007CM) (in ug/m^3)												Percent reduction in a surrogate for long-term exposure-related mortality (alternative standard compared with current standard)[6]				
					15/35 [2]		14/35		13/35		12/35		13/30		12/25						
		Annual	24-Hr	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	14/35	13/35	12/35	13/30	12/25
	Proportional				13.3	11.6	13.3	11.6	12.8	11.2	11.8	10.5	11.5	10.0	9.7	8.4	0%	7%	19%	27%	54%
Pittsburgh, PA [5]	Hybrid	19.8	60.0	14.9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				15.6	13.1	15.6	13.1	15.3	11.7	15.3	11.0	15.6	11.2	13.8	9.3	0%	20%	29%	26%	52%
	Proportional				7.7	7.5	7.7	7.5	7.7	7.5	7.7	7.5	6.7	6.6	5.7	5.6	0%	0%	0%	55%	110%
Salt Lake City, UT	Hybrid	11.6	55.0	11.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				10.8	9.5	10.8	9.5	10.8	9.5	10.8	9.5	10.8	8.6	8.9	7.4	0%	0%	0%	24%	58%
	Proportional				14.9	12.9	14.0	12.1	13.0	11.3	12.0	10.4	12.8	11.1	10.8	9.3	10%	23%	35%	25%	50%
St. Louis, MO	Hybrid	16.5	39.0	14.3	15.0	13.5	14.0	12.6	13.0	11.7	12.0	10.8	13.0	11.7	11.0	9.9	12%	23%	35%	23%	47%
	Peak Shaving				16.5	14.1	---	---	---	---	---	---	14.1	12.3	11.7	10.2	---	---	---	25%	50%
	Proportional				8.4	8.0	8.4	8.0	8.4	8.0	8.4	8.0	7.4	7.0	6.3	6.0	0%	0%	0%	46%	93%
Tacoma, WA	Hybrid	10.2	43.0	9.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				8.3	7.8	8.3	7.8	8.3	7.8	8.3	7.8	7.1	6.7	5.9	5.5	0%	0%	0%	57%	114%

[1]For some locations (e.g., Atlanta) more than one "version" (group of counties) was used in the risk assessment. In this table only the version that was used for mortality associated with short-term exposure to $PM_{2.5}$ (Zanobetti and Schwartz, 2009) is included.

[2] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] The hybrid rollback method was applied to only a subset of the risk assessment locations. The "---" for a given location indicates that the hybrid rollback method was not applied to that

[4] The peak shaving method was applied to a location-standard combination only if the daily standard was controlling in that location. The "--" for a given location-standard combination indicates that, for that set of annual and daily standards in that location, the annual standard was controlling and so the peak shaving method was not applied.

[5] The proportional rollback and peak shaving methods were applied to Pittsburgh differently from the way they were applied in the other locations. See Sections 3.2.3.2 and 3.2.3.3 for

[6] Percent reduction in composite monitor value (CMV) with consideration for LML of 5.8 ug/m^3. Percent reduction = ($CMV_{current\ standard}$ - $CMV_{alternative\ standard}$)/($CMV_{curremt\ standard}$-LML). Note that greyed cells identify instances where percent change differs by >10% across alternative rollback methods (for a given alternative standard level/study area combination).

Table F-50. Maximum 3yr Monitor-Specific Average and Annual Composite Monitor Value Given Different Rollback Methods (with percent difference in surrogate for long-term exposure-related mortality across rollback methods)

Risk Assessment Location [1]	Rollback Method	Design Value		Recent Air Quality (2007)	Maximum Monitor-Specific Avg. of 2005, 2006, 2007 Annual Avgs. (Max. M-S) and 2007 Annual Average at Composite Monitor (2007CM) (in ug/m3)												Percent difference between composite monitor value with hybrid or peak shaving compared with proportional (surrogate for difference in long-term exposure-related mortality)[6]					
					15/35 [2]		14/35		13/35		12/35		13/30		12/25							
		Annual	24-Hr	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	15/35	14/35	13/35	12/35	13/30	12/25
Atlanta, GA	Proportional	16.2	35.0	15.3	15.0	14.2	14.0	13.3	13.0	12.3	12.0	11.4	13.0	12.3	11.8	11.2	cells used as basis for calculation					
	Hybrid [3]				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving[4]				---	---	---	---	---	---	---	---	---	---	13.6	11.31	---	---	---	---	---	1%
Baltimore, MD	Proportional	15.6	37.0	13.9	14.8	13.1	14.0	12.5	13.0	11.6	12.0	10.7	12.7	11.3	10.7	9.5	cells used as basis for calculation					
	Hybrid				14.3	13.0	14.0	12.7	13.0	11.8	12.0	10.9	12.3	11.2	10.3	9.4	-2%	4%	4%	4%	-2%	-3%
	Peak Shaving				15.2	13.6	---	---	---	---	---	---	13.0	11.9	10.8	9.8	6%	---	---	---	8%	7%
Birmingham, AL	Proportional	18.7	44.0	15.7	15.0	12.7	14.0	11.8	13.0	11.0	12.0	10.2	13.0	11.0	11.1	9.4		---	---	---	---	---
	Hybrid				15.0	14.2	14.0	13.2	13.0	12.3	12.0	11.4	13.0	12.3	11.3	10.7	18%	19%	20%	21%	20%	26%
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	11.9	10.9	---	---	---	---	---	29%
Dallas, TX	Proportional	12.8	26.0	11.4	12.8	11.4	12.8	11.4	12.8	11.4	12.0	10.7	12.8	11.4	12.0	10.7	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Detroit, MI	Proportional	17.2	43.0	13.9	14.1	11.4	14.0	11.4	13.0	10.6	12.0	9.8	12.2	9.9	10.2	8.3	cells used as basis for calculation					
	Hybrid				13.2	11.7	13.2	11.7	13.0	11.5	12.0	10.6	11.4	10.1	9.6	8.5	4%	6%	16%	18%	5%	7%
	Peak Shaving				13.9	12.6	---	---	---	---	---	---	11.9	10.8	9.8	8.9	17%	---	---	---	18%	19%
Fresno, CA	Proportional	17.4	63.0	17.4	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	8.6	8.6	7.3	7.3	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				9.8	9.9	9.8	9.9	9.8	9.9	9.8	9.9	8.4	8.5	6.9	7.0	0%	0%	0%	0%	-5%	-21%
Houston, TX	Proportional	15.8	31.0	13.2	15.0	12.5	14.0	11.7	13.0	10.9	12.0	10.1	13.0	10.9	12.0	10.1	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Los Angeles, CA	Proportional	19.6	55.0	14.6	12.7	9.5	12.7	9.5	12.7	9.5	12.0	9.0	10.9	8.2	9.2	7.0	cells used as basis for calculation					
	Hybrid				13.3	10.5	13.3	10.5	13.0	10.3	12.0	9.5	11.5	9.1	9.6	7.7	21%	21%	17%	13%	26%	38%
	Peak Shaving				13.9	12.0	13.9	12.0	13.9	12.0	---	---	11.8	10.4	9.8	8.8	40%	40%	40%	---	47%	60%
New York, NY	Proportional	15.9	42.0	13.8	13.3	11.6	13.3	11.6	13.0	11.3	12.0	10.4	11.5	10.0	9.7	8.4	cells used as basis for calculation					
	Hybrid				13.6	11.8	13.6	11.8	13.0	11.3	12.0	10.4	11.7	10.2	9.8	8.5	3%	3%	0%	0%	4%	5%
	Peak Shaving				14.2	13.2	14.2	13.2	---	---	---	---	12.1	11.5	10.1	9.5	22%	22%	---	---	26%	30%
Philadelphia, PA	Proportional	15.0	38.0	13.4	13.9	12.3	13.9	12.3	13.0	11.6	12.0	10.7	11.9	10.7	10.0	9.0	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				15.5	12.9	15.5	12.9	---	---	---	---	14.1	11.2	11.7	9.3	8%	8%	---	---	10%	9%
Phoenix, AZ	Proportional	12.6	32.0	9.9	12.6	9.9	12.6	9.9	12.6	9.9	12.0	9.4	11.8	9.3	9.9	7.8	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				---	---	---	---	---	---	---	---	---	---	10.1	8.9	---	---	---	---	---	35%
Pittsburgh, PA [5]	Proportional	19.8	60.0	14.9	13.3	11.6	13.3	11.6	12.8	11.2	11.8	10.5	11.5	10.0	9.7	8.4	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				15.6	13.1	15.6	13.1	15.3	11.7	15.3	11.0	15.6	11.2	13.8	9.3	21%	21%	8%	10%	22%	24%

Table F-50. (cont'd) Maximum 3yr Monitor-Specific Average and Annual Composite Monitor Value Given Different Rollback Methods (with percent difference in surrogate for long-term exposure-related mortality across rollback methods)

Risk Assessment Location [1]	Rollback Method	Design Value		Recent Air Quality (2007)	Maximum Monitor-Specific Avg. of 2005, 2006, 2007 Annual Avgs. (Max. M-S) and 2007 Annual Average at Composite Monitor (2007CM) (in ug/m3)												Percent difference between composite monitor value with hybrid or peak shaving compared with proportional (surrogate for difference in long-term exposure-related mortality)[6]					
					15/35 [2]		14/35		13/35		12/35		13/30		12/25							
		Annual	24-Hr	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	Max. M-S	2007 CM	15/35	14/35	13/35	12/35	13/30	12/25
Salt Lake City, UT	Proportional	11.6	55.0	11.4	7.7	7.5	7.7	7.5	7.7	7.5	7.7	7.5	6.7	6.6	5.7	5.6	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				10.8	9.5	10.8	9.5	10.8	9.5	10.8	9.5	10.8	8.6	8.9	7.4	53%	53%	53%	53%	72%	111%
St. Louis, MO	Proportional	16.5	39.0	14.3	14.9	12.9	14.0	12.1	13.0	11.3	12.0	10.4	12.8	11.1	10.8	9.3	cells used as basis for calculation					
	Hybrid				15.0	13.5	14.0	12.6	13.0	11.7	12.0	10.8	13.0	11.7	11.0	9.9	8%	6%	7%	7%	10%	13%
	Peak Shaving				16.5	14.1	---	---	---	---	---	---	14.1	12.3	11.7	10.2	15%	---	---	---	18%	19%
Tacoma, WA	Proportional	10.2	43.0	9.7	8.4	8.0	8.4	8.0	8.4	8.0	8.4	8.0	7.4	7.0	6.3	6.0	cells used as basis for calculation					
	Hybrid				---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Peak Shaving				8.3	7.8	8.3	7.8	8.3	7.8	8.3	7.8	7.1	6.7	5.9	5.5	-9%	-9%	-9%	-9%	-36%	157%

[1] For some locations (e.g., Atlanta) more than one "version" (group of counties) was used in the risk assessment. In this table only the version that was used for mortality associated with short-term exposure to $PM_{2.5}$ (Zanobetti and Schwartz, 2009) is included.

[2] The current primary $PM_{2.5}$ standards include an annual standard set at 15 ug/m^3 and a daily standard set at 35 ug/m^3.

[3] The hybrid rollback method was applied to only a subset of the risk assessment locations. The "---" for a given location indicates that the hybrid rollback method was not applied to that location.

[4] The peak shaving method was applied to a location-standard combination only if the daily standard was controlling in that location. The "--" for a given location-standard combination indicates that, for that set of annual and daily standards in that location, the annual standard was controlling and so the peak shaving method was not applied.

[5] The proportional rollback and peak shaving methods were applied to Pittsburgh differently from the way they were applied in the other locations. See Sections 3.2.3.2 and 3.2.3.3 for details.

[6] Percent reduction in composite monitor value (CMV) with consideration for LML of 5.8 ug/m^3. Percent reduction = ($CMV_{\text{peak shaving or hybrid}}$ - $CMV_{\text{proportional}}$)/($CMVp_{\text{eak shaving or hybrid}}$-LML). Note that greyed cells identify instances where two values differ by >25% across alternative rollback methods (for a given alternative standard level/study area combination).

APPENDIX G: SUPPLEMEMNT TO THE NATIONAL-SCALE ASSESSMENT OF LONG-TERM MORTALITY RELATED TO $PM_{2.5}$ EXPOSURE

Appendix G. National-Scale Assessment of Long-Term Mortality Related to $PM_{2.5}$ Exposure (additional technical detail regarding inputs used in the analysis)

This technical appendix includes additional details regarding the inputs to the national-scale current conditions health impact analysis. Below we present air quality modeling, exposure and risk information.

Air Quality Modeled Inputs

The Community Model for Air Quality (CMAQ) model was used to estimate annual $PM_{2.5}$ concentrations for the year 2005 for the continental US. These data were then combined with ambient monitored $PM_{2.5}$ measurements to create "fused" spatial surfaces supplied to BenMAP.

