

**THE VALUATION OF ENVIRONMENTAL HEALTH DAMAGES  
IN DEVELOPING COUNTRIES: SOME OBSERVATIONS**

by

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Prepared for the Biannual Workshop of the Economy and Environment Program of South East Asia (EEPSEA), Chiang Mai, Thailand, November 21, 2000

Acknowledgments: I am grateful for the helpful comments and suggestions of Dale Whittington, David Glover, Herminia Francisco, and participants in the EEPSEA Workshop.

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## Introduction:

I chose the topic of the valuation of environmental health damages for this paper because of my belief that this topic is not getting sufficient attention in the research activities of EEPSEA. There are 22 research projects and proposals up for discussion or presentation during the research; but only two of them directly involve environmental health. I think that environmental health issues are under represented in this workshop both in terms of the policy relevance and important of environmental health problems and because of the opportunities for substantive research here that can advance our economic knowledge.

This paper is based on the premises that human health problems related to environmental degradation and resource use are potentially serious in many parts of the developing world and that the scarcity of resources and the opportunity costs of environmental protection make it important for policy makers to consider the benefits and costs of improving human health through measures to prevent or reduce environmental pollution. There is a substantial literature on both the conceptual and empirical aspects of the economic valuation of policies to improve human health (Cropper and Freeman, 1991; Freeman, 1993; Johansson, 1995; US Environmental Protection Agency, 1997 and 1999). And we are beginning to see some studies of the benefits of improved health in developing countries, some of which will be cited below. But in my judgement, there is not yet an adequate body of empirical studies to support the economic assessment of policies to deal with the most pressing environmental health issues facing developing countries today.

My objective in this paper is to identify the most serious gaps and the conceptual issues surrounding the economic valuation of environmental health damages in developing countries. My focus is on disease associated with anthropogenic environmental degradation; I do not discuss issues associated with, for example, AIDS, malaria, and other infectious diseases or food safety, even though economic methods can be applied to the valuation of policies to reduce diseases in these categories. The paper takes the form of a series of ten "observations" about environmental health valuation with supporting detail and discussion. Three of these

observations are general in nature. I then turn to specific categories of sources of environmental health damages.

**Observation #1: The environmental health problems that should be of most concern to policy makers in developing countries are those associated with conventional air pollutants (especially suspended particulate matter), exposures to pesticides in rural areas, elevated levels of lead in the blood, and environmentally transmitted diarrheal disease, with the latter two being especially important in children.**

Why have I chosen to focus on these four problems? There can be little doubt that exposures to suspended particulate matter, especially to particles of less than 10 microns in diameter (fine particles), increase the risk of premature death and the incidence of various respiratory diseases. The evidence on the adverse effects of fine particles is compelling and getting stronger day by day. The evidence from the US was reviewed by the US EPA in its retrospective and prospective benefit-cost assessments of the Clean Air Act (US EPA, 1997, and US EPA, 1999). And a recent reanalysis of the long term cohort epidemiology studies relied upon by EPA has confirmed these results (Health Effects Institute, 2000).

It is not only the strength and the statistical significance of the association between particulate matter exposures and disease; it is also the numbers of people worldwide who are exposed to high levels of particulate matter that are of concern. For example, the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) report on air pollution in the world's megacities listed eight major cities in south and southeast Asia in which suspended particulate concentrations exceeded WHO health standards by factors of two or more (UNEP/WHO, 1994, Krupnick, 1997). And after reviewing seven studies that combined estimates of dose-response functions from various sources and economic valuation data for the health effects of concern, David Pearce (concluded that some forms of air pollution, and especially particulate matter represent potentially serious problems in many parts of the developing world.

Turning to pesticides, I have not found any data on worldwide exposures to pesticides for farm workers or on the aggregate health impacts of these exposures. But several microlevel studies (to be cited below) have shown effects of short term exposures on workers' health and productivity. And given the high proportions of the labor force still involved in agriculture in many developing countries and the potential for health impacts on other members of the rural populations, this category of environmental health effect deserves more investigation.

