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EXISTING LITERATURE AND RECOMMENDED STRATEGIES FOR VALUATION OF CHILDREN'S HEALTH EFFECTS

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EXISTING LITERATURE AND RECOMMENDED STRATEGIES FOR VALUATION OF CHILDREN'S HEALTH EFFECTS*

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Abstract: This paper focuses on the availability and use of existing literature for the valuation of children's health effects. Because the emphasis on children's health is relatively new, available studies focus on a small subset of health effects and the economic data available are very limited. This paper first presents an overview of methodologies used in the existing literature and provides an overall structure for discussing major classes of children's health effects. We then classify the available literature by health effect category, discuss the literature and suggest strategies for the use of valuation and other information in benefits and policy analyses. Our overall conclusion is that analysts need to interpret the existing child-focused studies with care.

Subject Area Classifications: 57. Benefit-Cost Analysis, 62. Valuation, 63. Children's Health

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Within the Environmental Protection Agency, increasing emphasis has been placed on separately assessing the environmental health risks faced by children. There is significant scientific evidence that indicates children can be more susceptible than adults to adverse health effects caused by environmental contamination (EPA 1996). In addition, EPA has been criticized in the past for adopting regulations that do not adequately ensure children's health. EPA is currently addressing these concerns by supporting scientific, health, and economic studies that address issues specific to children's health.

This paper focuses on the availability and use of existing literature for the valuation of children's health effects. Because the emphasis on children's health is relatively new, available studies focus on a small subset of health effects and the economic data available are very limited. In addition, the quality and availability of children's health effects valuation studies are uneven, reflecting the lack of consistent scientific and economic data. This paper first presents an overview of methodologies used in the existing literature and provides an overall structure for discussing major classes of children's health effects. We then provide a more detailed discussion of the available literature (grouped by health effect category), and finally we suggest strategies for the use of valuation and other information in benefits and policy analyses. Our overall conclusion is that analysts need to interpret the existing child-focused studies with care. Our practical suggestion is to encourage a heavy emphasis on clearly laying out the results and implications of existing work, but drawing conservative quantitative conclusions for valuation of benefits. In some cases the conservative approach may require reliance on the more widely understood and more prevalent studies that focus on adult health effects.

OVERVIEW OF COMMONLY APPLIED METHODOLOGIES

A typical economic paradigm for valuation of the avoidance of health effects is based on individual willingness to pay (WTP). WTP provides a useful measure of the increased well-being (or economic welfare) that accrues to individuals whose risk of contracting certain health effects is reduced through the adoption of environmental improvement and/or safety measures. Individual *children's* WTP may be a less useful measure, however. Children are not typically relied upon to provide consistent and well-structured preferences for goods and services, and hence are not likely able to reliably balance their own health and safety concerns with other basic needs (see Agee and Crocker 1999). As a result, discussion of children's health effects typically relies on parents' tastes and preferences for the safety and health of their children, or on the actions of a household as expressed through parents' decisions made for the household.

Agee and Crocker (1999) outline several potentially applicable methods for estimating WTP to avoid risks of health effects in children. They conclude that the two most promising techniques are contingent valuation (eliciting parents' preferences) and the household production model approach. Although there are a few examples of contingent valuation studies aimed at estimating parents WTP, and several studies that employ a household production approach, the majority of the existing literature is based on the cost of illness approach. As is well-documented in the literature, the cost of illness approach may leave out significant components of total willingness to pay, for example, pain and suffering, which may be particularly large for effects of long duration or extreme severity (Freeman 1993, also see EPA 1998a for a review of estimates of pain and suffering). In evaluating the strengths and weaknesses of the existing valuation literature, we consider these significant limitations of this approach. Nonetheless, we acknowledge that well-documented and appropriately caveated quantitative estimates, or qualitative characterizations of value, are nonetheless potentially useful in considering the benefits of policies to provide greater health and safety protection for children.

Evaluation of the cost of illness approach is facilitated by establishing a basic understanding of the categories of costs that can be considered in these studies. A complete cost of illness estimate considers both direct and indirect costs that are specific to children. Direct costs associated with a health effect include the value of goods and services used to diagnose, treat, rehabilitate, and accommodate ill or impaired individuals.[1] Direct cost estimation techniques used for adult populations may be appropriate for application to children's health effects (e.g., see Agee and Crocker 1999) -- in some cases, the *results* of adult studies may even be appropriate, for example, in the estimation of treatment costs where the treatment course is similar in children and adults. There may be significant additional uncertainty in evaluating direct costs for children, however. For example, estimates of adults' values to avoid pain and suffering that apply to their own health may not be useful indicators of parents' (or children's own) values for avoidance of pain and suffering in children. Differences in the severity and duration of the effect among child and adult populations may be a part of the difference. For example, some childhood diseases (e.g., measles) are less serious in children than adults,

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[1]Direct costs may also include a pain and suffering component, although cost of illness studies would generally omit this component.

and values to avoid these effects among the child population therefore may be less than values to avoid the effect in the adult population. In addition, there may be components of direct costs that are unique to children's effects. For example, children with developmental difficulties may require special education and development services to counteract the effects of their disabilities.

Indirect costs reflect the value of foregone productivity due to the health effect. In studies of adult health effects, this is most often estimated using foregone earnings. Studies evaluating children's health effects have incorporated parents' foregone earnings, as well as developed estimates of the foregone earnings for the affected child (EPA 1997). At least one study we are aware of has attempted to estimate the value of a missed school day (Weiss et al. 1992), although this study estimated the value to be equal to a mother's foregone earnings for the day. This approach obviously underestimates the total costs associated with the missed school day, because it omits the child's marginal educational loss. Studies of developmental disabilities must also evaluate the effects of reduced educational attainment on future earnings, as well as reduced labor force participation.

