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ESTIMATES OF WILLINGNESS TO PAY FOR POLLUTION-INDUCED CHANGES IN MORBIDITY: A CRITIQUE FOR BENEFIT-COST ANALYSIS OF POLLUTION REGULATION

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1.0 INTRODUCTION

Purpose and Goals of this Report

This report reviews estimates of willingness to pay for the reduction or prevention of pollution-induced morbidity. The purpose of this review is to provide information that may assist in decisions concerning the regulation of environmental pollution. Many of the programs and policies under development by the U.S. Environmental Protection Agency are designed to protect human health. The potential health effects of concern cover a wide range, from risks of death to eye irritation. This review focuses specifically on nonfatal health effects.

An important motivation for this review is Executive Order 12291, which requires an assessment of potential benefits and costs before any major regulation is adopted. Benefits and costs are to be quantified in dollar terms whenever possible. Although the protection of human health is only one type of benefit from regulating impacts on the environment, it may be the most important type. Whenever such benefits can be estimated in dollar terms, comparison with other types of benefits, and with costs, will be facilitated.

This review critiques studies that have estimated willingness to pay (WTP) and willingness to accept compensation (WTA), and related efforts, specifically for changes in m orbidity. Four ‘types of studies are reviewed. Health production function (HPF) studies are discussed in Chapter 2. They use the concept of a health production function, which specifies a relationship between the individual’s health and his expenditures of time and money in response to and for prevention of illness. These studies provide a theoretical analysis of the determinants of an individual’s WTP (WTA) for changes in morbidity and some preliminary empirical estimates have been based on this approach.

Cost of illness (COI) studies are discussed in Chapter 3. These studies typically estimate the direct and indirect dollar costs associated with illness, which consist primarily of medical expenditures and income lost due to being sick. COI estimates are not equivalent to WTP (WTA) estimates for changes in morbidity, but under some circumstances they may provide a lower bound. There is an extensive COI literature and a wide range of applications. Two important COI studies are reviewed in detail in Chapter 3 and issues of application of COI methods for morbidity related to environmental pollution are discussed.

Contingent valuation (CV) approaches are discussed in Chapter 4. These use surveys designed to elicit WTP or WTA estimates from individual respondents. These approaches are in developmental stages when it comes to estimating WTP (WTA) for changes in pollution related morbidity. Empirical estimates obtained to date are reviewed.

The health status index (HSI) research, from the psychology and public health literature, is discussed in Chapter 5. This research typically involves a subjective weighting or rating of different states of health in order to evaluate programs with different kinds of health outcomes. These studies do not provide estimates of WTP (WTA), but they provide information about the relative disutility of different types of morbidity. They also suggest some directions for future efforts to estimate WTP or WTA for changes in morbidity.

Chapter 6 provides a summary of the estimates of WTP reviewed for preventing or reducing morbidity and an assessment of their usefulness for environmental regulation decisions. Some recommendations for future research are also presented.

In a previous report for the U.S. EPA, Violette and Chestnut (1983) reviewed estimates of WTP and WTA for changes in risks to human health. The studies covered in that review focused primarily on risks of death. It became clear as the review progressed that very little information was available about WTP (WTA) for pollution-induced changes in nonfatal health effects. The majority of the studies that have estimated WTP (WTA) for changes in risks of &ath have been based on analyses of wages and how they vary across jobs with different levels of risks. Nonfatal injuries also occur on-the-job, but due to the widespread existence of worker's compensation, paid sick leave, and employer-paid medical insurance, a wage premium that compensates for differences in risks of nonfatal injuries may not exist, although a few studies have attempted to estimate premiums for nonfatal injuries (see, for example, Viscusi, 1978). The reader is referred to Violette and Chestnut (1983) for more information on studies that examine WTP (WTA) for changes in risks of death and on-the-job injuries. Consumer market studies also reviewed by Viole tte and Chestnut considered tradeoffs between injuries from automobile accidents and residential fires and expenditures of time and/or money. These involve both fatal and nonfatal injuries, but the estimates of WTP (WTA) for reduction of nonfatal injuries alone, were based on arbitrary allocations of total WTP (WTA) between fatal and nonfatal injuries. lNeither of these categories of studies is discussed in this report.

To set the stage for the subsequent study reviews, the remainder of this chapter provides a summary of economic concepts related to values for changes in morbidity.

