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Children's Health Valuation Handbook

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NOTICE

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1. Introduction

In the last few years, the plight of our nation's children has been a growing concern both within the U.S. Environmental Protection Agency (EPA) and across other Federal agencies. In the fall of 1995, the Administrator directed EPA to consider environmental health risks of infants and children in all risk assessments, risk characterizations, and public health standards set by EPA for the United States. A year later, in October 1996, the Administrator announced EPA's National Agenda to Protect Children's Health from Environmental Threats. The Agenda focuses on several areas: standards protecting children; research strategy; community right-to-know; and educational efforts for parents, teachers, healthcare providers, and environmental professionals. The Agenda was followed by the 1997 Executive Order (E.O.) 13045, "Protection of Children from Environmental Health Risks and Safety Risks." E.O. 13045 states that "each Federal agency: (a) shall make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children; and (b) shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks." It requires, for each covered regulatory action,[1] "(a) an evaluation of the environmental health or safety effects of the planned regulation on children; and (b) an explanation of why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the agency."

While the Agency's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a) provides general guidance on how best to perform benefit-cost assessments of policies and programs, this Handbook discusses issues concerning the valuation of health benefits accruing to children that are not directly covered in the Guidelines. Information provided in this Handbook, when used in conjunction with that provided in the Guidelines, should allow analysts to more fully characterize the benefits of Agency policies and programs.

1.1 Purpose

This Handbook is a reference tool for analysts conducting economic analyses of EPA policies when those policies are expected to affect risks to children's health. For the purposes of this document, a child is considered to be a person under the age of 18.[2] Thus, the focus of this

[1] E.O. 13045 defines a "covered regulatory action" as one that "may (a) be 'economically significant' under E.O. 12866 (a rule-making that has an annual effect on the economy of $100 million or more or would adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities); and (b) concern an environmental health risk or safety risk that an agency has reason to believe may disproportionately affect children."

[2] In various instances, the legal and appropriate definition of "child" may vary. In some cases, adults with limited cognitive capabilities may be considered children. For help in determining if a policy is expected to affect children and whether a separate analysis of impacts on children is needed, see *EPA Rule Writer's Guide to Executive Order 13045* (U.S. EPA, 1998).

Handbook is on valuing the reduction of environmental risks to children living today[3] (or for the purposes of multi-year analyses, in the very near future) and not on future generations. To that end, the Handbook does not consider issues relevant to inter-generational analyses. Instead, it focuses on the challenging task of identifying special concerns that arise when considering risks to the unique subpopulation of those under 18 years of age.

The specific purpose of this document is to inform analysts attempting to estimate the value of changes in risks to children's health caused by environmental improvements or degradations. This Handbook:

- Describes three alternative perspectives to a child-determined value of reducing child health risks (Section 2.2.1);

- Provides information on the valuation of children's health effects by discussing if, when, and how values for children may differ from values for adults for the same effects (Section 2.2);

- Gives guidance on qualitatively describing the likely over- or under-valuation of reduced child risk resulting from the transfer of risk values estimated for adults to children (Section 2.2.2);

- Suggests a practical method for adjusting adult health values to better approximate child health values (Section 3.1.3.1);

- Provides a description of the best way to value risk experienced by children, recognizing that direct estimates of these values are not yet available (Section 4.1.2.2);

- Discusses how economic methods used to estimate values for adult health effects can be applied to value children's health effects (Chapter 4);

- Provides instructions on when and how to transfer value estimates derived for adults to scenarios involving children, as a second best alternative to actual child values (Chapter 3);

- Describes additional analyses that should accompany value estimates as part of a sensitivity analysis. When other information is lacking, these analyses can substitute for value estimates as a third best alternative to actual child values (Chapter 5);

- Describes a team approach to risk assessment in which risk assessors and economists collaborate to arrive at meaningful risk estimates for children (Chapter 6); and

[3] Even when environmental risks to children result in outcomes that manifest themselves in adulthood, the techniques and recommendations contained in this Handbook are relevant.

- Provides an annotated bibliography that identifies and describes the limited economics literature that estimates children's health effect values (Appendix A).

Further, this Handbook presents and discusses issues that may not be satisfactorily addressed by the current state of knowledge. Discussion of these issues should improve economic analyses of children's health effects by alerting analysts to unresolved areas and by identifying areas for future research. In this way, the Handbook will serve as a description of EPA's needs for valuing children's health effects and will encourage research among EPA and non-EPA economists as well as other experts.

It is important for readers to note that while this document sometimes makes specific suggestions, it is generally meant to be informative rather than prescriptive. This is largely because the current state of economic science has not reached conclusions on many issues related to children. With few exceptions, in fact, economics literature has not historically considered children in the context of health valuation. As more information becomes available, this Handbook will be updated to reflect relevant additions to the literature.

1.2 The Need to Value Children's Health Benefits

A major emphasis of the *Children's Health Valuation Handbook* is ensuring that the economic impacts of a regulation or other policy on children are fully considered in the supporting economic analyses. This includes incorporating children's health considerations in an assessment of efficiency, as well as in any distributional analysis that seeks to examine the implications specifically for children. In both cases, the welfare measures for the populations of concern should be as comprehensive and complete as possible.

1.2.1 Benefit-Cost Analysis

One useful tool for characterizing the efficiency of policies, programs, and activities, regardless of whether they affect children, is benefit-cost analysis. Benefit-cost analysis allows decision-makers to directly compare costs and benefits using the same measure (dollars). For policies that have a substantial impact on children's health, any complete benefit-cost analysis must consider the resulting changes in children's welfare. Ignoring these effects may alter the conclusions of the analysis. In an effort to help analysts more fully characterize benefits and, therefore, produce more complete benefit-cost analyses, this Handbook discusses issues concerning the valuation of health benefits accruing to children.

To estimate the value of the health benefits to children from a given environmental improvement and incorporate this value into the benefit-cost analysis of a proposed rule, analysts typically complete the following general procedures:[4]

[4] Chapter 7 of EPA's *Guidelines for Preparing Economic Analyses* (2000a) defines and describes a general process for benefits analysis, including concerns associated with quantifying significant physical effects.

- **Hazard identification:** Identifying the adverse health effects in children that can be caused by exposure to the contaminant being considered.

- **Dose-response evaluation:** Describing how the likelihood and severity of adverse health effects in children are related to the amount and conditions of their exposure to the contaminant.

- **Exposure assessment:** Measuring or estimating the magnitude, frequency, duration, and distribution of children's exposure to the contaminant.

- **Risk characterization:** Integrating exposure and toxicity information to produce an estimate of the health risk, often presented as a probability that an adverse health effect will occur. Risk characterization includes descriptions of the statistical and biological uncertainties associated with the estimate.

- **Quantification of welfare effects:** Specifying the ways in which changes in children's health affect welfare. These may include impacts on school attendance, parents' attendance at work, medical expenditures, pain and suffering endured, etc.

- **Valuation of the welfare effects:** Monetizing the expected changes in welfare using appropriate economic techniques. If monetization is impractical, alternatives including simple health effect inventories are considered.

Generally, the first four steps of the process (hazard identification through risk characterization) fall under the realm of risk assessment.[5] In the final two steps, quantification and valuation of the welfare effects, economists use estimates provided by risk assessors and produce monetary values of the expected changes in welfare.[6] These two steps are the main focus of this Handbook.

It is important to note that an explicit or separate analysis of children's welfare may not be necessary in a benefit-cost analysis if such effects are already embedded in existing welfare measures. This is most likely to be the case if the household, rather than the individual, is the unit of analysis. For example, when valuation estimates are based upon household preferences for risk reductions, and those households include children, it is reasonable to expect that the value of reduced health risks to children are embedded in the estimates. Because it is not generally possible to estimate the portion of the household's willingness to pay that is specific to children, the precise magnitude of the children's health benefits will be unknown. Nonetheless, benefits to children are included in such measures and therefore are already incorporated into the benefit-cost

[5] EPA's *Risk & Decision Making* (1992) and *Guidance for Risk Characterization* (1995) both provide a description of the components of risk assessment.

[6] For general information on valuing welfare effects, see Chapter 7, Section 7.5 "Methods for Benefits Valuation" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a).

analysis. In these cases, a separate, additive estimate of children's health benefits would lead to double-counting.[7]

In practice, many valuation estimates are expected to measure welfare changes for an individual only. Such cases include, but are not limited to, value-of-statistical-life measures from wage-risk studies, most cost-of-illness estimates, and some contingent valuation estimates. Because children are not explicitly considered in these value estimates, it should not be assumed that benefit-cost analyses utilizing these values fully account for children's welfare. If children comprise a significant proportion of the affected population, a separate, explicit benefit estimate may be required. These estimates will then need to be added to other estimates of welfare changes in the benefit-cost analysis to examine the efficiency of a proposed policy action.

1.2.2 Distributional Analysis/Equity Assessment

Policymakers may also find it useful to have information on a policy's specific impact on children's health, regardless of whether the impact heavily influences the overall benefit-cost analysis. Analysts may wish to conduct an equity assessment with children as the target sub-population. An equity assessment is a distributional analysis that examines the net costs, net benefits, or other economic impacts of a policy that accrue to a specific subpopulation.[8] E.O. 13045 states that regulations with annual national economic impacts beyond $100 million should be accompanied by evaluations of the regulation's effects on children. Such evaluations can occur via equity assessments.

Even for policies with smaller national economic impacts, analysts might wish to conduct child-focused equity assessments. Two separate, but potentially related, reasons to do so would be if the policy was expected to have a large or disproportionate impact on children's health or on children's economic well-being. E.O. 13045 directs policy makers to identify, assess, and address health risks that disproportionately affect children. Children may be disproportionately affected by a health risk for a number of reasons including that they make up a substantial component of the affected population. A different reason might be that they experience exposures to and effects from pollution that are greater than those of the population as a whole.

A policy might also have a disproportionate impact on the economic well-being of children. A higher proportion of children live in poverty, thus children are more likely than adults to be economically disadvantaged (Dalaker and Naifeh, 1997). As a result, the ability of households with children to undertake averting behaviors might be compromised.

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[7] More information on methods that may have embedded values for children's health can be found in Section 5.1.2.

[8] See Chapter 9, Section 9.3 "Equity Assessment" and Chapter 10, Section 10.3.2 "Results from Economic Impacts Analysis and Equity Assessment" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a) for further discussion of the meaning and content of an equity assessment.

In addition, a third reason to conduct an equity assessment for children for any policy expected to affect them is that adults do not necessarily act in the best interest of children, regardless of intention. As a result, children's interests may be less well represented in benefit-cost analyses.

1.2.3 Valuing Children's Health Effects

As a final note, analysts may often lack information on risk and/or valuation, making it difficult to present first-best valuation estimates specific to children in any analysis.[9] In these cases, analysts should choose one of two alternatives as appropriate. As a second-best option, they might wish to transfer benefit values estimated for adults to children. Transferred adult values should be accompanied by a qualitative description of expected differences between children and adults. Together, Chapters 2 and 3 give guidance for this type of analysis. Box 1.1 shows several examples where EPA and other agencies have relied on adult values for morbidity and mortality risk reductions to children. These examples highlight the need for research and analysis targeted at finding values for children's health effects. As a third-best option, analysts facing an absence of appropriate values for transfer might choose to analyze impacts via cost effectiveness, breakeven, or bounding analyses. Chapter 5 gives guidance for these kinds of analyses.

[9] Chapter 4 discusses the options when appropriate child-specific valuation information is not available.

Box 1.1 Examples Where Children's Health Values Are Needed

There are several examples where regulatory impact analyses have differentiated risks to children from risks to adults, when appropriate, by identifying exposure and response differences, either qualitatively or quantitatively. However, in valuing the health effects, most economic analyses rely on adult values for children's health effects, due to lack of current valuations of children's health effects.

The following are three examples from three different federal agencies:

- EPA conducted an economic analysis for the final Heavy-Duty Engine/Diesel Fuel Rule. The economic analysis specifically discusses impacts on children's health, including acute bronchitis (children, 8-12), lower respiratory symptoms (children, 7-14), and upper respiratory symptoms (asthmatic children, 9-11). However, in valuing avoided health effects, no distinction is made between children's health and adult health effects. Willingness-to-pay (WTP) values for avoiding these symptoms based on studies of adults were used, because WTP values for avoiding these symptoms in children were not available. (U.S. EPA, 2000f)

- The Food and Drug Administration (FDA) conducted an economic analysis in developing final regulations for the safe and sanitary processing of fruit and vegetable juices. FDA issued these regulations to address food hazards, including some directly affecting children. These included long-term toxic effects of non-microbial hazards since children consume larger quantities of juice relative to body weight, well-documented developmental effects in children due to lead, and illnesses due to *E. coli* and other bacteria that affect children more adversely. While effects on children due to different types of contamination are discussed, the valuation using cost of illness, does not distinguish between adult and children health end points. (U.S. Food and Drug Administration, 2001)

- The National Highway Traffic Safety Administration conducted an economic analysis in support of a final rule to upgrade the Agency's standard to improve occupant protection provided by air bags. The analysis quantified risks posed to infants, children, and adults. Alternative regulatory strategies are evaluated using a cost-effectiveness approach and alternatives are compared by net cost (or savings) per fatality saved. The total adult, child, and infant fatalities are combined in this calculation, effectively evaluating fatalities across all age groups equally. (U.S. National Highway Traffic Safety Administration, 2000)

1.3 Organization of the Handbook

The remainder of this Handbook begins in Chapter 2 by briefly outlining the distinction between risk differences and valuation differences in adult and child health effects. The rest of Chapter 2 discusses the perspectives that can be taken in estimating values for health risk reductions in children and then describes the economic reasons for the valuation differences in child and adult health benefits. In many instances, conducting original valuation research is impractical, requiring analysts to turn to benefits transfer. This is the subject of Chapter 3 – when and how to transfer value estimates derived for adults to scenarios involving children. Chapter 4 reviews issues associated with applying standard and alternative valuation techniques to children's health effects. Chapter 5 follows with a description of important types of analyses that may complement, or when valuation data are scarce, substitute for, benefits valuation. Chapter 6 describes a team approach to risk assessment in which economists and risk assessors collaborate early in the benefits valuation process with useful results.

Although the focus of this Handbook is on benefits valuation for use in benefit-cost analysis, it also discusses measures used in other types of analysis. For the reader's reference, Box 1.2 briefly defines these types of analyses and associated measures and references sections where more information can be found in the Handbook.

The Handbook includes two appendices. Appendix A is an annotated bibliography of the current literature providing estimates of child health effect values plus references for relevant papers that have been presented at conferences and workshops. Appendix B summarizes EPA's response to comments received during an external review of the draft Handbook.

Box 1.2 Types of Analyses and Measures Discussed in This Handbook

Type of Analyses and Measures Used	More Information
Benefits Analysis *Used to estimate the beneficial consequences of policy for use in a benefit-cost test of efficiency. Measures used in benefits analysis, in order of desirability, include:*	Chapter 3
• Primary WTP estimates: WTP estimates drawn from the context in which they are used.	Chapter 4
• Transferred WTP estimates: WTP estimates from other contexts applied to the policy case using benefit transfer techniques.	Chapter 3
• Cost-of-illness estimates: Direct and indirect cost of medical treatment and lost productivity; usually lower than WTP for the same health endpoint.	Page 4-7
Cost-Effectiveness *Used to rank policy alternatives according to most "bang for the buck." Measures used in cost-effectiveness analysis include:*	Chapter 5
• Physical measures of health such as lives saved or cases avoided.	Page 5-1
• Utility measures of health such as quality-adjusted-life-years (QALYs) and disability-adjusted-life-years (DALYs).	Page 5-2
Health-Health Analysis *Compares regulatory costs to estimated threshold at which regulatory costs result in a statistical life lost.*	Page 5-4
Breakeven Analysis *Used when valuation or risk data are unavailable; identifies what the value would need to be for an option to be efficient and/or more cost-effective than other alternatives.*	Page 5-3
Bounding Analysis *Used when valuation data are unavailable; may place upper and lower bounds on the value of reduced health effects by referencing known values for other effects.*	Page 5-4

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2. Fundamental Differences Between Adult and Child Health Benefits Valuation

When estimating children's health benefits for any analysis, two sets of potential differences between children and adults may exist:

- **Risk differences:** Children and adults differ in exposure to pollutants and in the nature and magnitude of health effects arising from exposure.

- **Valuation differences:** Individuals may systematically place a different economic value on reducing health risks to children than on reducing health risks to adults.

When these differences exist, estimates of the value of children's health benefits are likely to differ from those for adults. These risk and valuation differences will vary in importance depending upon the particular health benefits associated with a proposed policy. No hard and fast rules currently exist for determining when a separate valuation of childhood risks should be conducted. However, analysts should consider estimating and presenting the dollar value of changes in health risks specifically to children when the differences in risk and/or valuation between children and adults are potentially important. The greater these differences, the more valuable will be estimates of health benefits specific to children. The implications of both types of differences are discussed in the sections that follow.

2.1 Risk Differences[10]

Risks from environmental contamination may not affect children and adults in the same manner due to differences in exposure and the response to that exposure. Generally, accounting for the risk differences between children and adults should be a component of risk assessments. While risk assessment is not the focus of this Handbook, many important decisions that may ultimately affect the final value assigned to children's health effects are made during the risk assessment process. Economists should be aware of the implications of these decisions for value estimation. In Chapter 6, the importance of good risk assessment data for an economic analysis is discussed, and suggestions for stimulating productive communication among health professionals, risk assessors, and economists are provided. A team approach to assessing risks to children is recommended when differences in risk are suspected.

2.1.1 Exposure Differences

Children's exposures often vary from those of adults. Due to their higher metabolic activity, children have higher daily requirements for food, water, and oxygen per unit of body weight than do adults (International Life Sciences Institute, 1992; Bearer, 1995). To the extent that these

[10] This section is based in part on information presented in Thompson, 1999.

media provide the routes of exposure to the substance, children can experience a larger effective dose than adults. Box 2.1 provides an example of how exposure differences were considered in the arsenic in drinking water rule.

Box 2.1 Arsenic in Drinking Water: An Example of Exposure Differences

The Office of Ground Water and Drinking Water conducted an economic analysis in December 2000 for the arsenic in drinking water rule. The analysis specifically considered impacts on children. Due to their higher fluid and food intake in relation to their body weight, children's dose (milligrams per kilogram of body weight per day - mg/kg/day) of arsenic will be, on average, greater than that of adults. For example, an intake of 1.2 liters per day in a 70 kg adult yields an overall water intake of 0.017 liters per kg of body weight. An infant who consumes 1 liter per day and weighs 10 kg is consuming 0.1 liter per kg of body weight, which is more than 5 times the water intake per kg of an adult. Any contaminant that is present in the water will be delivered at a correspondingly higher level on a daily basis.

Source: U.S. EPA, 2000d.

Children's activity patterns may also differ significantly from those of adults. Consequently, some exposure scenarios or conditions that apply to one group might not apply to the other. For instance, occupational exposure scenarios for adults would probably not apply to children. Conversely, exposure due to extended periods of time spent crawling on the ground, excessive hand-to-mouth behavior, or high rates of soil ingestion would probably not apply to adults.

Lack of child-specific risk information may lead to uncertain risk measurements. Children are less often exposed to levels of substances that cause observably harmful effects. For instance, children do not endure hazardous occupational exposures, as do some adults, nor do they participate in clinical trials of exposure to environmental contaminants. Even when the affected population consists of adults, EPA analysts, who typically are studying scenarios involving low levels of exposure, must extrapolate from limited data on health effects observed at high levels of exposure. The problem is compounded when estimating effects on children, since now information about health effects observed in adults experiencing high levels of exposure must be extrapolated to children experiencing low levels of exposure. The limited existing data that demonstrate differential effects on children as compared with adults largely come from infrequent cases where children experienced accidental, high exposures that resulted in significant numbers of cases of relatively rare, detectable diseases (Rogan, 1995).