Most valuation studies, whether focused on adult or child populations, omit another potentially important factor - the effect of altruism on valuation. All of the existing children's mortality studies, for example, attempt only to capture parents' valuations, leaving out the potential societal altruism that may exist for prevention of child mortality. A few studies have examined the effect of considering altruism on total societal WTP for avoidance of health risks (see for example, Jones-Lee et al. 1985, Viscusi et al. 1987), and suggest altruistic values may be substantial. A full and complete treatment of the effect of altruism on the valuations presented here is beyond the scope of this paper. Nonetheless, further consideration of this issue in the future may provide valuable insights into the relationship between parental values for their children and individual values for own risk reduction. We return to this issue in the conclusion of the paper.

OVERVIEW OF EXISTING STUDIES

This paper is focused on review and analysis of existing studies of *children's* health effects — while in a few cases we discuss estimates developed for adult populations, the detailed reviews apply only to studies where we can distinguish a separate value for child subjects. We identified relevant studies by relying on an existing literature review (Dickie and Nestor 1998), supplemented by OCHP's and our own research. The specific studies examined are summarized in tables throughout the paper. Values in those tables are presented in 1997 dollars, adjusted from their original values using the Consumer Price Index for all goods (CPI-U), except where noted.[2] We would like to stress to the reader that, while we provide estimates of specific values that can be found in the literature, we urge analysts considering the use of these values in policy studies to carefully read the studies and understand fully the context in which the estimates were developed. In the interests of space and clear presentation, we have necessarily omitted many of the details of these studies that might nonetheless be

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[2] Our choice of an inflation index does not necessarily reflect an endorsement of the CPI-U as the only appropriate or applicable index. For example, cost-of-illness values are often adjusted using the medical expenditures component of the CPI; WTP values may be adjusted using the GDP implicit price deflator. We chose CPI-U for convenience and consistency.

relevant to understand before applying estimates. For example, while we cite a wide range of estimates on valuation of health risks associated with lead exposure, not all of the estimates are necessarily appropriate for all types of policies that reduce lead exposure or all severities of lead poisoning.

In the remainder of the paper we organize our discussion of results and recommendations for using existing literature according to broad classes of health effects. We developed health effects groupings by considering several key characteristics: severity; duration; reversibility; and exposure period (pre- and postnatal). Our categorization yields six major groups of health effects: (1) mortality; (2) childhood cancers; (3) chronic effects; (4) acute effects; (5) effects associated with prenatal exposure; and (6) reproductive effects.[3] The categorization provides a useful way to summarize our recommendations and reflects our conclusion that there are distinctly different issues in assessing health effects that vary across these key characteristics, particularly duration and reversibility. The categorization is not meant to imply, however, that the valuation estimates for effects in a given category ought to necessarily be of a similar magnitude; in other words, although issues in interpreting and developing values may be similar within categories, there also may be much variation within categories in estimates of the value of avoiding those effects.

MORTALITY

The value of mortality risk reductions among the general population is generally

[3]Reproductive effects include infertility/virility effects, which are not technically effects on children but which are nonetheless sometimes considered to be a class of children's health effects.

estimated using the value of statistical life (VSL) — the willingness to pay for small reductions in mortality risks in a population. EPA's recent Report to Congress, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, included a selection of 26 studies estimating the VSL.[4] 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 $4.8 million (in 1990 dollars). The VSL estimates included among the 26 are most appropriate to estimate the value of mortality risk reduction among middle-aged individuals. While EPA has endorsed the qualified use of these estimates in its analyses of adults, it is unclear whether these values ought to be used to value mortality risk reductions among children.[5]

The economic valuation literature includes several efforts to address potential differences in the value of statistical life due to differences in the age of the population affected, but in general there are few insights as to the effect for ages less than 18. These studies tend to focus on whether the elderly have a different VSL than younger adults (see, for example, Johannesson and Johansson 1997, 1996). While it may seem intuitive to assume that VSL is greater for young people than older people, because of the greater remaining life expectancy among younger individuals, studies of peoples' willingness to engage in high risk behavior and related issues suggest a more complex relationship. Both economic theory and recent research indicate that VSL may follow an inverse "U" shaped pattern that peaks around middle age and decreases at younger and older ages

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[4] U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, October 1997.

[5] EPA's draft *Guidelines for Preparing Economic Analyses* (September 1998, EPA 1998c) recommends using this range of estimates to value reductions in the risks of premature mortality, adjusting values to the current year and adding values derived from more recent studies as needed.

(although none of these studies attempts to extend values to individuals younger than 18 years) (see Jones-Lee et al. 1985, Shepard and Zeckhauser 1984, and summary of the literature in EPA 1997).

As noted above, the methodologies employed in these studies (wage-risk and contingent valuation) cannot be directly applied to child populations, thus limiting the ability to develop robust estimates of the VSL for a child except through evaluation of parental choices. A few studies have attempted to estimate the value of a statistical child's life using alternative methodologies, including human capital approaches, health production functions, and averting behavior studies. In Table 1 and the discussion below we briefly review those studies and discuss the contributions and limitations of each.