Why We Want Estimates of WTP or WTA

The motivation for this review is the desire to develop dollar estimates of the benefits of reducing or preventing morbidity due to environmental pollution, as inputs to benefit-cost analysis of environmental regulations. Conversely, such values can be used in estimating the. loss of health benefits if environmental requla tions are relaxed. Economic theory suggests that the appropriate measure of the social benefits of any program should reflect the total increase in well-being that it provides for everyone whom it affects. Maximum WTP reflects how much of other goods and services the individual is willing to give up in order to" obtain a reduction or prevent an increase in morbidity. This, therefore, gives a dollar measure of the change in well-being that the individual expects to experience. Summing this measure of benefits across all affected individuals provides an estimate "of the total benefits.[1]

[1]This kind of aggregation is often criticized because it implies the acceptability of the current distribution of income. WTP is obviously constrained by the individual's income. This is not undesirable from the individual's or societ y's point of view. It simply makes use of the concept that the chosen allocation of scarce resources (income) does (in the private sector) and should (in the public sector) reflect the relative utility of the goods and services among which it is allocated. The problem is that using WTP to determine the allocation of public resources implies that more weight will be given to those with more money, as is the case in the private sector as well. Criticisms of this approach on this basis generally reflect an unhappiness with the underlying distribution of income, rather than a criticism of the concept of WTP itself.

The concepts of WTP and WTA are illustrated in Figure 1.1. Suppose that U1 and U2 are two indifference curves for an individual. Each indifference curve represents the tradeoffs between health and all other goods and services (represented by income) that would keep the individual's utility (or well-being) constant. This means that along curve U1, the individual's utility is constant at every point. U2 is a similarly defined indifference curve representing a level of utility higher than U1. If the individual is at health level H1 and income level M, he is at point A with utility U1. If health were increased to H2, while income remained at M, the individual's utility would increase to U2 (at point D). This increase in health results in the same utility increase as would an income increase of AB while remaining at health level H1. We therefore say that AB is the maximum that the individual would be willing to pay to obtain H2, but remain at income M. This is called the equivalent surplus measure because it represents the change in income that is equivalent to the change in health. A slightly different measure would be how much income would have to be reduced to bring the individual back to utility level H1 when health has increased to H2. This is amount CD and is called compensating surplus because it is the amount that would compensate (in this case negatively) for the change in utility caused by the change in health (and leave the person with the higher health level at C).[2]

If instead of starting at point A, the individual started at point D with health H2 and experienced a reduction in health to H1, CD would be the equivalent surplus measure and A B would be the compensating surplus measure of this loss. In this case, A B represents the minimum compensation that would be required for the individual to voluntarily accept a reduction. in health from H2 to H1 and CD is the maximum amount the individual would be willing to pay to prevent the reduction in health from H2 to H1. As this figure illustrates, WTP and WTA can be represented by "equivalent or compensating surplus measures depending on the direction of change in health and whether the question is phrased in terms of compensation or payment. These different measures are not expected to be exactly the same and one is not necessarily better than the other. Theoretical analysis indicates that in most cases the differences between these measures