CMAQ Model Application and Evaluation

CMAQ is a non-proprietary computer model that simulates the formation and fate of photochemical oxidants, including $PM_{2.5}$ and ozone, for given input sets of meteorological conditions and emissions. This analysis employed a version of CMAQ based on the latest publicly released version (i.e. CMAQ version 4.7[2]).

Model Domain and Grid Resolution

The CMAQ modeling analyses were performed for two domains covering the continental United States, as shown in Figure G-1. These domains consist of a horizontal grid of 36 km covering the entire continental US and a finer-scale 12-km grid covering the Eastern U.S. The model extends vertically from the surface to 100 millibars (approximately 15 km) using a sigma-pressure coordinate system. The 36-km grid was used to establish the incoming air quality concentrations along the boundaries of the 12-km grids. Table G-1 provides some basic geographic information regarding the CMAQ domains. The 36-km and both 12-km CMAQ modeling domains were modeled for the entire year of 2005. All 365 model days were used in the annual average levels of $PM_{2.5}$.

[2]CMAQ version 4.7 was released on December 1, 2008. It is available from the Community Modeling and Analysis System (CMAS) at: http://www.cmascenter.org.

Table G-1. Geographic Information for Modeling Domains

	CMAQ Modeling Configuration	
	National Grid	**Eastern U.S. Fine Grid**
Map Projection	Lambert Conformal Projection	
Grid Resolution	36 km	12 km
Coordinate Center	97 W, 40 N	
True Latitudes	33 and 45 N	
Dimensions	148 x 112 x 24	279 x 240 x 24
Vertical Extent	24 Layers: Surface to 100 mb level	

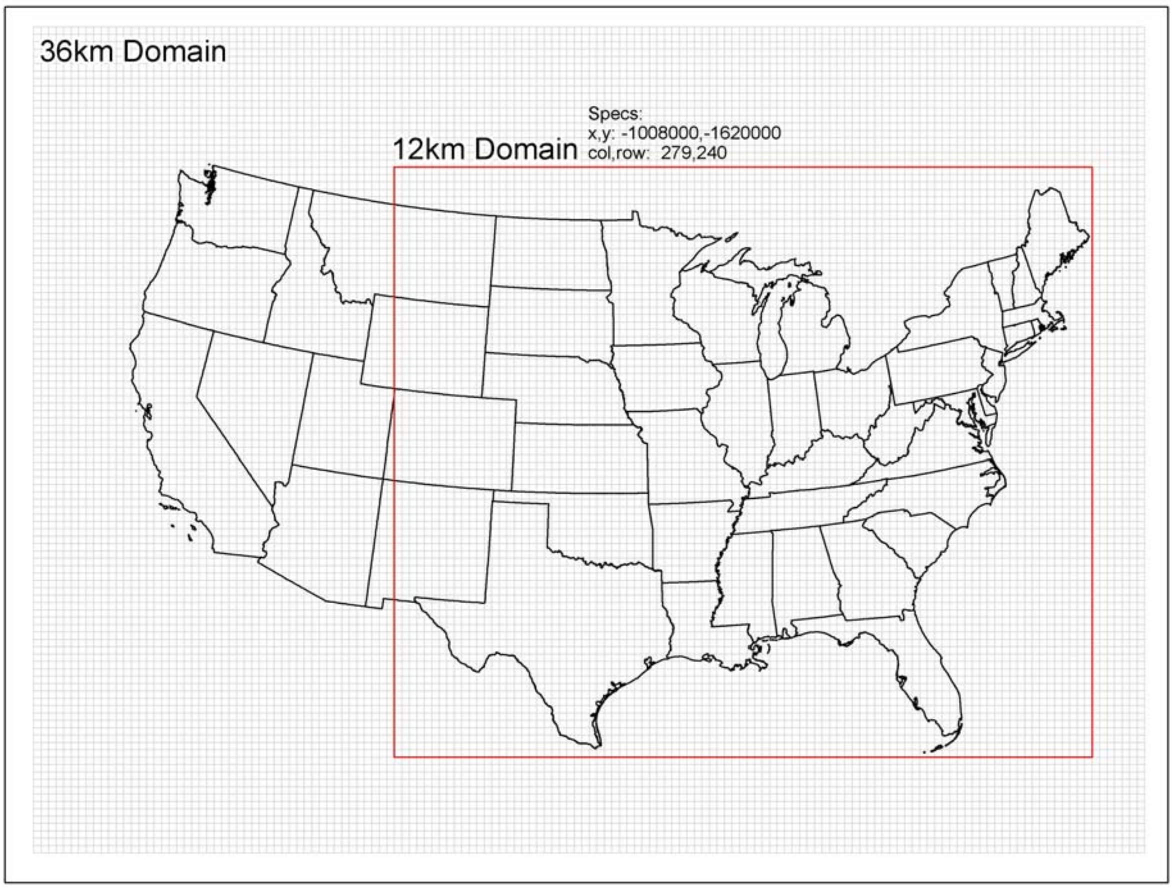


Figure G-1. Map of the CMAQ Modeling Domain (Note, the black outer box denotes the 36-km national modeling domain; the red inner box is the 12-km Eastern U.S. fine grid).

CMAQ Model Inputs

Emissions:

The 2005 emissions inputs to CMAQ included five source sectors: a) Electric Generating Units (EGUs); b) Other Stationary Sources (Point and Nonpoint); c) Onroad and Nonroad Mobile Sources; d) Biogenic Emissions; and e) Fires. The fires portion of the inventory included emissions from wildfires and prescribed burning computed as hour-specific point sources.

Electric Generating Units (EGUs)

Annual emissions estimates for EGUs for all National Emissions Inventory (NEI) air pollutants for 2005 were developed using data reported to the USEPA's Clean Air Marketing Division's (CAMD) Acid Rain database. The Acid Rain database contains hourly emissions for SO2 and NOx emissions plus hourly heat input amounts. These three values are reported to the database by the largest electric generating facilities, usually based upon Continuous Emissions Monitors (CEMs). For all pollutants except the directly monitored SO2 and NOx, the ratio of the Acid Rain heat input for 2005 to the Acid Rain heat input for 2002 was used as the adjusting ratio to estimate the 2005 emissions.

Other Stationary Sources (Point and Nonpoint)

Emission estimates for other stationary sources including both point and nonpoint stationary sources were held constant at the level in Version 3 of the 2002 NEI. The only exception to this was that some information on plants that closed after 2002 was incorporated into the emissions modeled. Emissions for plants that closed were set to zero. U.S. EPA, 2008c provides complete documentation on the development of the 2002 NEI.

Onroad and Nonroad Mobile Sources

Emission estimates for all pollutants were developed using EPA's National Mobile Inventory Model (NMIM), which uses MOBILE6 to calculate onroad emission factors. A full VMT database at the county, roadway type, and vehicle type level of detail was developed from Federal Highway Administration (FHWA) information. However, state and local agencies had the opportunity to provide model inputs (vehicle populations, fuel characteristics, VMT, etc) for 2002 and 2005. If the state or local area submitted 2005 VMT estimates, these data were used. However, if the state or local area only provided 2002 VMT estimates that were incorporated in the 2002 NEI, the 2002 NEI VMT data were grown to 2005 using growth factors developed from the FHWA data, and these grown VMT data replaced the baseline FHWA-based VMT data. Otherwise, the FHWA-based VMT data were used.

Emission estimates for NONROAD model engines were developed using EPA's National Mobile Inventory Model (NMIM), which incorporates NONROAD2005. Where states provided alternate nonroad inputs, these data replaced EPA default inputs, as described above. For more information on how NMIM is run, refer to the 2005 NEI documentation posted at ftp://ftp.epa.gov/EmisInventory/2005_nei/mobile/2005_mobile_nei_version_2_report.pdf.

<u>Fires</u>

Fires in the 2005 emissions inventory were modeled with the same methodology as used for the 2002 NEI (U.S. EPA, 2008). However, as described in Raffuse et al., 2008, the wildland fire emission inventories for 2005 were produced using the BlueSky framework for the conterminous United States, which used the Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) as the fire information source. SMARTFIRE is an algorithm and database system designed to reconcile these disparate fire information sources to produce daily fire location and size information (Sullivan et al., 2008).

<u>Biogenic Emissions</u>

Biogenic emissions were computed for CMAQ based on 2005 meteorology data using the BEIS3.13 model (Schwede, et. al, 2005) from the Sparse Matrix Operator Kernel Emissions (SMOKE). The BEIS3.13 model creates gridded, hourly, model-species emissions from vegetation and soils. It estimates CO, VOC, and NOX emissions for the U.S., Mexico, and Canada. The inputs to BEIS include:

- temperature data at 10 meters which were obtained from the CMAQ meteorological input files, and
- land-use data from the Biogenic Emissions Landuse Database, version 3 (BELD3), which provides data on the 230 vegetation classes at 1 km resolution over most of North America.

<u>Meteorological Input Data:</u>

The gridded meteorological input data for the entire year of 2005 were derived from simulations of the Pennsylvania State University / National Center for Atmospheric Research Mesoscale Model. This model, commonly referred to as MM5, is a limited-area, nonhydrostatic, terrain-following system that solves for the full set of physical and thermodynamic equations which govern atmospheric motions (Grell et al., 1994). Meteorological model input fields were prepared separately for both of the domains shown in Figure G-1 using MM5 version 3.7.4. The MM5 simulations were run on the same map projection as CMAQ.

Both meteorological model runs were configured similarly. The selections for key MM5 physics options are shown below:

- Pleim-Xiu PBL and land surface schemes
- Kain-Fritsh 2 cumulus parameterization
- Reisner 2 mixed phase moisture scheme
- RRTM longwave radiation scheme
- Dudhia shortwave radiation scheme

Three dimensional analysis nudging for temperature and moisture was applied above the boundary layer only. Analysis nudging for the wind field was applied above and below the boundary layer. The 36 km domain nudging weighting factors were 3.0×10^4 for wind fields and temperatures and 1.0×10^5 for moisture fields. The 12 km domain nudging weighting factors were 1.0×10^4 for wind fields and temperatures and 1.0×10^5 for moisture fields.

All model runs were conducted in 5.5 day segments with 12 hours of overlap for spin-up purposes. Both domains contained 34 vertical layers with an approximately 38 m deep surface layer and a 100 millibar top. The MM5 and CMAQ vertical structures are shown in Table G-2 and do not vary by horizontal grid resolution.

Table G-2. Vertical Layer Structure for MM5 and CMAQ (heights are layer top).

CMAQ Layers	MM5 Layers	Sigma P	Approximate Height (m)	Approximate Pressure (mb)
0	0	1	0	1000
1	1	0.995	38	995
2	2	0.99	77	991
3	3	0.985	115	987
	4	0.98	154	982
4	5	0.97	232	973
5	6	0.96	310	964
6	7	0.95	389	955
	8	0.94	469	946
7	9	0.93	550	937
	10	0.92	631	928
8	11	0.91	712	919

CMAQ Layers	MM5 Layers	Sigma P	Approximate Height (m)	Approximate Pressure (mb)
	12	0.9	794	910
9	13	0.88	961	892
10	14	0.86	1,130	874
11	15	0.84	1,303	856
12	16	0.82	1,478	838
13	17	0.8	1,657	820
14	18	0.77	1,930	793
15	19	0.74	2,212	766
16	20	0.7	2,600	730
17	21	0.65	3,108	685
18	22	0.6	3,644	640
19	23	0.55	4,212	595
	24	0.5	4,816	550
20	25	0.45	5,461	505
	26	0.4	6,153	460
21	27	0.35	6,903	415
	28	0.3	7,720	370
22	29	0.25	8,621	325
	30	0.2	9,625	280
23	31	0.15	10,764	235
	32	0.1	12,085	190
24	33	0.05	13,670	145
	34	0	15,674	100

The meteorological outputs from the MM5 sets were processed to create model-ready inputs for CMAQ using the Meteorology-Chemistry Interface Processor (MCIP), version 3.4, to derive the specific inputs to CMAQ.

Before initiating the air quality simulations, it was important to identify the biases and errors associated with the meteorological modeling inputs. The 2005 MM5 model performance evaluations used an approach which included a combination of qualitative and quantitative analyses to assess the adequacy of the MM5 simulated fields. The qualitative aspects involved comparisons of the model-estimated synoptic patterns against observed patterns from historical weather chart archives. Additionally, the evaluations compared spatial patterns of monthly average rainfall and monthly maximum planetary boundary layer (PBL) heights. Qualitatively, the model fields closely matched the observed synoptic patterns, which is not unexpected given the use of nudging. The operational evaluation included statistical comparisons of model/observed pairs (e.g., mean normalized bias, mean normalized error, index of agreement, root mean square errors, etc.) for multiple meteorological parameters, including temperature, humidity, shortwave downward radiation, wind speed, and wind direction (Baker and Dolwick, 2009a, Baker and Dolwick, 2009b). It was ultimately determined that the bias and error values associated with the 2005 meteorological data were generally within the range of past meteorological modeling results that have been used for air quality applications.