Table 1

SUMMARY OF ESTIMATES FOR VALUE OF CHILDREN'S HEALTH EFFECTS

Mortality

Description of Health Effect Studied	**Author(s)**	**Estimated Value (1997$ except where indicated)**	**Type of Estimate: Study Methodology**
Implied Value of Statistical Life of an Infant	Joyce, Grossman, and Goldman (1989) (see note below)	Whites: $43,000 to $750,000 per birth; $70,000 to $1,250,000 per mother. Blacks: $59,000 to $1,450,000 per birth; $130,000 to $3,375,000 per mother.	WTP of parent: household production model
Value of Statistical Life for a Child under Age 5	Carlin and Sandy (1991)	Net of child-raising costs: $627,000/child. Gross of child-raising costs: $783,000/child.	WTP of parent: consumer market study

Value of Child's Foregone Production	Prinzinger (1993)	Total estimated investment in a first child expected to go to college: $220,000 to $277,000; Each additional child: $196,000 to $219,000 (1991$)	Foregone production: human capital model
Note: Estimates of implied value of statistical life are based on subsequent analysis of the Joyce et al. results by Dickie and Nestor (1998) — see text for further explanation.			

Joyce, Grossman and Goldman (1989) develop a health production function based on neonatal survival and apply it to a model of family utility to estimate the value of reductions in infant mortality associated with improvements in ambient air quality. The health production function is used to estimate the marginal product of increases in prenatal or neonatal care in reducing infant mortality. The study estimates the average willingness to pay for a ten percent reduction in annual average sulphur dioxide concentrations using the marginal products derived from the health production function and the cost of prenatal care and then, separately, the cost of neonatal intensive care as indicators of societal willingness to pay. Separate estimates are developed for white and black populations, and the results are generated per mother (a WTP for all children) and per birth (a lesser value that reflects the average family size among the two race categories). Dickie and Nestor (1998) then use the Joyce et al. WTP estimates, along with estimates of the risk of infant death, to calculate WTP to avoid a statistical death (there are the values reported in Table 1 above). As Dickie and Nestor point out, it is interesting that WTP is higher among blacks, a result that runs counter to the conventional view that using WTP has negative implications for environmental justice.

Carlin and Sandy (1991) estimate the value of a statistical life of a child under five years old using an averting behavior methodology that analyzes the costs and benefits associated with child safety seats. Costs associated with child safety seats include purchasing the seat and time costs associated with buckling the child, while benefits are reductions in mortality risks. Before subtracting the costs of child rearing to age 18, a negative benefit of survival, the estimates obtained are comparable to the estimates derived for adults from seat belt usage. The estimate of net value, however, which the authors suggest more accurately represents parental WTP, is lower than estimates for adults.

Prinzinger (1993) develops a "human capital" estimate of the value of a child's life by defining children as an "investment," undertaken only if the benefits exceed the costs. While he cannot estimate the benefits of the investment in children, he instead focuses on the cost of the investment. The study is focused on developing an estimate that could be appropriate for wrongful death cases; as a result, the estimate is more appropriate for *ex post* application. Combining the work of other forensic economists, he 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 estimates the time devoted to raising a child, and he assigns a monetary value to that time using the average hourly wages of maids, housemen, and janitors. An illustrative example of total costs is developed using the Consumer Price Index and a financial rate of interest to derive a present value of the expenditures.[6] The results are summarized in Table 1.

While these studies are an attempt to remedy an important gap in economic valuation literature, each suffers from methodological flaws that prevent it from accurately estimating the value of a statistical child's life. For example, the Carlin and Sandy study is constrained by the assumption that parents fully understand mortality risks when deciding whether to purchase a safety seat; studies have suggested that this may not be true. The Joyce et al. study relies on social costs to estimate a mother's WTP, rather than examining the actual costs faced by the mother. Despite these and other limitations, however, the results are useful for expanding our understanding of the difference between WTP for a statistical child's life versus the statistical life of an adult. Additional studies that examine differences in mortality risk valuation across age classes might provide a good basis for evaluating the relative value of reducing risks to children compared to adults, but must recognize the limitations of the methods applied.

The current state of the literature, in our opinion, does not support the use of an age-differentiated or age-adjusted value of statistical life that would be appropriate and defensible for application to mortality risks to children. In this situation, use of the adult VSL as a "default" value may be the next best alternative, though this type of application should include an extensive qualitative discussion of the limitations of using adult values, including a discussion of alternative values for children such as those summarized above. As detailed in EPA's draft *Guidelines for Economic Analysis*, while the adult VSL is not without limitations, it benefits from a reliance on a broad base of well-understood

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[6] The financial rate of interest preferred by the author is the rate for long-term US Treasury bonds. In the illustrative calculation he uses rates for specific years, looking retrospectively over the 18-year life of a deceased child. The annual rates therefore vary between 5.63 and 13.44 percent.

revealed preference studies. The emerging literature on child values may continue to provide information on the characteristics of risks to children that might differentiate the comparatively well-supported adult VSL from a value that reflects the complete context of fatal environmental risks to children.

CHILDHOOD CANCER

Estimating willingness to pay to avoid childhood cancer, which could be considered to be a special class of mortality, chronic, and acute effects, is particularly difficult and controversial. Fatal cancer cases often include a latent period, a period of morbidity and sometimes painful treatment, culminating in mortality. Methods that do not include pain and suffering, including cost-of-illness, may greatly underestimate the total willingness to pay, and a simple application of a VSL based on immediate death may also be incomplete.

Nonetheless, as scientific research improves the established links between carcinogens and cancer cases, health economists may be called on to develop estimates for the value of avoiding cancer. Currently, an EPA contractor is analyzing the costs associated with acute lymphoblastic leukemia, the most common childhood cancer (EPA 1998b). While this research will provide a good estimate of the medical costs associated with treating acute lymphoblastic leukemia, this component of total WTP to avoid the cancer may be small compared to other components, such the value of pain and suffering, and other non-monetized costs.