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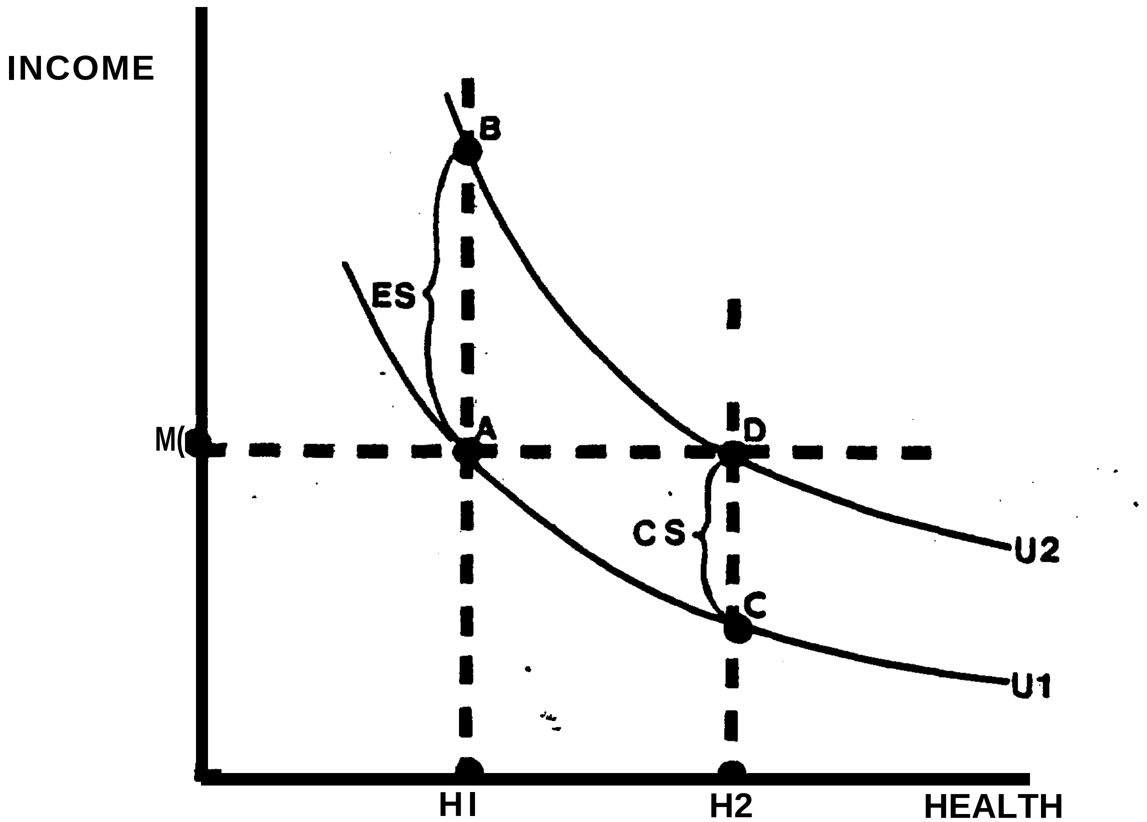
[2] In this simplified presentation prices are assumed to be constant and the cause of a hypothesized change in health is unspecified. If price changes are involved in the change in health, then the appropriate estimate of the change in well-being is WTP (WTA) for the change in health minus the change in expenditures, which will be the compensating or equivalent surplus.

Figure 1.1
WTP and WTA Measures



can be expected to be small,[3] but some contingent valuation studies have found surprising and somewhat inexplicable differences between them. Whether the individual is facing a potential decrease or a potential increase in utility seems to be very important and may have some implications regarding the level of environmental quality to which the individual feels he has a right.

An additional concern about WTP (WTA) for changes in morbidity related to environmental pollution is that in most cases pollution affects the risks of morbidity, rather than leading to a specific change with certainty in the health of any one individual. If a change in air pollution, for example, causes the probability of an individual getting a respiratory infection to increase from four percent to nine percent, then it might be argued that the individual can be expected to be willing to pay five percent of what his WTP (WTA) would be to prevent respiratory infection "for sure:' This may not be the case if the individual is risk averse and willing to pay something more than five percent of his WTP (WTA) to prevent an infection that is certain. In most cases, the studies reviewed here have estimated WTP (WTA) for changes in morbidity assumed to occur with certainty, but policy questions will sometime require consideration of changes in risks of morbidity and this distinction needs to be recognized.

Social Versus Individual WTP (WTA) for Chamzes in Morbidity

Most of the theoretical literature that discusses WTP (WTA) for changes in environmental quality presumes that it is the exposed individual (or owrier of the exposed property) who incurs the benefit or damage as a result of changes in pollution. Changes in illness, however, can affect many people in addition to t~ person who is sick. The extensive availability of paid sick leave, medical insurance, subsidized medical care and other public health programs means that all the direct costs of illness are seldom incurred entirely by the individual who is sick. The illness of a' friend or family member can also cause concern and inconvenience in addition to any monetary costs incurred. The evaluation of a public program or regulation should consider all the benefits and costs to society. Considering only the sum of individuals' WTP to prevent an increase or obtain a

[3] Willig (1976) concluded that CV and EV measures would be similar unless expenditures on the good are a large component of income, the price or quantity change is large, or the income effect is large.

decrease in their own morbidity can be expected to understate society's total WTP because of:

1. some costs being covered by others through insurance, etc.,

2. suffering and costs (e.g., to send flowers or visit the sick person) to family and friends,

3. altruism - the willingness to pay of some individuals to protect the health of others for the good of society.

Studies that estimate WTP (WTA) for changes in morbidity need to be clear about whether they are covering individuals' WTP (WTA) or society's WTP (WTA).