As for children's exposure to lead, the most widespread source of lead exposures for children is the deposition of lead from air emissions from cars that burn leaded gasoline. For at least 15 years, it has been known that at concentrations of lead in children's blood that were not uncommon in the US at the time, the neurotoxicity of lead was associated with problems in cognitive development and loss of intellectual capacity as measured by standardized tests such as the IQ test. With the continued use of lead as a gasoline additive in many developing countries (UNEP/WHO, 1994, p. 32), this looming public health problem should be of major concern. In fact Krupnick cites an estimate that "60 per cent of children living in developing countries have blood-lead content of 25  $\mu\text{g}/\text{dl}$  or higher, as compared to the WHO guideline of 20  $\mu\text{g}/\text{dl}$  (Krupnick, 1997, p. 438-439). For comparison, the current US action level is 10  $\mu\text{g}/\text{dl}$  of blood.

Finally, as for diarrheal disease, the WHO estimates that nearly one million people died from this cause in southeast Asia in 1999 and that over 2.2 million deaths occurred in developing countries worldwide (WHO, 2000, Annex Table 3). Most of these deaths were children; and the principal cause was exposure to pathogens through drinking contaminated water, through poor sanitation and personal hygiene, or through playing or swimming in polluted waterways.

**Observation #2: Information on the economic values of reducing these problems will be especially valuable to policy makers.**

Pointing to significant numbers of sick and dying people is not enough to justify taking actions to deal with any of these problems, because such steps also involve costs. There is always the question of whether dealing with these problems represents a wise use of an

economy's scarce resources. And to answer this question, we need information about the benefits or the values of the improvements in health that are expected as well as estimates of the costs of such programs. This is the primary reason for doing valuation studies. But there is a second reason as well.

Consider a political economy model of how environmental policy gets made. Not only is benefit information important in the normative process of policy assessment and evaluation and priority setting. But it is also important in getting mobilizing support for environmental health programs and getting them onto the political agenda. This positive political economy model of environmental policy suggests a role for information on values in calling attention to important problems and helping to bring them to the attention of relevant policy makers. This attention-getting role for value information might be especially important for the problem of children's exposure to lead. The effects of elevated blood lead levels are subtle and not easily visible. It might take an economic analysis of the costs of lost development of human capital in this generation of children to convince policy makers that this is a potentially serious problem.

**Observation #3: Using the methods of benefits transfer is an attractive approach for providing estimates of the economic values of proposed policies. However, there are serious problems with using benefits transfer; and caution is appropriate until these problems can be resolved satisfactorily.**

Benefits transfer for the economic evaluation of environmental policies is endorsed by the Asian Development Bank (for example, ADB, 1996) and other agencies. And this is for good reason. Doing primary economic valuation studies is usually time consuming and expensive, at least if it is being done well. So there is great pressure to provide timely information without overburdening very limited and scarce staff analytical resources. But we must weigh the possible costs of errors associated with benefits transfer against the benefits of quick results and cheaper analysis. And in order to do this, we need to gain a better understanding of the nature and sources of these errors.

What we have learned about this so far is not reassuring. Recent comparisons of benefits transfer values with the results of primary studies have shown significant differences, whether the transfers are done by simple adjustments for factors such as income or by benefits transfer functions or value functions (for example, Alberini, et al., 1997 and Navrud, 1999). For example, there is now substantial evidence that the practice of making simple proportionate adjustments in values for differences in income (that is, assuming an income elasticity of one) is inappropriate and that lower income elasticities should be used where the evidence supports this (Kristrom and Riera, 1996, and references therein).

I conclude that we need more primary valuation studies to better support policy decisions and that where possible, these studies should be designed to facilitate comparisons with primary studies from other countries so that we can learn more about to do good benefits transfer in the future. What I mean by this is the following kind of study design. First select an issue where there is a good valuation study from another country (the study site country). Then do a primary valuation study using similar method in the country of concern (the policy site country). This study will be of direct relevance to policy makers. Then compare the results of the primary valuation study with the results of a benefits transfer from the study site country, thus adding to our knowledge of the possible errors associated with cross-country benefits transfer.