While in some cases extrapolation from data based on limited evidence from a cohort of occupationally exposed adults may be required to estimate the effects on children, in others, the best available evidence may be from animal studies. Under this scenario, risk assessors are forced to extrapolate toxicological data across species as well as across groups.

One notable exception is research on the effects of exposure to ambient air pollution. A large number of epidemiological studies exist that focus on the relationship between health risks among children (e.g., asthma and low birth rate) and ambient levels of criteria air pollutants (Fauroux et al., 2000; McConnell et al., 2002; Maisonet et al., 2001). Age specific studies on health risk should be used when available.

2.1.2 Dose-Response Differences

A child's response to exposure to a given level of toxic substances can differ from that of an adult in outcome (a qualitative difference) and in severity (a quantitative difference). For instance, examples exist of cases where exposures of children resulted in health effects that did not occur in exposed adults (e.g., vaginal and cervical cancer from fetal exposure to diethylstilbestrol) and vice versa (e.g., sterility following adult exposure to mumps) (Wilson et al., 1991). Examples also exist of cases where adults are more sensitive to exposure (i.e., endure a more severe outcome) than children for the same effect (e.g., liver toxicity from exposure to acetaminophen) and vice versa (e.g., neurological damage from exposure to lead or hexachlorophene) (Kauffman, 1992; Davis and Grant, 1992; Kacew, 1992). Box 2.2 provides examples of differences in both outcome and severity.

Box 2.2 Examples of Dose-Response Differences

Health Effects Due to Lead: An Example of Response Outcome Differences

EPA's Office of Air and Radiation developed a retrospective analysis estimating the benefits and costs of the Clean Air Act itself covering the period beginning with passage of the Clean Air Act Amendments of 1970 until 1990 when Congress enacted the most recent comprehensive amendments to the Act. Appendix G, "Lead Benefits Analysis," of *The Benefits and Costs of the Clean Air Act, 1970 to 1990* identifies quantified and unquantified health effects of lead and differentiates children from adult males and females as follows:

Population Group	Quantified Health Effect	Unquantified Health Effect
Adult Male	*For men in specified age ranges:* Hypertension Non-fatal coronary heart disease Non-fatal strokes Mortality	*For men in other age ranges:* Other cardiovascular diseases Neurobehavioral function
Adult Female	*For women in specified age ranges:* Non-fatal coronary heart disease Non-fatal stroke Mortality	*Health effects For women in other age ranges*: Other cardiovascular diseases Reproductive effects Neurobehavioral function
Children	IQ loss effect on lifetime earnings IQ loss effect on special educational needs Neonatal mortality due to low birth weight caused by maternal exposure to lead	Fetal effects from maternal exposure (including diminished IQ) Other neurobehavioral and physiological effects Delinquent and anti-social behavior

Source: U.S. EPA, 1997.

Ground Water Rule: An Example of Severity of Response Differences

EPA's Office of Ground Water and Drinking Water conducted a regulatory impact analysis for a proposed ground water rule (GWR) in April 2000. The primary goal of the proposed GWR was to improve public health by identifying public ground water systems that are, or are likely to become, fecally contaminated, and to insure adequate measures are taken to remove or inactivate pathogens in drinking water provided to the public by these systems. Rotavirus represents a large group of viruses suspected to cause outbreaks of gastroenteritis in public water system drinking water supplies. These viruses include Norwalk, Norwalk-like small round structured viruses, caliciviruses, adenovirus, astrovirus, and other enteric viruses. The populations that are particularly sensitive to this class of viruses include infants and young children. For example, there are response differences between children less than two years old and the rest of the population. The probability of illness given a rotavirus infection is 0.88 for children less two years old and 0.10 for all others. The regulatory impact analysis indicates that the viral and bacterial illnesses of concern to the GWR disproportionately affect children; therefore, the benefits of the proposed rule accrue disproportionately to children.

Source: U.S. EPA, 2000e.

Also, the degree of vulnerability to exposure to a particular substance may vary by stage of development. Recent research on teen cigarette smoking, for example, suggests that smoking earlier in life may lead to permanent DNA damage (Wiencke et al., 1999). This same damage does not occur in those who start smoking later in life.

Analysts should also be aware of relevant advances in medical technology. Economists valuing childhood cancer cases, for example, may need to factor in higher survival probabilities due to recent advances in the successful treatment and management of many types of childhood cancers (Carroquino et al., 1998).

Finally, analysts should remember that in many cases children represent a group that is relatively understudied toxicologically. Historically, pediatric populations have not been the subject of sufficient pharmaceutical trials (U.S. Department of Health and Human Services, 1997) or of epidemiological studies due to the relative rarity of disease (Grufferman, 1998). Because sufficient information is often lacking, analysts should not automatically assume that children are unequivocally more (or less) sensitive and vulnerable to adverse health effects from exposure to toxic substances than adults (i.e., that children always have higher (or lower) risk). Instead, the evidence that is available for children suggests that relative risk must be assessed on a substance-by-substance basis.

2.2 Valuation Differences

The theoretically preferred method for estimating the value of health risk reductions is to measure the affected population's *ex ante* WTP to avoid the health risk.[11] However, sometimes the only practical estimation alternative is to measure the costs of illness (COI). The primary purpose of this section is to discuss differences between the WTP for child health and the WTP for adult health. In addition, we discuss differences that should be expected in values intended to represent the costs of illness. For an explanation of how to estimate values under the two methods, please see Chapter 4.

While the economics literature contains many estimates of WTP for adult health risk reductions, it contains very few for children. As a result, distinctions between WTP values applied to risk reductions experienced by children and those applied to risk reductions experienced by adults are difficult to make, even though they are likely to exist for a number of reasons. Currently, the only practical alternative for estimating WTP for child health is to transfer values estimated for adults to children.[12] If the value of reducing risks to children's health does indeed differ from that of

[11] *Ex ante* WTP is generally preferred for a regulatory context in which the relevant question is how to reduce the chances of an adverse event occurring (and not how to compensate individuals who have already experienced an event). For an explanation of the conceptual underpinnings of WTP in benefits analysis, see Chapter 7, Section 7.2 "A Conceptual Framework for Benefits Analysis" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a).

[12] See Chapter 3 for a detailed discussion of the benefit transfer of adult values to children.

adults', this practice may bias the conclusions of an economic analysis and result in inefficient policy choices.

A few studies have gathered evidence supporting the notion that the value of reducing health risks to children differs from that of adults. They are based on surveys that collect information on the public's preferences for saving lives or improving the health of individuals who belong to one age group versus another. Generally, these studies find that preferences for reducing morbidity and mortality risks vary with the age of the affected population. Where children are explicitly included, children's health benefits are ranked more highly than adults' health benefits, with certain stages in adult life receiving a higher value than others (Jones-Lee, Hammerton, and Philips, 1985; Williams, 1988; Lewis and Charney, 1989; Busschbach, Hessing, and De Charro, 1993; Cropper, Aydede, and Portney, 1994). Other research has generated estimates of WTP for child and adult health that are directly comparable, since they are derived using comparable data and methods. The findings vary. One study estimates the value of a statistical child's life as lower than the value of a statistical adult's (Jenkins, Owens, and Wiggins, 2001). A different study estimates the WTP for child health as higher than the WTP for adult health (Liu et al., 2000).

The sections that follow provide a more detailed discussion of the economic reasons for the differences in child and adult health benefit values. The fundamental issue of whose perspective should determine the WTP for child health is tackled first. Three possibilities are discussed and assessed in terms of their validity, use, and practicality. This is followed by a discussion of eight potential differences between values associated with children's health risks and values estimated for adults. Of the eight differences, only the one stemming from expected lifetime wealth suggests a practical method for adjusting an adult value to bring it closer to a child value. The method is outlined and the reader is referred to sample applications presented in a later chapter.

2.2.1 Perspective and Childhood Health Values

Childhood health valuation presents the economist with a unique question, "Whose preferences should determine the value?" Welfare economics rests on the assumption that decisions are made by rational individuals. Rationality, while not meant to imply sensibility, does imply that the decision process is coherent and logically consistent. Individuals are assumed to be capable of ranking alternate consumption bundles and determining the final choice, as constrained by a budget. The suggestion is that individuals are best suited to judge for themselves the value of goods or services (Randall, 1987). Thus, when economists have estimated values of risk reduction, they have preferred to derive these estimates from the willingness of individuals to pay for risk reductions that affect themselves. For the purposes of policy assessment, these individual risk-dollar trade-offs are then aggregated over the population at risk to calculate measures such as the value of a statistical life (VSL) for fatal risks or the value of a statistical injury (VSI) for non-fatal health risks. Although in some cases altruism may serve to increase the value of reducing an individual's risk, adult health risks are typically valued using data on trade-offs made between "own-risk" and "own-income."[13] Estimates of these values have typically been derived from data on observed behavior in the labor market or from surveys directed at valuing self-experienced risks.

Unfortunately for the analyst valuing childhood risks, children cannot reasonably be assumed to exhibit rationality. Due to their immature cognitive ability, children do not have well-defined preferences over the full range of health and safety alternatives. In addition, they do not have control of the financial resources required to make trade-offs between money and health. In short, the basic tenets of welfare economics cannot reasonably be assumed to represent children.

Dockins et al. (2002) thoroughly explores the different viewpoints from which child health values could be estimated. They suggest that researchers focus their inquiry on what individuals who have the long-run best interests of the child at heart would pay. They discuss three possible alternative perspectives – that of society, by which is meant an aggregation of parent and non-parent adults; that of adults placing themselves in the position of children, for example by thinking back to their own childhoods; and finally, that of parents assessing risks faced by their own children.[14]

2.2.1.1 The Societal Perspective

Dockins et al. (2002) explain that one approach to valuing risk reductions to children in a public policy context is to rely on values that reflect both parents' preferences for risk reductions to their own children as well as adult altruistic concerns for children in general. Limited empirical evidence suggests that values associated with altruism may be substantial, particularly for children (Viscusi, Magat, and Forrest, 1988). While altruism does not necessarily increase the value of risk reductions, it has the potential to do so. If altruism is paternalistic – an individual is concerned with the level of safety experienced by his neighbor but does not respect his neighbor's preferences for risk – it will result in higher values (Jones-Lee, 1992). For children's health valuation, if an adult were concerned about children's health risks and did not respect the parents' risk preferences toward their own children, then it may be appropriate to include these additional values in an assessment of social valuation.

While it is interesting to consider societal preferences for children's health, the practical implications are quite limited. As mentioned, when assessing adult WTP for reductions in adult risks, economists measure personal WTP for one's own health. Estimates of societal WTP for adult risk reductions are generally unavailable because of the difficulty in assessing the degree and

[13] Altruism does not necessarily increase the value of risk reductions. Only if altruism is paternalistic – an individual is concerned with the level of safety experienced by his neighbor but does not respect his neighbor's preferences for risk – will it result in higher values (Jones-Lee, 1992).

[14] They also briefly consider the possibility of relying on children themselves and for similar reasons as those above, determine that this is ill advised.

type of altruism in WTP estimates for the health of others (or for the health of other people's children).[15] Lacking these measures, analysts must turn to more practical considerations.

2.2.1.2 The Perspective of Adults-as-Children

Another perspective from which to assess values of childhood risk is termed by Dockins et al. as the "adults-as-children" perspective (2002). It requires adults to place themselves in the position of children, for example by asking adults about preferences they currently exhibit as they think back to their own childhood and the risks they faced. This approach allows the analyst to avoid relying on irrational (child) decision-makers and bestows the further advantage that the values are reported by individuals considering their own selves.

There are several concerns about this perspective. First, one method for measuring it might literally involve asking adults to think back to their childhoods and assess values of risk reductions. Such a question would be extremely difficult for a researcher to develop and for a respondent to answer. Respondents simply might not be able to entirely accept whatever hypothetical scenario is postulated and as a result could respond based on an *ex post* position. This would cause the responses to diverge from the researcher's objective of estimates of *ex ante* WTP for reductions in risk. Finally, by asking adults to think back in time, the method neglects to account for the expected growth in income to be earned by today's children over the course of their lives relative to today's adults. Concern about wealth growth is covered in more detail in Chapter 3 where we present a practical method to account for it.

A second concern is that there is a gap in the economics literature regarding this perspective. Models to represent it have only recently been developed and, to our knowledge, no applications of the method currently exist with one exception. Researchers have represented the perspective via the human capital approach. Here is where the perspective holds promise. One approach for estimating values representative of the adult-as-child perspective is to construct value estimates that provide some sort of bound on what a child might express as WTP if that child was an adult looking back. For example, if an early intervention increases a child's expected lifetime earnings, one might reasonably assume that this hypothetical child would be willing to pay up to the present value of those larger returns to secure them.[16]

2.2.1.3 The Parental Perspective

Children rely upon parents and other caregivers to monitor and make decisions concerning health and safety for them. Thus, a logical valuation-by-proxy approach for children's health risk is the elicitation of values from parents or other primary caregivers. The sparse existing research that

[15] For further discussion of the problems involved in identifying the extent and type of altruism in WTP for children's health, see Dockins et al. (2002).

[16] For a discussion and application of estimating the value of a child's reduced human capital, see Chapter 4, Section 4.2 and Box 4.1.

has estimated the WTP for children's health has relied upon the preferences of parents and guardians, or in one case, of adults in the same household as children. For example, Carlin and Sandy (1991) examine car safety seat purchases and use behavior of mothers to estimate the value of a statistical child's life (VSCL). Agee and Crocker (1996a) rely on parents' decisions to treat their children's elevated blood-lead level to infer WTP for reduced burdens. Viscusi, Magat, and Huber (1987) present evidence on the value of reducing health risks to children from misuse of household chemicals based on the preferences or decisions of adults living in the same household as children. Indeed, a complete review of this literature reveals that economists have emphasized the importance of households as the relevant decision-making unit regarding children's health and have modeled children's health values accordingly. See Chapter 4 for a discussion and assessment of the relevant household models.

An advantage of the parental perspective is its reliance on adults who seem likely to have the child's best interests at heart. A disadvantage is that it introduces a third party into the valuation exercise; that is, it does not gather values from economic agents who are considering their own selves. This introduces a number of special concerns.

- **Parental motivations:** It is possible that parents might not always be motivated to make decisions in a child's best interests (Agee and Crocker, 1999). If this is the case, then parental values for child risk reductions may be incomplete or biased, a concern suggested by some of the empirical work on child health valuation. Two potential motivations are concern about self in old age and safety-focused paternalistic altruism.

    - *concern about self in old age* – Parents concerned mainly about their own security during old age may generate value estimates that reflect only the "use value" of services provided by grown children and exclude the other positive effects of reducing risks to children, such as higher future utility experienced by the child himself. In this extreme example, a parental intermediary might underestimate the full value to the child of reducing his risks.

    - *safety-focused paternalistic altruism* – Parental values for reducing a child's risk might reflect paternalistic altruism. In this case, parental values of a child's risk reduction may be inflated as compared with the value that the child himself would have as a competent adult looking back at his childhood.

- **Information deficiencies:** Parents might not possess complete information regarding children's health and safety risks. For instance, uninformed parents might not be aware of the impact some of their own actions have on the welfare of their child and may engage in actions that contribute to illness or injury in their own children. Dickie and Nestor (1998) note some of these actions, including parental smoking, failure of parents to manage childhood asthma, and resistance to the use of child safety seats. Of course, a similar concern can be expressed regarding adult ignorance of consequences to his own health caused by similar actions, such as smoking. That parents are intermediaries representing children's interests, however, suggests a greater likelihood of ignorance because the child, and not the parent, actually experiences the consequences.

- **Extreme cases:** Certain information deficiencies and motivations not aligned with the children's best interests are likely to affect parental decision-making in only a few extreme cases, for example, when parents suffer from severe mental illness. In general, from a valuation standpoint, these cases pose little concern since economic values used in benefit-cost analyses are estimated by averaging over a large number of individuals. However, if these characteristics describe large segments of the parent population, the resulting values may not be appropriate for policy analysis.

- **Parents' budget constraint:** Parents must operate within their budget constraint while making decisions regarding their children's health. Two aspects of the parents' budget constraint warrant consideration.

    - It is important to recognize that parents may react to a policy intended to reduce children's health risk by redistributing household resources among different activities. Parents may change the amount of resources being devoted to the human capital or consumption of other family members.[17]

    - As already mentioned, the expected lifetime wealth of children is higher than that of adults. Generally, parents cannot borrow against children's future incomes and so might be constrained to value their own children's health less than would their hypothetical grown-up child.

2.2.1.4 Practical Conclusions

Although there are concerns regarding use of the parental perspective, it seems well-suited to the task of estimating child health values. The perspective is from individuals likely to have children's best interests at heart, it is modeled within the context of the household where most decision-making regarding health actually occurs, and is estimated using numerous practical methods, including examining safety product spending or modeling parental decisions regarding treatments or preventions.

The primary advantage of the parental perspective over the adult-as-child perspective is that there is a literature, albeit a sparse one, that has focused on the parental perspective. This literature on WTP for child health has offered theoretical models to represent the parental perspective while only preliminary modeling efforts have been directed at the adult-as-child perspective. The literature has also led to the development of more than one practical estimation method for representing a parent's perspective. These advantages might diminish with further research into the adult-as-child perspective. The primary advantage of the adult-as-child perspective over the

[17] For a full discussion, please see the discussion in Chapter 4 regarding household production models and intrahousehold allocation models, Sections 4.1.2.1 and 4.1.2.2, respectively.

parental perspective is that it does not present the variety of issues that arise from obtaining values from a third party.[18]

In conclusion, both the parental and adult-as-child perspectives are useful for representing children's health values. Each offers distinct advantages and disadvantages. Analysts are likely to encounter values representative of the parental perspective when gathering estimates of WTP for child health currently available in the economics literature. Values representative of the adult-as-child perspective are more closely linked to the COI method. These values can be estimated via the human capital approach by measuring lost lifetime income due to childhood illnesses. This approach has been taken by government agencies measuring the impact of lead poisoning on children's future earnings potential.[19]

Recommendation (perspective): *Based on the discussion above, analysts can rely on either the parental or the adult-as-child perspectives for representing children's health values. Concerns regarding reliance on third party proxy values aside, the parental perspective provides value estimates from individuals likely to have the child's best interest at heart, incorporates the household context into the estimation approaches, and can be implemented using a variety of valuation techniques. The adult-as-child perspective, on the other hand, although perhaps more difficult to implement, does not suffer from the problems associated with using proxy values. Regardless of which perspective is ultimately chosen, the analyst should take care to make the perspective explicit.*

2.2.2 Other Important Factors

In practice, because of the paucity of estimates of WTP for children's health, analysts will often transfer estimates of WTP for adult health to childhood cases. Because of practical difficulties in obtaining even adult WTP values for many health endpoints, analysts will also occasionally need to transfer estimates of COI for adult health to children. Table 2-1 lists factors that suggest that transferring adult values to children introduces a bias. When possible, the expected direction of the bias is discussed. For some factors there is an expected direction for this bias and other factors have an unknown bias. Therefore it is not possible to conclusively know the direction of bias introduced by all the factors together. As noted in the table, some of the factors are relevant to both transferred WTP and transferred COI estimates, while others to only one of these valuation methodologies.

Interestingly, for the transferred adult WTP values, the biases introduced by the factors in Table 2-1 do not depend on the perspective the value is intended to represent. Whether the analyst is interested in representing the parental or the adult-as-child perspective, the direction of the impact of each factor is expected to be the same. This is explained in the discussions of the bias associated with each factor that follow the table.

[18] For further discussion of these perspectives, please see Dockins et al., 2002.

[19] Please see Chapter 4 for a discussion and applications of the human capital approach.