2.0 HEALTH PRODUCTION FUNCTION STUDIES CONCERNING CHANGES IN ENVIRONMENTAL POLLUTION

The health production function (HPF) analysis concerning WTP (WTA) for changes in environmental pollution is based on a theory of consumer behavior developed by Becker (197 1) and first used to analyze health by Grossman (1972). The basic concept is that the individual combines purchased goods and services with his own time and skills to produce desired outputs, and it is these outputs that contribute to the individual's utility (or well-being). What this means for health is that the individual uses medical care and health enhancing activities, such as exercise and sleep, to maintain his health at an optimal level, given his preferences, time and dollar budget constraints, and effectiveness at producing health. The individual thus chooses his level of. health; given certain constraints. The relationship between the individual's health and health enhancing e xpenditures and activities is what is referred to as the health production function. Technology, biological endowment, and pollution levels will influence this relationship. The H PF model provides an analytical tool for examining the effect of pollution "induced health effects on the individual's utility.

Cropper (198 1), Gerking et al. (1983) and Barrington and Portne y (1982) have used this analytical approach to develop WTP (WTA) expressions for changes in environmental pollution as it affects human health. Two of these studies also provide empirical estimates of WTP (WTA) based on these expressions. The first, section of this chapter describes the health production function models presented in these three studies and discusses the implications and limitations of the derived WTP (WTA) expressions for changes in the health effects of environmental pollution. The second section of this chapter reviews the empirical estimations of WTP (WTA) presented by Cropper (1981) and Gerking et al. (1983).

2.1 HEALTH PRODUCTION FUNCTION MODELS Or CONSUMER BEHAVIOR

The basic premise of the health production function models is that the individual can be expected to take action to protect or enhance his health. People do not necessary accept the effects of pollution passively, but may respond with actions that will mitigate the health effects that otherwise would have occurred. This premise does not necessarily require that people know what the e ffects of pollution are, or even that they know it is pollution that is affecting them. It merely req uires that people respond when they feel their health deteriorate with efforts to mitigate the deterioration.

Incorporating these defensive and mitigative actions is the primary analytical contribution of the health production function models relative to estimation approaches that have simply taken the observed effects of pollution on human health and then estimated values for preventing or reducing these effects. This latter approach ignores the efforts individuals will make to avoid additional illness (or" the efforts they no longer have to make) when pollution increases (or deceases) and can therefore be expected to understate total WTP (WTA) for changes in pollution.

The basic health production fungtioci mode 1 of "consumer behavior presented below is a synthesis of the models presented by Gerking et al. (1983) and Barrington and Portney (1982). This model is useful because it defines specific components of an individual's WTP (WTA) for changes in his own pollution-related morbidity by analyzing all the ways that pollution-related morbidity can be expected to affect an individual's utility. The results of the analysis may suggest ways to approach the estimation of WTP (WTA) and give criteria by which to evaluate the completeness of other WT P (WTA) esth,n ates. Many simplifying assumptions are used in the model. The effects of relaxing these assure ptions on the empirical usefulness of the model results are discussed.

The individual% utility is a function of the goods and services consumed and his or her state of health, which directly influences the enjoyment of life's activities and how good the individual feels. The direct effects of the individual's state of health on utility would include pain and discomfort experienced during an illness.

$$U = U(X,H) \tag{2.1}$$

Where:

U = the individual's utility in a given time period

X = goods, services and leisure activities the individual consumes that are unrelated to his or her health

H = the individual's state of health

"The individual's state of health (H) is a function of defensive expenditures and health enhancing activities undertaken, including such things as preventive medical care, exercise and diet; exogenously determined levels of pollution; [1] and biological, social and economic characteristics of the individual (such as congenital conditions, age and education) that influence the ef festiveness with which he can maintain a given state of health. A simplifying assumption used here is that defensive expenditures and activities affect utility only through their effect on health. In reality, many of these activities and expenditures jointly produce utility in other ways as well, such as the enjoyment of playing tennis produced jointly with the health benefit. Taking this jointness into account would result in a much more complex model. The level of defensive expenditures and activities is, chosen by the individual as a function of pollution levels and other characteristics of the individual (22).

$$H = H(D,P,Z1) \tag{2.2}$$

$$D = D(P,Z2) \tag{2.3}$$

Where:

D = defensive expenditures and activities

P, = pollution

Z1 = biological, social and economic characteristics of the individual entering the health production function

Z2 = biological, social and economic characteristics of the individual that influence defensive expenditures

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[1] A health production function model could treat pollution exposure as an endogenously determined variable, but these three studies have not. Treating pollution exposure as endogenous (as in some circumstances it may well be) would complicate the analysis of WTP for changes in pollution induced health effects.

