&EPA   Project Summary

Final Sampling Report for the Study of Personal CO Exposure

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This report describes the sampling design phase of a study funded by the EPA and conducted by the Research Triangle Institute in 1982 and 1983 to evaluate methodology for collecting representative personal exposure monitoring (PEM) CO and corresponding activity data in an urbanized area. This involved telephone screening of households and sample selection of respondents in the metropolitan areas in and around Denver, Colorado and Washington, DC. Data on CO breath levels were also collected in Washington, DC. (PEDCo Environmental conducted the field work in Denver.) The target population in both cities consisted of the non-institutionalized, non-smoking adults (ages 18 to 70) of these metropolitan areas. The sampling design in each city was a stratified three stage design. Area segments were selected at the first stage; households were selected at the second stage; and individuals were selected for monitoring at the third stage.

Based on the experience gained during the study, the methodology developed, with some modifications, may be used effectively in other areas of the country for collecting PEM data. Modifications of the sampling design should make the methodology more cost effective and improve the response rate.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

As the control of emissions increases, the burden of proof on EPA to show that a particular level of emission control is justified also increases. It has become more and more important to show that a given level of control is justified for each air pollutant, with the relative risk of public health approximately comparable for each pollutant controlled.

A critical factor in determining the degree of risk to the population is the exposure of members of the population. In the past, monitoring of airborne pollutants has necessarily been based on the assumption that fixed-site monitoring is representative of concentrations surrounding the site, since monitoring techniques were generally not developed for determining personal exposures. Then to obtain estimates of population exposure, techniques such as computer simulation or overlaying isopleths of pollution concentrations measured at fixed sites on population density maps have been used. For some pollutants, these techniques may be reasonable approximations; however, recent work has shown that many pollutant concentrations are not homogeneous and that activity patterns play an important role in an individual's actual exposure. Therefore, data from ambient fixed sites often differ significantly from the concentrations with which people actually come into contact.

Accordingly, RTI and EPA formulated a study plan to develop and field test a population exposure methodology using CO while making sure that the methodology was broad enough to accommodate other pollutants of concern. The specific objectives of this study were the following:

- To develop a methodology for measuring the distribution of carbon monoxide (CO) exposures of a representative population of an urban area for assessment of the risk to the population.

- To test, evaluate, and validate this methodology by employing it in the execution of pilot field studies in Denver, Colorado, and in Washington, DC.

- To obtain an activity-pattern data base related to CO exposures.

Carbon monoxide was selected for primary emphasis in the current study because:

- Accurate and portable field tested instruments now are available for CO.

- Most of the CO to which the public is exposed can be attributed to motor vehicles.

- It appears that CO is a good "indicator" (i.e., surrogate) pollutant for estimating exposures to several other motor vehicle pollutants of interest.

- Because CO is a nonreactive air pollutant, it is simpler to treat analytically.

- The health effects of CO are reasonably well documented, and NAAQS based on these effects have been promulgated.

- Considerable data exist showing that CO varies spatially and that many locations in cities have concentrations that differ from those reported at fixed air monitoring stations.

The study was carried out in Washington, DC and Denver, Colorado during the winter of 1982-83 (the period of the year with maximum ambient CO concentrations). The population exposure profile was determined by direct measurement of CO with personal exposure monitors (PEMs) through the use of statistical inference from the statistically drawn sample. The study provided sufficient data to determine exposure as a function of concentrations within significant microenvironments (home, in-transit, work, and leisure) and individual activity patterns.

The report describes in detail the sampling design employed, and recommendations for improving the sampling design for future monitoring studies of a similar nature. It is extremely important to note that the study not only developed and tested methodology for measuring the distribution of CO in an urban area but also produced direct estimates of CO exposure that apply to two large metropolitan areas. In addition, a very important product of this work is a unique and valuable database on individual exposures to CO and the corresponding activities that led to these exposures.

Summary of Sampling Design

The target population consisted of the non-institutionalized, non-smoking adults (ages 18-70) in the metropolitan areas in and around Denver, Colorado and Washington, DC. A probability sample of the target population was selected in both cities. This sample was a stratified, three-stage, probability-based design. Area sample segments defined by Census geographic variables were selected at the first stage of sampling. Households were selected at the second stage, and a household member was administered a short screening interview covering all household members to identify individuals with characteristics believed to be positively correlated with CO exposure. Household members with these characteristics were oversampled in the third stage. Donnelley Market Corporation listings were used to help select households for the screening interview. The third stage sample was a stratified sample of screened eligible individuals (i.e., non-smoking, aged 18 to 70). The individuals in the third stage sample were administered a Computer Model Input Questionnaire and were asked to carry a personal CO monitor and an Activity Diary for 24 or 48 hours (for Washington and Denver, respectively). A breath sample was also requested from these individuals and they were asked to fill out a Household (Study) Questionnaire. The third stage sample design also allocated individuals to specific days within the sampling period. A detailed discussion of the sample design is given in the report.

To carry out the sample design, RTI developed the data collection instruments and worked with EPA in obtaining OMB approval for the study. An initial telephone screening was carried out in both Denver and Washington, DC by using RTI's Computer Assisted Telephone Interviewing (CATI) system.

This telephone screening was supplemented by limited field screening in both sites. Specific information collected during this interview included: time spent in regular commuting and smoking status of each household member, as well as presence of gas appliances and attached garages in their residences. After the initial screening and the initial selection of potential participants, another telephone interview was conducted. The purpose of this call was to contact the selected individual to further explain the study and attempt to enroll him (her) into the study. If the individual agreed to be part of the study, an appointment was established for a field interview. In addition, during this call, a Computer Model Input Questionnaire was administered which collected additional data on commuting patterns, demographics of household members, and household characteristics.