Initial and Boundary Conditions:

The lateral boundary and initial species concentrations are provided by a three-dimensional global atmospheric chemistry model, the GEOS-CHEM model (Yantosca, 2004). The global GEOS-CHEM model simulates atmospheric chemical and physical processes driven by assimilated meteorological observations from the NASA's Goddard Earth Observing System (GEOS). This model was run for 2002 with a grid resolution of 2.0 degrees x 2.5 degrees (latitude-longitude) and 24 vertical layers. The 2005 CMAQ 36km simulation used non-year specific GEOS-CHEM data, which was created by taking the median value for each month in each individual grid cell of the 2002 GEOS-CHEM data described above. The predictions were used to provide one-way dynamic boundary conditions and an initial concentration field for the CMAQ simulations. More information is available about the GEOS-CHEM model and other applications using this tool at: http://www-as.harvard.edu/chemistry/trop/geos.

CMAQ Model Performance Evaluation

An operational model performance evaluation for $PM_{2.5}$ and its related speciated components was conducted for 2005 using state/local monitoring sites data in order to estimate the ability of the CMAQ modeling system to replicate the concentrations for the 12-km Eastern domain and 36-km domain in the west. The principal evaluation statistics used to evaluate CMAQ performance included two bias metrics, normalized mean bias and fractional bias; and two error metrics, normalized mean error and fractional error. For the 12-km Eastern domain, performance evaluation statistics were computed for the entire domain as well as its subregions. For the 36-km domain, evaluation focuses on the parts of the US not covered by the 12-km Eastern domain by computing performance evaluation statistics for the states included in the Western Regional Air Partnership (WRAP).

The $PM_{2.5}$ evaluation focuses on $PM_{2.5}$ total mass and its components, including sulfate (SO4), nitrate (NO3), total nitrate (TNO3 = NO3 + HNO3), ammonium (NH4), elemental carbon (EC), and organic carbon (OC). PM2.5 ambient measurements for 2005 were obtained from the following networks for model evaluation: Speciation Trends Network (STN), Interagency Monitoring of PROtected Visual Environments (IMPROVE), and Clean Air Status and Trends Network (CASTNET). For PM2.5 species that are measured by more than one network, we calculated separate sets of statistics for each network. Table G-3 provides annual model performance statistics for $PM_{2.5}$ and its component species. Based on the bias and error values associated with the 2005 CMAQ-modeled $PM_{2.5}$ concentration data, it was determined that the annual average $PM_{2.5}$ data were generally within the range of past modeling results used for air quality applications and are applicable to be used for this national-scale current conditions analysis.

Table G-3. CMAQ modeled performance evaluation statistics for PM2.5 for 2005.

CMAQ 2005 Annual			No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
PM2.5 Total Mass	STN	12-km EUS	11622	-2.2	39.1	-4.7	40.3
		Northeast	2795	4.2	41.3	3.4	39.5
		Midwest	2318	4.3	35.2	5.0	34.1
		Southeast	2960	-13.0	37.5	-15.9	41.1
		Central	2523	-2.2	43.1	-8.4	45.6
		36-km West WRAP	3082	-35.1	50.7	-40.3	57.4
	IMPROVE	12-km EUS	10534	-9.4	44.3	-13.8	48.6
		Northeast	2464	5.3	48.6	2.3	46.2
		Midwest	668	-4.6	38.2	-7.3	40.8
		Southeast	1963	-20.8	42.8	-25.9	51.3
		Central	2768	-10.5	42.8	-12.9	47.7
		36-km West WRAP	10,122	-21.0	56.0	-24.4	57.6
Sulfate	STN	12-km EUS	13317	-17.1	34.0	-13.5	37.0
		Northeast	3247	-13.7	32.4	-9.4	34.3
		Midwest	2495	-10.9	33.9	-4.4	34.9
		Southeast	3499	-19.2	32.8	-16.8	35.8
		Central	2944	-25.7	38.7	-23.1	43.5
		36-km West WRAP	3450	-21.9	46.4	-15.0	46.5
	IMPROVE	12-km EUS	10164	-21.8	36.4	-13.2	41.1
		Northeast	2393	-14.6	35.5	-6.6	38.6
		Midwest	622	-19.0	34.5	-9.4	36.7
		Southeast	1990	-25.2	35.9	-22.3	41.1
		Central	2640	-27.9	38.0	-22.0	42.4
		36-km West WRAP	9693	-5.2	45.2	9.6	47.6

CMAQ 2005 Annual			No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
	CASTNet	12-km EUS	3170	-16.5	22.9	-15.6	26.0
		Northeast	786	-11.7	20.5	-9.8	22.6
		Midwest	615	-13.6	21.4	-11.2	22.2
		Southeast	1099	-18.4	22.9	-19.6	25.7
		Central	300	-29.4	32.5	-30.3	36.1
		36-km West WRAP	1112	-12.6	34.5	-3.2	36.7
Nitrate	STN	12-km EUS	12186	20.1	67.8	-10.1	76.3
		Northeast	3248	28.7	70.2	-3.7	74.1
		Midwest	2495	20.2	61.0	9.2	63.0
		Southeast	3499	23.5	84.0	-25.0	87.2
		Central	1812	8.1	60.2	-5.9	72.4
		36-km West WRAP	15,533	15.2	79.3	-15.6	85.9
	IMPROVE	12-km EUS	10157	30.1	85.2	-32.5	99.1
		Northeast	2388	67.0	108.9	0.5	93.4
		Midwest	622	14.0	67.9	-24.1	88.9
		Southeast	1990	37.4	104.6	-46.2	105.9
		Central	2640	17.3	70.8	-19.3	89.6
		36-km West WRAP	17,452	33.1	99.1	-41.9	109.9
Total Nitrate (NO_3+HNO_3)	CASTNet	12-km EUS	3170	24.6	39.7	17.8	38.0
		Northeast	786	36.5	43.0	30.3	40.6
		Midwest	615	23.3	36.5	23.9	33.2
		Southeast	1099	23.6	42.2	12.8	40.5
		Central	300	10.6	35.5	5.0	35.0
		36-km West WRAP	4065	37.7	51.9	24.2	45.1
Ammonium	STN	12-km EUS	13317	1.8	41.9	8.3	45.6
		Northeast	3247	7.1	42.9	18.9	45.7
		Midwest	2495	7.1	40.5	16.4	41.4
		Southeast	3499	-2.1	40.5	2.9	43.3
		Central	2944	-7.6	44.0	-4.0	51.4
		36-km West WRAP	16,680	8.1	47.2	12.8	48.9

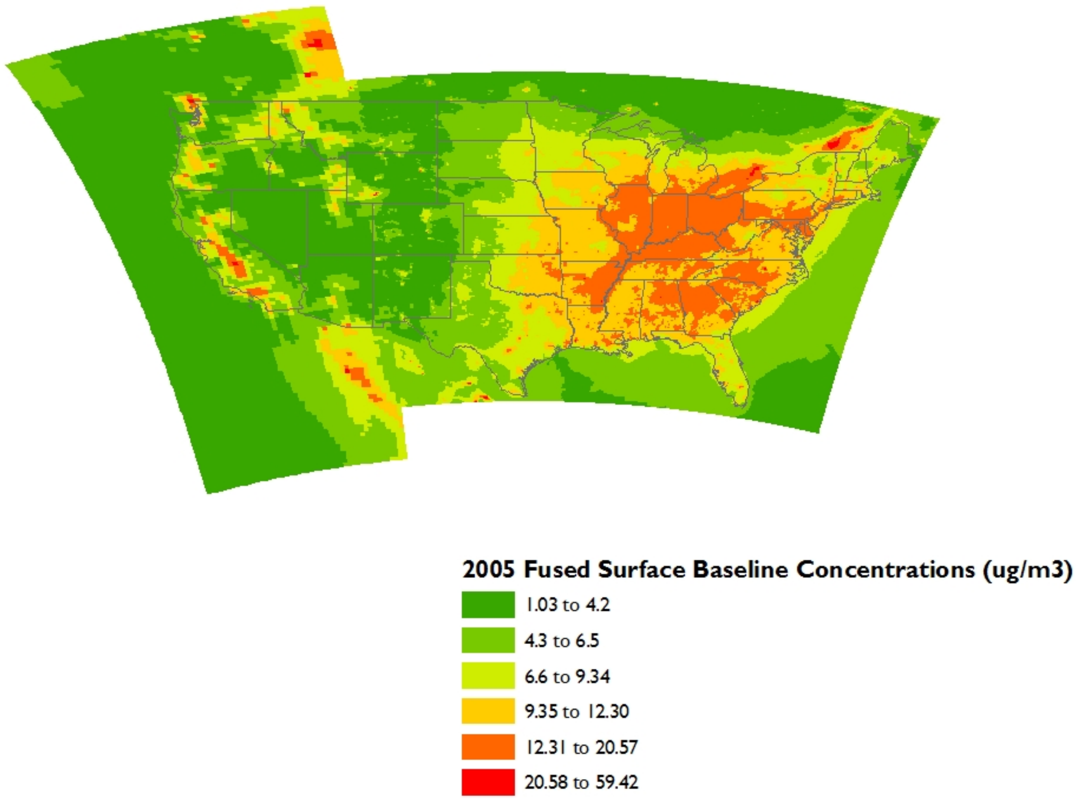
CMAQ 2005 Annual			No. of Obs.	NMB (%)	NME (%)	FB (%)	FE (%)
	CASTNet	12-km EUS	3170	2.2	35.4	3.1	36.5
		Northeast	786	9.2	38.1	13.3	36.6
		Midwest	615	10.9	35.3	14.8	33.7
		Southeast	1099	-9.2	33.3	-9.7	37.6
		Central	300	1.5	36.9	3.0	40.2
		36-km West WRAP	4065	12.8	39.6	13.0	40.1
Elemental Carbon	STN	12-km EUS	13460	19.7	63.5	11.9	53.9
		Northeast	3230	20.8	61.9	14.6	52.0
		Midwest	2502	7.3	46.1	10.8	44.9
		Southeast	3495	10.2	60.2	3.0	50.6
		Central	3107	47.6	88.2	23.0	64.9
		36-km West WRAP	16,700	2.6	56.7	2.6	55.0
	IMPROVE	12-km EUS	10244	-29.0	49.7	-39.1	61.3
		Northeast	2341	-17.8	49.2	-25.6	57.7
		Midwest	696	-26.7	41.9	-39.6	55.7
		Southeast	1995	-45.6	53.3	-58.5	69.8
		Central	2626	-22.9	49.2	-31.3	56.8
		36-km West WRAP	17,289	-16.6	53.4	-23.4	60.2
Organic Carbon	STN	12-km EUS	12118	-36.5	53.6	-40.6	66.5
		Northeast	3083	-29.1	53.1	-27.6	64.2
		Midwest	2385	-42.5	52.6	-41.7	65.3
		Southeast	3442	-42.6	53.5	-55.6	70.2
		Central	2164	-30.6	57.7	-39.6	66.5
		36-km West WRAP	15,397	-41.2	56.1	-45.7	69.2
	IMPROVE	12-km EUS	10210	-34.7	53.7	-53.0	70.0
		Northeast	2336	-21.0	52.2	-29.2	58.4
		Midwest	696	-41.3	47.6	-55.7	63.6
		Southeast	1993	-40.4	53.7	-64.0	74.2
		Central	2622	-34.1	52.8	-52.7	68.1
		36-km West WRAP	17,295	-22.5	57.5	-40.8	67.6

"Fused" Spatial Surfaces

Spatial surfaces of the 2005 data were created by fusing CMAQ-modeled annual average PM2.5 concentrations with total $PM_{2.5}$ data from STN, IMPROVE, and CASTNET monitoring sites for the two domains shown in Figure 1. We used the EPA's Model Attainment Test Software (MATS) (Abt, 2009) which employees the Voronoi Neighbor Averaging (VNA) interpolation technique (Abt, 2008). This technique identifies the set of monitors that are nearest to the center of each grid cell, and then takes an inverse distance squared weighted average of the monitor concentrations. The "fused" spatial fields are calculated by adjusting the interpolated ambient data (in each grid cell) up or down by a multiplicative factor calculated as the ratio of the modeled concentration at the grid cell divided by the modeled concentration at the nearest neighbor monitor locations (weighted by distance).