Time spent sick and medical expenditures made in response to illness enter into the individual's budget constraint because they affect the amount of time and money the individual has for other things, but they do not directly enter the individual's utility function. These medical expenditures do not prevent additional illness, but may mitigate the discomfort and activity interference of illness that occurs.

$$Ts = Ts(H) \tag{2.4}$$

$$M = M(Ts) \tag{2.5}$$

Where:

Ts = time spent sick.

M = medical expenditures in response to illness.

The individual faces the following time and budget constraints.

$$X*Px + D*Pd + M*Pm \;.\; w*Tw + 1 \tag{2.6}$$

$$X*Tx + D*Td + M*Tm + Ts + Tw = T \tag{2.7}$$

Where:

Pi = price per unit of i, for i=x, d, and m

Ti = time per unit of i, for i=x, d, and m

Tw = time spent working

w = the individual's wage rate

I = nonwage income

T = total time available

Equations 2.6 and 2.7 can be combined into a "full income" constraint by assuming that all time is valued at the wage rate and defining a com bined dollar and time cost: Qi = Pi + w*Ti. Using w as the value for all time assumes that individuals choose to work to the point where the marginal benefits of working (the wage earned) just equal the marginal costs in terms of the value of time lost from other activities. In this simple model, it is also assumed that all costs of defensive and medical care are borne by the individual and that prices in the medical care market reflect marginal social costs of producing medical care.

$$X*Qx + D*Qd + M*Qm + w*Ts = w*T + I \qquad (2.8)$$

The individual can be expected to choose levels of X and D that maximize utility (equation 2.1) subject to the constraints of equations 2.2-2.8. This will be done by allocating time and dollar expenditures such that the marginal benefits equal the marginal costs of each good and service for the individual. For defensive expenditures the marginal benefit is the dollar value of the improvement in utility obtained with an additional unit of defensive efforts plus the medical expenditures that no longer have to be incurred and the opportunity costs of time no longer spent sick as a result of a unit increase in defensive ef forts.[2] The marginal cost is the unit cost of defensive efforts including both money and time (Qd). This means that the amount of defensive efforts undertaken will depend on the effectiveness of these efforts in maintaining health and on the costs and discomfort associated. with time spent sick, as well as on the direct costs of the defensive efforts.

These utility maximization conditions mean that when there is a change in pollution, the individual will adjust the allocation of his resources so as to minimize any adverse effect on utility or maximize any advantageous effect. For example, if pollution increases, the individual may choose to completely” offset the effects on his health by increasing defensive expenditures, if the resulting reduction in income available for other goods (X) reduces utility less than that from the decrease in H that would have occurred. The individual will, of course, be constrained by his ability to affect health with defensive expenditures. An expression for marginal WTP for a change in pollution (p) can be derived from the model by calculating the increase in dollar income that would offset the reduction in utility resulting from an increase in P (a compensating surplus measure), or the decrease in dollar income that would be equivalent to the increase in utility resulting from a decrease in P (an equivalent surplus measure).[3] The derived expression for

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[2]The first order condition for defensive efforts (D) is

$$\partial L/\partial D = U_H*H_D - \lambda\,(Qd + M_{Ts}*Ts_H*H_D*Qm + w*Ts_H*H_D) = 0,$$

Where subscripts denote partial derivatives.

[3]See Chapter 1 for an introduction to the concept of WTP (WTA).

marginal WTP can be written as folIows[4] (where, for example, dM/dP is the total change in medical expenditures as a result of the change in P after the individual has adjusted to maximize utility):

$$MWTP = W^*(dTs/dP) + Qm^*(dM/dP) + Qd^*(dD/dP) + \lambda(-dU/dP) \quad (2.9)$$

The first term is the opportunity cost of the change in time spent sick associated with a change in pollution (through its effect on H), the second term is the change in medical expenditures associated with the change in pollution, the third term is the change in defensive expenditures associated with the change in pollution, and the fourth term is the dollar equivalent of the direct change in utility (i.e., the pain and discomfort) associated with the change in pollution (through its effect on H). λ is the dollar equivalent of a unit change in U (i.e., the marginal utility of a one unit change in income).

An expression for WTA would be the same, only the reference Ievel of utility would be different. WTA for an increase in pollution would be the increase in dollar income that would offset the decrease in utility associated with the increase in pollution, and for a decrease in pollution would be the decrease in dollar income that would offset the increase in utility associated with the decrease in pollution.