**Observation #4: Some analysts have used a variation on benefits transfer to estimate the reductions in adverse health effects associated with policies to reduce air pollution, a practice I will call “dose-response transfer.” But the available evidence suggests that caution is appropriate here as well.**

Several authors have used air pollution dose-response information from developed countries to estimate the effects of air pollution on health in developing countries. Ostro (1994) was perhaps the first analyst to make use of the extensive body of epidemiology literature from the developed world to estimate the health impacts of conventional air pollutants and emissions of lead in a developing country. Other examples include Krupnick, et al. (1996), Zhang Shiqui

and Duan Yanxin (1999), and Orbeta, Rufo, and Indab (2000). I do not mean to be overly critical of this approach to estimating health effects; but I do urge caution. The motivation for doing this kind of dose-response function transfer is clear. Human epidemiology studies require good data on pollutant concentrations, the incidence of the health effects of concern, and the relevant characteristics of the population at risk. The most convincing evidence of the impact of air pollutants on mortality comes from long term cohort studies in which individuals are followed for a substantial period of time, say 10 years or more (for example Pope, et al., 1995 and Dockery et al., 1993). And such studies are expensive and time consuming to carry out.

But there are several reasons why such dose-response transfers might give very misleading results. First, if pollution levels are higher in the developing country than in the country that is the source of the dose-response function (which is likely to be the case), then the transfer involves extrapolation outside of the range of the data (Cropper, et al., 1997). If the dose-response function is nonlinear at the higher concentrations (which might not be apparent from the data from the developed country), the errors introduced by this factor could be substantial.

Second, the evidence from the U. S. indicates that the elderly are more sensitive to the life-shortening effects of particulate matter. Extrapolations from the U. S. population to a population with a much younger age structure would likely lead to an overestimate of the effect of pollution on premature mortality (Cropper, et al., 1997). Third, measured particulate matter is a heterogeneous mixture of solids and liquid. Differences in the physical and chemical composition of particulate matter could lead to quite different relationships between measures of particulates and the health effects of concern across countries (Ostro, et al., 1996). For example, in some cities, the major constituent of particulate matter might be the relatively inert forms of fugitive dust, while in other cities it could be the much more reactive particles from diesel engines use in transport.

Fourth, for a variety of reasons, there could be differences between the pollution measures used in the analysis and the actual exposures of the populations at risk and these

differences could vary from one city to another. For example, the spatial distribution of monitors relative to the population at risk could vary across cities (Ostro, et al., 1996). Or there could be differences across populations in the amount of time spent outdoors or in the more highly polluted parts of the city. And finally, where the measure of effect has a behavioral component, for example, loss of a day of work or restrictions on activities, or where self-reported symptoms are involved, differences in social, economic, and cultural factors could affect the relationship between the measured effect and pollution (Alberini and Krupnick, 1997). For example, workers whose employers grant sick leave with pay are more likely to stay home from work when experiencing a given level of air pollution induced illness than workers who would lose a day's pay.

How important are these problems with dose-response function transfers? The evidence on the prevalence and importance of these factors is mixed. In the case of particulate matter and mortality, both Ostro, et al. (1996) and Chestnut, et al. (1997) found dose-response coefficients that were similar to those from the U. S. literature in their daily time series studies of Santiago, Chile and Bangkok, respectively. But Cropper et al. (1997) found that changes in TSP had only about one-third the impact on premature mortality in Delhi, India as in the U. S. As for morbidity, Alberini and Krupnick (1997) and Chestnut, et al. (1997) found significant differences in the impact of particulate matter on reported incidence of various acute respiratory symptoms in the comparisons of U. S. results with those from Taiwan and Bangkok, respectively. But none of these studies shed any light on the relative importance of the five factors identified above.

The bottom line is that dose-response function transfer will often be necessary in the estimation of health benefits from controlling air pollution and other environmental health threats. But analysts should be careful to discuss the issues raised here, properly qualify their results, and be honest about the uncertainties that are introduced by this practice.



**Observation #5: The practice of using values of statistical life (VSL) based on hedonic wage studies to value reductions in premature mortality from air quality improvements raises important issues regarding the appropriateness of this form of benefits transfer.**

In the U. S. the typical practice for valuing reductions in premature mortality has been, until recently, to use a VSL derived from the range of results from hedonic wage and, perhaps, contingent valuation studies in the U. S. and the U. K. For example, the U. S. EPA (1997, 1999) fitted a statistical distribution to the VSLs from 26 different studies and used the mean of this distribution for their “best estimate” and its variance in their uncertainty analysis of the benefits of reduced air pollution related mortality. This practice is itself a form of benefits transfer in that the value placed on reducing the risk of immediate death by a workplace accident for a group of healthy workers is being used to value the reduction in risk of death from a different set of causes by a different group of people, including less healthy elderly and people out of the labor force for various reasons. Questions have been raised about: differences in the age structures of the populations at risk; differences in WTP to reduce risks of deaths by various causes; differences in the prior health status of those affected by air pollution and healthy workers; and differences in the degree of voluntariness or controllability, among other things (for example, Revesz, 1999). We do not presently have an adequate body of evidence to know whether to adjust hedonic wage based VSLs for any of these other factors within a given country, if at all, and if so, how to do it.