Given the current state of the literature, we suggest careful accounting of the outcomes of cancer incidence (mortality, long-term illness and/or disability, and largely complete recovery or remission). On option is to consider mortal cancers in the same class as other mortal risks, with discussion of available information on latency as well as the potentially significant dread of cancer risk that can be avoided through preventive measures. Cost of illness studies are currently the best option for characterizing the value of avoiding chronic or acute illness, but need to be focused on treatment and indirect costs for reducing risks among children. Use of these studies also requires discussion of the potential magnitude of the omitted components of WTP.

CHRONIC HEALTH EFFECTS

Chronic health effects in children are characterized by illness or disability that initially occurs in childhood and continues through adulthood. Examples of chronic health effects that have been associated with environmental contaminants include respiratory problems (e.g., asthma induced from air pollution) and developmental disabilities (e.g., from exposure to lead).

Because of the relative ease of application, the cost-of-illness methodology may be the best option to provide initial approximations of willingness to pay to avoid a chronic health effect. However, the duration of chronic disease may require sophisticated analysis of indirect costs and future direct costs, including reduced educational achievement and foregone future earnings. Many of the studies outlined in Table 2 below are considered among the best efforts to quantify these categories of costs.

Table 2

SUMMARY OF ESTIMATES FOR VALUE OF CHILDREN'S HEALTH EFFECTS

Chronic Effects

Description of Health Effect Studied	**Author(s)**	**Estimated Value (1997$ except where indicated)**	**Type of Estimate and Study Methodology**
Total Direct and Indirect Costs Associated with Chronic Health Effects	Hoffman, Rice, and Sung (1996)	Direct Costs, prevalent population ages 0-17: $22.9 billion (1987$) Indirect Costs, prevalent population under 25 years: $13.2 billion (1990$)	Cost of illness — direct and indirect costs
Lead — Medical and Special Education Costs	EPA (1985)	$5,221 per child with over 25 µg/dL	Cost of illness -- indirect costs
Lead — Permanent IQ loss	EPA (1997)	$3,684 per lost IQ point. $51,576 per case. (Does not include neonatal mortality estimates.)	Cost of illness -- indirect costs, lost future earnings
Lead — Asymptomatic Children, Direct Costs to Age 6	EPA/Abt (1998)	$105 (lowest risk class) $5,200 (highest risk class) (1996$)	Cost of illness — direct costs
Lead — Willingness to Pay for a One Percent Reduction in Child's Lead Burden	Agee and Crocker (1996)	Households not choosing chelation treatment: $16 per child. Households choosing chelation treatment: $155 per child. Overall average: $24 per child.	Parents' WTP -- household production model
Asthma — Costs per case for children under 18.	Weiss, Gergen, and Hodgson (1992)	U.S. Total: $1.92 billion. $641 per case, excluding medication costs.	Cost of illness — direct and indirect costs

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Chronic Effects

Description of Health Effect Studied	**Author(s)**	**Estimated Value (1997$ except where indicated)**	**Type of Estimate and Study Methodology**
Asthma — Costs per family with an asthmatic child.	Marion, Creer, and Reynolds (1985)	$1,087 per family per year.	Cost of illness — direct and indirect costs

One study (Hoffman, Rice, and Sung 1996) uses 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,* were used to estimate indirect costs, including mortality costs measured by lost expected earnings. This study does not estimate per case costs, but nonetheless provides some useful information to consider in characterizing the prevalence and relative magnitude of costs associated with chronic conditions among children. The authors present their results by age group. Indirect and direct costs, however, are presented separately and the age group categories do not overlap exactly. Direct costs are presented for ages 0-17, while indirect costs are presented for all ages under 25 years.

In addition to showing the large overall financial impact of chronic conditions in children, the study's results also indicate that over one fourth of children with a chronic condition have multiple chronic conditions. The study notes that children with multiple conditions experience more missed school days, more time spent in bed, and higher costs. The prevalence of co-morbidities in the current population, and the overall prevalence of chronic conditions in the child population, may suggest greater emphasis on baseline health status (i.e., existing chronic conditions) in valuation efforts aimed at discerning the marginal impact of reducing new chronic condition incidences.

These two medical surveys are commonly used to provide estimates of direct and indirect costs for specific conditions as well. While the Hoffman et al. study focuses on the sum total cost of all chronic conditions, the chronic health effects of lead exposure and asthma on children have each been the subject of several specific valuation efforts.

Lead

The health effects of lead have been studied extensively, and it is well known that high levels of lead can cause serious developmental disabilities and even death in children. Nonetheless, these effects are difficult to quantify, and efforts have focused on estimating the costs associated with certain symptoms. While most studies use a cost-of-illness approach, one study used a household health production function approach.

In 1985, EPA conducted a ground-breaking cost-benefit analysis of removing lead additives from gasoline. The study evaluates the benefits of reduced direct medical costs and special education costs by estimating these costs for children with blood lead levels over 25 μg/dL. Medical costs include screening, follow-up tests, physician visits, hospitalization and chelation. 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. This study was expanded in 1987 by incorporating foregone earnings for parents of children with high blood lead levels, and by distinguishing the estimates by risk class.

EPA's ongoing cost-of-illness research (EPA 1998b) analyzes the costs of treating asymptomatic children with high blood lead levels identified through screening programs. Costs are estimated by the same risk classes as EPA's 1987 study.[7] Each risk class is assigned a treatment profile and costs are estimated for the components of the different profiles. 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.