Table 2-1. Transferring from Adult to Child: Factors That May Cause Differences in Values Estimated for Children Compared to Values Estimated for Adults

Factor That May Cause Difference	Potential Difference Relative to Transferred Adult Values	Type of Value to be Transferred from Adult to Child
Preferences for Risk		
• Risk aversion	• Higher child values	• WTP
• Involuntariness of risk	• Higher child values	• WTP
• Ambiguous risk	• Higher child values	• WTP
Time/Age		
• Duration of illness/ life expectancy	• Higher child values	• WTP and COI
• Expected lifetime wealth	• Higher child values	• WTP and COI
• Discount rate	• Unknown	• WTP
Costs Associated with Illness		
• Medical treatment	• Unknown	• COI
• Value of time (including caregivers' time)	• Higher child values	• WTP and COI

2.2.2.1 Preferences for Risk

Individual preferences about risk suggest three reasons to expect transferred WTP values for adult health to be different from WTP values estimated directly for children.

- **Risk aversion:** Parents might be more conservative in their decisions to expose children to risk or, stated differently, might be more risk averse with respect to their children's well-being than they are regarding their own. In addition, adults thinking back to risks experienced during childhood might exhibit greater aversion to risks experienced by their child selves than to those experienced by their adult selves. Evidence of this can be found in common everyday actions as well as in U.S. law. For instance, parents may take greater care in washing their children's fruits and vegetables free of potentially harmful pesticides than they do their own. Another example can be found in statewide bicycle helmet laws that apply only to children (of various age ranges). In addition, the Food Quality Protection Act of 1996 requires an additional tenfold margin of safety for children to ensure that they face no harm from aggregate exposure to pesticide and chemical residues. While the risks faced by adults and children may differ considerably in these examples, the level of protection mandated for children suggests that society is more risk averse in the case of children. Greater risk aversion suggests that reducing risks to children is likely to be valued more highly than reducing similar risks to adults.

- **Involuntariness of risk:** A different aspect of risk is the degree to which the voluntary nature of risks influences WTP. Research suggests that individuals generally prefer to avoid risks to themselves that are less voluntary (Fischhoff et al., 1978; Slovic, 1987). It is unclear, however, whether parents’ attitudes about the voluntariness of risks to themselves are the same as their attitudes toward risks to their children. There has been no empirical research on this subject, likewise for adults thinking back to risks experienced during childhood. One might argue, however, that the issue of voluntariness is always important in the case of risks to children because in some sense all risks to children are involuntary in that children rely on the risk-related decisions of caregivers.

- **Ambiguous risk:** Finally, the uncertainty surrounding the risk estimate itself may have an effect on the value individuals place on the risk. Economists distinguish risk from the uncertainty about that risk, terming the latter “ambiguity.” Individuals appear to exhibit ambiguity aversion, preferring certain risks to those that are less certain (Viscusi, Magat, and Huber, 1991). These preferences have strictly been found to hold for different degrees of uncertainty in otherwise identical risks. It is reasonable, however, to expect many situations in which adults and children face risks of similar magnitude, but for which the children’s estimates are much less certain. This follows from the fact that, for ethical reasons, children are excluded from the pool of subjects available for clinical trials of harmful exposures and do not face occupational exposures like adults. To the extent that parents must balance relatively well-defined risks to themselves against relatively ambiguous risks to their children, ambiguity aversion would lead them to prefer reducing the latter, all else equal. For the same reason, adults thinking back to childhood experiences might exhibit more conservative preferences regarding risks experienced during childhood compared to risks experienced during adulthood. Thus, the value of risk reductions to children may include a component of ambiguity aversion.

2.2.2.2 Time/Age

Three factors related to time or age suggest that transferred WTP or COI values for adult health should be different than values estimated for child health. The first, and perhaps most obvious, is that children have a greater number of life years remaining (all else equal) as compared with adults. Second, children have a greater expected lifetime wealth as compared with adults. The third factor concerns the potential for the application of different discount rates used to calculate the present value of latent health effects. While all three of these factors may cause differences in health risk valuation, it should be noted that a practical method for adjusting adult values to better approximate child values has been developed for one of them – expected lifetime wealth. In fact, of all the factors listed in Table 2-1, expected lifetime wealth is the only factor at this time for which a quantitative adjustment is offered.

- **Duration of illness/life expectancy:** All else equal, children have more years of life remaining than adults. This implies that in terms of years, a larger number will be lost when a child dies than when an adult dies, all else equal. A child may also experience a longer period of morbidity than an adult for some chronic, non-fatal health endpoints, such as asthma or a longer period of disability for a permanent injury. This suggests that, whether estimating WTP or COI, avoiding a child's illness, injury, or death is likely to be valued more highly than avoiding the same in an adult.[20]

- **Expected lifetime wealth:** The expected lifetime wealth of an average citizen increases as the years pass.[21] Thus, the wealth expected to accumulate over the life span of someone who is currently young is greater than that expected to accumulate over the life span of someone who is currently old. Estimates of the elasticity of WTP with respect to income for reduced mortality or morbidity risk are available in the economics literature and range from 0.3 to 1.0 (Blomquist, 1979; Jones-Lee, Hammerton, and Philips, 1985; Evans and Viscusi, 1990; Liu, Hammitt, and Liu, 1997).[22] Assuming that the average elasticity is positive but less than 1.0, as wealth increases, VSL should also increase, albeit by a smaller proportion. Everything else held constant, this suggests that the WTP for a reduced risk expressed by a current adult will be lower than the WTP for the same risk expressed by a future adult.[23]

  A parent reporting WTP to avoid health risks faced by their child is considering the welfare of a person who is currently young and whose wealth will grow. Parents may, consciously or unconsciously, attempt to account for these future expected increases in their children's wealth when determining their WTP for child risk reductions. Analysts attempting to represent the parental perspective will therefore want to adjust transferred adult values to reflect the expected growth in lifetime wealth of children.

  The adult-as-child perspective can be measured via two different approaches. One involves an adult thinking back in time which would not lead to WTP estimates that take into account future wealth growth. Thus, analysts interested in representing this

[20] The greater life expectancy for children may also increase the value of other investments besides risk reduction. Because WTP for health reflects the household's trade-off between spending on risk reduction and spending on other goods and services, when the value of spending on other investments in children rises along with the value of health spending, WTP for health might not necessarily increase.

[21] While real GDP per capita has fluctuated over the years, and annual growth rates have occasionally been negative, it has trended upwards for at least the last 70 years.

[22] It is assumed that income is a proxy for lifetime wealth.

[23] Examples of variables held constant are tastes, all other prices, and skill at avoiding risks. Also held constant is the timing of risk. For example, if the risk considered by a current adult is an immediate risk, then so is the risk to be considered by a future adult.

perspective would not necessarily adjust for this factor.[24] However, another approach to the adult-as-child perspective is to estimate a lower bound of what a child might express as WTP if that child was an adult. Such an estimate can be obtained via the human capital method. Under this approach, the adult-as-child perspective would indeed account for the greater expected lifetime wealth of children.

Unlike all the other factors expected to cause a difference in child and adult health values (see Table 2-1), the growth in expected lifetime wealth suggests a practical method for adjusting a transferred estimate of WTP for adult health to bring it closer to a WTP for child health. This method is presented in Chapter 3.

- **Discounting a latent health effect:** In cases where the latency period is short enough so that both adults and children experience the health effect, differences may arise in the discount rate itself. It is possible that parents discount their WTP for their own latent health effect using a different discount rate than one that they would apply to their WTP for a child's latent health effect or that adults thinking back to their childhood or hypothetical grown-up children might apply a different discount rate. Still, there is little empirical evidence that this is the case and research in this area has only recently begun (Agee and Crocker, 1996b; Tolley and Fabian, 1999).[25]

- **Discounting benefits to future generations:** Finally, while it may be tempting to think of children as a "future generation" and therefore expand the time issue to incorporate intergenerational discounting, analysts should remember that, for the purposes of this Handbook, children have been defined as individuals under the age of 18. As such, their welfare and preferences are considered in the decisions made for them by their parents. In addition, the values analysts are interested in are of risk reductions to children in the current time period, not some distant future. Intergenerational discounting, therefore, should not be applied to children.[26] In the context of a multi-year economic analysis, however, care should be taken to appropriately project population growth by age group to properly capture and assess a rule's effect on the exposed child population.

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[24] However, an analyst on theoretical grounds might justifiably desire a wealth adjustment to any WTP estimate representing the adult-as-child perspective. Adjusting for future wealth seems to move closer to what a current child himself would be willing to pay as a competent adult looking back at his childhood.

[25] Please see EPA's *Guidelines for Preparing Economic Analyses* (2000a) for a discussion of discounting over latency periods.

[26] For more information on the appropriate use of intragenerational and intergenerational discounting, see Chapter 6, Section 6.3, "Approaches to Social Discounting" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a).

2.2.2.3 Costs Associated with Illness

The final two factors consist of the costs that are borne due to an illness and are relevant to transferred COI estimates; although the latter of the two, the value of time, is also relevant to transferred WTP estimates. Important disparities may exist in the measurable costs of a child's illness or death as compared with an adult's. These differences are due primarily to differences in the costs of medical treatment and the opportunity cost of time.

- **Medical treatment:** Medical treatment costs are likely to differ between adults and children; however, the direction of the difference is unclear. For some illnesses, children may be more resilient and may require less recuperation time than adults. On the other hand, the same illness may require a different course of treatment and, therefore, a different cost of treatment in children than in adults. Child asthmatics, for instance, are more likely to use nebulizers to deliver medication to their bronchial passageways than adult asthmatics who are more likely to use inhalers.[27]

- **Value of time:** The value of time lost due to a child's illness will be different than that associated with the same illness for an adult because of the number of individuals directly affected by the illness. When an adult is ill, the cost of the time spent recuperating is generally measured by an estimate of productivity loss. This is often calculated using lost wages (real or inferred) or other measures of restricted-activity-days or bed-disability-days (these methods do not work for valuing a child's lost time, see Section 4.2). When a child falls ill, however, both the child and the caregiver are affected. The productivity loss of both affected individuals should be included in the valuation estimate of a child's illness. This double productivity loss is also likely to affect individual's WTP for child health. To the extent that a caregiver is more likely to be involved when a child is recuperating, the total value of lost time is likely to be higher for a child's illness than for an adult's.

2.3 Summary and Implications for Benefit Transfer

This chapter has identified two fundamental sources of differences between adult and child health benefit values – differences in risk and differences in economic valuation. Not only can the youthfulness of the exposed population affect the level of susceptibility and the response to that exposure, it also affects the value individuals place on reducing risks to that population.

There are three possible perspectives from which to measure WTP for child health – that of society, the adult-as-child, and parents. Only the latter two are both practical and legitimate. Each of the two offers a distinct set of advantages and disadvantages and analysts can legitimately rely on either for representing children's health values.

[27] A more detailed description of the cost-of-illness method for valuing health benefits is provided in Section 4.2.

As summarized in Table 2-1, there are eight sources of bias when transferring to child cases estimates of WTP or COI for adult health effects to child cases. Only one of the eight sources of bias, expected lifetime wealth, actually suggests a practical method (presented in Chapter 3) for adjusting adult health values to more closely approximate child values. The other sources of bias sometimes suggest a likely direction of difference between child and adult values. Until better estimates become available, benefit-cost analyses of regulations affecting children can incorporate this information in two ways. First, transferred adult benefit values can be quantitatively adjusted to reflect that children have higher expected lifetime wealth. Second, analysts can write careful qualitative descriptions of the likely over- or under-valuation of reduced child risk resulting from the transfer of risk values estimated for adults to children.

The results discussed above suggest it may be likely that VSCL is higher than that for adults. This difference will be compounded in an economic analysis if children are more susceptible to the risk being studied. The difference will be smaller in cases where the children are less susceptible to the risk being studied. In short, analysts could introduce error into child health values if they simply transfer unadjusted values from adults if risk and/or valuation differences exist.

Recommendation (differences between child and adult values)*: Given the likely differences between adult and child values and the paucity of available age-specific value estimates for health outcomes, analysts would do well to qualitatively describe the likely over- or under-valuation of reduced child risk resulting from the transfer of risk values estimated for adults to children. Analysts may wish to undertake the quantitative adjustment suggested by the discussion of expected lifetime wealth. Directions for this adjustment are given in Chapter 3.*

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3. Benefit Transfer[28]

The benefit transfer approach to valuation relies upon existing data, rather than on primary data collection efforts, to estimate willingness to pay for risk reductions and other benefits of EPA rules and policies. EPA typically relies upon benefit transfer because conducting original research is often prohibitively time-consuming and expensive. For more specific information on how to conduct appropriate benefit transfer and deal with difficult analytic issues embedded in transferring benefits, analysts are encouraged to refer to the *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a).[29]

This section of the Handbook describes analytical considerations when conducting a benefit transfer for children's health effects. Because the empirical literature on child-specific valuation is relatively thin, the recommendations in this section generally assume analysts will be transferring from studies that have estimated adult willingness to pay to reduce their own risk. This section, however, does contain some notes on benefit transfer based on child-specific estimates. As primary research on valuing children's health effects expands, analysts will become increasingly able to draw upon such studies in their analysis, and the Handbook will be updated accordingly.[30]

3.1 Benefit Transfer Technique and Children's Health Valuation

As suggested in Chapter 2, there are many aspects of children's health values that differ from those of adults. Transferring adult risk reduction value estimates to children generally will not be a straightforward process. Critical considerations of children's health issues must enter into the benefit transfer steps illustrated in Table 3-1.[31]

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[28] This chapter is in part based on information presented in Markowski, 1999.

[29] Specifically, please see Chapter 7, Section 7.5.4, "Benefit Transfer" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a).

[30] Dockins et al. (2002), Neumann and Greenwood (1999), and Dickie and Nestor (1998) describe existing studies that provide estimates of child-oriented values related to mortality, childhood cancers, chronic effects, acute effects, prenatal exposure effects, and reproductive effects. These papers identify relatively few (approximately 20) existing studies of child-oriented values. See Appendix A for a summary of these studies.

[31] As mentioned, more information on the benefit transfer approach in general can be found in Chapter 7, Section 7.5.4 in EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). In addition, general information on transferring benefit estimates is contained in EPA's *Handbook for Non-Cancer Health Effects Valuation* (U.S. EPA, 2000b); a special issue of *Water Resources Research* dedicated to the topic (1992, volume 28, number 3); Desvousges, Johnson, and Banzhaf (1998); and the proceedings of the 1992 AERE workshop (U.S. EPA, 1993). While not particular to children, Desvousges, Johnson, and Banzhaf (1998) presents a well-developed case study that analyzes electricity generation and Kask and Shogren (1993) develop the approach for surface water contamination.

Analysts should note that the final step in Table 3-1 is somewhat different from that in the *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). In addition to characterizing the uncertainty in the resulting estimate, analysts are directed to qualitatively evaluate the differences between the study and policy cases that result from systematic, unquantifiable differences between valuing risk reductions for children and doing so for adults. Particular attention should be given to factors outlined in Table 2-1 and discussed in Chapter 2.

Table 3-1. Steps in the Benefit Transfer Process

Benefit Transfer Step	Selected Factors to Consider
Step 1: Describe the Policy Case	
• Health effect measurement	Definition of the physical effect. Definition of the welfare effect measurement (e.g., restricted activity days).
• Health effect characteristics	Probability of occurrence. Frequency, duration, and severity. Defensive behaviors. Single vs. multiple symptoms. Latency or lagged effects.
• Impacts on well-being	Exclusion of lost school time. Caregiver disutility due to child pain and suffering. Caregiver foregone earnings. Child caregiver foregone future earnings.
• Population characteristics	Socioeconomic variables, including age, income, baseline health level, and education level.
Step 2: Assess the Suitability of Existing Studies	
• Study quality	Use of best research practices. Peer review and acceptance in the scientific community. Consistency with other studies. Consistency with theoretical expectations.
• Study similarity	Differences in policy and study case populations. Differences in health effect characteristics and severity levels.
Step 3: Transfer the Estimates	
• Point estimate approach	Point estimates for scoping or screening.
• Benefit function transfer	Equivalence of parameter estimates for adults and children in benefit function transfer.
• Other techniques	Ability of the approach to capture household level decisions and capture factors noted above.
• Lifetime wealth adjustment	Suggests a practical method for adjusting an adult value to bring it closer to a value for a child.
Step 4: Evaluate Qualitatively and Characterize Uncertainty	
	Qualitatively discuss differences between study and policy cases for which quantitative adjustments are not feasible. Characterize and quantify overall uncertainty, noting major sources from the policy case, the study case, and the benefit transfer process.

Each of the steps in the benefit transfer process is discussed in detail below, focusing on the transfer of adult values to children.

3.1.1 Step 1: Describe the Policy Case

The first step in conducting a benefit transfer is to describe carefully the policy case. This includes a description of:

- How the health effects of the policy are defined and measured, including an assessment of the magnitude of the risk change;
- The characteristics of the health effect likely to influence the valuation measure used;
- How a change in the health effect will affect well-being; and
- The population experiencing the change in the health effect.

Several considerations specifically related to children arise in each step of describing the policy case.

3.1.1.1 Health Effect Measurement

It is important to detail how health effects are defined and measured, and to consider how this might differ between adult and child populations. Two key questions to address are:

- **How are the physical and welfare effects defined?** The physical effect described in the risk assessment must have an impact on welfare for it to have economic value. Analysts should carefully define this physical effect in order to ensure that it is economically meaningful. Adults and children may experience the same physical effect from environmental contamination, but suffer different welfare impacts. For example, elevated blood lead levels in children (a physical effect) lead to cognitive impairments, while elevated levels in adults appear to be associated with hypertension, kidney problems, and other health problems. It is important to carefully define the welfare impact that will serve as a basis of comparison with adult effects from possible policy studies.

- **How is the welfare effect measured?** Welfare effects – the result of the physical effect – may reflect a health effect alone, such as an asthma attack, or a behavioral response as well, such as a day of work loss. Measures described by a behavioral response assume some action on the part of those affected by the policy. The behavior assumed should be made clear so that the analyst can later assess how it compares to what was captured in candidate policy studies, and whether the action is reasonable for child populations as well.

3.1.1.2 Health Effect Characteristics

The valuation measure under the policy scenario may be affected by health effect characteristics, including:

- **Probability, or risk, with which the health effect is likely to occur.** Under reasonable theoretical conditions willingness to pay for small reductions in health risks is linear in the magnitude of the risk (Shepard and Zeckhauser, 1982; Cropper and Sussman, 1990). The upshot of this finding is that for small health risks and risk changes, analysts can apply a per unit value for reduced risk. However, large risk changes may not be consistent with the linearity assumption and may require adjustments to be made if they are markedly different in size from those in candidate policy studies.

- **Baseline level and policy-induced change in the frequency, severity, and duration of the health effects.** All of these dimensions should be detailed because children may experience a given health effect more or less often than adults and at a higher or lower level of severity. Each health effect must be considered individually. Improvements in environmental conditions may have differential effects on baseline values for children and adults.

- **Availability of defensive behaviors to easily avoid or relieve the health effect**. Adults and children may not face the same set of available opportunities to avoid or mitigate health effects. The analyst will need to catalog the behaviors available to children in the policy situation so that they can be compared later to any adult behaviors present in candidate study cases.

- **Nature of the health effect as occurring in isolation or with other symptoms.** Depending on the specific health effect, adults and children may tend to have particular symptoms grouped with other symptoms. These groupings may be different for adults and children. Because the value of eliminating a symptom in isolation may be valued more or less highly than a symptom occurring in conjunction with others, analysts will need to carefully define any relevant groupings for later comparison with candidate studies.

- **Existence of a latency period associated with the health effect.** Reduced risks of delayed effects are generally valued less than reduced risk of an immediate effect. Where there is a distinction between latency periods in adults and children, analysts should gather this information. Currently there are relatively few empirical estimates of any kind that include the latency associated with health effects, but any differences between adult and child latency can be expected to have a significant impact on value.