These issues are all in addition to the problem of transferring a VSL from one country to another which were discussed in the more general context at Observation #3. We are beginning to see hedonic wage studies and estimates of VSLs for developing countries (Liu, Hammitt, and Liu; 19, Hammitt, Liu, and Liu 2000; and Shanmugam, 2000). But transferring the results of any of these studies to other developing countries will face the problems described above, as well as the standard problems of adjusting for differences in currencies, income levels, and so forth. At present, the most that can be said is that analysts should be careful to qualify the results of these transfers and to be clear and explicit about the nature of the uncertainties involved.

**Observation #6: The concept of “collateral benefits” is likely to be very important in formulating and evaluating air pollution policy in developing countries.**

The term “collateral benefits” refers to the benefits of a policy in some other category than the direct target of the policy. For example, a policy to reduce automotive air pollution by reducing the reliance on the automobile could produce collateral benefits of reduced congestion on roads and shorter trip times for drivers. And policies to reduce emissions of particulates from power plants that had the effect of inducing fuel shifting away from coal and the replacement of old, inefficient boilers could produce collateral benefits in the form of reduced emissions of CO<sub>2</sub>. Similarly, to turn things around, policies to reduce greenhouse gas emissions could also produce collateral benefits in the form of reduced emissions of conventional pollutants (Burtraw and Toman, 1997).

There are really two points here. First, of course, where collateral benefits would be generated by a proposed policy, the analyst should identify them and include them in the policy assessment. For example, if joint implementation under the Kyoto Protocol or some other form of international trading of greenhouse gas emissions were to become a reality, the collateral benefits of reduced emissions of conventional air pollutants would strengthen the case for a country to participate in the program and to actively pursue these opportunities. And second, in the policy design process, there should be a search for options that are likely to generate collateral benefits, since these are likely to be the policies with the highest net benefits.

**Observation #7: Using the standard individual willingness to pay (WTP) approach to value improvements in the health of children is problematic. And this may be an especially important issue with regard to the valuation of reductions in blood lead levels and incidence of waterborne diarrheal disease in children.**

The conventional paradigm of environmental valuation is to value impacts according the WTPs of the individuals whose welfare is improved by the policy. First, the conventional

paradigm is based on the assumption that individuals have well-defined preferences over all alternative states of the world. But this assumption is unreasonable for children, especially younger children and infants. Second, it is assumed that individuals have information on alternatives and the cognitive ability to analyze this information when they make choices, so that the choices reflect their preferences subject to the constraints imposed by the economy and nature. And third, even if children did have well-formed preferences and adequate information and cognitive ability, their expressed WTP will depend on an income constraint that is imposed by their parents' economic circumstances and the decisions parents make about granting economic resources to their children.

One approach to valuing effects on children is to base values on what a rational well-informed adult would have chosen for him/herself in childhood. This is the perspective most consistent with the basic principles of welfare economics. But it is very difficult to implement in practice. We can't observe the relevant choices that the "child as adult" would make. So we would have to use stated preference methods with adults. And it would impose difficult cognitive tasks on respondents to ask them to imagine themselves as physical children but emotional and intellectual adults.

An alternative approach to the valuation of health effects on children is to make the assumption of "parental sovereignty" and to value these impacts according to the parents' WTPs for them (for example, Agee and Crocker, 1996). But there is no clear reason for believing that parents' WTPs for changes that affect their children will be equal to the WTPs that the children would have for changes that affect their own well being. Some authors have noted that parents do not always seem to be the best judges of what is good for their children and sometimes engage in activities such as smoking and drinking that actually harm their children. At a more fundamental level, I think that parental sovereignty has some ethically unattractive implications. The economic analysis of fertility choice emphasizes the utility that children convey to parents and the potential economic benefits they bring through providing labor, household production, and, in the long term, economic security for their parents. If the marginal

utility of a child or its marginal productivity is decreasing in the number of children, then the value to the parent of reducing the risk of death to the child or preventing disease depends on the number of children in the family and, perhaps, on its birth order. The stated preference responses or revealed preference behavior of parents would reflect this effect. But many people would reject the values derived from this behavior on ethical grounds.