To create the spatial surfaces for use in BenMAP, the 2005 CMAQ-modeled annual average $PM_{2.5}$ concentrations were "fused" with 2005 total $PM_{2.5}$ ambient monitoring data from STN, IMPROVE, and CASTNET sites. This was done for both the 36km national domain and the 12km eastern US domain. The spatial surface of annual average PM2.5 air quality concentrations produced by this technique is shown in Figure G-2 for the continental U.S. Where available, the 12km spatial surface was used to supply BenMAP with annual average $PM_{2.5}$ concentrations. In the western part of the U.S., annual average $PM_{2.5}$ concentrations were supplied from the 36km domain.

Figure G-2: 2005 Predicted Annual Mean $PM_{2.5}$ Levels



Advantages and Limitations

As compared to using monitored data alone, an advantage of using the CMAQ model output for comparing with health outcomes is that it has the potential to provide more complete spatial and temporal coverage. In addition, “fusing” the CMAQ data with ambient monitoring data allows for an improvement over non-fused fields (Timin et al., 2009). Doing so allows for a combination of the advantages of both sets of data: better spatial coverage and more accurate air quality estimates. Of course, the more accurate the model estimates of $PM_{2.5}$, the better the performance of the “fused” spatial fields. Therefore, it is important to use model outputs that have adequate $PM_{2.5}$ performance. As discussed above, we believe that the 2005 CMAQ-modeled $PM_{2.5}$ concentration data showed adequate model performance to be used for this national-scale current conditions analysis.

As with any model estimate of air quality, there are limitations. For example, the emissions and meteorological data used in CMAQ can each have large uncertainties, in particular for unusual emission or meteorological events. There are also uncertainties associated with the chemical transformation and fate process algorithms used in air quality models. For these reasons, CMAQ predicts best on longer time scale bases (e.g., synoptic, monthly, and annual scales). These limitations have led us to use modeled air quality estimates in this analysis that are “fused” with measured ambient data and averaged over an annual scale.

Air Quality Estimates

Figures G-3 through G-6 below illustrate the spatial distribution of air quality impacts. Figure 1 illustrates the modeled 2005 $PM_{2.5}$ air quality levels across the U.S. Figures 2 and 3 display the PM2.5 air quality levels after being adjusted so that the maximum level is no higher than the LML reported in the Krewski et al. (2009) and Laden et al. (2006) studies. Figure G-4 displays the PRB by region of the county.

Figure G-3: 2005 Predicted Annual Mean $PM_{2.5}$ Levels

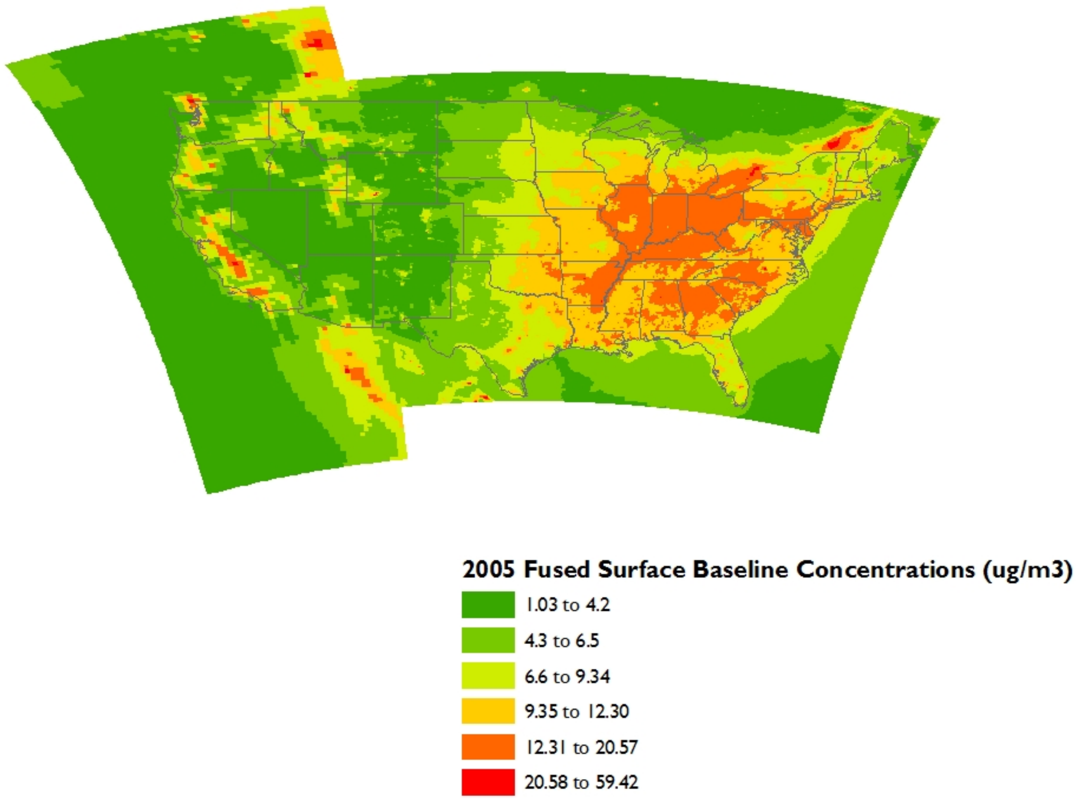


Figure G-4: 2005 Predicted Annual Mean $PM_{2.5}$ Levels Adjusted for LML of the Krewski et al. (2009) study

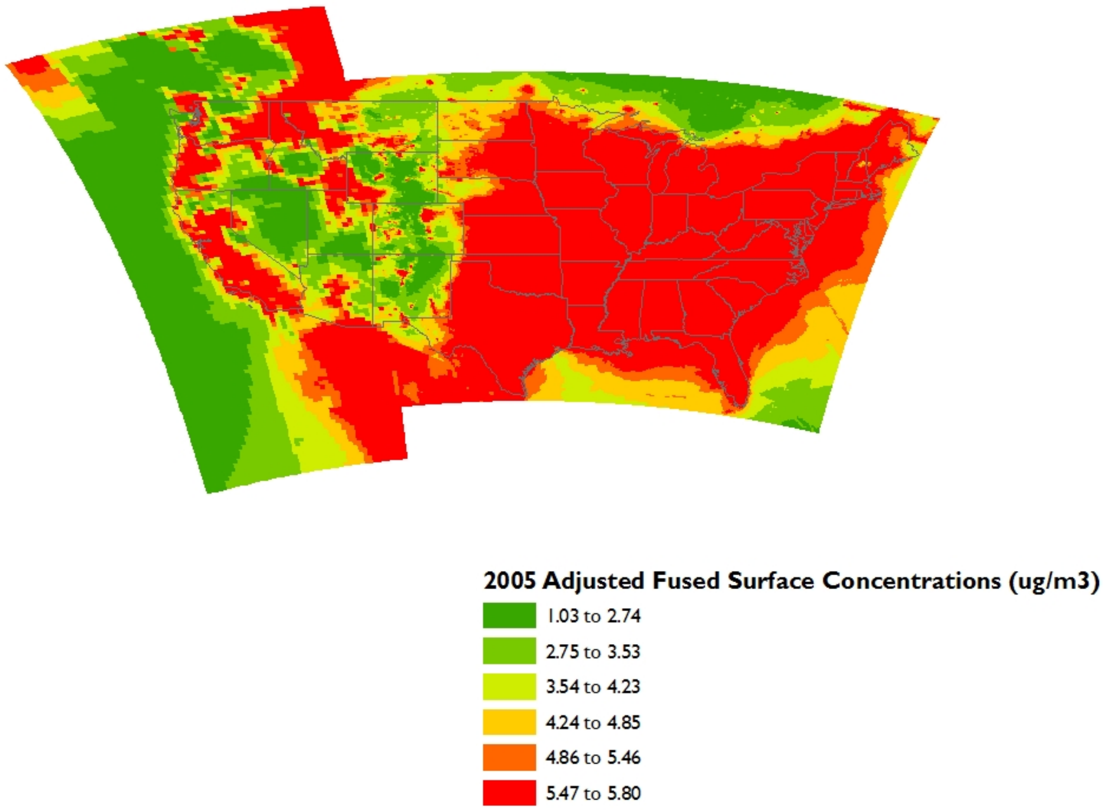


Figure G-5: 2005 Predicted Annual Mean $PM_{2.5}$ Levels Adjusted for LML of the Laden et al. (2006) study

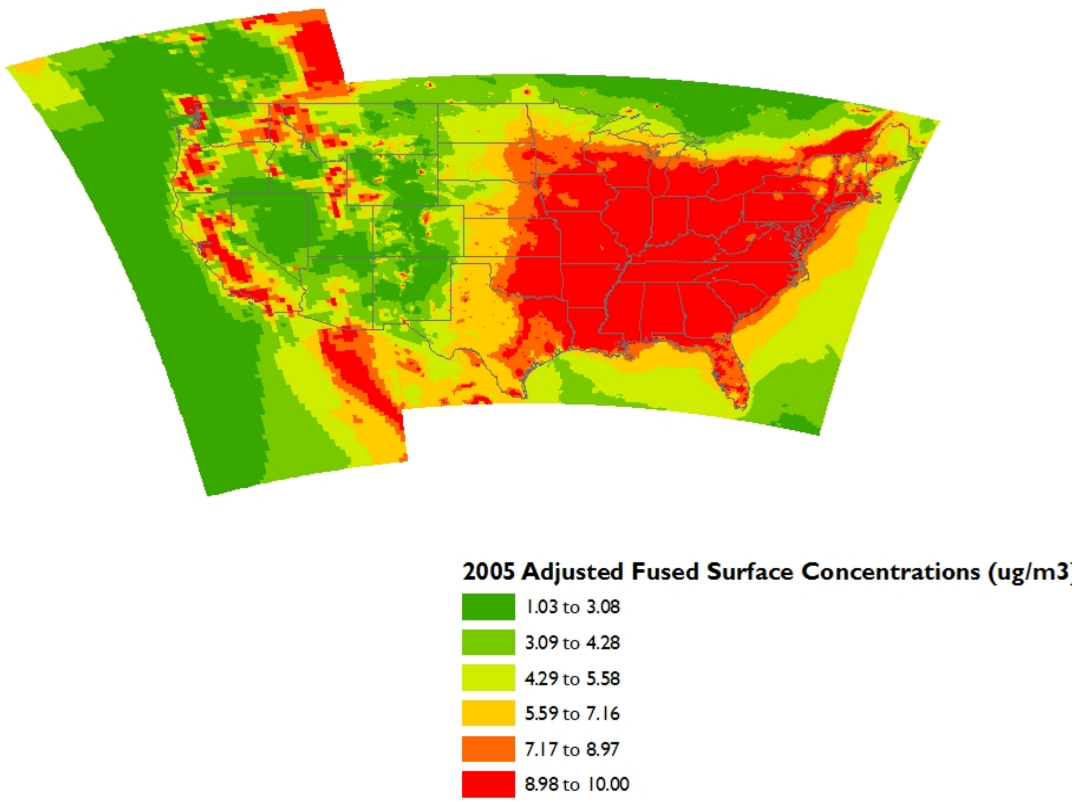


Figure G-6: PRB by Geographic Area in the U.S.

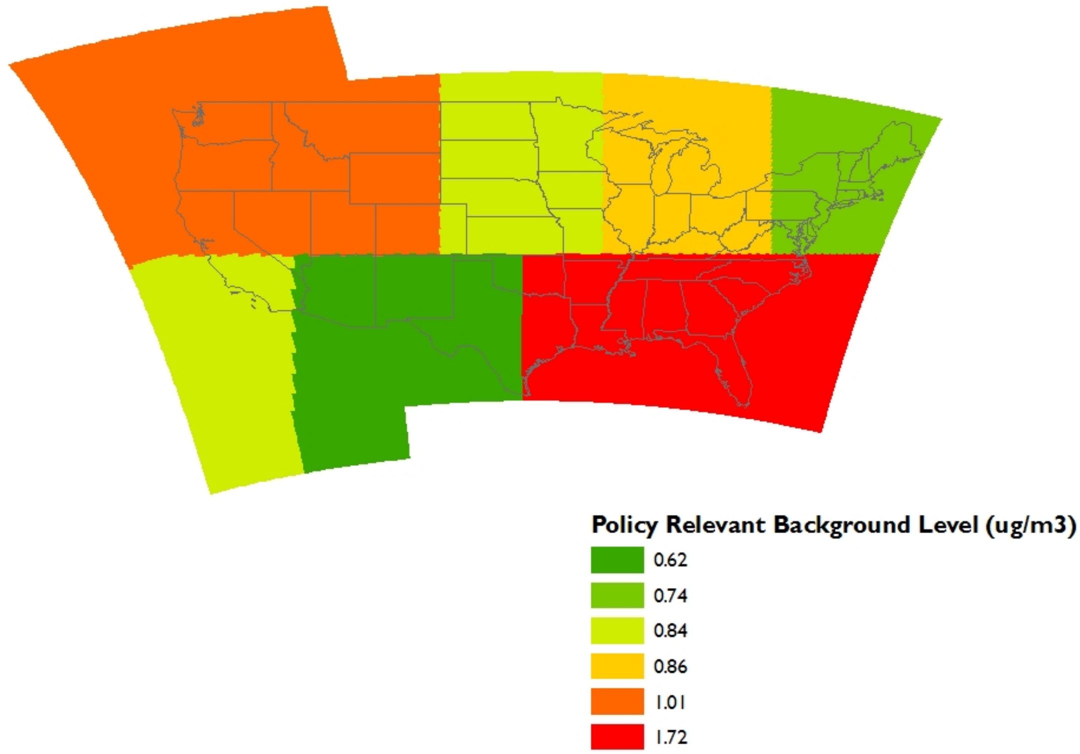


Figure G-7 displays the distribution of grid cells at different baseline $PM_{2.5}$ air quality levels. Figures G-8 through G-10 displays the distribution of grid cells according to the incremental change in $PM_{2.5}$ air quality for each of three scenarios: current conditions to 10 µg/m3, current conditions to 5.8 µg/m3 and current conditions to PRB.