Using the results of accumulated research over the previous 10 to 15 years, EPA estimates the value of reduced lead exposure in children that resulted from ambient lead reductions under the Clean Air Act in its 1997: *The Benefits and Costs of the Clean Air Act, 1970 to 1990* (EPA 1997). EPA develops estimates for the value of lost IQ from its effects on future earnings potential and special education costs, and for reduced neonatal mortality caused by maternal exposure to lead. The study first identifies the relationship between blood lead levels and IQ, then estimates the effect of IQ on earnings, and adjusts total lifetime earnings for savings in direct and indirect schooling costs due to reduced educational attainment. EPA relies on the results of seven previous studies to formulate the data for this analysis. Special education costs are calculated for children with IQs under 70 for grades one through twelve, and valued according to the procedure in EPA's

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[7] The risk classes were defined by the national Center for Disease Control and Prevention and were based on information concerning blood lead concentration.

1985 study. To develop an estimate for the value of reduced infant mortality caused by reduced maternal exposure, EPA first establishes the link between maternal exposure and increased infant mortality using data from the Centers for Disease Control (CDC), and monetizes the reduced risk using the same VSL estimate used throughout the study (see discussion above under the Mortality heading). This study does not value medical costs associated with elevated blood lead levels.

While the above studies identify certain effects of lead exposure, and then estimate costs for each one, Agee and Crocker (1996) develop a health production function and apply it to a model of family utility to estimate the value of parents' willingness to pay to avoid high blood lead levels in a child. The model estimates the factors responsible for the demand for chelation therapy, and determines that family income and the child's lead level both increase the demand for chelation, while time costs of therapy decrease the demand. The study assumes the direct medical costs for the therapy were zero because of insurance. The model produces estimates of WTP well in excess of EPA's 1985 study, suggesting that perhaps total WTP significantly exceeds medical expenses plus the costs of special education.

Asthma

Health science studies show that childhood asthma is aggravated by environmental contaminants such as ambient air pollution and tobacco smoke. While most patients suffer from minor asthma symptoms that can be controlled through medication, emergency room visits and inpatient visits may sometimes be necessary for moderate and severe cases, especially with children. Several studies estimate the costs associated with childhood asthma.

Marion, Creer, and Reynolds (1985) estimate the financial impact of pediatric asthma including direct and indirect costs. The study includes transportation (e.g., to and from school to pick up a child after an asthma attack), lost work time, and child care (e.g., babysitting other children while the child with asthma is at the doctor) in the indirect cost calculation. Participating families completed an asthma workbook, which documented all asthma-related expenditures for a year. The study assessed the financial data contained in 25 workbooks. The results of the study show that the families spend an average of about $1,000 a year in asthma-related expenses, representing an average of 6.4% of the families' incomes.

Weiss, Gergen, and Hodgson (1992) analyze total direct and indirect costs of asthma in the U.S. Inpatient services, outpatient visits, emergency room use, physician services, and medications are included in the direct cost estimates, but the study does not include diagnostic and educational services or home equipment. Indirect costs are estimated using the value of lost time from school, foregone earnings, and decreased household production from morbidity and mortality. The value of time lost from school was estimated using a mother's foregone earnings or the time value of keeping house. The study values mortality by estimating foregone earnings based on life expectancy at the time of death. In 1998, Farquhar, Sorkin, and Weir expand this study to include the direct costs of medical equipment and home health care, as well as administrative overhead costs attributable to asthma.

EPA's cost of illness research (EPA 1998b) includes plans for estimating the cost of asthma. The research will provide an incidence-based estimate (*ex ante* values associated with risk reductions), where the previous two studies develop prevalence-based estimates (*ex post* values associated with actual cases). EPA expects to develop different estimates based on age of asthma onset, including ages 2 and 10, as well as ages 20, 30, 40, 50, 60, and 70.

Rowe and Chestnut (1985,1986) conducted a contingent valuation study to estimate the willingness to pay to avoid or reduce the effects of asthma. They surveyed 82 people, including 18 parents of asthmatic children, using daily diaries of asthma symptoms and perceptions, and a questionnaire designed to elicit WTP estimates for a 50 percent reduction in "bad asthma days," an outcome left up to the respondent to determine. Separate estimates for children's asthma were not presented; instead, the authors present their results by level of asthma severity. The estimates range from $12 per day for an asthma patient with no symptoms to $54 per day for a moderate asthmatic (1990$). EPA, in its cost-benefit analysis of the Clean Air Act, condensed the results of this study to develop a central estimate of $32 per day of acute asthma avoided (1990$) (EPA 1997).

Summary

The existing lead and asthma literature, largely based on the cost of illness approach, suggest that significant, focused effort is needed to adequately characterize the value of avoided chronic effects. In addition, the results of the Agee and Crocker WTP study adds weight to the hypothesis that the omitted pain and suffering component of these effects can be large, although available evidence suggests that attempts to use the Agee and Crocker study to develop generic WTP/COI ratios for application to other health effects could provide misleading results — WTP/COI ratios tend to vary considerably by health effect (see EPA's *Handbook for Noncancer Health Effect Valuation* for more information). In general, both COI and contingent valuation WTP estimates (using parents WTP) are useful in characterizing the value of chronic effects. The two methods serve as consistency checks on the results of each, suggesting that the joint pursuit of these types of approaches is a good model to follow for valuation of other chronic health effects.

ACUTE HEALTH EFFECTS

Some environmental contaminants cause acute health effects in children without causing long-term effects. We define an acute health effect to include a temporary period of illness followed by complete recovery. The duration of illness can vary, perhaps continuing for up to a year in extreme cases, and the severity of the case and the impairment that results can be a critical factor in characterizing the value of avoidance. For example, certain drinking water contaminants are associated with acute health effects such as nausea, diarrhea, and stomach cramps, but these symptoms can vary from annoyance level to serious debilitation. In addition, some acute health effects may present a risk of death. As described above for childhood cancers, for valuation purposes we suggest treating fatal risks separately from nonfatal acute health risks.