3.1.1.3 Impacts on Well-Being

Individual health effects often have identifiable sets of impacts on well-being. A given illness, for example, may lead to pain and suffering, increased medical expenses, and work loss. Analysts will need to categorize these health-related impacts on children's well-being for later comparison with the effects in original studies. While welfare effects on children have not been systematically explored, there are some outcomes that may be common to many childhood illnesses. In addition to direct consequences such as a child's pain and suffering, childhood illnesses may lead to lost earnings of caregivers who are responsible for taking the child for medical care. Additional welfare impacts may include caregiver disutility from witnessing a child's pain and suffering, reduced human capital for the child due to lost school time, and increased averting expenditures. In the case of a minor illness, the effects of lost school time on human capital may be negligible or reversible; however, for chronic illnesses these effects could be significant.

3.1.1.4 Population Characteristics

A complete description of the policy case includes a discussion of the demographic characteristics likely to affect the valuation measure such as income, age, education, health status, and other socioeconomic variables. In the case of children's health, this description will generally need to include the characteristics of the adult caregivers and of the children affected by the policy. Data such as caregiver's income, education level, ethnicity, and immigrant status are necessary because these adult characteristics may affect the degree and type of mitigation, the caregivers' knowledge concerning the health effect, and the accuracy of the caregivers' perceptions of the risks to the child. Characteristics of the affected children, including education level and age, can also be expected to influence the valuation measure and should be included in the policy case description. All of this information will also be necessary in assessing the suitability of existing studies for transfer to the policy case.

3.1.2 Step 2: Assess the Suitability of Existing Studies

Two major issues involved in reviewing existing studies for relevance to the policy case concern the quality of the existing studies and their similarity to the new policy situation. Study quality refers to the soundness of the research methodology employed and the reliability and precision of the estimates obtained. Study similarity refers to the match between the study case (the situation examined in the original study) and the policy case (the situation relevant to the new policy).[32] Because child- and adult-oriented value determinants differ, any particular study that is suitable for an adult policy case may not be for a children's policy case.

3.1.2.1 Study Quality

A useful general reference for study quality can be found in the discussion of analytic methods in Chapter 7 of the *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a). The discussion of each benefit estimation method concludes with a section titled "Considerations in

[32] A summary of the criteria for evaluating the quality and similarity of existing studies in general can be found in Desvousges, Johnson, and Banzhaf (1998).

Evaluating and Understanding" studies using the method. For the case of children's health, questions to consider when evaluating the quality of a study for use in a benefit transfer include:

- **Does the study employ the "best research practices" for estimating health values?** Indicators of study quality generally depend on the method used. When the study case does estimate the value of children's effects, analysts can use the information Chapter 4 provides on existing estimation methods and their applicability to children's health[33]. Currently, the "best research practices" for estimating health values for children are largely undefined, although these practices are relatively well-defined for studies targeting adult effects. Section 7.5 of the *Guidelines for Preparing Economic Analysis* summarizes many best practice considerations for a number of stated and revealed preference methods. Particularly useful may be subsections titled "Considerations in Evaluating and Understanding..." under each type of benefit valuation method described.

- **Has the study been published in a peer-reviewed journal, and is it currently being cited by the professional community?** Publication in a peer-reviewed journal is an excellent first check on study quality. However, even peer-reviewed, published studies may become dated and analysts will need to assess the study's current standing in the economic literature. The relative novelty of valuation studies focused on children's health suggests that analysts may find useful studies in the "gray literature" and so may need to seek the opinion of external experts on the quality of such studies.[34]

- **Are the study results consistent with results from other studies?** If the study's focus is on children's health risks then there may be few similar studies for comparison, but it is useful to consider how the study compares with adult-oriented studies and/or studies that deal with comparable but not equivalent endpoints, particularly those employing the same analytical approach. In making the comparison, analysts will need to pay particular attention to the extent to which the candidate study addressed many of the same factors as other studies. For example, did a wage-risk or consumer product study consider all health endpoints associated with job accidents or mitigated by use of the product, respectively?

- **Do the study results conform with theoretical expectations?** In all cases, analysts should take care to ensure that studies used in benefit transfer conform to the theoretical expectations of the authors and to well-developed theoretical expectations in the economics literature. Often studies that are focusing primarily on theoretical or methodological issues will include a comment by the authors on the appropriateness of the study for policy analysis.

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[33] EPA's *Guidelines for Preparing Economic Analyses* (2000a) provides information on assessing the quality of studies for benefit transfer.

[34] "Gray literature" may include working papers, papers presented at conferences, dissertations, theses, unpublished manuscripts and reports.

3.1.2.2 Study Similarity

For any type of health-related benefit transfer, similarity can be assessed by comparing the study case with the policy case regarding the way in which the health effects are measured, the impacts on well-being, and the affected population. Elements to consider when assessing the comparability of the study case to the policy case include:

- **How similar are the study and policy case populations?** Similarity should be assessed for both adults and children from both the policy and study cases. The caregivers' age, income, location, number of children, and the relative prices they face for goods and services may influence decisions caregivers make about children's health. Key elements for the children that may influence the decisions of their caregivers include the child's age and health status.

- **Is the physical effect in the policy case equivalent to that being valued in the study case?** As noted earlier, there may fundamental health effect differences (physical responses) that may exist between adults and children. For example, because elevated lead blood levels affect adults and children differently, an adult WTP estimate for reduced blood lead burden would not be a useful study case for estimating the same value in children.

- **How does the welfare measure in the case study compare to that in the policy case?** Comparability of welfare measures between a study case and a policy case may not be as straight-forward as it appears initially. A "work loss day," for example, may still be appropriate to the value of a children's health effect because caregivers may have to miss work to care for a sick child. But the degree to which parents miss as much work when their child is sick as they do when they are sick themselves may differ according to the health effect in question. A "work loss day" may also fail to reflect effects that children experience (e.g., missed school).

- **Are the policy and study cases broadly similar in their baseline risk levels and the change in risks?** While WTP for risk reductions is expected to vary according to the baseline level of risk, the effect will not be large for most of the risks subject of EPA policies. WTP is generally expected to be proportional to the risk change. This means that analysts will usually only need to confirm that the policy cases and study cases are roughly similar in baseline and marginal risk. If the baseline risk levels of the policy and case studies differ greatly, analysts would need to use a benefit transfer function to infer how WTP would also differ.

- **Are the policy and study cases similar in the severity of the effects?** Even if the basic physical effect is the same in policy and study cases, the same health effect in adults and children may differ in frequency, duration, or other measures of severity. As a result, the analyst must be sure to investigate the potential differences in physical effects from contaminant exposure between children and adults for each policy case. Because children have longer expected lives than adults they may experience a chronic health effect for a longer duration than an adult. This is a particularly important consideration when an illness leads to significant and long-term indirect effects (e.g., educational attainment impacts).

- **Are the policy and study cases similar in the averting behaviors available to those affected?** In children's health valuation, it is important to consider how risk enters into the caregiver's decision process, and how that decision process compares with the model described and estimated in the existing studies. For example, analysts must consider whether the study case accounts for caregiver actions to reduce risk (i.e., an averting behavior) and to lessen the effect on the child (i.e., a mitigating behavior), and then determine the extent to which the same or similar measures can be expected in the policy case. Averting behavior may be more difficult to fully describe with children's versus adults' health values. The caregiver may try to control the child's behavior in an effort to avoid or relieve a given health effect, and the child may or may not respond to this intervention. In addition, caregiver behavior or intervention may not accurately reflect child health values if the caregiver is unaware of the risks to the child's health or does not perceive the health risks accurately.

3.1.3 Step 3: Transfer the Estimates

In any benefit transfer, transferring estimates involves adjusting and applying (and, in some cases, combining) estimates from the appropriate study case(s) to the policy case, aggregating benefits to the relevant population, and considering the uncertainties and limitations of the procedure. There are three general transfer approaches: (1) the point estimate approach, (2) the benefit function transfer approach, and (3) meta-analytic techniques. Meta-analytic techniques are appropriate when multiple studies are available. As child-oriented studies are relatively scarce, and it is often the case that multiple studies dealing with the same health endpoints in adults are not available (asthma may be an exception), meta-analytic techniques are not discussed here at this time.[35] The remainder of this section discusses the applicability of the point estimate and benefit function transfer approaches in the context of a transfer from an adult to a child.

3.1.3.1 Point Estimate Approach

The point estimate approach is most appropriate for scoping and screening analyses. It is rare that a policy case and study case will be identical when considering children's health values. Analysts may adjust point estimates based on judged differences between the study and the policy cases (e.g., growth in income over time or duration of illness). When transferring adult health

[35] Interested analysts should see Desvousges, Johnson, and Banzhaf (1998) for an excellent discussion of meta-analysis. Desvousges, Johnson, and Banzhaf also describes benefit transfer using Bayesian techniques. Another emerging benefit transfer alternative is "preference calibration," which uses available benefit measures to estimate a preference function and transfers estimates from that function. While this technique is relatively new, it has some advantages over other approaches (Smith, Van Houtven, and Pattanayak, 1999).

values for children, these adjustments should also account for known differences in the determinants of values that may exist for adults and children (see Table 2.1 for a summary of suspected differences). The rationale for these adjustments should be stated explicitly and clearly in the analysis.

3.1.3.2 Benefit Function Transfer

Benefit function transfer is a richer, but more complex approach for transferring value estimates from adults to children. If a study case provides a willingness-to-pay function and relevant data from the policy case are available, valuation estimates can be updated by substituting applicable values of key variables, such as baseline risk and population characteristics (e.g., mean or median income, racial or age distribution) from the policy case into the benefit function.

The relevant factor to consider in transferring adult values to the case of children's health is whether the characteristics of the policy case (i.e., characteristics specific to children) are significantly different from the characteristics of the adult study sample. The validity of transferring a benefit function relies, in part, on the equality of the coefficients of the study case with those of the policy case (if such a function were to exist to describe the policy case) (Loomis, 1992).[36] In this case, the existing parameter estimates of the adult-oriented valuation model would only be peripherally useful for valuing children's health effects. Crucial valuation elements, such as intertemporal effects, duration, and altruism, may play a significant role in children's health values that may not be represented in existing models of adult valuation. As a result, the child-specific factors omitted from the adult-oriented model have the effect of biasing the estimated coefficients for purposes of benefit transfer (see Table 2.1).

3.1.3.3 Lifetime Wealth Adjustment

To the extent possible, analysts should consider adjusting adult WTP estimates to account for a child's greater expected lifetime wealth as part of the benefit transfer exercise. Chapter 2 describes the underlying theoretical basis for this adjustment, noting that it is independent of the choice of perspective for the analysis.

The growth in expected lifetime wealth suggests a practical method for adjusting an adult value to bring it closer to a value for a child. This adjustment would only be appropriate when transferring existing adult value estimates to children, and should not be used for study cases of parental values for children. The latter might already include consideration of higher expected lifetime wealth for children.

[36] In some cases, benefit function transfer has been shown to be unreliable (Kirchhoff, Colby, and LaFrance, 1997; Downing and Ozuna, 1996).

The following equation relates a present adult's WTP for risk reduction to a future adult's WTP.

$$WTP(f) = [(1+g)^{e}]*WTP(p)$$

where WTP(.) is adult WTP for a risk reduction to self;
f and *p* designate the future and present generations, respectively;
g is the total growth in future generation's income relative to present generation; [37] and
e is the income elasticity of WTP for risk reductions.[38]

Applying this equation to adult values would produce estimates that are more appropriate for transfer from adults to children in the context of an economics analysis involving health risks to children.

Box 3.1. Examples of Adjustments to WTP to Account for Growth in Expected Lifetime Wealth

Three examples of the expected lifetime wealth adjustments are presented below. In each, we assume that WTP(*p*) = $1 and *g* = 0.56;

Depending on the value assumed for the income elasticity of WTP for risk reductions, WTP(*f*) varies from $1.17 (with *e* = 0.3) to $1.56 (with *e* = 1.0). Thus, the range of elasticities currently reported by the economics literature leads to increases in future WTP ranging between 17 and 56 percent.

Hypothetical Future WTP for Risk Reduction

e	WTP(*f*)
0.3	$1.17
0.7	$1.39
1.0	$1.56

3.1.4 Step 4: Evaluate Qualitatively and Characterize Uncertainty

The latter sections of Chapter 2 suggest several factors to consider in adult-to-child benefit transfers. For each relevant factor, the analyst should discuss whether it is expected to have a positive or a negative effect on the child values estimated. For example, it is likely that children diagnosed with asthma will experience the condition for a greater number of years than will be

[37] Note that this is the relative difference wealth and not an annual rate of growth. If Y_p is the adult's income and Y_c is the child's income, then $g=(Y_f-Y_p)/Y_p$. The Bureau of Labor Statistics produces projections for changes in national income over time. These estimates are the best available data for estimating expected generational differences in lifetime wealth.

[38] This assumes that income elasticity for future generations is the same as the present one. It is not clear in which direction this assumption may bias results, but it is consistent with the general presumption that the next generation exhibits preferences that are similar to the current one.

similarly afflicted adults, assuming the children do not "outgrow" the condition. All else equal, this suggests that reductions in child risks of asthma will command a greater value than similar reductions for adults. Regardless of whether point estimates or benefit functions are transferred, it is unlikely that the analyst will be able to quantitatively account for the differences in willingness to pay related to this time dimension.

Analysts will also need to characterize overall uncertainty in the resulting transferred estimates, noting major sources from the policy case, the study case, and the benefit transfer process itself. In many cases, risk assessments for children's health effects may be more uncertain than those for adults due to lack of child-specific data.[39]

3.1.5 Summary

The current practice of using benefit transfer to estimate rough approximations of the monetary benefits of avoiding adverse health effects appears to be the best strategy that is currently attainable for children's health values. However, benefit transfers should always be conducted and interpreted with careful consideration of potential sources of inaccuracy or imprecision. At the same time, inaccuracy and imprecision must also be weighed against the uncertainty that might arise in conducting incomplete primary research. In some cases it may be important for some policy analyses to more accurately estimate children's health values. In cases where the rough approximations of children's health values indicate that this category of benefits may be a crucial component in the policy analysis, additional primary research to estimate child-related values may be prudent.

***Recommendation (benefit transfer)**: With few child health valuation studies available, analysts may need to rely on transferring adult benefits to children until more information becomes available. Table 3-1 summarizes the steps an analyst will follow when conducting a benefit transfer exercise. Because of the factors discussed within Chapter 2, the study case and policy case will likely have many differences. Therefore, the qualitative discussion of these differences (Step 4), becomes very important in situations where adult benefits are transferred to children. In general it is appropriate to account for differences in lifetime earnings when transferring WTP estimates from adult-based studies to the case of children.*

3.2 Applications of Benefit Transfer to Mortality Risks

The value of mortality risk reductions among the general population is generally estimated using the value of a statistical life (VSL). This measure is an aggregation of the willingness to pay for

[39] See Chapter 5, Section 5.5.1 "Guiding Principles for Uncertainty Analysis" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a) for a general discussion of how to account for uncertainty in economic analyses.

small reductions in the chance of dying over the population at risk.[40] It can also be viewed as a simple normalization of WTP for small risk changes. For example, if a person is willing to pay $600 for a 1/10,000 reduction in the risk of death, then their VSL is $600 divided by 1/10,000 – or $6 million. However one views their construction, VSL measures are not values for saving a specific individual's life.

Currently, a relatively large number of such estimates exist, although most are based on adult populations. The *Guidelines for Preparing Economic Analyses* (2000a) conclude that there is not sufficient support in the economics literature for making adjustments to the existing estimates to account for the impact of age (including children), health status, and many other socioeconomic characteristics. Therefore, the Guidelines recommend that a central VSL estimate serve as a default value for all economic analyses dealing with reductions in mortality risks. The VSL figure was derived for EPA's recent Report to Congress, *The Benefits and Costs of the Clean Air Act, 1970 to 1990* (1997), and is based on a selection of 26 studies estimating the VSL. These estimates, derived from wage-risk and contingent valuation studies of adult subjects, range from $0.6 million to $13.5 million with a mean of $5.8 million (in 1997 dollars) per statistical life.

The Guidelines recognize that there are limitations associated with this single point estimate, recommending that analysts present the limitations associated with use of the central VSL estimate and that analysts consider sensitivity analyses to address uncertain benefit transfer factors. Factors for which sensitivity analysis may be appropriate include the age of the affected population, their baseline health status, their level of risk aversion, and the voluntariness of risk.[41] Some of these factors are more relevant than others when transferring adult-based WTP estimates to children's risk.

3.2.1 Age

All else equal, children can be expected to have a greater number of years ahead of them. This suggests that reductions in mortality risks to children would be valued more highly than those for adults.

One measure of the benefits of reduced mortality risk that attempts to account for age is the value of a statistical life-year. *The Benefits and Costs of the Clean Air Act, 1970 to 1990* (U.S. EPA, 1997) developed estimates of the value of a statistical life-year. Here EPA followed the approach suggested by Moore and Viscusi (1988) in which the value of a statistical life is the number of expected life years remaining multiplied by the value of one life year. Given that those represented in the 26 values used to estimate VSL have approximately 35 life years remaining, two estimates of the value of a statistical life-year were calculated — approximately $166,000 (1997 dollars) (remaining life years not discounted) and approximately $270,000 (1997 dollars)

40 An extensive discussion of this topic can be found in Chapter 7, Section 7.6.1 "Human Health: Mortality Risks" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a).

41 Each of these factors has been discussed in Chapter 2.

(remaining life years discounted at an annual rate of 3 percent). However, the relationship between the value of risk reductions and expected remaining life years is more complex than the simple discounted linear relationship assumed by Moore and Viscusi (1988). Current research does not provide a reliable method for estimating a value of a statistical life-year.

3.2.2 Risk Aversion

The general population is thought to be more risk averse than the average worker considered in wage-risk studies because workers selected the riskier jobs voluntarily. Parents may be even more risk averse when it comes to the safety of children. If this is the case, then labor market-based VSL estimates will be even less representative of the preferences of parents and more likely to be underestimates of their willingness to pay to reduce mortality risks to children.

3.2.3 Voluntariness of Risk

It is often thought that job-related risks are undertaken more voluntarily than are environmental risks, and research suggests that people tend to prefer reducing involuntary risks over voluntary ones (Slovic, 1987; Fischhoff et al., 1978; Revesz, 1999).[42] At first glance, this issue does not seem to be particular to children; however, there is no reason to suspect that parental preferences for reducing involuntary mortality risks to themselves are the same as their preferences for reducing such risks to their children. In fact, it may be that parents are willing to pay more to reduce involuntary mortality risks to their children. If this is the case, it suggests that existing VSL estimates understate true parental willingness to pay to reduce mortality risks to children.

Recommendation (premature mortality valuation): *Because of the paucity of studies, the current literature on the value of reductions in fatal risks to children does not provide distinct, defensible VSL estimates for children for use in policy analyses. As such, until more child-specific research becomes available, the practical alternative appears to be the use of the adult VSL as a "default" value. However, as stated in the Guidelines, "it is important to recognize the limitations of a single VSL point estimate and to consider whether any of the factors discussed" have a significant impact on the benefit estimates. In most cases, it is likely that there will be several differences, in addition to age, between the base and policy cases. As such, analysts may wish to "explore where sensitivity analysis can satisfactorily address some" of the other concerns that arise from the use of a VSL point estimate. As high-quality estimates of the value of fatal risk reductions to children become available, analysts should begin to incorporate these estimates into their analyses.*

[42] It should be noted that all of these studies are based on adults' preferences for reducing risks.

4. Valuation Methods

This chapter discusses issues surrounding the methods for estimating child health benefit values. It discusses the theoretical underpinnings of several valuation techniques. In addition to a discussion of standard economic valuation techniques that yield willingness-to-pay values, this chapter presents a discussion of the cost-of-illness approach including human capital approaches. This chapter identifies particular issues or problems that might arise when estimating children's health benefits with each of these techniques. This discussion is of particular interest to researchers who are estimating original health effect values.