Figure G-7: The Number of Grid Cells at Each Level of $PM_{2.5}$ Concentration in 2005 Current Conditions Air Quality Modeling Run

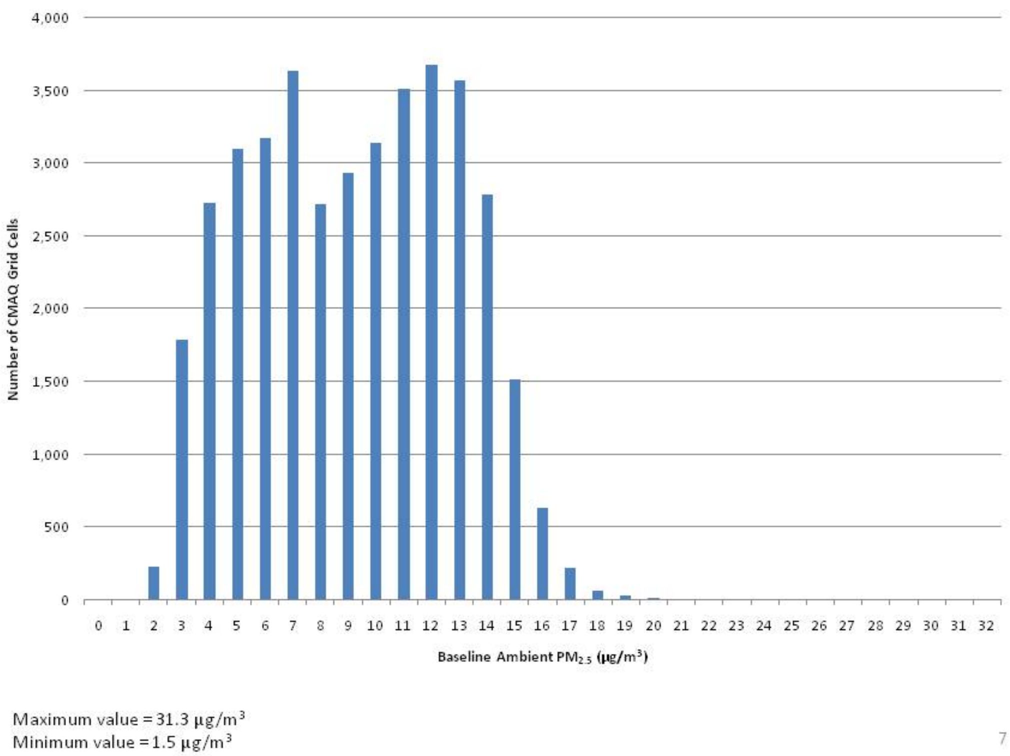


Figure G-8: The Number of CMAQ Grid Cells Experiencing an Incremental Change in Annual Mean PM2.5 (µg/m^3) (Current Conditions – 10 µg/m^3)

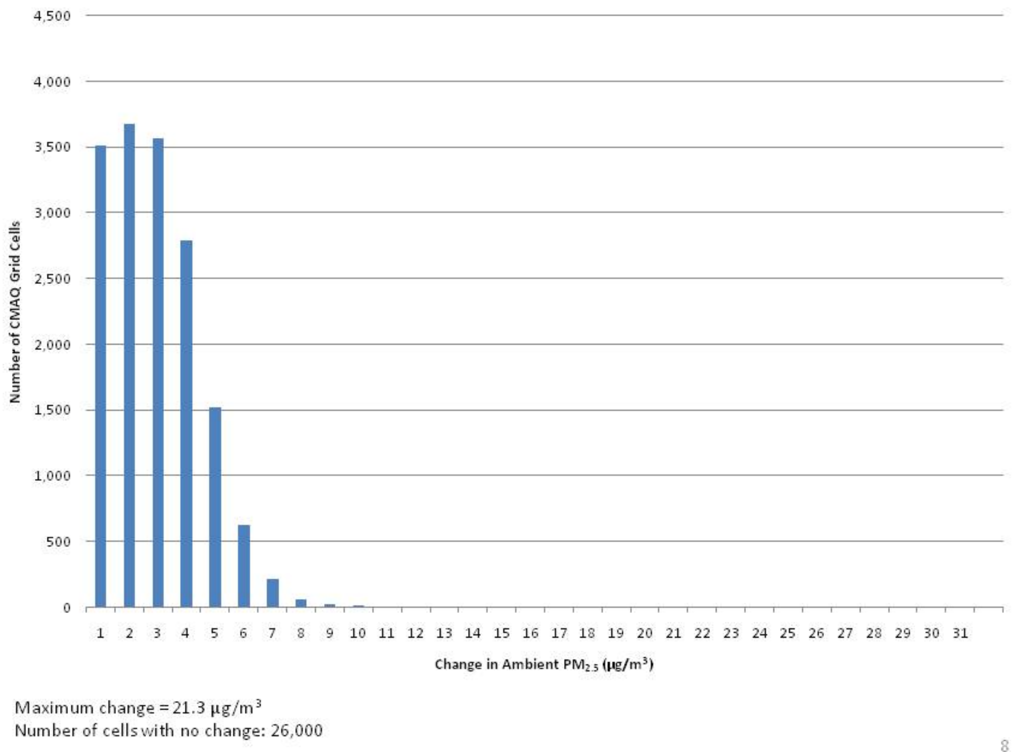


Figure G-9: The Number of CMAQ Grid Cells Experiencing an Incremental Change in Annual Mean $PM_{2.5}$ (µg/m^3) (Current Conditions – 5.8 µg/m^3)

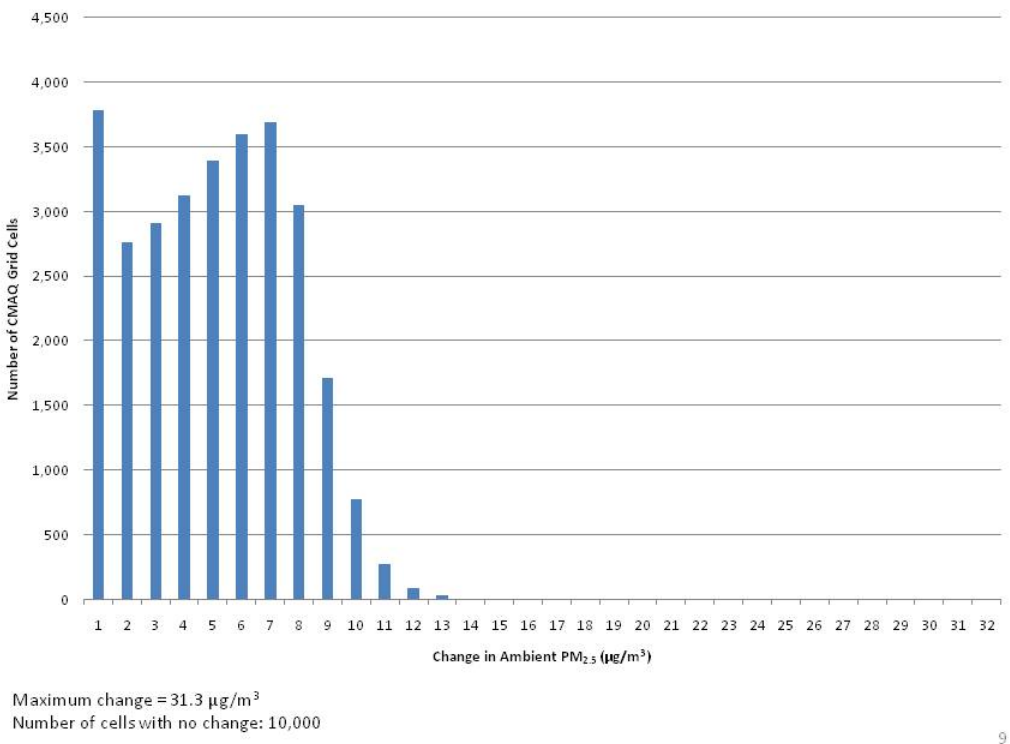


Figure G-10: The Number of CMAQ Grid Cells Experiencing an Incremental Change in Annual Mean $PM_{2.5}$ (µg/m^3) (Current Conditions – Policy Relevant Background)

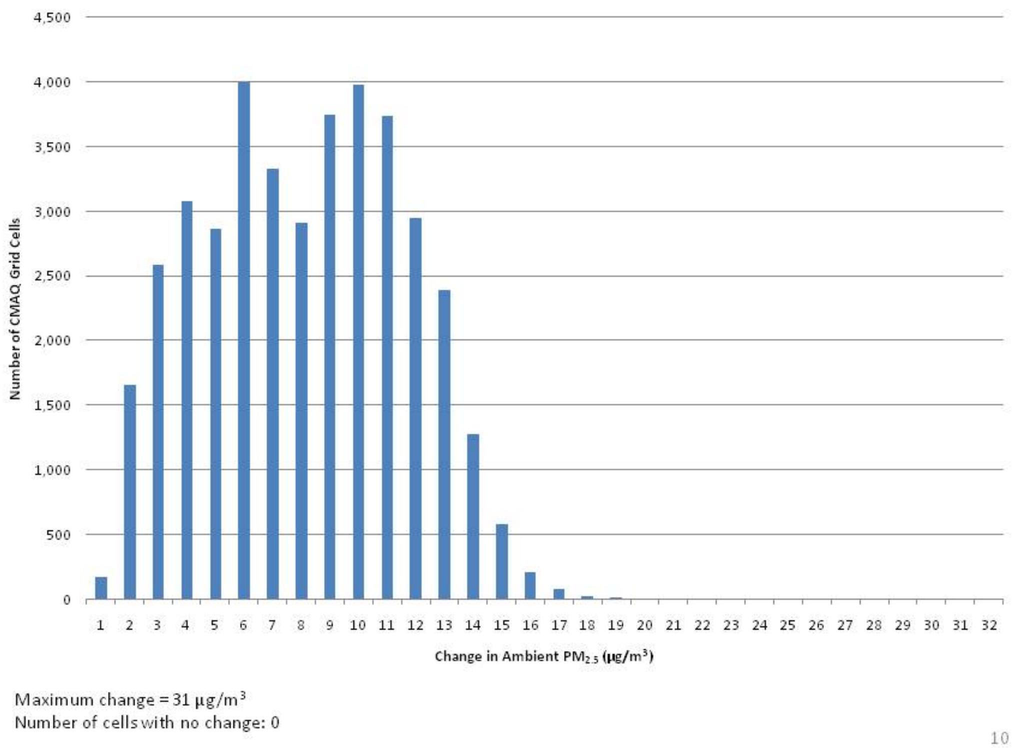


Figure G-11 displays the cumulative distribution of grid cells at each baseline concentration. Figures G-12 through G-14 display the cumulative distribution of grid cells experiencing an incremental air quality change.