Table 3

SUMMARY OF ESTIMATES FOR VALUE OF CHILDREN'S HEALTH EFFECTS

Acute Effects

Description of Health Effect Studied	Author(s)	Estimated Value (1997$ except where indicated)	Type of Estimate: Study Methodology
Value of Statistical Case of Child Chemical Poisoning	Viscusi, Magat, and Huber (1987)	Insecticide: $4,188 per injury. Toilet Bowl Cleaner: $1,479 per injury.	WTP of parents with children -- contingent valuation study

Few studies have explicitly examined the value of acute health effects among children, perhaps because with limited research funding the focus remains on more debilitating and/or long-term health effects. Viscusi, Magat, and Huber (1987) conducted a contingent valuation survey to test general risk valuation hypotheses; the results of the study, however, may be used to analyze willingness to pay to reduce the risks of childhood illnesses. Respondents were asked if they would pay more to reduce risks of injury associated with one of two consumer products. Parents of young children were asked to evaluate the risks of child poisonings along with the risks of other minor health effects.

The scarcity of studies of acute health effects in children suggests that more research is needed. Results of adult studies may provide useful conclusions to direct that research. For example, well conducted cost-of-illness studies may be a good starting point for valuation of acute effects that are of mild severity. A review of available data on WTP to COI ratios for a wide range of health effects in adults suggests that the WTP/COI ratio may be lower for less severe effects (EPA 1998a, Miller 1997). Although the data are limited, and the more conclusive findings apply to injury severity, in those cases where direct and indirect costs account for a large component of total WTP to avoid an acute health effect the pain and suffering omission associated with COI estimates may be less important. In addition, it may be more straightforward to design contingent valuation studies to assess the valuing of avoiding acute health risks on children because acute health effects tend to be less severe and subjects are not required to consider latency or other complicating issues. A very useful CV project might involve defining broadly applicable characteristics of effects in an attempt to generalize about the value of avoiding acute effects of varying duration and severity, or effects that vary with respect to the relative importance of direct costs, indirect costs, and pain and suffering. While some research of this type was attempted for adults in the past (Loehman et al. 1979, Dickie et al. 1987), these studies do not reflect the current state-of-the-art in CV design, and no evidence of values for children is available.

PRENATAL EXPOSURE

When a pregnant woman is exposed to certain environmental contaminants, the development of the fetus can be affected by the exposure. For example, children whose mothers were exposed to high levels of polychlorinated biphenyls when pregnant are likely to have learning disabilities and delayed development.[8] Another example of the effect of prenatal exposure is the link between smoking during pregnancy and low birth weight. Effects associated with prenatal exposure present special issues because of the exposure and risk targets are actually different individuals. These circumstances may strengthen the case for using parent's WTP to avoid these effects, because the scenario for avoiding the effect involves averting or mitigating actions that might be undertaken

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[8]U.S. Environmental Protection Agency, *Environmental Health Threats to Children*, Office of the Administrator, EPA 175-F-96-001, September 1996.

by the parent. Below, we discuss studies that evaluate two health effects that may be caused by prenatal exposure to environmental contaminants: birth defects and low birth weight.

Table 4

SUMMARY OF ESTIMATES FOR VALUE OF CHILDREN'S HEALTH EFFECTS

Birth Defects and Low Birth Weight

Description of Health Effect Studied	Author(s)	Estimated Value (1997$ except where indicated)	Type of Estimate: Study Methodology
Birth Defects — Lifetime Cost of Effect	Waitzman et al. (1996)	Figures range from $85,800 per case (atresia of the small intestine) to $577,720 per case (truncus arteriosus).	Cost of illness - direct and indirect costs
Low Birth Weight — Hospital Costs	Schwartz (1989)	Hospital costs for a LBW infant are over 13 times those for a normal birth weight infant.	Cost of illness - direct costs
Very Low Birth Weight — Direct medical costs in year after hospital discharge	McCormick, et al. (1991)	$13,841 per case	Cost of illness - direct costs
Low Birth Weight — Prevalent Population under age 17	Lewit, et al. (1995)	$7.3 billion in the US $2,086 per case	Cost of illness - direct costs
Low Birth Weight	EPA (1998b)	Lifetime costs of LBW, 5 percent discount rate: $57,064	Cost of illness - direct and indirect costs

Table 4 SUMMARY OF ESTIMATES FOR VALUE OF CHILDREN'S HEALTH EFFECTS Birth Defects and Low Birth Weight			
Description of Health Effect Studied	**Author(s)**	**Estimated Value (1997$ except where indicated)**	**Type of Estimate: Study Methodology**
Very Low Birth Weight	Boyle, et al. (1983)	Costs incurred through hospital discharge, per survivor: $128,430 (1000-1499 g), $221,230 (500-999 g); Lifetime Cost per life year: $6,250 (1000-1499 g), $48,350 (500-999 g); Lifetime Cost per QALY: $6,920 (1000-1499 g), $48,350 (500-999 g).	Cost of illness - direct and indirect costs

Birth Defects

The term birth defects, also known as congenital anomalies, encompasses a wide variety of different effects, which can be further classified into structural defects (visible or detectable upon physical examination) and functional defects (deformities that affect a body's ability to function properly). Birth defects range according to severity and the ability of doctors to remedy the symptoms. Many congenital anomalies continue to disable throughout childhood and adulthood, and are associated with higher mortality rates, especially in infants.