These thorny issues have not been directly addressed in the major valuation studies of environmental health effects in children in the U.S. The largest set of studies in this area has involved reductions in blood lead levels in children. In these cases, value measures have been based on the cost of illness approach, where the costs of illness have included costs of screening, medical treatments, compensatory education, and the reduction in lifetime earnings associated with the predicted reduction in IQ. But economic theory (see Freeman, 1993) and empirical evidence (Alberini and Krupnick, 2000) suggest that cost of illness measures will be a lower bound on and often seriously underestimate true WTP. And if an important component of the cost of illness is children's absence from schooling or from home production, valuing this lost time will be difficult.

As with so many of these observations, there is no simple solution to the problems being raised. But the analyst must be open about them in presenting the results of the analysis, no matter how these problems are handled.

**Observation #8: Estimates of the benefits of reducing childhood exposure to lead in the US suggest that there are likely to be high payoffs to addressing the lead problems of developing countries. But the problems of benefits transfer in general and the issues of valuing improvements in children's health will make it difficult to provide policy makers with defensible estimates of the benefits of these policies.**

My conjecture that the childhood lead problem may be of serious concern is based in part on the information about the continued use of leaded gasoline in many developing countries and in part on the fact that one of the principal routes of exposure to lead for children is playing

outdoors on soils contaminated with lead deposited from automobile emissions. If the U. S. experience of the 1970s and '80s is any guide, one would expect to see elevated blood lead levels in children in developing nations, at least in areas where there is substantial automobile traffic.

The first step in developing a policy toward children's exposure to lead in the environment is to sample children in areas of expected high exposure to lead and to measure their blood lead levels. I know of only one such survey cited in the literature. Chandrasiri (1999, p. 7) cites a blood sampling survey in Colombo, Sri Lanka that, surprisingly, shows low blood lead levels in children 4-5 years old and seriously elevated levels only in traffic policemen. It is possible that the sampled children lived in areas with low automobile traffic. So the results of this one survey should not be taken as showing that there is no lead problem in Sri Lanka. And elevated blood lead levels in adults have now been found to be associated with increased risks of hypertension and cardiovascular disease, including strokes and heart attacks (US EPA, 1997, and US EPA, 1999).

Where elevated blood lead levels are found, the next step is to identify policies for reducing them. This will probably involve a mix of screening to identify those children with extremely high levels who are candidates for treatments that help children eliminate lead from the body and steps to reduce lead emissions by reducing or eliminating the use of lead as a gasoline additive. But, it should be noted that there are other possible sources of lead contamination for children, primarily industrial sources of air emissions, leaching of lead from solder connections into drinking water, and ingestion of flakes and dust from lead-based paints. And where relevant, policies to address these other routes of exposure should be investigated. At this point, we would like to have estimates of the benefits and costs of reducing childhood exposures to lead. The first step is to quantify the expected reductions in adverse health effects associated with alternative policies. The problems of dose-response function transfer identified above are likely to be not as important in this case as with air pollution and mortality. SO with proper qualification, basing estimates on the well-studied US experience is probably appropriate.

But for the economic valuation of these effects, benefits transfer from the U. S. studies is difficult to support. As I mentioned, the US studies are based on a cost of illness approach. It seems unlikely that the relative costs and prices of the medical resources used in screening children and treating them and the economic gains from preventing IQ loss and increasing educational attainment will be the same in developing countries as in the U. S. I think that the best that can be said is that any benefits transfer for lead control from the U. S. to a developing country can not be treated as a literal transfer but only as an illustrative calculation to support an argument that qualitatively similar results are likely to be found in the developing country.

**Observation #9: The high incidence of environmentally transmitted diarrheal disease and the high mortality rates for poor children suggest that there are likely to be high payoffs to addressing these problems in developing countries. But, again, the problems of benefits transfer in general and the issues of valuing improvements in children's health will make it difficult to provide policy makers with defensible estimates of the benefits of these policies.**

I am surprised at the paucity of studies of the value of reducing the incidence of disease in children in developing countries, whether based on the cost of illness or the parental sovereignty approach. Given the prevalence of this type of disease in many developing countries, it deserves study from an economic perspective. As in the case of lead, benefits transfer from a developed country context is problematic. So I think that there is real value to primary research in this area. Granted that there are conceptual issues involved in valuing reductions in morbidity and mortality in children and problems in measuring the opportunity cost of time spent sick for children. But well done cost of illness measures will, I think, be useful for policy makers.