Finally, participating individuals were met at their home or other convenient location and given all study materials. These participants carried both a REM (a model COED-1, which utilized a data acquisition package supplied by Magnus, Inc.) for the 24 hours of their participation and an Activity Diary in which to record a description of their activities. Participants were requested to push a button on their PEM every time they changed activities and to record descriptions of the new activities in their diaries. In addition, for a small sample of participants, a GE/HP PEM (which utilized a Hewlett-Packard HP-41CV programmable calculator) was used which allowed the participant to also enter an activity code into the monitor. Participants were also asked to complete a self-administered Household Questionnaire which provided information on themselves and on their home and work environments. The telephone screening and sample selection of individuals for both Denver and Washington were carried out by RTI as was the field work in Washington.

The results of the telephone screening and field activities for the study are described in detail in the report. Briefly, 8643 household screenings were attempted by RTI in Washington, DC and 4987 were attempted in Denver, Colorado. The successful screening rates were 75.8 percent in Washington and 70.4 percent in Denver. From these telephone and field screenings, 5418 eligible respondents were identified in Washington and 2232 in Denver. From this population of eligibles, 1987 individuals were selected for

participation (i.e., to carry a PEM) in Washington and 1139 in Denver. Of these selected individuals, 58 percent actually scheduled appointments to carry a PEM in Washington. Finally, 35.8 percent of the individuals in Washington selected to participate contributed usable CO monitor data. This represented 712 sample respondents. Instrument failure was one of the major reasons for the low response rate. Specifically, CO data was not collected or was unusable for analysis purposes for 232 respondents (22% loss rate) due to monitor failure or malfunction. Usable CO breath data corresponding to the usable CO monitor data was collected on 659 sample respondents.

Sampling weights based upon the probability of inclusion in the sample were computed according to well-established formulas. Analysis weights adjusted for nonresponse were also computed so that the weights could be used to draw inferences to the target populations. The sampling weights were merged with the corresponding field data on a computer file for analysis.

Detailed statistical analyses were carried out using computer data files with PEM CO and activity diary data. Estimates computed during this analysis were weighted estimates for the population of inference--adult non-smokers in the Washington, DC metropolitan area. Standard errors of estimates were produced by using specially written software designed for analysis of data from complex sample surveys.

Summary of Study Results and Conclusions

Based on the experience gained during the Washington, DC and Denver PEM CO studies, the methodology developed, with some modifications (see the detailed report) may be used effectively in other areas of the country for collecting PEM data. Experience gained during this initial study will improve the execution of such similar studies. A modified sampling design using the classified telephone directory listings is recommended. The modified design should be more cost effective and improve the response rate.

Important new information was learned for each of three sampling methodology studies of the project: (1) It was found that geographically classified telephone directory listings can be used in a cost-effective manner in association with standard area household sampling techniques for personal monitoring

studies like the current CO study. The sampling design for the cost-effective use of these telephone directory listings differs substantially from the design used for the CO study, however (details are given in the report). (2) Sending lead letters to individuals who were selected for personal monitoring prior to calling to schedule an appointment was found to be an effective strategy. (3) The need for person-day sampling for studies that monitor personal exposure to airborne pollutants is apparent. The CO study gained valuable experience with this technique. Further study, possibly even another methodological study, is needed to refine this technique.

Using the data collected in the Washington, DC and Denver metropolitan areas with the Household Screening Questionnaire, weighted estimates of population characteristics were computed. These estimates were based on screening interviews in 4394 households in Washington and 2128 households in Denver. In particular, the population estimate for the number of households in the two areas are 953,714 for Washington and 345,163 for Denver. Population estimates of percentages of households with various characteristics were as follows:

	Washington	Denver
Use Fireplace	*33%*	*30%*
Use Wood Stove	*4%*	*6%*
Use Gas Furnace	*56%*	*71%*
Use Gas Stove	*64%*	*25%*
Use Gas Hot Water	*57%*	*78%*
Have Attached Garage or Multi-Family Garage	*22%*	*35%*

In addition to household characteristics, several estimates were also obtained for individuals' characteristics in the two areas. For example,

	Washington	Denver
Male	*48%*	*47%*
Smokers (13 years or older)	*33%*	*38%*
Work (13 years or older)	*70%*	*72%*
Travel ≥3 times/ weeks	*84%*	*82%*

Regarding estimates of CO exposure for the winter of 1982-83 in Washington DC, a data base was constructed from the raw CO levels by activity data which con-

sisted of hourly CO values on 712 respondents, activity patterns and corresponding CO levels on 705 respondents, and CO breath measurement corresponding to the PEM CO data on 659 respondents. These data were used to obtain estimates of CO exposure for the population of inference-- the adult (18 to 70 years old), non-smokers in the urbanized portion of the Washington, DC SMSA. The size of this population was estimated to be 1.22 million individuals.

Detailed discussion of project results is found in *Study of Carbon Monoxide Exposure of Residents of Washington, DC and Denver, Colorado* by T. D. Hartwell, et. al. The sampling design employed for this project is discussed in detail in the *Final Sampling Report for the Study of Personal Exposure* by Roy W. Whitmore, et. al.
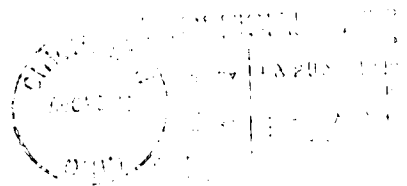
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