Barrington and Portney (1982) use this derived expression for WTP for changes in pollution to argue that under certain reasonable assumptions, cost of illness estimates for changes in pollution that include income lost and medical expenditures can be expected to be a lower bound on WTP. Income lost due to time spent sick will be less than or equal to the first term, which is all time. spent sick multiplied by the wage rate. Medical expenditures are equivalent to the second term. Cost of illness will be less than WTP as long as the third and fourth terms are non-negative for an increase in pollution. This requires the assumption that the relationships in the model are such that when pollution increases, the new equilibrium level of health is the same or lower and that defensive efforts stay the same or increase.[5]

[4]The derivation of this expression relies on the assumption that the first order condition for defensive efforts holds.

[5]The analysis by Courant and Porter (1981) suggests that it is at least conceivable that the health production function and the utility maximizing conditions of the model might be such that when pollution increases, health increases because the chosen increase in defensive efforts is so effective that it overcompensates **for** the increase in pollution, or that defensive efforts might decrease because they become so ineffective in the face of increased pollution.

Critical Assumptions and Simplifications of this HPF Model

The HPF model presented here uses the marginal wage rate as the value for all time spent sick. The theoretical basis of this characterization of the value of time is analysis of consumer behavior that concludes that individuals will choose to spend their time earning money to the point where the marginal opportunity cost of time just equals the marginal benefit of working. There are several potentially problematic assumptions underlying this conclusion. One is that individuals can freely trade their time between work and leisure. The constraints of the standard 40 hour week make this difficult for many people. Although people do find ways to work overtime or part-time, they often face quite different wage rates when they choose to do so. Another assumption is that the only benefit derived from working is income. If people work because they enjoy it as well as earn money, then the wage rate will understate the true opportunity cost of their time. Valuing all sick time at the same rate also implies that all sick time is the’ same. Using the wage rate implies that a person is either fully functioning or fully non-functioning.

The assumption that the marginal wage rate approximates the value of time presents some problems for. empirical applications because it leaves unclear what the opportunist cost of time is for people who choose not to work at all. One approach would be to define it as the wage the individual could be earning, and another would be to use the market value of time spent in homemaking services.[6]

There are also problems with empirical application of this concept of the value” of time for employed people. What we really want is an estimate of the wage rate that the individual would obtain if he worked one more hour, or would lose if he worked one less. There is little empirical information on this. Information on average wage rates is readily available, but this may be a poor approximation of the marginal wage rate.

The use of the wage rate as a proxy for the value of time is not a requirement of the model, but is a simplification that makes empirical application of the model more manageable. The model could be generalized to incorporate different values of time for different activities. The conclusion that willingness to pay exceeds cost of illness would

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[6] Hawrylyshyn (1976) reviews both of these methods for estimating the value of household services.

be unchanged unless the value of nonwork time were negative, or the value of work time were less than the wage. Nonwork time spent sick, even if valued at something other than the wage rate, could be expected to increase willingness to pay for changes in pollution relative to costs of illness.

The HPF model characterizes choices as if all the expenses and inconveniences of illness are home by the individual, ignoring the widespread availability of paid sick leave, medical insurance coverage and subsidized medical care. These are typically transfers of the costs of illness from the individual to others, rather than any additional cost of illness. The problem for applications of the model is that the utility maximizing choices of the individual are likely to be different if he does not bear the full costs. For example, if the price of medical care to the individual is less than the price to society, the individual may choose to use more medical care and incur lower defensive expenditures and less illness than he would if he faced the full price.

Equation 2.9 is still an appropriate expression for the individual's willingness to pay if the price of medical care (Qm) reflects the price to the individual, but it will understate society's willingness to pay for that individual's health due to the medical care costs that are incurred on his behalf by others. Cost of illness estimates typically include all costs, regardless of who incurs them; therefore, comparisons of willingness to pay and cost of illness estimates should take this into consideration.

The model as formulated here also does not allow for any interdependence of utility among friends and family members. In reality one individual may be willing to pay something to prevent or reduce the illness of another, beyond any direct expenses that may be incurred due to the other's illness. The possibility that the health of others affects the utility of the individual could be incorporated into the model. Again, this would not appear to change the conclusion that willingness to pay could be expected to exceed cost of illness.

Regarding the effects of pollution on human health, the authors of the HPF studies examined here point out that their analyses are not suited for examining the effects of long term changes in health or non-marginal changes in pollution. The model discussed here considers only one time period and assumes that health in this time period is independent of health in previous time periods (except possibly through changes in Z1). Chronic illnesses would have to be approached in a multi-period framework, because they can be affected by activities, expenditures and exogenous factors in previous periods and because they can affect health in future periods. Cropper (1981) uses a multiperiod model, but still assumes that health in each time period is independent of health in preceding periods. The treatment of non-marginal changes in pollution and/or long term changes in health would require more avenues by which utility could be affected and more adjustments by the individual. For exam pie, a long term change in health could affect the individual's wage rate, which would have many ramifications through the model.