Figure G-11: Cumulative Distribution of Baseline $PM_{2.5}$ Concentrations ($\mu g/m^3$)

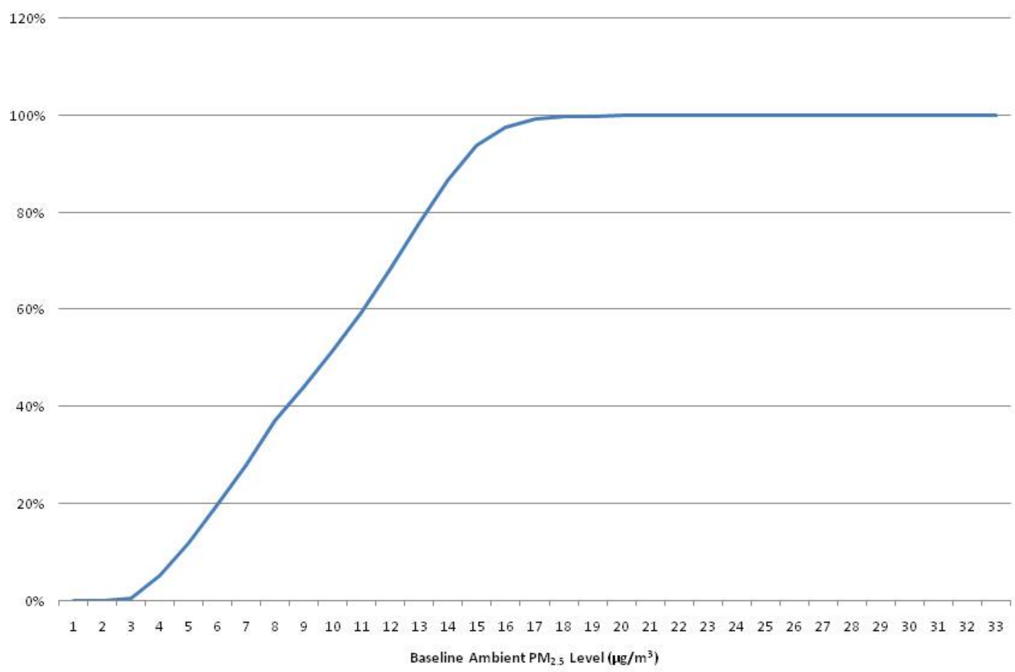


Figure G-12: Cumulative Distribution of $PM_{2.5}$ ($\mu g/m^3$) Changes (Baseline – 10 $\mu g/m^3$)

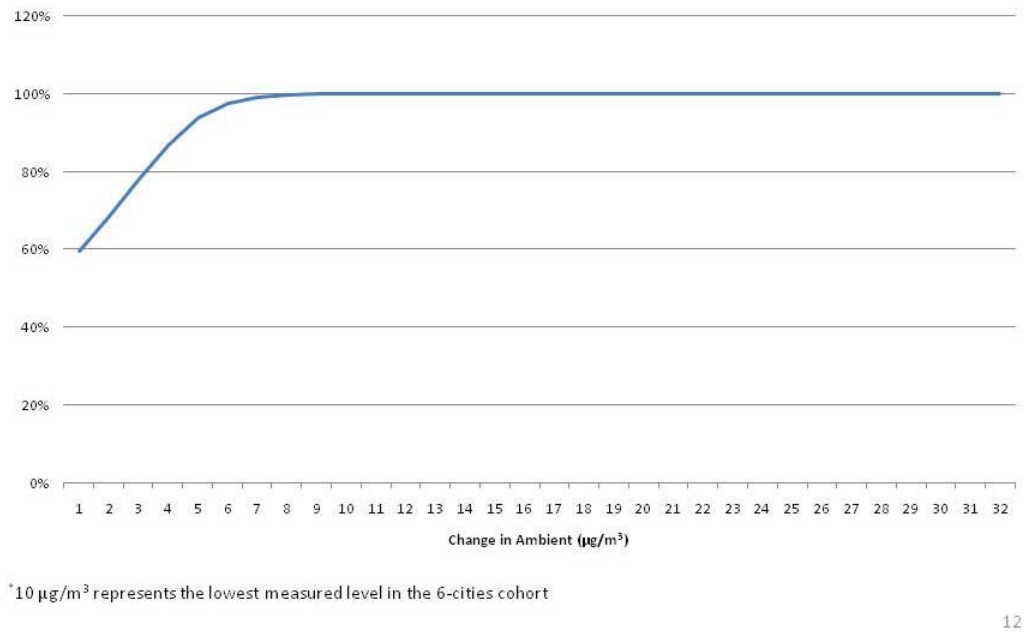


Figure G-13: Cumulative Distribution of $PM_{2.5}$ ($\mu g/m^3$) Changes (Baseline – 5.8 $\mu g/m^3$)

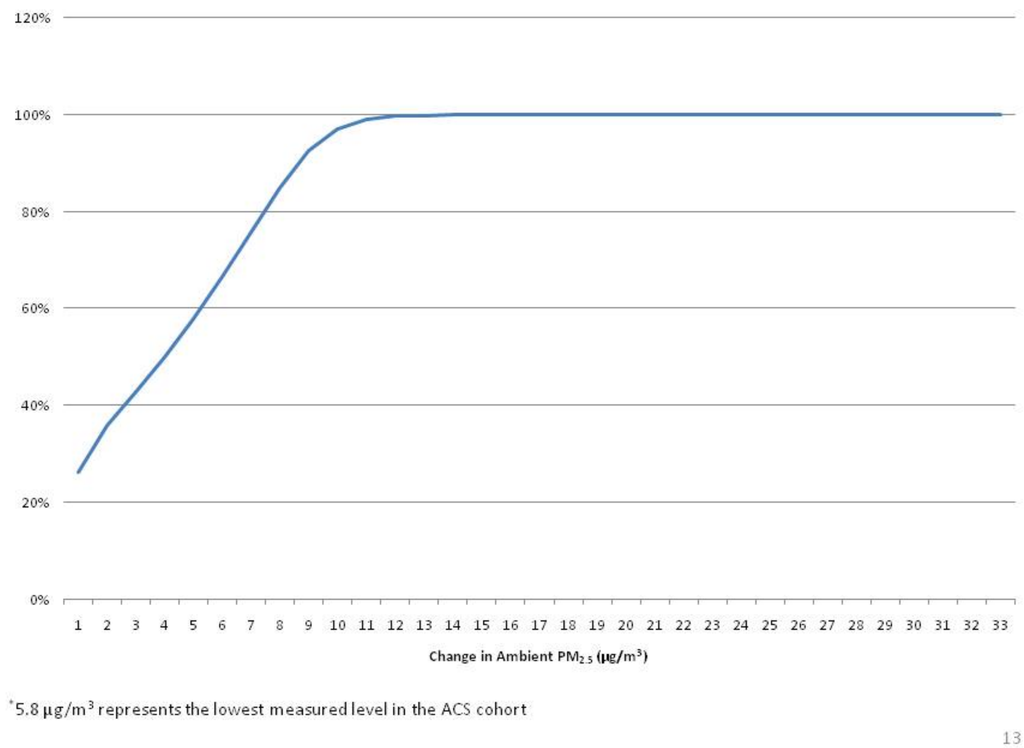
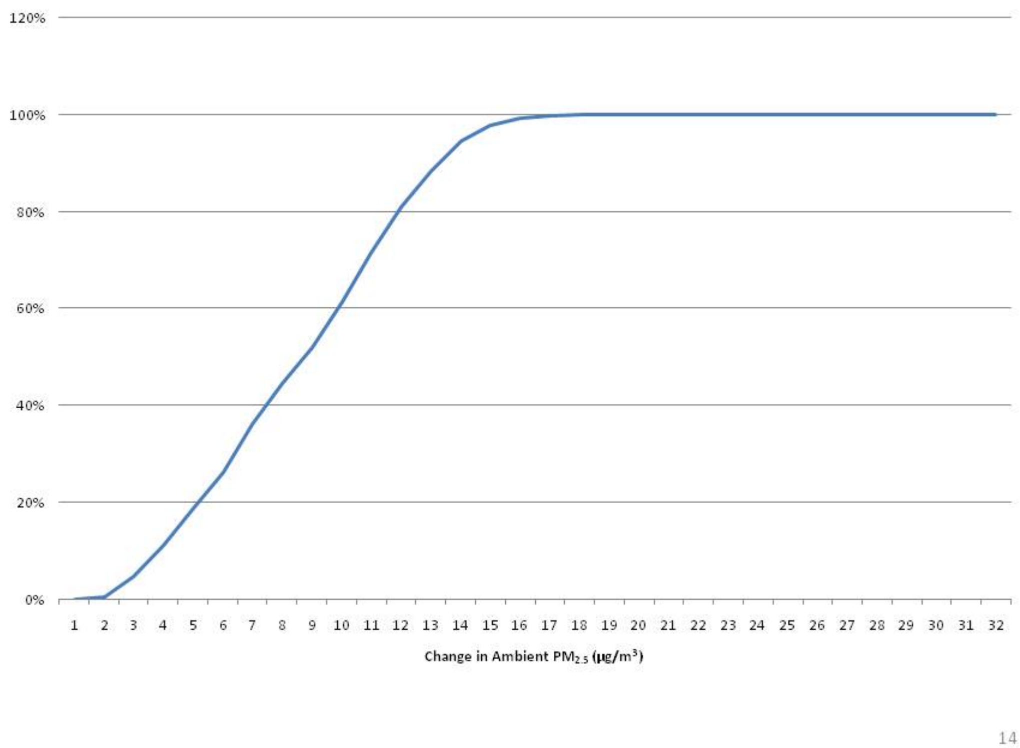


Figure G-14: Cumulative Distribution of $PM_{2.5}$ ($\mu g/m^3$) (Baseline – Policy Relevant Background)



<u>Exposure Estimates</u>

Below we provide additional details regarding the estimated exposure changes occurring as a result of each of the air quality changes assumed in each of the three health impact assessments: current conditions incremental to 10 µg/m3, 5.8 µg/m3 and PRB. Table G-4 summarizes the population-weighted air quality change occurring among populations 30-99 (the age range considered in the ACS cohort) for each scenario.

Population-weighted air quality change is the average per-person change in $PM_{2.5}$. It is estimated by calculating the summation of the population in each grid cell multiplied against the change in annual mean $PM_{2.5}$ concentration in that grid cell and then dividing by the total population.

Table G-4. Estimated Change in Annual Mean Population-Weighted $PM_{2.5}$ by Model Scenario

Model scenario	Population-weighted air quality change or baseline
Current conditions to 10 µg/m^3	2.6 µg/m^3
Current conditions to 5.8 µg/m^3	6.3 µg/m^3
Current conditions to PRB	11 µg/m^3
Current conditions	12 µg/m^3

Health Impact Estimates

Figure G-15 through G-17 illustrate the distribution of total mortality attributable to $PM_{2.5}$ exposure for each of three scenarios: current conditions to 10 µg/m^3, 5.8 µg/m^3 and PRB.

Figure G-15: The Percentage of Total Mortality Attributable to $PM_{2.5}$ Exposure: Baseline – 10 μg/m^3

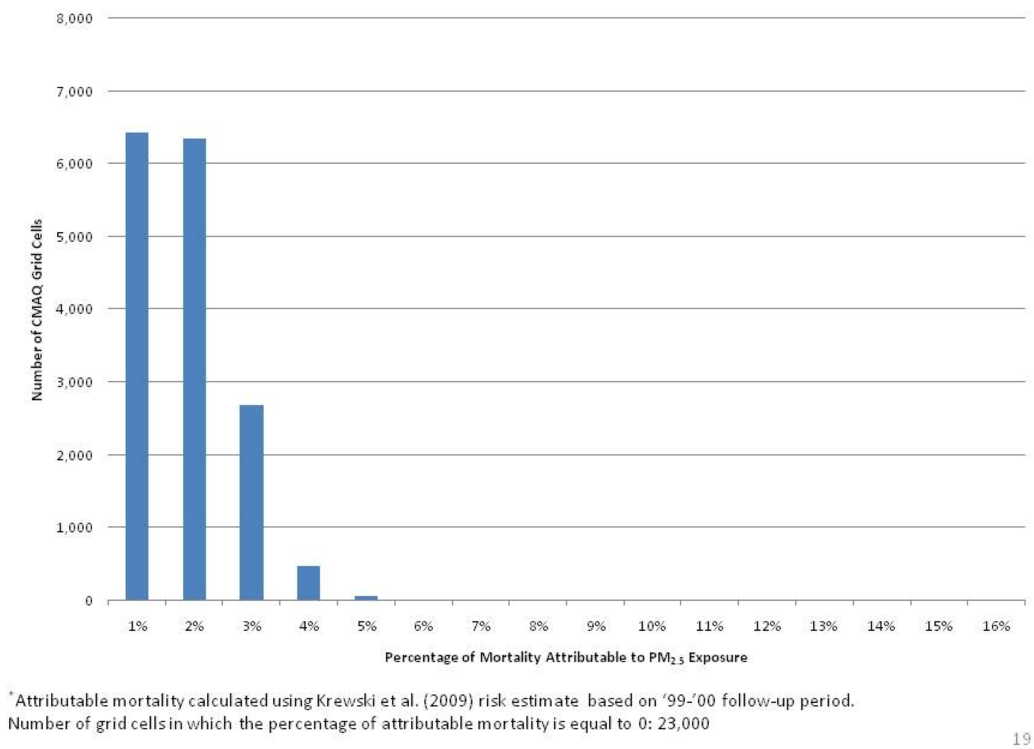


Figure G-16: The Percentage of Total Mortality Attributable to $PM_{2.5}$ Exposure: Baseline – 5.8 µg/m^3