4.1 Standard Economic Valuation Techniques

Changes in welfare are the basis for measuring the benefits of a policy. Economists generally measure changes in welfare by estimating willingness to pay (WTP). In the case of an environmental policy, WTP is the maximum amount of money an individual would voluntarily exchange to obtain an improvement (or avoid a decrement) in the environmental effects of concern.[43] The benefits of a policy are the total of each affected individual's WTP for the policy. When one method alone does not fully capture WTP for improvements in children's health, analysts may choose to combine valuation techniques to yield more complete benefit estimates.

Prior to selecting a valuation approach, analysts should recognize the advantages and limitations of each of the available methods.[44] This section discusses standard economic valuation techniques and issues surrounding their application to valuing child health benefits. The three methods presented here that yield willingness-to-pay values are hedonic models, averting behavior models (via safety product market models, household production models, and intrahousehold allocation models), and stated preference methods, including contingent valuation (CV). Researchers have begun to assess how these methods may be applied to children's health valuation. Recent efforts include Dockins et al. (2002), Agee and Crocker (1999), and Tolley and Fabian (1999).

Some of the methods listed above yield a value for reduced risk to individual members of a household while others produce values for reduced risk to the household as a whole. For instance, some, although not all, averting behavior models can produce value estimates to individual members of the household. Specifically, safety product models in which specific

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[43] See Chapter 7, Section 7.2.1 "Welfare Measures: WTP and WTA Compensation" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a) for a thorough description of the meaning of WTP and the related concept of willingness to accept (WTA).

[44] Explanations of these methods appear in Chapter 7, Section 7.5 "Methods for Benefits Valuation" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a) and can be found in Chapter 3 of EPA's *Handbook for Non-Cancer Health Effects Valuation* (U.S. EPA, 2000b). The general merits of these and other methods are discussed extensively in many texts such as Freeman (1993) and Braden and Kolstad (1991). None of these sources detail the unique or important considerations associated with estimating values for children's health effects, however.

products are purchased for identifiable members of the household can lead to value estimates for reduced risk to that person (Jenkins, Owens, and Wiggins, 2001). However, household production models and hedonic models tend to produce willingness-to-pay estimates for reduced risk to the household. Since estimates are based on household expenditure decisions, it is often difficult to tease out values for specific family members. Fortunately, these values at least *include* the value of improved protection of children. In the future, as these models are applied to a wider variety of products, separate values for improved children's health may indeed be possible. In addition, while value estimates derived from stated preference methods *can* reflect reduced risk to individuals depending on how the questions are structured, stated preference methods can also produce estimates of the value of reduced risk to entire households without separately identifying the portion of value assigned to different household members. The value obtained will ultimately be determined by the manner in which the questions are framed and the position of the respondent within the family.

The perspective achieved also differs across methods. As mentioned above, hedonic property models and averting behavior models generally produce estimates of the value of reduced risk to entire households. As the decision-makers within a household with children present are parents, these models yield values from the parental perspective. To the extent that safety products can be identified that protect a specific individual rather than an entire household, safety product studies may yield individual estimates of value of statistical life (VSL) from a parental perspective (Jenkins, Owen, and Wiggins, 2001; Carlin and Sandy, 1991). Stated preference techniques could be used, however, to elicit values for risk reductions from adults thinking back to their own childhood.

4.1.1 Hedonic Method

Hedonic wage and property value methods give estimates of consumer willingness to pay to avoid (or willingness to accept compensation for) a health risk at the margin. These methods are applied to heterogeneous goods and services, which are differentiated from each other by the quantity and quality of various attributes, including environmental quality or exposure to pollutants.

In general, using differences in property values or wages to determine the value of health benefits from reductions in environmental hazards rests on a variety of strong assumptions. Thus, empirical implementation of hedonic methods is not always straightforward. The case of children's health poses additional challenges. First, because young children do not generally work for wages in our society, hedonic wage models cannot estimate the value of risk reductions to children. Hedonic property models can potentially yield values of risk reduction that reflect the value to the household of protecting its children as well as its adult members, although existing analyses have focused on individual mortality risk valuation (Portney, 1981). In that sense, hedonic property models include, and do not neglect, the value of health benefits to children. However, in order to separate out the benefits to children, the value of the environmental hazard's contribution to child health at a site must be distinguished from the value of its contribution to the health, amenities, and productivity of the child's caregiver(s). With current methods, making this separation will be difficult, if not impossible. At the very least, it requires empirical implementation of a model of internal household decision-making. Such a model is discussed further in Section 4.1.3. Hedonic property value models could control for the presence, number, and age distributions of the household's children as additional "attributes" of the choice scenario, as a start.[45]

Hedonic property models focus on the behavior of the individual household and are limited to private features of protecting children from environmental hazards. The benefits measured accrue to the household. To the extent that there is a substantial public good component to improvements in children's health, hedonic property measures will be incomplete.

4.1.2 Averting Behavior Approach

Averting behavior models make use of existing data on risk reducing behaviors and/or actions taken to mitigate the effects of exposure to a particular risk. For instance, purchase decisions of products that increase safety can be used as an input in the willingness-to-pay calculation for reduced risk of death or injury. Examples of mitigating actions include the purchase of additional health care to alleviate the symptoms associated with a health outcome. Since children are not considered mature enough to make rational decisions regarding their own health and safety, analysts must rely on risk reducing behaviors in which parents and caretakers engage on behalf of their children. Ultimately, the perspective achieved using the averting behavior approach is that of the parent. Three modeling approaches have been developed that incorporate these decisions – the household production model, the intrahousehold allocation models, and the safety product market models.

4.1.2.1 Household Production Model

The household production model assumes that parents have the ability to protect their children from known hazards. Generally, the model consists of a production function in which parents combine private commodities either to reduce their child's risk of harm (which may include fatality) or to enhance their child's general health or safety. Linkages between groups of private commodities and a non-marketed good provide a means of inferring the value of the good (Bockstael and Kling, 1988). For example, the value of risk reduction might be inferred from the demand for a child-protection commodity. Empirically tractable expressions for the demand for environmental quality have been developed.[46]

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[45] Some researchers have used other models in settings involving housing or product choices, and some of these models may perform better under some circumstances. Cropper et al. (1993), for example, shows that random utility models allow more flexibility in including individual characteristics of purchasers relative to hedonic models. Nonetheless, hedonic models are the most widely used approach in these settings.

[46] See, for example, Pollak and Wachter (1975), Bockstael and McConnell (1983; 1993), Mäler (1985), Gerking and Stanley (1986), and Agee and Crocker (1999).

Typically, values derived from the household production model involve expressions for the demand for an input that can either be classified as a substitute or a complement to the environmental service or state in question. These inputs either may be directly observed (e.g., medical care to alleviate sickness) or inferred from other observable behaviors (e.g., the demand for child health). In both cases, these inputs contain enough information to infer value, but must be subject to certain restrictions to justify the value on theoretical grounds.

Thus far, two methods have been applied to market data in the literature, both of which are similar in the initial modeling stage. The first method involves the case of perfect substitutes (also called pure averting goods), in which two items can replace each other in a health production technology. For example, a child health ailment, such as a cough, can be alleviated by the purchase of a medication. Smith (1991) shows that for the case of perfect substitutes, parental valuation of increased child health (i.e., reducing a child's coughing) can be inferred by estimating an expression for the demand for the cough suppressant (including the opportunity cost of parental time to administer it, valued at the parent's wage or opportunity cost of time).

The second method involves inputs that are essential to the production of child health. Bockstael and McConnell (1983) show that, with or without other inputs, the area under the demand curve for an essential input will provide an accurate and theoretically sound value for the environmental commodity. However, if an essential input cannot be identified, but clearly important health production inputs *are* observable, then the area under the demand curve for the observable input represents a lower bound to the parent's true willingness to pay for the child's health state.

Unfortunately, most health technologies are not so simple and cases with perfect substitutes and essential inputs are the exception rather than the rule. As discussed in Chapter 3, economics generally sheds light on the ability and willingness of households to substitute one product for another. However, there are limits to this knowledge and these limits might be pronounced for behaviors or products connected to children. Researchers may under-specify the full set of potential behaviors available to parents in the face of changes in environmental quality. Caregivers must control child activities along an extensive margin (i.e., which behaviors to allow) and an intensive margin (i.e., what frequency or duration of each behavior to allow). Because it is relatively more difficult for caregivers to control their children's behavior at the intensive margin than it is to control the behavior for themselves, they may opt not to allow the behavior at all. If researchers fail to recognize the potential for changes along the extensive margin, their results may be biased. These kinds of complexities often make empirical work very difficult.

Currently, there are very few empirical studies that use a household production technique to assess monetary equivalents of parental benefits of reduced pollution-related health effects in children.[47] Data limitations have probably hampered their development. Researchers need

[47] Agee and Crocker (1996a) use expenditures on lead chelation therapy to reveal the values parents place on reductions in perceived risks to their children's health from exposure to lead sources. Inferences are based on a household production model in which parents invest in medical treatments and other exposure reducing activities to reduce their perceived risk of their child developing lead-induced neurological deficits. Similarly, Joyce,

detailed household level data on parental expenditures, time allocations, commodity prices, and wage rates, along with environmental quality measures experienced by these same households. Without these data, few empirical advances can be made in applying the approach more generally.

Finally, analysts should note that, like hedonic models, the household production model is limited to estimating the value the household places on improvements in their own children's health. Altruistic values held by others outside of the household will not be captured in these models.

4.1.2.2 Intrahousehold Allocation Models

Intrahousehold allocation models explore relationships among household members and how these relationships affect the allocation of resources among family members. In models with children present, parents make decisions that affect each family member. Two forms of the intrahousehold allocation model exist with the difference being that one assumes parental consensus and the other does not (Behrman, Pollack, and Taubman, 1995).

In the parental consensus models, parents are assumed to act as if they are maximizing a single utility function, subject to appropriate constraints (similar to a household production model). The parents' utility function, however, does not explicitly reflect the preferences of the children but rather the parents' utility depends on outcomes (or utilities) experienced by their children. Although children are generally incorporated in these models as passive participants, on occasion they have been modeled as active, independent decision-makers. In these cases, however, parents are able to exert their influence on their children's behavior by conditioning certain parental decisions (e.g., bequests) on their children's actions.

Non-consensus parental preference models, in which the two adult household members are allowed to disagree, view household behavior as the outcome of either a non-cooperative or a cooperative game. This model holds considerable promise in understanding the interactions between parents and children as well as between individual children when there is dissent. To date, however, non-consensus models have generally been applied to capture the interactions between husbands and wives and have not been extended to include children.[48, 49]

4.1.2.3 Safety Product Market Models

Safety product market models (also known as consumer market studies) are a third application of

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Grossman, and Goldman (1989) develop a health production function in which mothers' decisions regarding neonatal and prenatal care are modeled.

[48] A theoretical structure does exist for intrahousehold allocation models to determine whether a household operates with one, two, or more than two decision-making units. If this structure is applied to a household with children and observable behaviors suggest the presence of more than two decision-making units, then one can conclude that at least one of the children plays an active role in household decisions (Browning and Chiappori, 1998).

[49] See Mount et al. (2000) for an application of the intrahousehold allocation model.

averting behavior models that allow estimation of willingness-to-pay values for reduced mortality risk and reduced morbidity risk. These models combine existing data on consumer purchases of safety products with assumptions regarding use and maintenance of the products in order to infer values for health risk reductions. As discussed in the *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a), the purchase decision (and therefore risk reducing activity) often occurs as a discrete rather than a continuous action and may lead to underestimation of the value of the risk reduction to the consumer. Furthermore, to the extent that unobserved costs (e.g., equipment maintenance time or time spent using equipment) are not adequately captured, risk reduction values may be underestimated.

These models can be useful for valuing risk reductions to children only insofar as products can be identified that reduce these risks. Examples of applications of this approach include Carlin and Sandy (1991) and Jenkins, Owens, and Wiggins (2001),which examined child safety seats and bicycle safety helmets respectively.

4.1.3 Stated Preference Methods

Stated preference methods generally rely on surveys to estimate the benefits of a broad range of environmental improvements. Contingent valuation (CV), the most widely used of these methods, generally either asks respondents if they would pay (accept) a specified amount for a described hypothetical commodity or asks for their highest willingness to pay for it (lowest willingness to accept).[50] A few applications of this method to valuing child health risks exist in the literature.[51]

In general, a major advantage of stated preference methods is their flexibility. Questions can be framed to capture aspects of individuals' preferences, including uncertainty about the state of the world. Furthermore, a good can be alternatively described so as to elicit the importance of different motives for desiring such a good or service, both at the present time and in the future.

For surveys to provide useful value estimates, the market must be specified and described in enough detail to allow respondents to understand all of its important dimensions. In the context of children's health, design of a survey instrument may be difficult. In the event that parental preferences are sought, it is important to keep in mind that caregivers have often had little direct experience with environmental hazards to children (e.g., ambient lead prior to the 1980s). They may even be ignorant of the existence of a hazard and, if not, are uncertain as to how they feel about the severity and the time pattern of its consequences. Further, CV surveys of children's health changes might be at particular risk for problems with embedding. That is, respondents

[50] For a good overview of the CV method, see Mitchell and Carson (1989) or Kopp, Pommerehne, and Schwarz (1997).

[51] See Appendix A for an annotated bibliography of studies that estimate of the value of child health benefits.

might interpret the hypothetical commodity more broadly than the researcher intended. Failure to account for this may lead to biased value estimates (Tolley and Fabian, 1999).

The value of a child's health to society might differ from the value to his or her own parents for a variety of reasons, including any possible public good aspects. Stated preference methods are unique in their potential to contribute to our understanding of the value of children's health by providing an avenue for assessing the values people attach to these possible public good reasons for protecting children from environmental hazards. However, as noted by Tolley and Fabian (1999), estimating a value for this component will require careful construction of information given to respondents.[52]

The gradual transformation of a child into an adult means that there is an uncertain period, probably during the teenage years, when researchers may need to consider the child's own preferences for risk reduction in addition to those of their caregivers.[53] Many factors will influence how quickly a child matures into a rational decision-making consumer, including physical maturation rate and cultural expectations. Furthermore, maturation may be uneven in that a child may demonstrate adult behavior and rational thinking for some issues earlier than for others. Thus, the degree of consumer sovereignty exercised by children might be different for different risks. When consumer sovereignty exercised by children is high, analysts may, at a minimum, need to account for how the child's own actions relating to health and health risks compares to those assumed in caregivers' responses. Also, the dynamics of household allocation may change as children take greater control of resources and make more independent decisions.

The final alternative is to turn to adult respondents and ask that they value risk changes in their own childhoods (the adult-as-child perspective described in Chapter 2). This task, however, may prove to be too cognitively challenging to yield reliable estimates given the length of time separating the adults from their childhood experiences and the fact that the risk in question has already occurred.

Examples of stated preference approaches applied to children's health valuation include Liu et al. (2000) and Viscusi, Magat, and Huber (1987). Both examples employ the parental perspective.

[52] Several practical problems, not unique to children's health, also arise in applying stated preference methods. For more information, please see U.S. EPA (2000a); Cummings, Brookshire, and Schulze (1986); and Hanemann (1994).

[53] Davis and Meltzer (2002) review evidence from the health economics literature suggesting that although parents assessment of their children's quality of life is closer to the child's own than are assessments by health professionals, there are often significant discrepancies between the caretakers' and child's own rankings. The data indicate that household composition may affect how parental assessment of their child's health-related quality of life.

4.2 An Alternative Approach to WTP: Cost of Illness (COI)

When willingness-to-pay values are not available for a specific health endpoint, analysts will generally be forced to rely on cost-of-illness estimates to value health benefits. The cost-of-illness (COI) method estimates the value of a health benefit as the direct savings in the medical costs and time costs of an illness that result from a reduced occurrence of an illness. Medical costs include such items as expenditures on diagnosis, treatment, rehabilitation, and accommodation. Generally, analysts would follow similar steps to estimate the medical cost savings associated with children's health benefits as they would to estimate adults' health benefits by this method.[54] Care should be taken to use the most up to date estimates of medical costs as possible since rapidly changing medical technologies could render estimates obsolete in a relatively short period of time. Analysts should also be aware that differences in medical treatment occur by age in some cases and COI estimates should reflect these differences when possible.

Under the COI method, it has been noted that the value of reduced illness commonly includes estimates of the value of time lost to illness. When a child is ill, time is lost by both the caregiver and the child. For the caregiver, the cost of time of obtaining medical treatments for the child should be valued either as lost work time (using the caregiver's wage rate) or as lost household production time (using the caregiver's imputed wage rate). Imputed wage rates are difficult to estimate and, to the extent that they are disproportionately affected by childhood illnesses, they introduce additional error into estimates of COI for children.

The child's time lost to sickness also has value, although no direct measure exists for this loss. If a health effect is serious enough to reduce a child's human capital (e.g., through missed schooling) or life expectancy, then there are additional costs of time lost due to illness. Under the COI technique, these would include the (discounted) future losses in labor market earnings, although these losses are likely to be very small for most minor and acute illnesses. Determining future earnings requires difficult predictions of the child's educational choices and career path over the life cycle. In practice, a simplified relationship such as that of IQ and average earnings may serve as a proxy. Regardless of how values are estimated, these costs of time lost due to illness introduce additional difficulties in estimating COI values for children's health effects.[55] An application of the cost-of-illness methodology to children appears in Box 4.1.

[54] Note that medical treatment costs associated with a particular illness may vary across age groups. See the discussion in Section 2.2.2 for more details.

[55] Estimation of parents' foregone earnings due to their child's ill health appears somewhat more straightforward than that of a child's foregone future earnings. However, because COI estimates focus on output or production lost, whether market or non-market related, the measure does not capture all the costs a parent or caregiver incurs with the child's medical and remedial treatments. Utility maximizing behavior implies that parents will allocate time toward work, childcare, and other household-related activities, including leisure. At the margin, the value of leisure time equals the value of working time (assuming at the margin, that the time spent at work itself has no effect on utility). Thus, additional time allocated to care of a sick child, whether it comes from leisure time or from work time, is generally valued by the wage rate of the individual.

Box 4.1. The Case of Lead-Based Paint Hazards: An Application of COI Methodology to Children

Exposure to lead during childhood can result in impaired cognitive functioning and loss of IQ. Recently, U.S. EPA set standards for lead-based paint hazards to reduce childhood exposure to lead from deteriorating paint and contaminated soil and dust. Several standards were considered and the benefits of each were presented in the supporting economic analysis. A brief summary of the analysis appears below.

Because little information is available on society's willingness to pay to avoid cognitive impairment or IQ loss, analysts focused on three economic consequences of increased blood lead levels that could be valued using COI techniques. These included decreased expected lifetime earnings, increased educational resources expended, and costs of increased medical intervention associated with several critical blood lead levels requiring follow-up monitoring and/or specific medical intervention.

Decreased Expected Lifetime Earnings
To calculate the loss of expected lifetime earnings associated with loss of IQ, analysts first calculated the average expected earnings stream for an average newborn in 1997. Earnings data by age and education level were taken from the 1992 Current Population Survey and were adjusted for survival probability and expected increases in productivity and were then discounted to express the figure in present value terms. The present value of expected lifetime earnings for the entire population was found to be $366,021.

Effects of a single IQ point loss on expected lifetime earnings were then calculated using a study by Salkever (1995). Both direct and indirect effects are considered, including the direct effects of IQ on employment and earnings for employed persons holding years of schooling constant and the indirect effect of IQ on employment through schooling. The participation-weighted average effect across men and women was calculated as a 2.379 percent reduction in earnings per IQ point loss or $8,708.

The final calculation, however, must also take into account the reduced number of years of education pursued and the associated expenditures with a loss of IQ. Salkever estimated a 0.1007 reduction in years of education per IQ point which translates to a reduction in educational expenditures of $554 (1995). After adjusting this amount for the opportunity cost of lost income while in school, the total decrease in expected lifetime earnings associated with a single IQ point loss is $8,346.