**Observation #10: There has been some important work on estimating the effects, including economic costs, of pesticide exposures on farm workers' health and productivity. It seems reasonable to expect that there are similar impacts on other members of rural**

**communities; and there may be other more subtle adverse health effects associated with long term pesticide exposures that are not adequately reflected in existing studies of impacts and health values. There are issues of both the magnitude of the problem and the valuation of the effects that need to be addressed by additional research.**

I am aware of four separate studies of the effects of pesticide exposures on the health of farmer applicants in developing countries. In the first, Antle and Pingali (1994) used the results of clinical examinations and health histories of applicators to quantify the health impacts and found that these were positively and significantly related to number of applications of pesticides. They also found that health impairment was positive and significant in their estimated cost function for farmers. The magnitude of the cost increase is a cost of illness measure of the value of eliminating pesticide related health impairment. Pingali, Marquez, and Palis (1994) report these costs to be 765 peso per year for a farmer using two applications, a number larger than the increase in the value of output associated with the pesticide application. Crissman, Cole, and Carpio (1994) conducted a similar study of pesticide application in Ecuadorian potato farmers. The other two studies involved pesticide use in Vietnam in the production of rice and vegetables (Dung, et al., 1999, and Dung and Dung, 1999). In both cases, the values of applicator health effects were based on a cost of illness approach. Dung, et al., also reported a positive WTP on the part of farmers in one region to avoid pesticide related illness. But the method for obtaining this WTP was not described. Although this limited body of evidence is suggestive, it is important to obtain data covering additional crops and countries and identifying the specific pesticides involved and the extent of usage and exposure.

There are three additional limitations on the available data that I want to call attention to. The first is that the value measures are based only on estimates of the cost of illness, either in the form of productivity loss or combined productivity loss and direct medical costs. Comprehensive measures that include the value of lost utility or pain and suffering are not available, although Antle and Capalbo (1994) include this component of value in their conceptual model.

The second limitation is that the available data so far only cover impacts on the applicators and not on other people in the area who might also be exposed, that is, farmers' family members and other rural residents. These other people might be exposed through pesticides brought into the home on the worker's clothing or body, through airborne transport of spray products, or through contamination of local drinking water supplies. The third limitation is that the available data cover only the direct impacts that show up as acute cases requiring treatment or leading to impairment of productivity of applicators. They do not cover possible longer term consequences of exposure such as cancer, neurotoxic or developmental impacts, depressed immune function, endocrine system disruption, birth defects, and the like. There is increasing concern in the U.S. for this broader range of potential victims of exposure and possible impacts of pesticide use in rural areas. For a review of some of the evidence supporting these concerns and a description of a large prospective cohort study that is underway to investigate these effects in the agricultural communities of the U. S., see Alavanja, et al. (1996).

### Conclusions:

I want to emphasize three main points from this series of observations. The first is the importance of obtaining better information on the benefits of improved environmental health. I have identified several serious gaps in our knowledge about environmental health effects in developing countries. These gaps affect our ability to provide evaluations and economic assessments of policies to deal with important and widespread environmental health problems.

The second point concerns three major conceptual and empirical issues that are faced by analysts charged with providing valuation information for policy assessments. The first of these issues is the limited current state of knowledge about benefits transfer as an acceptable shortcut to doing primary valuation studies. This has not been the primary focus of this paper. But my review of health valuation issues has shown that it is important. The second issue involves a similar set of problems related to dose-response function transfer. This question has been given relatively little attention in the literature so far. But policy assessments are equally dependent on



valid dose- response information. And there is reason to believe that at least in the case of the air pollution and health effects transfer of these relationships from industrialized could introduce serious errors. The third issue is the appropriate ethical perspective from which to value health effects on children, that is, the individualistic WTP perspective, “parental sovereignty,” or some other perspective. This set of issues is only now receiving attention in the economics literature. But it may be of even more serious concern in developing countries because of the higher incidence of childhood diseases of many types in the developing world.

Finally, I have some advice on the practical level: In compiling their estimates of environmental benefits, analysts should use the best information that is presently available but be explicit about the gaps, omissions, biases, and uncertainties in their estimates. And they should treat these uncertainties as formally as possible.

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