Waitzman, Scheffler, and Romano (1996) estimate the costs associated with 17 structural birth defects.[9] They employ the cost-of-illness methodology to develop estimates for direct and indirect costs on an incidence basis. Direct costs include medical costs and the cost of special education and developmental services. Foregone earnings from disability or death, and losses due to a limitation on the type of work that can be performed, make up the indirect costs. For each birth defect, Waitzman, *et al.* estimate an incidence-based cost, and then aggregate those numbers for the population. The authors also compare their results to similar studies and determine that their estimates are similar to those in other incidence-based studies.

The Waitzman, et al. study provides thorough estimates of the costs associated with several birth defects; it is one of few to capture indirect costs due to limited earning potential. We expect the cost of illness approach to fall short of total willingness to pay for these health effects, however, because it does not incorporate values for the pain and suffering associated with birth defects. Unfortunately, there are no current WTP studies for similar effects.[10]

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[9]The study also examined the costs associated with cerebral palsy, which is not usually considered a birth defect. EPA also presents the results of the Waitzman study in the draft *Cost of Illness Handbook*.

[10] Some researchers have suggested that there may be useful information to be gleaned about WTP in jury award studies, although the link between jury awards and WTP remains tenuous. For example, Lopez, Dexter, and Reinert (1995) review jury awards in tort cases involving plaintiffs with severe birth defects. The estimates they obtain greatly exceed Waitzman et al.'s estimates, a conclusion which may reflect the value of pain and suffering and other nonmonetized costs, but may also be attributable to the weaknesses of the jury award approach. Juries theoretically determine the remuneration necessary to compensate someone for experiencing an avoidable adverse health effect, albeit in an *ex post* setting and with detailed knowledge of individual circumstances, as opposed to an *ex ante* setting involving non-identifiable statistical cases (see EPA 1998a and Freeman 1993 for a good discussion of the differences). In general, a jury award does not represent an individual's willingness to pay. Jury award studies are flawed by the unrepresentative sample of cases that go to trial, the potentially punitive nature of awards, and the uneven reporting of award values in cases that settle. For these reasons, we suggest the jury award studies not be used for valuation of health

Low Birth Weight

Infants born with low birth weight (less than five and a half pounds) are at greater risk for several adverse health effects, including developmental difficulties, morbidity, and mortality. The rates of mortality and morbidity increase dramatically with decreases in birth weight; for example, infants with low birth weight have a risk of death 40 times that of normal weight infants while infants with extremely low birth weight have a risk of death 600 times that of normal weight infants. While medical and technological advances have increased the survival rate of infants with LBW, morbidity has increased because of the survival of seriously ill infants.[11]

Several studies have examined the costs associated with low birth weight. Three studies have used the cost-of-illness approach, providing partial estimates of direct costs. One study develops a health production function to incorporate indirect costs into its estimate. Estimating the costs associated with low birth weight, however, is complicated by the range of concurrent effects and by the difficulty in clearly establishing which of these concurrent effects are linked to the low birth weight.

Schwartz (1989), in a study of perinatal centers across the US, estimates the incremental inpatient hospital costs for infants with low birth weight. As with mortality, Schwartz finds that costs increase dramatically with decreases in weight. Overall, he estimates that costs associated with LBW infants are 13 times those for a normal weight infant. McCormick et al. (1991) compare the medical costs for very low birth weight infants with the costs for normal weight infants. The study looks at medical costs for the

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effects, and have omitted them from Table 4.

[11]See EPA's draft *Cost of Illness Handbook.*

first year of life, recorded by parents in a diary. Hospitalization and increased visits to doctors account for most of the disparity in medical costs across the two populations. McCormick et al. estimate that costs associated with very low birth weights are over eight times as large as the costs for normal weight infants.

The above studies examine only a small portion of total costs associated with low birth weight. Lewit, et al. (1995) develop a more comprehensive methodology for estimating direct costs. The study includes estimates for incremental direct costs for child care and educational services to age 16, in addition to medical costs. After the first year of life, however, Lewit, *et al.* consider only medical costs from hospitalization, which are likely to significantly underestimate total medical costs. In addition, they do not develop comprehensive estimates for costs associated with children aged 1-2, 11-15, and 16 and older. EPA's draft 1998 *Cost of Illness Handbook* revises the Lewit et al. estimates to encompass costs for these missing years, and also develops estimates for outpatient medical costs.

A study conducted by Boyle et al. (1983) considers the direct and indirect lifetime costs of low birth weight. Boyle et al. consulted with two physicians to predict future medical costs and reduced productivity, then developed a health-state index to create an estimate of lost QALYs. The authors acknowledge that their estimates probably understate WTP.

Summary

Several obstacles complicate the valuation of developmental effects. First, WTP estimates are not available; if the Lopez et al. jury award analysis can be used as an indicator of total WTP, the underestimate from using cost of illness studies may be substantial. Second, available COI estimates may not provide adequate coverage of all potentially relevant birth defects. For example, the Waitzman study addresses less than twenty birth defects, some of which may not be relevant for environmental exposures. Third, the health science linking environmental exposures to specific birth defects or low birth weight is currently limited. The best current strategy for valuation of these effects is use of cost of illness estimates, with qualitative discussion of the potential magnitude of the COI to WTP "gap" suggested by jury award studies. Further economic research to improve benefits valuations should be linked to new developments in the health science to ensure that the effects examined are those most likely to be associated with environmental exposures.

REPRODUCTIVE EFFECTS

The value associated with reducing exposure to environmental contaminants that cause infertility or reduced fecundity has been estimated by analyzing willingness to pay for in vitro fertilization procedures. Neumann and Johanneson (1994) administered a contingent valuation survey to a small, unrepresentative sample as part of a pilot study. The 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. The results of this study indicate that contingent valuation may be a viable method for valuing reproductive effects, although the actual estimates are limited in applicability due to the small sample size.