Increased Educational Resources Expended
Analysts considered two categories of increased educational resource expenditure depending on the level of impairment suffered by affected children: special education for children with IQs less than 70 and compensatory education for children with blood lead levels greater than 20 µg/dL. The total cost of special education was calculated by multiplying the reduction in the probability a child will have an IQ less than 70 by the number of children born in a specified year and then by the cost of the special education. Special education costs were assumed to occur each year between the ages of 7 and 18 and were calculated assuming the child remained in a regular classroom. Reduced compensatory education benefits were calculated by assuming that 20 percent of the children with blood lead levels greater than 20 µg/dL received compensatory education for three years after which no further intervention was necessary. Costs were based on the same costs for special education.

Costs of Increased Medical Intervention
For this analysis, the costs of increased medical interventions were taken from a CDC report, *Preventing Lead Poisoning in Young Children*, which recommends protocols for blood lead screening and medical treatment for various blood lead levels (1991). Treatment costs were based on medical interventions recommended by the American Academy of Pediatrics.

Analysts should be aware that COI estimates do not necessarily capture a value for the pain and suffering associated with an illness and as a result do not reflect and individual's WTP to reduce risk. It is important to remember that COI estimates measure *ex post* costs associated with being ill rather than a willingness to pay to avoid an illness. In addition, most individuals purchase health insurance that drives a wedge between the WTP of households and costs charged by health care providers. Besides not reflecting WTP in its entirety, COI estimates may not even accurately reflect the costs of treating an illness when estimates are derived from hospital charges. For instance, hospital administration costs are often rather arbitrarily allocated across different medical procedures.

There is controversy in the economics literature about whether COI estimates reflect lower bounds to WTP (Berger et al., 1987; Harrington and Portney, 1987). COI estimates do not reflect the cost of many effects of disease. They neglect pain and suffering, defensive expenditures, lost leisure time, and any potential altruistic benefits.[56] Available comparisons of COI and WTP estimates suggest that the difference can be large (Rowe et al., 1995). However, this difference varies greatly across health effects and individuals. There is no *a priori* reason to suspect that the discrepancy is large or small for child health effects.

The COI method has great empirical feasibility. However, it is important to remember that it rests upon calculations of the medical and time cost savings that would accrue from reduced treatment of childhood illnesses. It is not a measure of willingness to pay. Nor can COI estimates be systematically rescaled (e.g., with a multiplier) to approximate willingness to pay values. There are additional weaknesses to the COI technique when valuing *children's* health effects, due to the need to value household production time and a child's expected future earnings. Despite these and other shortcomings, the COI approach remains widely accepted by many professionals as a practical method for estimating a lower bound for the value of changes in both child and adult health status, particularly when alternative methods are not available.

Recommendation (valuation techniques): *All of the valuation techniques discussed above are potentially viable for estimating the value of reduced risk to children. Each is associated with its own advantages and limitations with respect to children's health valuation. As such, each technique should be assessed for the particular health effect being valued. In general, hedonic, averting behavior, and stated preference methods are preferred over COI because they estimate the WTP for (or willingness to accept (WTA)) reduced risk, and WTP (WTA) gives the theoretically correct measure of the value of welfare change. At present, however, analysts may need to rely upon the results of COI studies until empirical estimates from other methods become available.*

[56] For the case of children, defensive expenditures would include parent spending on measures directed at preventing a child from exposure to a pollutant.

5. Other Important Types of Analyses

Alternative types of analyses exist that can support benefits valuation. These include cost-effectiveness analysis, breakeven analysis, bounding analysis, and risk-risk or health-health analyses. When robust value estimates and/or risk estimates are lacking, which in the short-term may be the case for children's health valuation, these types of analyses may provide decision-makers with some useful information. Additionally, given the various sources of divergence between child and adult values discussed in Chapter 2, analysts should expect that transferring adult values to children will often result in child benefit estimates that contain substantial error. Thus, analysts assessing children's health benefits may wish to perform one or more of these alternative techniques as a sensitivity or supplemental analysis in an effort to provide decision-makers with as complete a picture as possible of the impacts of a proposed policy or regulation. However, analysts should remember that because these alternatives do not estimate the net benefits of a policy or regulation, they fall short of benefit-cost analysis in their ability to identify an economically efficient policy. This and other short-comings should be discussed when presenting results from these analyses to decision-makers.

5.1 Cost-Effectiveness Analysis

Cost-effectiveness analysis ranks alternatives by the cost per unit of benefits, where the cost is the social cost of the policy as would be calculated for a benefit-cost analysis.[57] Benefits are generally expressed in terms of the number of adverse health outcomes avoided, for example, the number of statistical cases of illness averted or lives saved. However, cost-effectiveness analysis can use any number of adverse outcomes including, for example, pounds of a pollutant avoided. In terms of health, the most cost-effective policy alternative is the one with lowest cost per statistical life saved or the lowest cost per statistical case of illness averted. It should be noted that the most cost-effective alternative may not be efficient in an economic sense. Therefore, it does not necessarily point to a social welfare maximizing alternative.

Cost-effectiveness analysis gives more meaningful information when there is only a single health effect with a missing value. When more than one health effect cannot be valued directly, the manner in which the effects are weighted is arbitrary. This means that it is not possible to compare a policy that reduces relatively more expected cancers, but fewer expected cases of kidney failure, with one that has the opposite relative effects. As alternative tools are developed, a procedure for assigning non-arbitrary weights to physical outcomes might become generally accepted. Currently, there is no such procedure.

Even when there is only a single health effect with a missing value, the information provided by

[57] A brief explanation of cost-effectiveness analysis is in Chapter 10, Section 10.3.3 "Results from Cost-Effectiveness Analysis" in *Guidelines for Preparing Economic Analyses* (U..S EPA, 2000a). Boardman et al. (1996) presents an introduction to cost-effectiveness analysis that includes many examples from the medical and public health literature.

cost-effectiveness analysis is not easy to interpret if there are important non-monetized *non-health* effects. For example, some policies give important non-monetized ecological benefits. In these cases, dollar estimates of the costs-per-statistical-life-saved neglect the ecological benefits.

Cost-Utility Analysis and Health-related Quality of Life Measures

The fields of public health economics and policy make extensive use of various types of cost-effectiveness analysis. A form in which the outcome is a utility-weight rather than a health effect enjoys widespread acceptance. For this reason, these types of cost-effectiveness analyses are sometimes referred to as cost-utility analysis. These weights are expressed in a variety of measures that fall under the general heading of health-related-quality-of life, and include quality-adjusted-life-years (QALYs) and disability-adjusted-life-years (DALYs). QALYs, DALYs, and other measures may differ greatly from one another in their underlying assumptions and implications for policy, but they each purport to estimate some measure of utility loss from illness or death. Because utility is generally focused strictly on health, it is defined more narrowly in this context than in traditional benefit-cost analysis. Researchers have produced a substantial theoretical and empirical literature on QALY rankings and their use in these types of cost-effectiveness analyses. Health-related-quality-of-life measures are currently used by the World Health Organization, the World Bank, and some federal agencies.

Like more general cost-effectiveness analysis, cost-utility analysis cannot evaluate the efficiency of policy alternatives in the same manner as benefit-cost analysis. Instead, cost-utility analysis ranks alternatives according to which gives the greatest "bang for the buck" In the case of an analysis using QALYs, the preferred alternative would be that with the lowest dollar per QALY ratio. This alternative is not necessarily the one that provides the greatest net benefit as defined in a benefit-cost analysis.

Cost-effectiveness analyses using QALYs, DALYs or other utility measures face many of the same challenges detailed throughout this handbook related to benefit-cost analysis. For example, because QALY weights are elicited from surveys researchers must confront the issue of who should assess children's quality of life under health impairments in much the same way as contingent valuation surveys. A useful, recent reference looking at this and other issues in the use of QALYs for children's health is Davis and Meltzer (2002). The most widely cited general reference for these types of cost-effectiveness analyses is *Cost-Effectiveness in Health and Medicine* (Gold et al., 1996). This book describes the roles and limitations of cost-effectiveness analysis, provides background on its theoretical basis, and offers recommendations on various practical considerations.

5.2 Breakeven Analysis

Breakeven analysis is another alternative that can be used when either risk data or valuation data are lacking.[58] Analysts who have per unit estimates of economic value but lack risk estimates, cannot quantify net benefits. They may, however, estimate the number of cases (each valued at the per unit value estimate) at which overall net benefits become positive, or where the policy action will break even.[59] For example, consider a proposed policy that is expected to reduce the number of cases of Respiratory Syncytial Virus (RSV) with an associated cost estimate of $1 million. Further, suppose that the analyst estimates that willingness to pay to avoid a case of a RSV is $200 but that because of limitations in risk data, it is not possible to generate an estimate of the number of cases of RSV reduced by the policy. In this case, the proposed policy would need to reduce the number of cases by 5,000 in order to "breakeven." This estimate can then be assessed for plausibility either quantitatively or qualitatively. Policy makers will need to determine if the breakeven value is acceptable or reasonable.

The same sort of analysis may be performed when analysts lack valuation estimates, producing a breakeven value that should again be assessed for credibility and plausibility. Continuing with the example above, suppose the analyst estimates that the proposed policy would reduce the number of cases of RSV by 5,000 but does not have an estimate of willingness to pay to avoid a case of RSV. In this case, the policy can be considered to "breakeven" if willingness to pay is at least $200.

One way to assess the credibility of economic breakeven values is to compare them to risk values for effects that are more or less severe than the health endpoint being evaluated. For the breakeven value to be plausible, it should fall between the estimates for these more and less severe effects. For the example above, if the estimate of willingness to pay to avoid a case of a more serious health effect was only $100, the above "breakeven" point may not be considered plausible.

Breakeven analysis is most effective when there is only one missing value in the analysis. For example, if an analyst is missing risk estimates for two different health effects (but has valuation estimates for both), then they will need to consider a "breakeven frontier" that allows the number of both health effects to vary. It is possible to construct such a frontier, but it is difficult to determine which points on the frontier are relevant for policy analysis.

[58] Boardman et al. (1996) describes determining breakeven points under the general subject of sensitivity analysis and includes empirical examples.

[59] OMB (1996) refers to such values as "switch points" in its discussion of sensitivity analysis.

5.3 Bounding Analysis

Bounding analysis can help when analysts lack value estimates for a particular endpoint. As suggested above, reducing the risk of health effects that are more severe and of longer duration should be valued more highly than those that are less severe and of shorter duration, all else equal. If robust valuation estimates are available for effects that are unambiguously "worse" and others that are unambiguously "not as bad," then one can use these estimates as the upper and lower bounds on the value of the effect of concern. Presenting alternative benefit estimates based on each of these bounds can provide valuable information to policy makers. If the sign of the net benefit estimate is positive across this range then analysts can have some confidence that the program is welfare enhancing. It is worth pointing out that for children's health effects, determining appropriate bounding values may be difficult, especially if only adult risk reduction valuations are available. Analysts should carefully describe judgments or assumptions made in selecting appropriate bounding values.

5.4 Risk-Risk and Health-Health Analyses

Risk-risk and health-health analyses do not require benefits *or* costs to be monetized. A risk-risk analysis enumerates the risks that are reduced and those that are inadvertently increased by a government policy. For example, a policy that requires installation of scrubbers at coal-fired electric generating plants, will reduce health risks from air pollution but will also present risks to the construction crews installing the scrubbers. In risk-risk analysis, both the desirable and undesirable risk changes are denominated in physical, and not dollar, terms, although each could be denominated in different physical units. This type of analysis is most useful when policy options are very restricted as it usually cannot provide a clear ranking of policies.

The implementation of health-health analysis, in practice, has been restricted to cases of mortality risk reduction.[60] In this application, health-health analysis evaluates policies by comparing the number of deaths prevented by a government policy with the number of deaths induced by transferring income from individuals to the government in order to finance the policy. Generally, government programs, even those that directly serve public health, have to be financed. Money for those programs has to come from individuals; thus, paying for programs reduces individuals' ability to purchase risk reduction privately.

In principle, health-health analysis could include the detrimental effects of loss of income on morbidity, however, this would require aggregating health effects using quality adjusted life years[61] or some alternative, common metric. In current applications focused on mortality risks,

[60] Kuchler and Golan (1999) and Perkins (1998) provide reviews of existing health-health studies.

[61] While QALYs have been widely used in evaluating the cost-effectiveness of medical interventions and in some other policy contexts, methods involving their use have not yet been fully amalgamated into the welfare economic literature on risk valuation.

health-health analysis fails to consider non-fatal health effects and other welfare effects of policies.[62] If these other effects are expected to be significant, then this type of analysis can be misleading. For example, consider an expensive regulation that results in no reduction in fatalities, but a large reduction in childhood developmental impairment. In this case, the number of deaths prevented is zero, while the number induced due to diverting money from the private sector and hence reducing spending on safety goods is likely to be positive. Health-health analysis seems most useful as a screening tool for policies with insubstantial non-fatal health and welfare effects.

5.5 Summary

The techniques discussed, especially cost-effectiveness, breakeven, and health-health analyses, are most useful when there is only a single non-monetized benefit category. (For health-health analysis, the category must be mortality risk.) Most EPA policies generate multiple benefits, many of which are difficult to monetize. In such cases, analysts can determine if a single non-monetized benefit stands out as potentially the most significant—statistical lives or life years saved are likely candidates. Applying the above techniques to what analysts judge to be the most significant benefit category can provide useful information. However, care should be taken to remind policy makers relying on these alternative analyses that there are other, neglected, non-monetized benefit categories. Despite expectations that these others are less significant, analysts should remember that they are potentially important to decision-makers. In addition, analysts should remember that because these alternative types of analyses do not estimate the net benefits of a policy, they fall short of benefit-cost analysis in their ability to identify an economically efficient policy.

Recommendation (alternative analyses): *Despite the fact that the techniques outlined above do not provide information on net benefits, analysts assessing children's health benefits may wish to perform one or more of the alternative techniques as a sensitivity or supplemental analysis in an effort to provide decision-makers with a complete as picture as possible of the impacts of a proposed policy or regulation. This sort of analysis will be especially important when age-specific valuation estimates for the health effects of concern are not available. Regardless of the technique used, care should be taken to discuss the short-comings of the analysis.*

[62] Lutter, Morrall, and Viscusi (1999), for example, state the major assumption embodied in their empirical model is that "the purpose of health expenditures is to reduce mortality, not to reduce morbidity or provide peace of mind."

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6. Risk Assessment and Economic Analysis[63]

As noted in Chapter 1, estimation of the health benefits to children will generally involve six steps: hazard identification, dose-response evaluation, exposure assessment, risk characterization, welfare effect quantification, and valuation of the welfare effect. This Handbook focuses on issues directly relating to the valuation of changes in risks to children's health and, as such, is on the final two steps of this process. Previous chapters provide in depth discussion on issues relating to these two steps; however, in order to quantify the health benefits of environmental policies, economists generally require estimates of the type and number of cases of illness reduced. The development of such estimates involves the first four of the steps noted above and generally falls to risk assessors. Historically, economists and risk assessors have had little meaningful interaction regarding these six steps. However, in order for useful information on quantifiable and monetizable physical effects be developed, it is essential that risk assessors and economists work together as a team to complete all of the procedures presented. This type of collaboration should yield health outcomes that are specified in a way that is useful for subsequent economic valuation.

6.1 Communication Between Risk Assessors and Economists

Risk analysts and economists must communicate clearly if the risk assessment process is to produce useful estimates of physical benefits.[64] In the case of child-specific risks and benefits, clear communication may be even more important. Risk analysts and economists have generally had more experience working together assessing the effects of policies that alter risks to adults than those specific for children. New risk assessment and economic models are being developed for children and changes in both fields may occur rapidly. Unless clear and continuing communication exists among all analysts involved in assessing policies addressing children's health, developments might not be as productive as they would otherwise be.

The uncertainties surrounding estimates of risk and economic value may be greater for children's health effects. Assumptions used in assessing adult health risks may not be applicable for children's health effects (e.g., small children spend a lot of time on the ground or floor and put everything in their mouth – they therefore have a much higher exposure to lead and other pollutants found in dust and dirt). To perform a sound analysis of benefits, economists will need to know if new assumptions change the basic nature of the risk characterization. Economists and risk assessors both bear responsibility for sharing information about assumptions made. The interfaces between risk assessment and benefit analysis are dependent on the scope and methods

[63] This chapter is based in part on information presented in Thompson (1999).

[64] Chapter 7, Section 7.3 "The Benefits Analysis Process" in *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a) emphasizes that communication must begin early in the process of benefits analysis and should continue throughout the development of the analysis. A more formal discussion of the importance of communication between risk assessors and economists can also be found in Shogren and Crocker (1999).

of the underlying research. Risk assessments based on animal toxicological studies may require dialogue between risk assessors and economists at more steps in the analytical process than econometric studies where the health risks are endogenized. For example, an econometric study may examine what effect a change in drinking water quality has on a certain health outcome. By construction, the econometric study incorporates decisions consumers make about bottled water usage into the model, so human behavior is determined within the model. In contrast, using an animal toxicological study requires the analyst to construct a chain of events. For example, suppose a pollutant found to cause a health effect in animals is expected to cause the same effect in humans. The dose-response function estimated for animals for this particular pollutant is extrapolated to humans with appropriate adjustments. However, in order to estimate the human health outcome associated with a change in the pollutant level, the analyst must determine what changes in human behavior may occur (e.g., the pollutant creates a bad taste in drinking water causing more people to drink bottled water thereby avoiding exposure to the pollutant in question). Human behavior must be modeled and built into the chain of events.[65]

Risk assessors should interact with risk managers and economic analysts to discuss what risks will be assessed (i.e., what information decision-makers care about). Early discussions that jointly identify the key subpopulations (e.g., adults exposed to a pollutant that exhibits reproductive toxicity, pregnant women/fetuses, infants, adolescents, etc.) and potential health effects will focus the risk assessment and help economists plan for valuation. Economists should emphasize to risk assessors those endpoints that have economic value so that they can be included in the risk assessment. Early discussions among analysts can identify and circumvent many problems, and early discussions may also allow enough lead time for economists to collect additional necessary valuation data.

6.1.1 Economists' Contributions to a Risk Assessment

Economists and risk assessors may possess different types of information about the behavior of children. Economists can assist risk assessors by providing insights, information, and analysis concerning behavioral changes in the face of environmental risks that may affect the results of exposure assessment. For instance, the activity patterns of children and their caregivers may change due to perceived environmental risks. With increased environmental awareness and information regarding drinking water, soil, and air quality conditions, perceptions of environmental risks may change. The result may be increases in some averting or mitigating behaviors associated with elevated environmental risks. Examples of such behaviors include increased use of bottled and/or boiled water, increased time spent indoors, and reduced direct exposure to the sun. Consequently, the expected incidence of adverse health effects may diminish due to increased averting or mitigating behavior. In such cases, the benefits of reduced health risks to children should also include the gains from opportunities to reduce averting and

[65] Understanding averting behaviors is important when estimating the benefits of reducing pollution, not only because such behaviors reduce the population's exposure but also because the need for the averting behaviors is reduced. When calculating benefits, the value of the reduction in averting behavior is added to the value of reduced illness.

mitigating behavior. An effective dialogue between the risk assessors and economists is often the only way to determine if averting or mitigating behavior should be addressed and, if so, whether those factors are provided for in the risk assessment.

Economists can also provide insight on which kinds of risk information are most useful for benefits estimation, most notably in the hazard identification and risk characterization steps of the risk assessment process. In the hazard identification step, economists should make clear the need for information on particular health endpoints expected to have economic value. For example, forced expiratory volume is commonly used as a measure of lung function, but there is little evidence that small changes are correlated with a willingness to pay for relief. Because relatively small reductions in forced expiratory volume are not generally perceived as adverse, it is a poor candidate for economic valuation. While it may be infeasible to monetize these types of effects, quantifying them can give decision-makers useful information. In the risk characterization step, economists should discuss with risk assessors the need for information on probabilities and the distribution of risk in order to develop central and bounding estimates of benefits. Economists should also discuss with risk assessors how information on point estimates and reference doses alone may limit an economic analysis of benefits.