Another simplifying assumption in the HPF model examined here is that neither de fen-sive expenditures (D) nor medical expenditures (M) contribute directly to the utility of the individual. The only reason these expenditures (of time or money) are made is to affect health or time spent sick. This means that every additional expenditure for D or M means an equivalent decrease in resources available for consumption of goods (X) that do contribute to utility. This assumption is probably reasonable for M, but is probably unreasonable for D, which for many people consists of activities that are both enjoyable and good for their health, such as exercise. The model also does not incorporate any goods or activities that contribute to utility, but have a negative affect on health. Rosenzweig and Schultz (1982, 1983) have addressed this theoretically and empirically with regard to the effects of the mother's behavior on the birthweight of the infant. It would seem that a person who smokes, for example, might be more susceptible to the effects of air pollution and that his WTP (WTA) for changes in pollution might therefore be different.'

7Bockstael and McConnell (1983) have analyzed the consequences of jointness in the production of utility producing commodities (e.g., the case where D produces both H and some other commodity such as relaxation) in the household production model, in terms of the em pirical usefulness of the model. Their results indicate that the "demand" for produced commodities such as health cannot be defined in the usual way because the "price" of health becomes endogenous. This means that using the marginal cost of producing health as an estimate of the price of health is problematic.

2.2 ESTIMATES OF WTP BASED ON HPF MODELS

Cropper (1981) and Gerking et al. (1983) estimated values for WTP based on a health production function model. Because equation 2.9 is not directly observable, each of these studies was based on an alternative expression for WTP derived from the model. These expressions, the estimation procedures used, and the results obtained are described and evaluated below.

Cropper (1981) WTP Estimates

Cropper (1981) developed a HPF model for acute illness slightly different from the one presented in the previous section. The important differences in Cropper's model are that health does not enter the utility function directly and that medical expenditures in response to illness are ignored. Investment in health is defined as expenditures and activities individuals undertake to maintain a desired level of health (H). This is essentially equivalent to the defensive expenditure defined above as D. Time spent sick is defined as a function of H alone. The expression for margninal WTP (WTA) derived from this model is therefoce made up of terms equivalent to the first and third terms in" equation 2.9. Thus, the derived expression for marginal WTP is equivalent to (where subscripts denote partical derivatives):

$$\text{MWTP} = w*Ts_H*\frac{dH}{dP} + Qd*\frac{dD}{dP} \tag{2.10}$$

The author assumes specific functional forms for the relationships in the model, and demonstrates that for these functional forms the two terms in equation 2.10 will be equal. The empirical approach is therefore to estimate the value of time spent sick and multiply this by two to obtain an estimate of WTP.

To evaluate equation 2.10 for a given change in pollution, Cropper estimated an elasticity of time spent sick with respect to air pollution. In the model it was hypothesized that the natural log of time spent sick would be a function of the natural log of the individual's health. This functional form could, more closely approximate a relationship whereby many people could have very small, effectively zero time sick, in a given time period, than a linear functional form. Cropper therefore estimated a relationship between the log of time spent sick and the logs of several independent variables expected to determine the individual's optimal level of health. Health itself was not defined except in terms of these variables. One of these variables was the ambient levels of sulfur dioxide (SO_2) for each of the survey locations.

The data for this estimation were from the Michigan Panel Study of Income Dynamics for the years 1970, 1974 and 1976. They were for employed men between the ages of 18 and 45. Each individual had been asked to estimate the number of days during the year that he missed from work due to illness. This was adjusted for differences in weeks employed and used to calculate number of days ill out of the total 365 in the year. The log of this was the dependent variable in the estimation.

The estimation of results for the three sample years are shown in Table 2.1. A Tobit estimation model was used since about half of the sample reported zero days of illness. The Tobin model is designed for this kind of dependent variable with many zero values and a range of positive values (Tobin, 1958). The first four independent variables measure factors that the author hypothesizes affect the rate of decay of the individual's health. The second four independent variables are hypothesized to affect the productivity of investment in health. The pollution coefficients are positive and quite close in value across the three years, although their statistical significance is weak.

The strongest variable is whether or not the individual has a chronic health condition. This has a statistically significant positive influence on days sick in each year. Works in manufacturing (a proxy of on-the-job pollution exposure) and parents' income both have the expected signs, but statistical significance is weak in some years.