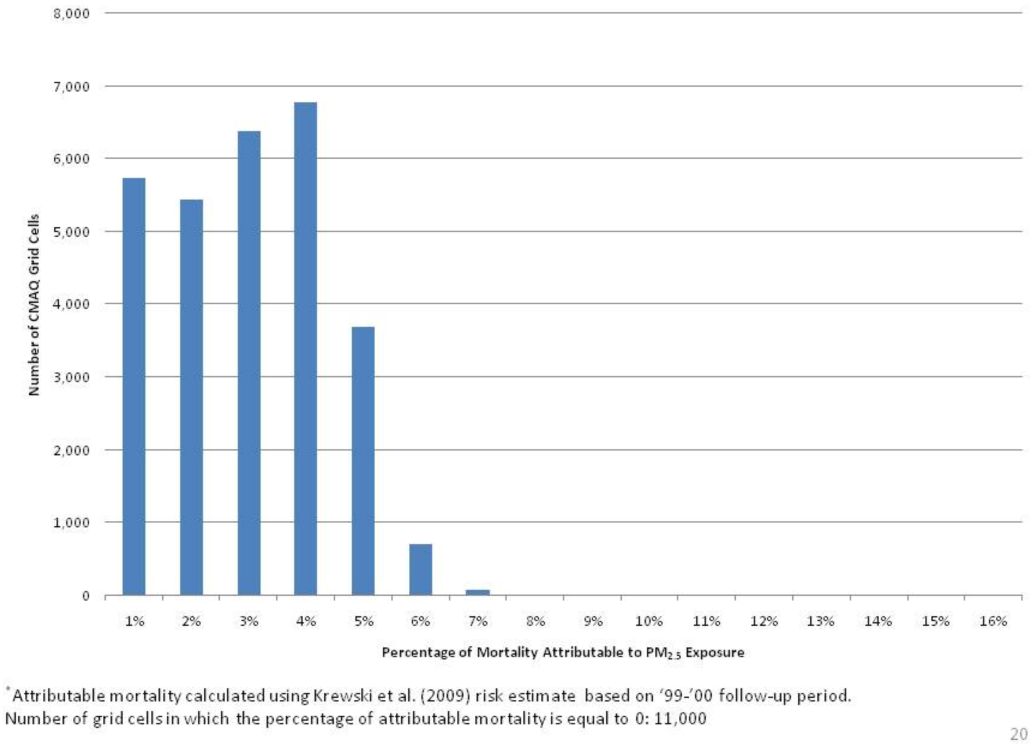
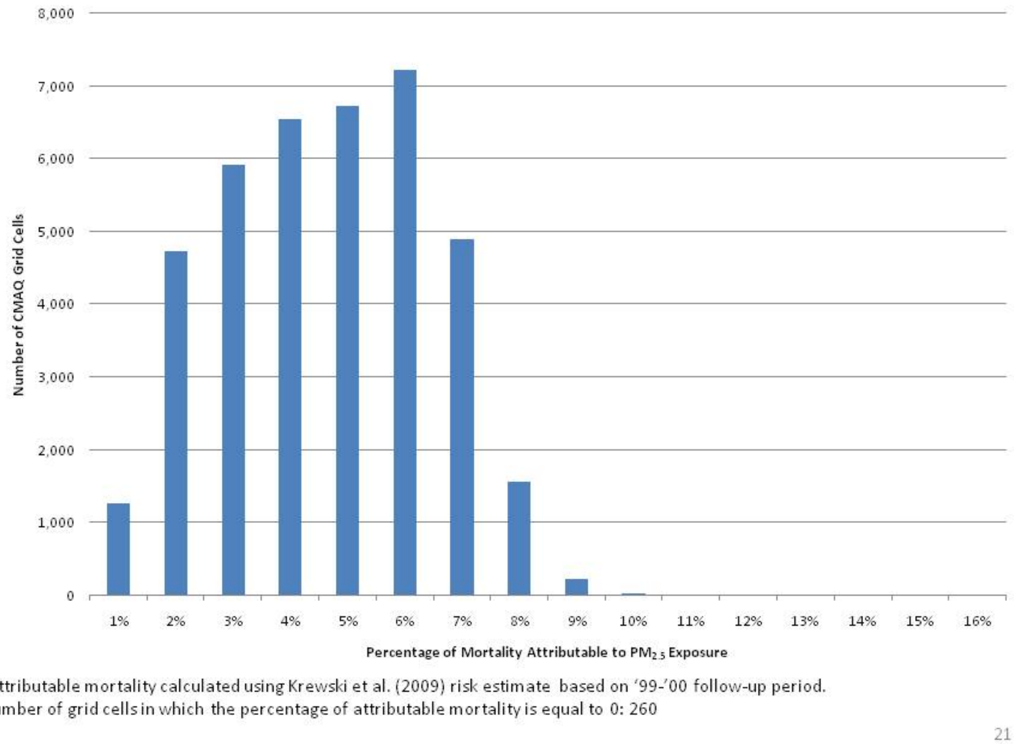


Figure G-17: The Percentage of Total Mortality Attributable to $PM_{2.5}$ Exposure: Baseline – Policy Relevant Background



Figures G-18 through G-20 illustrate the cumulative distribution of total mortality attributable to $PM_{2.5}$ exposure for each of three scenarios: current conditions to 10 µg/m^3, 5.8 µg/m^3 and PRB.

Figure G-18: The Cumulative Distribution of the Percentage of Total Mortality Attributable to $PM_{2.5}$ Exposure: Baseline – 10 µg/m^3

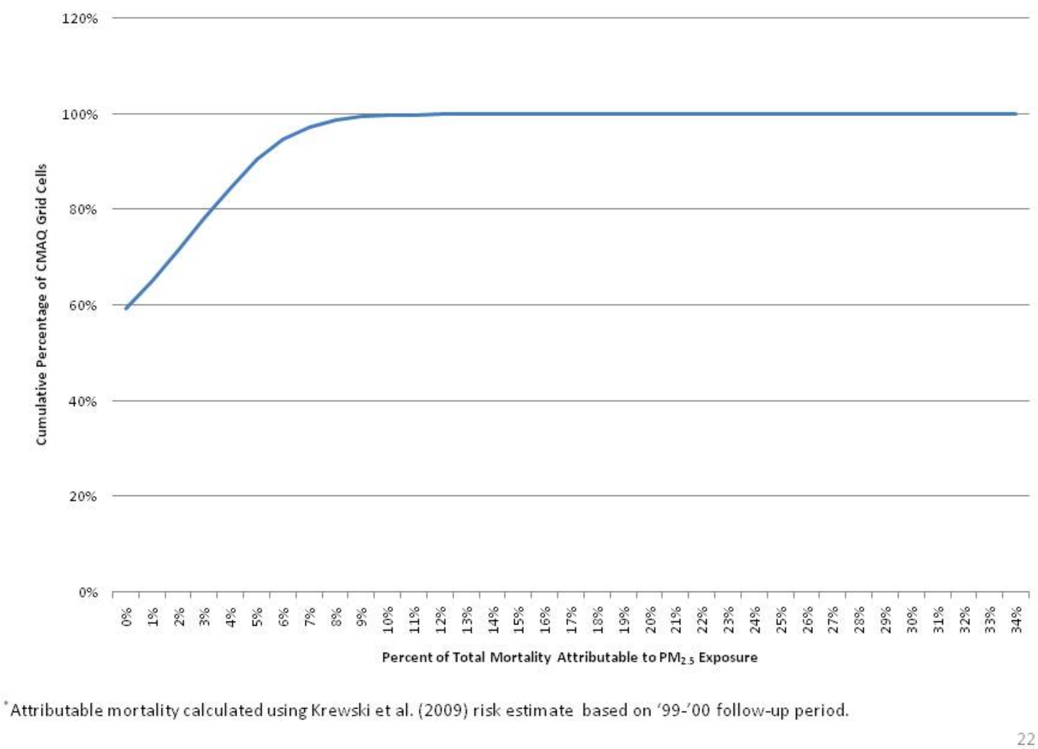


Figure G-19: The Cumulative Distribution of the Percentage of Total Mortality Attributable to PM2.5 Exposure: Baseline – 5.8 µg/m³

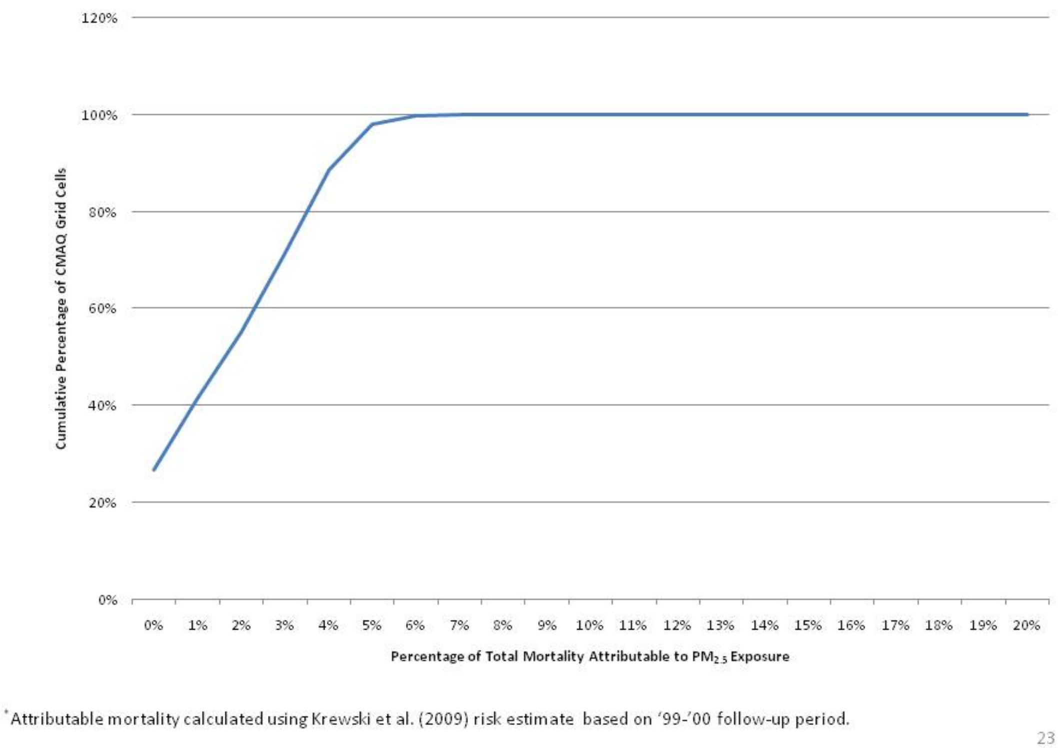
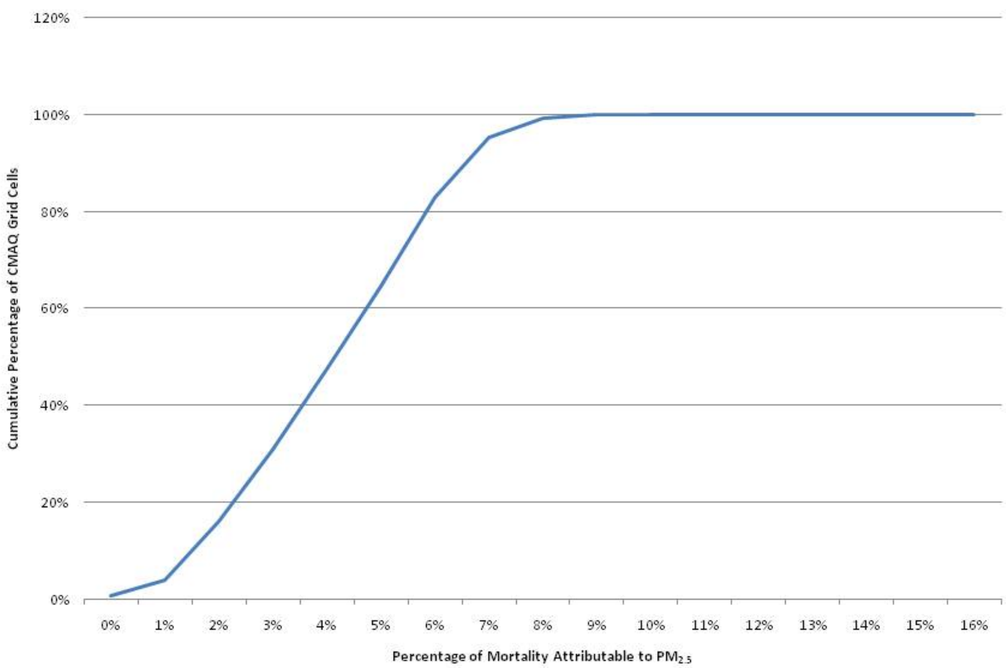


Figure G-20: The Cumulative Distribution of the Percentage of Total Mortality Attributable to $PM_{2.5}$ Exposure: Baseline – Policy Relevant Background



*Attributable mortality calculated using Krewski et al. (2009) risk estimate based on '99-'00 follow-up period.