6.1.2 Risk Assessors' Contributions to an Economic Analysis

Economists have a great deal to learn from risk assessors. Understanding the activity patterns of children at risk and their parents is often central to credible valuations of children's health. Activity patterns of children often vary on a daily, weekly, and seasonal basis. These patterns may be affected by a number of factors, including variations in the temperature, wind, and precipitation, regardless of whether information on pollution levels and risks is available. Assumptions about baseline conditions and their natural variability are addressed either explicitly or implicitly in any risk assessment. A full understanding of the context for the risk assessment helps in the design of the benefits analysis.

6.1.3 Interaction Between Risk Assessors and Economists

The impacts of environmental policies and regulations should be assessed using an "interactive team" approach in which risk assessors and economists work collaboratively rather than sequentially. Box 6.1 provides a list of questions designed to facilitate dialogue between risk assessors and economists. This list is not intended to be exhaustive, but rather to suggest a starting point for communication between risk assessors, economists, and other participants in the policy process. By discussing these questions specifically and through regular communication, risk and economic analysts will maximize the usefulness of risk assessment data. Answers to the questions in Box 6.1 will not always be available. Additionally, other specialists such as public health professionals, physicians, or industrial engineers are likely to provide more detailed answers to the questions and their opinions should be sought when appropriate.

Box 6.1 Discussion Questions to Facilitate Interaction Between Risk Assessors and Economists

1. What are the health outcomes (that will be) characterized?
2. How do the risk estimates support valuation?
3. How many children are expected to experience the outcome(s) without additional action?
4. How many children are expected to experience the outcome(s) with each additional action under consideration?
5. What risk factors put children particularly at risk?
6. What ages of individuals are exposed?
7. What is known about the susceptibility or sensitivity of the exposed children to the disease?
8. What, if any, trade-offs might be induced by the actions under evaluation?
9. What is the latency period between exposure and disease?
10. Is the disease detectable in children? treatable? reversible?
11. Does the disease alter the child's quality of life because it changes his or her normal growth or development?
12. What is the magnitude of the uncertainty around the quantitative estimates?
13. What assumptions drive this uncertainty?

Recommendation (interaction between economists and risk assessors): *Economists and risk assessors would do well to coordinate their efforts in an "interactive team" approach rather than working sequentially. Working together will help ensure that information needs for benefits estimation are met. Assumptions made collaboratively by both types of analysts should be made as transparent as possible.*[66]

6.2 Key Components of the Risk Assessment Data

Economists require various types of data to fully assess benefits. Some of these data are provided as a matter of course throughout the risk assessment process, but others may require further work on the part of both the economist and the risk assessment analyst, perhaps with the help of additional professionals. A description of these data is provided below.

- **A description of the type of risk estimate.** Economists generally need an estimate of the number of expected adverse health effects avoided as a result of the policy action. Risk characterizations produce estimates of the health risk associated with a particular

[66] EPA's *Guidelines for Preparing Economic Analyses* (U.S. EPA, 2000a), Chapter 7, Section 7.3.1 "A General 'Effect-by-Effect' Approach" outlines steps for risk assessors and economists to ensure that health outcomes are specified so that they are useful for subsequent economic valuation.

contaminant. But, the kinds of population risks most useful to economists are not always available. Some risk characterizations, such as those for cancer, are conducive to economic valuation because they can be converted into cases of illness. Others are less so, such as those that focus only on determining whether an individual is exposed above an acceptable threshold. Furthermore, valuing programs that emphasize individual risk estimates, rather than population risk, will typically require additional assumptions or data about the number of exposed individuals in the population in order to estimate social benefits.

- **A description of the changes and timing of changes in ambient concentrations.** Risk assessors might use monitored ambient pollutant concentrations and assume immediate decreases in those concentrations when estimating changes in relative risk, whereas economists might be working with modeled pollutant concentrations and/or permit limits and lagged compliance schedules when estimating economic impacts.

- **A description of the exposed population.** The economist also ideally needs a description of the demographic characteristics of the affected population or sub-population. This description should obviously include the age distribution of the exposed population.

- **A description of the adverse health effect.** This description should include a discussion of severity, duration, latency period (if any), and the percentage of cases that are typically fatal. Much of this information likely will come from medical professionals.

- **A description of uncertainties in the risk assessment.** Also of use to the economist is information about the models used by the risk assessor as well as any assumptions made in extrapolating from available data. When available, probability distributions that characterize the uncertainty or variability associated with risk estimates can be extremely valuable in assessing the uncertainty of the benefit analysis as a whole. This is especially important for children because the lack of child-specific information may result in relatively less certain risk estimates. At a minimum, risk analysts should qualitatively discuss the important sources of uncertainty and, when possible, should quantitatively demonstrate the impacts of different assumptions on the risk assessment results.[67]

More information on these issues as they apply to benefit transfer can be found in Chapter 5.

[67] A checklist of common assumptions focusing on children and used by risk assessors can be found in Thompson (1999). When listing assumptions, risk assessors should be as specific as possible so that economists and others can be fully informed of value judgments and limitations inherent in the analysis (Henry et al., 1992).

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Waitzman, N., P. Romano, and R. Scheffler. 1994. "Estimates of the Economic Costs of Birth Defects." *Injury*. 33:188-205.

Water Resources Research. 1992. 28(3):651-655.

Weiss, K.B., P.J. Gergen, and T.A. Hodgson. 1992. "An Economic Evaluation of Asthma in the United States." *The New England Journal of Medicine*. 326(13):862-866.

Wiencke, J.K, S.W. Thurston, K.T. Kelsey, A. Varkonyi, J.C. Wain, E.J. Mark, and D.C. Christiani. 1999. "Early Age at Smoking Initiation and Tobacco Carcinogen DNA Damage in the Lung." *Journal of the National Cancer Institute*. 91(7):614-619

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Wilson, J.D., E. Braunwald, K.J. Isselbacher, R.G. Petersdorf, J.B. Martin, A.S. Fauci, and R.K. Root. 1991. *Harrison's Principles of Internal Medicine*. 12th Edition. McGraw-Hill, Inc.: New York, NY.

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Appendix A

Annotated Bibliography

Twenty published studies were located that provide estimates of child-oriented values related to mortality, childhood cancers, chronic effects, acute effects, prenatal exposure effects, and reproductive effects.[68] Following are citations and annotations for them, followed by a list of citations of unpublished, on-going research in the area of children's health valuation.

Published Papers

Agee, M.D. and T.D. Crocker. 1996a. "Parental Altruism and Child Lead Exposure: Inferences from the Demand for Chelation Therapy." ***The Journal of Human Resources.*** **31:677-691.**

The authors use a household production model of the demand for chelation therapy to estimate parental willingness to pay (WTP) for reduced body-lead burdens for (their own) children. The data were obtained from a sample of 256 households with children attending the first and second grades between 1975 and 1978 in two Boston area communities. This sample was drawn from a larger sample interviewed initially during this time period. Body lead burden was determined for each child using shed teeth. Other relevant information was obtained from a physical examination of the child and a comprehensive medical and social history completed by the parent. Information on whether or not chelation therapy was pursued was collected in a follow-up survey conducted in 1985 together with wage information for the parents.

Parental willingness to pay for reduced child body lead burdens was calculated for parents who did not choose therapy as well as for those who did choose therapy. As a result, WTP ranged from $11.18 to $104.39. In addition, they find that aggregate WTP for a one percent reduction in child lead burden is no less than twice the value of *ex post* family and social, medical, and educational outlays saved by avoiding the "ill-omened" state.

Analysts should exercise caution in employing these values in a cost-benefit analysis of reduced body lead burdens among children. The sample is not necessarily representative of households across the country because every family possessed medical insurance. Also, the use of the wage rate of employed mothers as the parental opportunity costs of time is open to criticism.

[68]This appendix is based in part on information presented in Neumann and Greenwood (1999).

Boyle, M.H., G.W. Torrance, J.C. Sinclair, and S.P. Horwood. 1983. "Economic Evaluation of Neonatal Intensive Care of Very-Low-Birth-Weight Infants." ***The New England Journal of Medicine*****. 308(22):1330-37.**

The authors calculate the direct and indirect lifetime costs of low birth weight. The most relevant data concerned infants weighing 500 g to 1,499 g at birth and was collected from one county in Ontario, Canada, from 1973 to 1977. In addition, the authors consulted with physicians to predict future medical costs and reduced productivity and then developed a health-state index to create an estimate of lost quality-adjusted life-years.

Estimated costs per live birth through hospital discharge, to age 15, and to death are $14,200, $20,700, and $100,100, respectively, for 1,000 g to 1,499 g infants.[69] For 500 g to 999 g infants, these costs were $13,600, $19,900, and $43,600. Costs per life-year gained and per quality-adjusted life-year gained are also presented.

Analysts should exercise caution in applying these estimates in a benefit-cost analysis. At present, the science linking environmental exposure to low birth weight is limited. No estimates are presented for normal birth weight infants, eliminating the analysts ability to estimate the incremental cost per birth weight category. Additionally, it is likely that treatment course, length, and cost have changed, perhaps substantially, since the 1970s.

Carlin, P.S. and R. Sandy. 1991. "Estimating the Implicit Value of a Young Child's Life." ***Southern Economic Journal*****. 58:186-202.**

Carlin and Sandy collected data on car seat usage from ten cities in Indiana. At a site for each city, surveyors, with the help of state troopers, stopped every passing car that carried a child who appeared to be aged four or under. Data were collected about whether the child was properly restrained, and drivers were asked to complete a follow-up questionnaire and return it by mail. Carlin and Sandy combined the following data: drivers' reported wage rates; an estimated $80 price of a car seats in Indiana; an estimated amount of time spent harnessing and unharnessing the child; and data from the States of Washington and Tennessee on the reduction in the probability of death faced by a child wearing a car seat. They estimated, in 1985 dollars, a value of statistical life for a child of $418,597, which they amended to $526,827 by appending the costs of raising a child.

Analysts should exercise caution in applying these figures to a benefit-cost analysis for several reasons, one of which is that the data are regional. Secondly, estimates of the value of statistical life calculated by examining consumer expenditures on averting behaviors are lower bound estimates. Finally, the values estimated by Carlin and Sandy are for very young children – aged four or under – and are not intended to represent older children.

[69] Estimates are in 1978 Canadian dollars.

Dickie, M. and D.V. Nestor. 1999. "Valuation of Environmental Health Effects in Children: A Survey." Preliminary Draft.

With the aid of a simple formula, Dickie and Nestor use the Joyce, Grossman, and Goldman (1989) WTP estimates for improved neonatal survival from a 10 percent reduction in sulfur dioxide, along with estimates of the risk of infant death, to calculate WTP by mothers to avoid statistical infant deaths. (See the Joyce, Grossman, and Goldman, 1989 annotated bibliographic entry.) With information on the average number of births, they also calculate the WTP per birth.

Table A-1. Implied Values of Statistical Lives for Infants ($1977)

Race of mother	Based on prenatal care		Based on neonatal intensive care	
	Per mother	Per birth	Per mother	Per birth
White	$ 27,650	$ 16,265	$ 480,915	$ 282,890
Black	$ 50,955	$ 22,155	$ 1,273,360	$ 553,635

The same cautions given for the WTP estimates calculated by the Joyce, Grossman, and Goldman (1989) apply to the values of statistical life (VSLs) provided by Dickie and Nestor; that is, the data on which they are based are county-level and not individual-level and thus reflect substantial aggregation error.

Hoffman, C., D. Rice, and H.Y. Sung. 1996. "Persons with Chronic Conditions: Their Prevalence and Costs." ***Journal of the American Medical Association.*** **276(18):1473-1479.**

Hoffman, Rice, and Sung use the results of two national surveys to estimate the total direct and indirect costs associated with all chronic conditions. The 1987 National Medical Expenditure Survey was used to estimate the direct costs associated with chronic conditions, and the 1990 National Health Interview Survey, along with the 1990 *Vital Statistics of the United States,* was used to estimate indirect costs, including mortality costs measured by lost expected earnings. Results for both types of costs are presented by age group, but these age groupings differ by group due to differences in the underlying data. For persons aged 0-17, direct costs of chronic conditions in 1987 averaged $22.9 billion (1987 dollars), or $1,843 per chronically ill person in that age group. Indirect costs were estimated for persons under 25 years, and totaled $13.2 billion (1990 dollars) for 1990. Over $10 billion of this total is due to mortality associated with chronic conditions. The study also indicates that over one-fourth of children with a chronic condition have multiple chronic conditions; children with multiple conditions experience more missed school days, more time spent in bed, and higher costs.

While the study provides insight into the large financial impact of chronic conditions in these age groups and indicates the importance of considering co-morbidities, it does not provide estimates that are readily employed in benefit-cost analyses. The estimated costs of mortality are particularly ill-suited for use in Agency benefit-cost analysis because the authors focus on *ex post* productivity losses rather than *ex ante* estimates of willingness to pay to reduce risk.

Jenkins, R.R., N. Owens, and L.B. Wiggins. 2001. "Valuing Reduced Risks to Children: The Case of Bicycle Safety Helmets." ***Contemporary Economic Policy.*** **19(4):397-408.**

Jenkins, Owens, and Wiggins use the market for bicycle safety helmets to estimate a VSL for two child age groups and one adult age group. The following table, taken from their article, summarizes VSLs by age range and assumption.

Table A-2. VSL by Age Range and Assumptions (Million $1997)

Age	Helmet worn 100%of the time	Helmet worn less than 100 % of the time	Helmet worn less than 100 % of the time and equal weight on death and injury
5 - 9	$1.5	$2.7	$1.3
10 - 14	$1.1	$2.6	$1.3
20 - 59	$2.0	$4.0	$2.0

These estimates are the first directly comparable VSLs calculated for child and adult age categories and one of very few calculated for school age children. Analysts are not advised to directly use estimates such as these until many more child VSL studies have been completed using different data sources and methodologies.

Joyce, T.J., M. Grossman, and F. Goldman. 1989. "An Assessment of the Benefits of Air Pollution Control: The Case of Infant Health." ***Journal of Urban Economics*****. 25:32-51.**

Joyce, Grossman, and Goldman develop a health production function to estimate the social willingness to pay for improved neonatal survival associated with a 10 percent reduction in annual average sulfur dioxide concentrations. They use aggregate data on counties to derive two sets of estimates — one based on the cost of prenatal care and another based on the cost of neonatal intensive care. Separate estimates are developed for white and black populations, and the results are generated per mother (a WTP for benefits to all expected children). The authors assert that the methodology measures social WTP rather than private because most of the costs measured are covered by insurance.

Table A-3 WTP for Improved Neonatal Survival from a 10 Percent Reduction in Sulfur Dioxide ($1977)

	Black mothers	White mothers
Prenatal Care	$4	$1
Neonatal Care	$110	$16

These values, as they stand, are of limited use to analysts in need of estimates of the value of reduced morbidity or mortality. However, Dickie and Nestor (1999) convert the values in the table above to VSLs. (See the Dickie and Nestor (1999), annotated bibliographic entry.) The underlying data for the estimates are county level; thus, analysts should exercise caution in adopting them or their derivatives. Finally, the assertion by the authors that the estimates represent social WTP is questionable because the choice that they model regarding quantity of prenatal and neonatal care was made by parents, not society.

Lewit, E.M., L. Schuurmann Baker, H. Corman, and P.H. Shlono. 1995. "The Direct Cost of Low Birth Weight." ***The Future of Children*****. 5(1):35-56.**

Lewit et al. present estimates of the direct incremental costs of low birth weight. The study relies on analyses derived from two nationally representative population surveys, the 1988 Child Health Supplement of the National Health Interview Survey (CHS-NHIS) and the 1991 National Household Education Survey's (NHES) Pre-Primary and Primary Surveys.

Table A-4. Mean Incremental Cost per Low Birth Weight Child ($1988) by Age Group

Age group	Cost type	Mean incremental cost per low birth weight child (1988 dollars)
Infancy	Health care	$15,000
1 to 2 years	All	not available
3 to 5 years	Health care	$290
3 to 5 years	Child care	$180
6 to 10 years	Health care	$470
6 to 15 years	Special education	$150
11 to 15 years	Grade repetition	$45

Lewit et al. do not develop comprehensive estimates for costs associated with children aged 1-2, 11-15, and 16 and older. The authors point out that they fail to include very costly special services utilized by severely disabled low birth weight children and other early intervention services utilized by very young children. All of these factors imply that the values in the table above are underestimates. On the other hand, the authors point out that rapidly changing technology is leading to increased survival and lower costs in treating low birth weight babies (i.e., widespread adoption of the use of exogenous surfactant).

Liu, J.-T., J.K. Hammitt, J.-D. Wang, and J.-L. Liu. 2000. "Mother's Willingness to Pay for Her Own and Her Child's Health: A Contingent Valuation Study in Taiwan." ***Health Economics*****. 9:319-326.**

Liu et al. used the results of a survey of 700 Taiwanese mothers to estimate a WTP to avoid a minor illness themselves and a WTP to have their children avoid a similar illness. Respondents were asked, using binary-choice questions, how much they would be willing to pay for a preventative medicine that would cause them to avoid a cold with the same symptoms and severity of their most recent cold. They were asked a similar question with respect to one of their children. The authors estimate that the median mother is willing to pay $37 (U.S. $1995) to avoid her own cold, yet she is willing to pay $57 for her child to avoid a cold. When these values are adjusted for the fact that the average mother's cold is longer and more severe than the average child's, the child's value is about twice that of the mother's.

These values themselves may be of little direct use to U.S. policy analysis as they are more applicable to developing countries.

Marion, R.J., T. Creer, and R. Reynolds. 1985. "Direct and Indirect Costs Associated with the Management of Childhood Asthma." ***Annals of Allergy*****. 54:31-34.**

In this paper, the authors attempt to estimate the direct and indirect costs associated with the management of chronic, intractable childhood asthma. The results are based on reports kept over a year period by 25 families in Denver, CO. None of the families included in the study were enrolled in health maintenance organizations, and all reported at least 4 months of asthma-related expenditures over the year-long period. For the purposes of this study, direct costs were defined as those expenditures associated with the direct medical management of the child's asthma such as medications, laboratory tests, physician care, and hospitalizations. Indirect costs, on the other hand, included "peripheral" expenditures such as time lost from work, babysitter use, transportation costs, and other miscellaneous expenses such as purchases of air cleaners, humidifiers, or non-allergic bedding. A table from the paper summarizing their findings is reproduced below.

Analysts seeking to apply these numbers to a benefit-cost analysis should exercise caution. These figures are based on a small number of families in a specific locale. Furthermore, in the evaluation of air pollution regulations, these values may not be appropriate since they focus on asthma management rather than the alleviation of acute asthma symptoms. The scientific evidence is inconclusive regarding the role of air pollution as an inducer of asthma.

Table A-5. Direct and Indirect Asthma Expenditures for All Families and Costs by Percentage of Total Income (In Dollars Unless Otherwise Indicated)

N=25	Average	Range	
		Low	High
Income	24,744.40	5,500.00	85,000.00
Direct costs	940.72	52.25	3,935.55
Physician	358.80	0.00	1,902.00
Pharmacy	233.90	0.00	1,534.00
Hospital	204.86	0.00	1,872.31
Indirect costs	146.48	0.00	383.25
Miles	418 miles	0.0 miles	1,392 miles
Income loss	50.00	0.00	280.00
Miscellaneous	33.10	0.00	300.00
Total costs	1,087.19	88.86	3,965.25
Percent of total income			
Direct costs	5.50%	0.10%	32.8%
Indirect costs	0.87%	0.0%	6.3%
Total costs	6.40%	0.35%	33.0%

McCormick, M.C., J.C. Bernbaum, J.M. Eisenberg, S.L. Kustra, and E. Finnegan. 1991. "Costs Incurred by Parents of Very Low Birth Weight Infants After the Initial Neonatal Hospitalization." ***Pediatrics.*** **88(3):533-541.**

McCormick et al. compare the medical costs for 32 very low birth weight infants with the costs for 34 normal weight infants. The study looks at medical costs for the first year of life, recorded by parents in a diary and collected quarterly via telephone questionnaire. McCormick et al. estimate that direct medical charges for very low birth weight infants are $8,960 ($1,984 higher than full term infants) during the first year of life. Hospitalization and increased visits to doctors account for most of the disparity in medical costs across the two populations.