Table 5 SUMMARY OF ESTIMATES FOR VALUE OF CHILDREN'S HEALTH EFFECTS Infertility			
Description of Health Effect Studied	**Author(s)**	**Estimated Value (1997$ except where indicated)**	**Type of Estimate: Study Methodology**
Infertility — Pilot study. Willingness to pay for in vitro fertilization.	Neumann and Johanneson (1994)	Statistical Birth, *ex post*: $203,320 per birth; Statistical Birth, *ex ante*: $2.1 million per birth; Public Provision of IVF: $37 per person.	Prospective parents' WTP -- contingent valuation approach

Smith and Van Houtven (1998) analyze households' decisions concerning infertility risks. The authors develop a model of collective household decision making, and conduct a pilot contingent valuation survey to assess whether the model would reveal the economic tradeoffs that result from a couple's decision to pursue reducing the risks of infertility. The results indicate that women report meaningful responses to choices for postponing infertility — the results are less encouraging for men. The authors suggest that developing quantitative estimates from the results would be premature, and state that nature of the contingent valuation questions does not translate into an estimate of *ex ante* willingness to pay. As with the Neumann and Johanneson study, however this study suggests that contingent valuation may be a useful method for evaluating infertility.[12]

[12] A study conducted in Sweden by Granberg, Wikland, Nilsson, and Hamberger (1995) evaluates the costs and benefits of in-vitro fertilization and embryo-transfer procedures. The study conducted a contingent valuation survey to estimate the willingness to pay for these procedures and

The existing studies on reproductive health provide a useful basis both to frame the economic valuation question and to generally characterize the potential magnitude of WTP to avoid these effects. Analysts that attempt to make use of these estimates need to exercise care to establish a good link between the definition of the expected effect that emerges from the health science and the specific effects and scenarios evaluated in the economic studies.

CONCLUSION

Two of the most commonly applied and accepted techniques for estimating the full value of avoidance of mortality and morbidity risk in adults (CV and wage-risk studies) are not easily adapted for direct application to children. Well conducted CV studies nonetheless show promise for evaluating parents' WTP to avoid effects in children (see Agee and Crocker 1999). As a result of these limitations, the existing economic literature for valuing avoidance of children's health effects either provides incomplete estimates (e.g., using the cost of illness or human capital methods that exclude pain and suffering); relies on methods that some analysts believe provide less robust estimates (e.g., consumer market studies of parents' behavior) (see Viscusi 1992, for example); or are relatively new and not yet corroborated by other studies (e.g., the recent household production model-based estimates).

Nonetheless, at least some estimates exist that can be used to characterize the

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assessed the costs by evaluating data from private and public facilities. The results indicate that infertile couples assign a high priority to infertility treatment. We omitted these results from the table because they appear to be heavily influenced by the nature of the Swedish health care delivery system.

value of children's health effects. Chronic developmental effects associated with lead exposure and asthma, in particular, have been studied for many years, resulting in a range of estimates and techniques that can be applied. These existing studies provide a good model for how developmental effects of other contaminants (e.g., mercury, pesticides) might be characterized, even if the nature of the developmental effects caused may differ greatly. While few studies of acute effects in children are available, it is reasonable to conclude that both cost of illness results and available estimates for adults provide at least a good starting point for valuation of these effects in children.

Valuation of mortality risks among children is likely to remain particularly troublesome. Key analytic issues that remain unresolved include the potential discrepancies between:

(1) some theoretical models, human capital approaches, and intuition that suggest remaining life years ought to be correlated with values for mortality risk reduction (Shepard and Zeckhauser 1984);

(2) existing empirical information that suggests younger adults (but not necessarily children) may have lower values for risk reduction than middle-aged adults, perhaps because of a lower aversion to risk (Jones-Lee et al. 1985); and

(3) the few existing studies focused on children's mortality risk that appear to suggest a lower VSL for children than for adults (e.g., Carlin and Sandy 1991), although this may not be true in comparisons that control for the method of study.

Adding to the uncertainty are several additional factors: that the existing studies focused on children's lives are relatively few in number; that altruism for protection of children's lives is poorly understood; and that ongoing research into valuation of mortality risks for the elderly suggests a potentially wide range of outcomes on the value of a statistical life year or the value of age-specific risk reductions.

To begin to resolve some of these vexing issues, helpful research might focus on examination of preferences for policies that disproportionately affect children's mortality or morbidity. Such studies might also examine whether there are fundamental differences between valuation for a very young child, for whom most choices are made by adults, and adolescents who are beginning to make some choices, including economic choices, for themselves. The current literature provides virtually no insight on this issue. Additional focus on the proper application of current estimates of altruistic values would also be helpful. Rowlatt et al. (1998) suggests that the limited evidence on altruistic values (e.g,. from Jones-Lee 1985) might nonetheless be used as a lower bound on appropriate values for persons who are unable to speak for themselves. It is not clear, however, whether this alternative would be preferable to using adult values directly.

As research in the valuation of avoidance of children's health effects progresses, analysts conducting benefits analysis may face a choice between: (1) avoiding valuation altogether; (2) using the limited evidence on values for children; (3) using values developed for adults. The first strategy comes with the risk that children's health effects could be under-represented in decision-making. The second strategy may overstate the level of certainty and reliability that currently exists in the literature for these values. In many cases, therefore, it may be reasonable to adopt a conservative approach and apply established values for adults (such as the VSL that EPA has applied) and noting the significant uncertainties in transferring these values to children's risks. The strategy of clearly laying out the results and implications of existing work and drawing conservative quantitative conclusions for valuation of benefits is likely to be a practical general approach for EPA analysts during this very active period of research into valuation of the avoidance of children's health effects.

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