24

APPENDIX H: CONSIDERATION OF RISK ASSOCIATED WITH EXPOSURE TO THORACIC COARESE PM ($PM_{10-2.5}$)

H.1 OVERVIEW

This appendix discusses the issue of assessing public health risk associated with exposure to thoracic coarse PM ($PM_{10-2.5}$). As mentioned in Section 2.6, due to limitations in available monitoring data characterizing ambient levels of $PM_{10-2.5}$ in prospective urban study areas, together with limitations in the epidemiological study data available for deriving C-R functions for this PM size fraction, EPA staff has concluded that uncertainties in characterizing risk for $PM_{10-2.5}$ are potentially significant enough at this time to limit the utility of those estimates in informing the review of the PM coarse standard level. Therefore, we have not conducted a $PM_{10-2.5}$ risk assessment for this review; instead, we have included a summary of risk estimates for $PM_{10-2.5}$ generated as part of the last PM NAAQS review completed in 2005.[3]

As part of our summarizing $PM_{10-2.5}$ risk estimates from the last review below in section H.2, we have included a discussion of the limitations and uncertainties associated with those risk estimates which resulted in the decision by EPA not to use those risk estimates in recommending specific standard levels (USEPA, 2006 – Final Rule FR Notice, p. 61178). This discussion provides the basis for a more detailed discussion (in Section H.3) of our rationale for not conducting a $PM_{10-2.5}$ risk assessment as part of the current review. Specifically, in Section H-3, we consider each of the limitations in the $PM_{10-2.5}$ risk assessment from the last review and assess whether data available since the last review, including more recent ambient monitoring data and epidemiological study data, address these limitation. Our conclusion is that additional information on $PM_{10-2.5}$ that has become available since the last review does not substantially reduce overall uncertainty associated with modeling risk for this PM size fraction, and consequently, we conclude that conducting a $PM_{10-2.5}$ risk assessment is not supported at this time.

H.2 SUMMARY OF $PM_{10-2.5}$ RISK ESTIMATES GENERATED FOR THE PREVIOUS REVIEW

This section provides a brief overview of the approach used in completing the $PM_{10-2.5}$ risk assessment for the previous review and provides a summary of key observations resulting from that assessment. Additional details on the risk estimates can

[3] We note that inclusion in this appendix of a summary of the $PM_{10-2.5}$ risk assessment completed for the previous review should not be construed as implying that overall conclusions regarding limitations and uncertainties in that risk assessment have changed. Conclusions reached in the last review, that $PM_{10-2.5}$ risk estimates should not be used in recommending specific standard levels, still holds. Rather, we have included a summary of the $PM_{10-2.5}$ risk assessment completed for the last review in the interest of completeness.

be found in the risk assessment report completed for the previous analysis (USEPA, 2005).

The $PM_{10-2.5}$ risk assessment completed for the previous review is similar in design to the $PM_{2.5}$ risk assessment, although the scope is significantly more limited, reflecting the more limited body of epidemiological evidence and air quality information available for $PM_{10-2.5}$. The $PM_{10-2.5}$ risk assessment assessed risk for populations in three urban study areas (Detroit, Seattle and St. Louis), with a set of short-term exposure-related morbidity health endpoints being modeled, including: respiratory hospital admissions (for Detroit and Seattle), cardiovascular hospital admissions (for Detroit) and respiratory symptoms (for St. Louis). Selection of these three urban study areas reflected consideration of the locations included in epidemiological studies providing C-R functions, as well as availability of co-located PM_{10} and $PM_{2.5}$ monitoring data used in deriving estimates of ambient $PM_{10-2.5}$ levels for urban study areas. EPA staff noted in the last review that the locations used in the $PM_{10-2.5}$ risk assessment were not representative of urban locations in the U.S. that experience the most significant elevated 24-hour $PM_{10-2.5}$ ambient concentrations. Thus, observations regarding risk reductions associated with alternative standards in these three urban areas may not be fully relevant to the areas expected to have the greatest health risks associated with peak daily ambient $PM_{10-2.5}$ concentrations. This is a key limitation impacting the $PM_{10-2.5}$ risk assessment and remains a primary concern in conducting a $PM_{10-2.5}$ risk assessment (see below).

In summarizing $PM_{10-2.5}$ risk estimates from the last review, we focus here on risk estimates generated for the recent conditions air quality scenario.[4] In the risk assessment, risk estimates are provided for Detroit for several categories of cardiovascular and respiratory-related hospital admissions and show point estimates ranging from about 2 to 7% of cause-specific admissions being associated with “as is” short-term exposures to $PM_{10-2.5}$. The point estimate for asthma hospital admissions associated with short-term $PM_{10-2.5}$ exposures for Seattle, an area with lower $PM_{10-2.5}$ ambient concentrations than either Detroit or St. Louis, is about 1%. Point estimates for lower respiratory symptoms and cough in St. Louis are about 12 and 15%, respectively. These estimates use estimated policy-relevant background as the cutpoint.

The specific set of uncertainties that resulted in EPA staff concluding that the $PM_{10-2.5}$ risk estimates should not be used in recommending specific standard levels include, but are not limited to, the following (see USEPA, 2005, PM SP, Section 5.4.4.2):

[4] We have chosen not to discuss risk estimates generated for alternate standard levels here since uncertainty in those estimates would be even higher than for recent conditions estimates.

- Concerns that the current $PM_{10-2.5}$ levels measured at ambient monitoring sites during the study period for the risk assessment may be quite different from the levels used to characterize exposure in the original epidemiologic studies based on monitoring sites in different location, thus possibly over- or underestimating population risk levels;
- Greater uncertainty about the reasonableness of the use of proportional rollback to simulate attainment of alternative $PM_{10-2.5}$ daily standards in any urban area due to the limited availability of $PM_{10-2.5}$ air quality data over time (this uncertainty only being relevant to risk estimates generated for the alternative standard levels);
- Concerns that the locations used in the risk assessment are not representative of urban areas in the U.S. that experience the most significant 24-hour peak $PM_{10-2.5}$ concentrations, and thus, observations about relative risk reductions associated with alternative standards may not be relevant to the areas expected to have the greatest health risks associated with elevated ambient $PM_{10-2.5}$ levels; and
- Concerns about the much smaller health effects database that supplies the C-R relationships used in the risk assessment, compared to that available for $PM_{2.5}$, which limits our ability to evaluate the robustness of the risk estimates for the same health endpoints across different locations.

H.3 RATIONALE FOR THE DECISION NOT TO CONDUCT A $PM_{10-2.5}$ RISK ASSESSMENT AS PART OF THE CURRENT REVIEW

The decision not to conduct a $PM_{10-2.5}$ risk assessment for the current review is based on consideration of key uncertainties identified in the last review and an assessment as to whether newly available information has significantly reduced those uncertainties. Each of the sources of uncertainty is addressed below:

- *Concerns that monitoring data that would be used in a $PM_{10-2.5}$ risk assessment (i.e., for the period 2005-2007) would not match ambient monitoring data used in the underlying epidemiological studies providing C-R functions*: While this is always a concern in conducting PM-related risk assessments, due to the potential for greater spatial heterogeneity in $PM_{10-2.5}$ ambient levels (see final PM ISA, Sections 2.1.1.2 and 2.2.1, USEPA 2009b), the potential for discrepancies between the monitoring networks used in epidemiological studies providing C-R functions and the monitoring network used in the risk assessment introducing uncertainty is increased relative to $PM_{2.5}$. That is, the potential for greater spatial variation in $PM_{10-2.5}$ levels means that the particular mix of collocated monitors used in generating an exposure surrogate in epidemiological studies needs to be more closely matched to the monitoring network used in conducting the risk assessment if significant uncertainty is to be avoided.
- *Uncertainty in the prediction of ambient levels under current and alternative standard levels:* This remains a significant factor introducing uncertainty into $PM_{10-2.5}$ risk estimates generated for alternative standard levels, and continues to weigh against the use of these risk estimates in identifying alternative standard

levels for consideration in this review. Not only is the monitoring network (i.e., co-located PM_{10} and $PM_{2.5}$ monitors) available for characterizing $PM_{10-2.5}$ levels in candidate urban study areas limited (see above), given the potential for greater spatial heterogeneity in $PM_{10-2.5}$ levels (relative to $PM_{2.5}$ levels), generating representative estimates of ambient air profiles for $PM_{10-2.5}$ under alternative standard levels is substantially more challenging than for $PM_{2.5}$. In particular, the use of proportional rollback as a means for conducting rollbacks would be subject to significant uncertainty given the greater potential for local-scale gradients in $PM_{10-2.5}$ levels and the linkage of $PM_{10-2.5}$ to local-scale sources.

- *Concerns that locations used in the risk assessment may not be representative of areas experiencing the most significant 24-hour peak $PM_{10-2.5}$ concentrations (and consequently, may not capture locations with the highest risk)*: This concern still holds since the monitoring network available for characterizing $PM_{10-2.5}$ levels in urban areas has not been significantly expanded (final PM ISA, Section 3.5.1.2,). Specifically, the final PM ISA states that: "Given the limited number of co-located low-volume FRM PM_{10} and FRM $PM_{2.5}$ monitors, only a very limited investigation into the intra-urban spatial variability of $PM_{10-2.5}$ was possible using AQS data. Of the 15 cities under investigation, only six (Atlanta, Boston, Chicago, Denver, New York and Phoenix) contained data sufficient for calculating $PM_{10-2.5}$ according to the data completeness and monitor specification requirements discussed earlier." As noted in the previous risk assessment, these urban study areas may not capture locations with the highest peak levels of $PM_{10-2.5}$ based on consideration of general patterns in PM_{10} and $PM_{2.5}$ levels.
- *Concerns about the much smaller health effects database that supplies the C-R relationships (relative to PM2.5):* While a number of epidemiological studies have been published since completion of the previous PM NAAQS review, including several large multi-city studies that inform consideration of the effects of short-term exposure to $PM_{10-2.5}$, limitations in the available studies still result in uncertainty in specifying C-R functions for $PM_{10-2.5}$. For example, while Peng et al. (2008) and Zanobetti and Schwartz (2009) both provide effect estimates for short-term exposure-related mortality (with consideration of copollutant confounding by $PM_{2.5}$), both have specific limitations that impact their use in risk assessment. For example, Zanobetti and Schwartz (2009) derives estimates of $PM_{10-2.5}$ by subtracting county-level PM_{10} and $PM_{2.5}$ levels, rather than using collocated monitors. Given the significant spatial gradients associated with $PM_{10-2.5}$ relative to $PM_{2.5}$, the use of this approach for assessing exposure introduces significant uncertainty (i.e., exposure measurement error). In the case of Peng et al. (2008), significant uncertainty results from the study not providing regional and/or seasonally-differentiated effects estimates that control for $PM_{2.5}$. Given the potential for regional differences in the composition of $PM_{10-2.5}$ which could impact risk estimates, combined with the potential for $PM_{2.5}$ to vary regionally as a confounder for the effect of $PM_{10-2.5}$, EPA staff believes that C-R functions with control for $PM_{2.5}$ would ideally be available at the regional level. .

When considered together, the limitations outlined above resulted in EPA staff concluding that a quantitative $PM_{10-2.5}$ risk assessment would not significantly enhance the review of the NAAQS for coarse-fraction PM. Specifically, these limitations would likely result in sufficient uncertainty in the resulting risk estimates to significantly limit their utility in informing policy-related questions, including the assessment of whether the current standard is protective of public health and characterization of the degree of additional public health protection potentially afforded by alternative standards. Because of the decision not to conduct a quantitative $PM_{10-2.5}$ risk assessment, these questions will draw more heavily on the results of the evidence-based analysis to be discussed in the Policy Assessment.

United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Effects Division Research Triangle Park, NC	Publication No. EPA-452/P-10-001 February, 2010