Analysts should be wary of using these estimates for use in policy analyses. They are derived from a very small, unrepresentative sample.

Neumann, P. and M. Johannesson. 1994. "Willingness to Pay for In Vitro Fertilization: A Pilot Test Using Contingent Valuation." ***Medical Care*****. 32(7):686-699.**

To estimate the value of reducing human exposure to environmental contaminants that cause infertility or reduced fecundity, analysts could turn to estimates of the WTP for infertility treatments. Neumann and Johanneson estimate the WTP for in vitro fertilization procedures by analyzing the results of a small, unrepresentative sample consisting mainly of students, physicians, and nurses in and near Boston, Massachusetts. Respondents were interviewed as part of a contingent valuation survey pilot study. Their survey was designed to elicit estimates for willingness to pay for three situations: *ex post* (the couple knows they are infertile); *ex ante* (the couple does not know they are infertile); and a comprehensive program providing treatment for all couples in the State, to be financed by higher taxes. They find, in 1992 dollars, that the value of a statistical birth *ex post* is $177,730 per birth; the value of a statistical birth *ex ante* is $1.8 million per birth; and the value of public provision of in vitro fertilization is $32 per person per year.

Analysts should exercise extreme caution in adopting these estimates for use in policy analysis. They are derived from a very small, unrepresentative sample.

Prinzinger, J.M. 1993. "A Valuation of a Generic Child: The Investment Approach." ***Journal of Forensic Economics*****. 6(2):121-134.**

Prinzinger develops a "human capital" estimate of the value of a child's life. He presents children as an "investment" undertaken by parents only if expected benefits exceed expected costs. While he finds it impractical to estimate the benefits of an investment in children, Prinzinger instead estimates the costs. The objective of the paper is to develop estimates appropriate for wrongful death cases. As a result, the estimates are more appropriate for *ex post* application, that is for estimating the value of lives of identifiable children who have actually died. Thus, the estimates are not appropriate for estimating the value of a statistical life.

Combining the work of other forensic economists, Prizinger develops estimates for the direct costs of raising a child (e.g., food, clothing, education, etc.) and the indirect or opportunity costs (e.g., time spent caring for children or cleaning up after them). For the direct costs, Prinzinger relies on a previous study that uses the *Consumer Expenditure Survey* to estimate parents' expenditures on a child. Indirect costs are based on a previous study that analyzed the information contained in parents' time diaries. Prinzinger assigns a monetary value to that time based on the average hourly wages of maids, housemen, and janitors. He develops an illustrative example of total costs using the Consumer Price Index and a financial rate of interest to derive a present value of the expenditures. In the illustrative calculation, he uses long-term U.S. Treasury bond rates for specific years, looking retrospectively over the 18-year life of a deceased child. In 1991 dollars, Prinzinger estimates the total investment in a first child expected to go to college as $219,829 to $277,181. Each additional child is estimated to cost $196,207 to $218,850. The dollar values vary directly with the educational level of the parents.

To repeat, Prinzinger's estimates are appropriate for valuing the lost life of an identifiable child and not for valuing a statistical child life. Thus, estimates are of very limited use to analysts conducting benefit-cost analyses of EPA regulations.

Schwartz, R. 1989. "What Price Prematurity?" *Family Planning Perspectives.* 21(4):70-94.

The author calculates the direct costs for inpatient hospital case for neonates by birth weight. The data were obtained from a sample of 28 U.S. hospitals providing tertiary neonatal care.[70] These hospitals, representing 16 percent of total urban tertiary hospitals and 54 percent of low birth weight infants, provided data on infants that received care and were discharged to home during a 12-month period, including all or part of 1985. In order to standardize charges, all charges were converted to costs. The costs presented in the paper do not include medical education and capital expense.

The results presented indicate that hospital costs for low birth weight infants (less than 2,500 g) average $9,072, while those for normal birth weight infants average $678.[71] The author also presents the cost-savings per infant associated with a one category upward shift in birth weight. Calculated savings range from $1,890 (for a shift from 2,000 g - 2,499 g to 2,500 g or more) to $18,826 (for a shift from 500 g - 749 g to 740 g - 999 g).

Analysts should exercise caution in applying these estimates in a benefit-cost analysis. At present, the science linking environmental exposure to low birth weight is limited. The estimates presented are direct medical costs and additionally do not include costs associated with low birth weight incurred after release, which may be substantial. Also, it is likely that treatment course, length, and cost have changed since 1985.

U.S. Environmental Protection Agency. 1985. *Costs and Benefits of Reducing Lead in Gasoline: Final Regulatory Impact Analysis.* Washington, D.C.

EPA benefit-cost analysis of removing lead additives from gasoline evaluates the benefits of reduced blood levels in children. The study estimates direct medical costs and increased costs of special education for children with blood lead levels over 25 µg/dL. Medical costs were based upon previously published literature and include screening, follow-up tests, physician visits, hospitalization, and chelation. The average cost per child with blood levels exceeding 25 µg/dL is approximately $900 in 1983 dollars, with a range of $100 to $8,400. Special education costs are estimated assuming that 25 percent of children with blood lead levels over 25 µg/dL require part-time help but remain in the classroom. Each child was also assumed to need such care for 3 years

[70] "Hospitals were considered to provide tertiary care if they had a neonatal intensive care unit, retained all neonates who required treatment (with the exception of surgical cases) and had at least one full-time neonatologist on staff."

[71] All estimates are $1985.

at a total cost of about $2,600 per child (1983 dollars). Special education costs ranged from zero to $12,870. Total medical and special education costs average $3,500 per affected child.

This study did not include opportunity costs for parents' time or for lost lifetime earnings for the child resulting from elevated blood lead levels and associated IQ loss. The values reported in this study probably understate the direct and indirect costs of blood lead burdens in children. The estimates are almost certainly an underestimate of willingness to pay to reduce these blood lead levels.

U.S. Environmental Protection Agency. 1997. *The Benefits and Costs of the Clean Air Act, 1970 to 1990.* Washington, D.C.

This study estimates the value of reduced lead exposure in children that resulted from ambient lead reductions under the Clean Air Act over a 20 year period from 1970 to 1990. The cost of elevated blood lead levels in children are based on two components: (1) the loss of future earnings potential due to IQ associated with elevated blood lead levels, and (2) and special education costs incurred due to these IQ losses. The study also used a value-of-statistical-life approach to estimate the benefits of reduced mortality due to neonatal exposure to lead.

The study first employed a meta-analysis of existing studies to estimate average IQ loss from unit increases in blood lead levels. The effect of this IQ loss on earnings was then estimated, including adjustments for savings in direct and indirect schooling costs due to reduced educational attainment. The present value of reduced earnings was approximately $3,000 per IQ point in 1990 dollars. The blood lead-IQ relationship was also used to estimate the number of children with an IQ less than 70 due to lead exposure. These children are presumed to require special education from grades 1 through 12 at a cost of approximately $42,000 per child (1990 dollars).

These estimates probably understate the direct and indirect costs of high blood lead levels. The study did not include medical care costs, including the opportunity costs of parents' time, and special education costs assume that mentally handicapped children are kept in a regular classroom. Willingness to pay to reduce high blood lead levels almost certainly exceeds the values reported in this study.

U.S. Environmental Protection Agency. 1999. *Cost of Illness Handbook.* Draft Report prepared for the Office of Pollution Prevention and Toxics by Abt Associates, Inc. Washington, D.C.

EPA's ongoing cost-of-illness research analyzes the costs of treating asymptomatic children under 6 years old identified through screening programs as having high blood lead levels. Asymptomatic children do not present overt symptoms but may still suffer health impacts from lead exposure. Costs are estimated by risk classes defined by the CDC. Each risk class, based on information on blood lead concentration, is assigned a treatment profile and costs are estimated for the components of the different profiles. These costs are based on earlier EPA cost estimates. The study develops average costs per child screened in each risk class and adjusts the values by:

(1) the probability that a child is screened, and (2) the survival rates for the children. At a discount rate of 3 percent, the present value of treatment costs range from $104 (in 1996 dollars) for those in the lowest risk class, to $5,185 for those in the highest.

The values in this study capture only the costs of chelation therapy and other medical interventions and do not include indirect costs associated with the opportunity costs of time. As is the case for many estimates based on a cost-of-illness approach, the values here probably understate willingness to pay to reduce blood lead levels.

Viscusi, W.K., W. Magat, and J. Huber. 1997. "An Investigation of the Rationality of Consumer Valuations of Multiple Health Risks." ***Rand Journal of Economics*****. 18:465-479.**

This article reports the results of a survey of consumers to test risk trade-off hypothesis. Additionally, the article reports willingness to pay to reduce the risks of child poisoning. The sample was drawn from consumers at a Greensboro, North Carolina, shopping mall. All respondents were asked to consider a single product (toilet bowl cleaner or insecticide) and were given the number of injuries associated with use of 10,000 bottles. Consumers with children were asked to consider child poisoning and eye burns (toilet bowl cleaner) and inhalation and child poisoning (insecticide). Consumers were then asked to indicate their maximum willingness to pay for a specified reduction in risk of one injury.

Estimates of the value of avoiding a statistical injury ranged from $1,010 for child poisoning from the toilet bowl cleaner to $2,860 for child poisoning from the insecticide.[72] The results from this study may not be directly applicable to benefit-cost analyses of environmental regulations. First, the sample is not likely to be representative of households across the country. Second, the number or severity of child poisonings is probably not impacted by the majority of environmental rules and policies.

Waitzman, N., P. Romano, and R. Scheffler. 1994. "Estimates of the Economic Costs of Birth Defects." ***Injury*****. 33:188-205.**

This article examines the cost of birth defects in the United States. Most children with birth defects do not die in infancy, and they usually require special medical treatment, special education, and other services throughout their lives. This study uses a cost-of-illness methodology to estimate the cost of 18 clinically significant birth defects in the United States, including *Spina bifida*, *Truncus arteriosus*, single ventricle, cleft lip, and Down Syndrome. The authors estimate the incremental (above the costs of those incurred by the "average" infant, child, or adult) indirect mortality and morbidity costs and direct costs of medical, developmental, and special education services over the entire life span of those born with each defect in California in 1988. The total cost by birth defect are presented in below.

[72]Estimates are $1987.

Table A-6. Total Costs of Birth Defects in California ($ 000s 1988)

	Cost per case by discount rate		
Condition	**2%**	**5%**	**10%**
Spina bifida	538	258	121
Truncus arteriosus	908	437	242
Traposition/DORV	569	237	102
Tetralogy of Fallot	466	227	125
Single ventricle	747	304	121
Cleft lip/palate	246	92	29
TE fistula	295	128	61
Atresia, small intestine	123	64	40
Colorectal/anal artesia	278	111	45
Renal agenesis	667	230	59
Urinary obstruction	220	79	24
Upper limb reduction	238	91	30
Lower limb reduction	495	182	54
Diaphragmatic hernia	610	227	77
Gastroschisis	195	94	54
Omphalocele	415	159	58
Down syndrome	1,020	410	153
Cerebral palsy	1,067	445	167

Analysts should exercise caution in applying these estimates in a benefit-cost analysis. As mentioned, the above estimates include the costs of premature mortality (calculated as lost earnings). The authors also discuss other potential biases of their estimates including that profiles or care and treatment were calculated using 1988 cross-sectional data. Prevalence, incidence, survival, and cost data are primarily based upon records from California.

Weiss, K.B., P.J. Gergen, and T.A. Hodgson. 1992. "An Economic Evaluation of Asthma in the United States." *The New England Journal of Medicine*. 326(13):862-866.

Weiss et al. estimates the national direct and indirect costs associated with asthma for 1985, using data from the National Center for Health Statistics. The direct costs included expenditures on inpatient hospitalization, hospital outpatient services, emergency room services, medications, and physician services (both in-patient care and office visits). Indirect costs included value of time lost from school and work including both values for both outside employment and housekeeping. It should be noted, however, that no values were included for a child's time when the patient was below the age of 18. These indirect costs were only computed for adults and adult caregivers.

Results are reported separately for children (individuals aged 17 and under) and adults (individuals aged 18 and up). Of most interest to analysts are those national cost figures reported as reproduced below. Analysts should exercise caution in applying these figures to a benefit-cost analysis of the reduction of air pollution because the figures do not give an indication of the per case cost and the role of ambient pollution in inducing new asthma cases is still in question.

Table A-7. Costs of Asthma in 1985 Among Selected Age Groups

Category	Age 17 or under	Age 18 or over
Direct Costs		
Hospital Care		
Inpatient	250.3	808.4
Emergency room	90.4	109.9
Outpatient	37.1	92.1
Physicians' Services		
Inpatient	20.2	61.2
Outpatient	67.14	126.2
Medications	–	–
All direct costs	465.1	1197.8
Indirect Costs		
School Days lost	726.1*	726.1*
Loss of work		
Outside employment	–	284.7
Housekeeping	–	406.0
Mortality	99.0**	676.2**
All indirect costs	825.1	2093.0

* Includes value of caretaker time only.

** Valued using loss of future income (i.e., human capital approach).

Conference Presentations/Working Papers[73]

Agee, M., and T. Crocker. 2001. "Some Economics of Child Health and Environmental Tobacco Smoke." Paper presented at the Association of Environmental and Resource Economists 2001 Summer Workshop, "Assessing and Managing Environmental and Public Health Risks." Bar Harbor, Maine, June 13-15, 2001.

Agee, M.D. and T.D. Crocker.* 1999. "On Techniques to Value the Impact of Environmental Hazards on Children's Health." Issue paper prepared for the U.S. Environmental Protection Agency, National Center for Environmental Economics.

Brajer, V., J.V. Hall, and F. Lurmann. 2002. "Economic Valuation of Ozone-Related School Absences in the South Coast Air Basin of California." Paper presented at the Western Economic Association International Annual Conference. Seattle, Washington, June 29 - July 3, 2002.

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Appendix B

Summary of External Reviewer Comments

In an effort to ensure the Handbook presents quality, sound, and consistent, as well as practical, information on valuing improvements in children's health, a previous version of this Handbook was reviewed by Lauraine Chestnut (Stratus Consulting), A. Myrick Freeman (Bowdoin College), James Hammitt (Harvard University), and Jason Shogren (University of Wyoming). Their comments proved very useful and have lead to revisions that provide a clearer, more accurate and improved document. Below is a summary of their major comments along with more minor comments that readers may find interesting. Following each comment is discussion of where, how, or whether the document was revised.

In general, all of the reviewers felt that the document was well-written, technically accurate, and useful to program analysts within the Agency. One reviewer felt that there "is little practical guidance to give policy analysts at this point." Another reviewer noted, "Overall, I think this is an excellent report...[I]t appears to be technically accurate, reflects current economic research, and identifies relevant questions that have yet to be addressed. In addition, it is clearly written and provides technically sound but practical guidance for policy analysts."

The document should include a section that reviews welfare economics and discusses the perspective that should be adopted when valuing children's health. When valuing children's health, three potentially relevant perspectives exist: child, parental, and child-as-adult. Each reviewer made several comments related to the issue of perspective, including pros and cons of each perspective, suggestions for considering household decision making, and the impact of altruism.

> ***Response:*** The comments on perspective prompted inclusion of Section 2.2.1, Perspective and Childhood Health Values, where each perspective is described and its relevance for valuing children's health effects is discussed. Ideas developed in this section help shape additional sections of the Handbook. Specific examples include:

- The discussion in Chapter 2 of the factors that may cause differences in values estimated for children compared to values estimated for adults includes the influence that perspective may have on these factors; and
- The discussion in Chapter 4 where the perspective assumed by each valuation technique is highlighted.

The idea that there is a public good component to children's health and that improving children's health leads to a more productive society needs additional explanation and justification. The presumption that social values for children's health should be added to the values for use in a benefit-cost analysis is not necessarily correct and may, in fact, result in double counting benefits.

> ***Response:*** The authors of the Handbook did not intend to suggest that social values for children's health should somehow be added to the values traditionally used in a benefit-cost analysis in the reviewed version of the Handbook. The current version provides a more extensive and clearer description of the altruism concept. In responding to the comments, the authors found it difficult to distinguish a "public good component to children's health" that would somehow be different from a public good aspect of adult health, although some researchers have argued that such differences exist generally (Folbre, 1994). This version of the Handbook does not include the phrase "a public good component," but rather relies on the various forms of altruism to discuss the concept of one person's utility being a function of another person's utility.

Appropriate application of the lifetime wealth adjustment requires consideration of when the risk reduction takes place and who is expected to pay for the risk reduction.

> ***Response:*** The revised version of the Handbook clarifies the lifetime wealth adjustment that is only appropriate for benefit transfer of values for risk reductions experienced by adults to policy scenarios involving children's risks. The adjustment would not be appropriate when drawing on parental values for these risks. Please see the discussion in Chapter 3.

The Handbook would benefit from a more rigorous discussion concerning adjusting values for cross-sectional differences in income.

> ***Response:*** Agency policy currently does not support this type of adjustment. In this respect, EPA concurs with recommendations on the subject from the Environmental Economics Advisory Committee of the Science Advisory Board. Please see the SAB/EEAC report, "An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reductions" (http://www.epa.gov/sab/fiscal00.htm).

The document does not provide information on the treatment of health outcomes that are not manifest until adulthood but result from childhood exposures.

> ***Response:*** The techniques and recommendations contained in this Handbook are relevant to the situation described by the reviewer, and this is now noted explicitly in Footnote 3.

The document reasonably argues that children's health values might be different from those for adults; however, the document could provide more information on why these values may, in fact, be the same. For example, adult willingness to pay (WTP) for reduced morbidity and mortality risks does not vary by age as much as would be predicted if willingness to pay were proportional to remaining life years.

Response: The authors have sought to provide balance in presenting the factors that *may* cause differences in the values for children compared to the values for adults. The limited information that does exist suggests that there is a difference. Please see the discussion in Section 2.2, Valuation Differences.

It would help to make the writing more sensitive to the fact that health values are often treated as fixed values per case. Value of statistical life (VSL) is really an estimate of the marginal rate of substitution between income and mortality risk, which is expected to vary with the baseline risk. In benefits transfer, using a function allows the possibility of variation in unit values with the quantity obtained and/or with the baseline.

Response: The current version of the Handbook includes this point in Section 3.2.1 where “Study Similarity” is discussed. For most of the risks subject to Agency policy, this is not an issue.

Cost-of-illness (COI) estimates are not an “alternative measure of value” although they do provide valuable information. The real issue with these estimates is that they do not measure what is needed for use in benefit-cost analyses not that they do not measure well what they were designed to measure.

Response: The current version of the Handbook presents willingness-to-pay measures as the most theoretically desirable estimates for use in benefit-cost analysis. Cost-of-illness estimates are presented as alternative measures to WTP which, since they do not represent willingness to pay, are not as theoretically desirable for benefits analysis purposes. The Handbook no longer refers to COI estimates as an “alternative measure of value.” Please see Section 4.2, An Alternative Approach to WTP: Cost of Illness.

The document would benefit from a short section on quality adjusted life years.

Response: EPA's National Center for Environmental Economics and Office of Children's Health Protection have commissioned a white paper on the topic of quality adjusted life years and are considering their usefulness in benefits analysis of children’s health risk reductions.

The document should provide information on how to value the effects of parental or of other family members’ illness or death on children. If caregivers are fully informed, then such indirect effects are included in adult measures of willingness to pay for own risk reductions; however, if caregivers are not fully informed, such indirect effects may be underestimated.

Response: While indirect effects are important, the focus of the Handbook is on the direct health effects experienced by children. Intrahousehold allocation and household production models may provide a way for analysts to address indirect effects.

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