One problematic variable seems to be the wage rate. It is expected to have a negative coefficient, reflecting less time sick when the opportunity cost is higher. The only significant coefficient for wage is in the 1970 Sample and it is positive. The author suggests that the wage variable, an average wage for the survey respondent, may be a poor approximation of the marginal wage and the wage may be acting as a proxy for deleterious consumption habits that may increase the rate of decay in health. Another possibility is that the different specification of the equation for 1970 may have resulted in a misleading significant coefficient for wage. For this year only, a variable was included called risk aversion index and it shows a statistically significant negative coefficient.

Table 2.1

Health Equations for Men 18-45 Years 01'

Independent Variable	Interview Year[b] 1970	1974	1976
Constant	3.s474	−1.2320	-0.50[illegible]4
	(1.1253)	(0.9599)	(0.90[illegible]4)
Ln(SO_2 Mean)	0.2879	0.3168	031[illegible]9
	(0.2140)	(0.2076)	(0.18[illegible])
Works in Manufacturing[a]		0.5001	0.4[illegible]8
		(0.3659)	(0.31[illegible]3)
Parents' Income	-0.1632	−0.1310	-0.01[illegible]0
	(0.0936)	(0.1182)	(0.0953)
Race (1 =White)	0.7318	0.3768	−0.2950
	(0.2697)	(0.4052)	(0.30[illegible]4)
Has a Chronic Health Condition	1.1972	0.6515	0.93[illegible]7
	(0.4582)	(0.2862)	(0.2602)
Years of Schooling	-0,1317	−0.1091	0.0496
	(0.0795)	(0.1170)	(0.0508)
Marital Status (1=Married)	−0.9678	0.9321	-0.66[illegible]9
	(0.5096)	(0.4550)	(0.38[illegible])
Risk Aversion Index[d]	-0.3970		
	(0.0881)		
Ln(Wage)	0.7492	-0.0s99	0.17[illegible]9
	(0.2873)	(0.3353)	0.33[illegible]3)
•	2.1460	2.1s66	2.16[illegible]9
	(0.1824)	(0.2436)	(0.19[illegible]1)
n	361.	247.	m .

Sources: All variables are from the Michigan Panel Study of Income Dynamics except SO_2 which is from the U.S. Environmental Protection Agency.

[a]The dependent variable in each equation is the *log* of [work-loss days/(days worked + work-loss days)] x 365. Standard errors appear beneath coefficients.

[b]Each interview year correwsp;onds to the previous calendar year.

[c]M available in 1970.

[d]Not available in 1974, 1976.

Source: Cropper (1981)

The author does not discuss this, but given the definition of this variable in another study using the same data, it seems likely that it could be correlated with income.[8] Therefore, multicollinearit y could have caused the unexpected strong positive coefficient for wage in this equation. It is also possible that without controlling for paid sick leave, the wage rate is a poor approximation of the opportunity cost of time spent sick.

The author calculates the elasticity of sick time with respect to pollution as the- probability of being ill, times the coefficient of the log of pollution. This formula for the elasticity is based on the form of the Tobit function that was estimated. The fraction of the sample that was ill each year was about .5 and the coefficients on the pollution variable were each very close to .3, implying the elasticity of .15. Using this elasticity estimate, the 1976 sample mean wage of $6.00 per hour, and the sample mean days ill of 40 per year, an annual WTP for a 10 percent reduction in pollution was estimated to be $7.20.

comments

The results of this estimation provide limited information about willingness to pay changes in pollution because of the restrictive model assumptions that were used. The assumption that there are no direct utility effects of a change in health - but only indirect effects through the HPF which is a constraint on utility maximization - eliminates the most difficult to observe component of equation 2.9. Cropper derived an expression for willingness to pay for changes in pollution that is two times the opportunity cost of time spent sick. This derivation is dependent upon the untested assumptions of the model that the selected functional forms are appropriate and that direct utility effects and medical expenditures are relatively unimportant for acute illness. The empirical estimation of WTP was thereby reduced to an estimation of time lost from work due to pollution-induced illness (which has also been estimated by others including Ostro, 1983; Portney and Mullahy, 1983; and Crocker, 1979), and then multiplying this estimate times the wage rate and doubling the result.

8Crocker et al. (1979) use the same data set and give the following definition for the risk aversion index: “a weighted index devised by the survey team in which the individual’s degree of risk aversion increases if he drives the newest car in good condition, does not own a car, has all cars insured, uses seat belts, has medical insurance, smokes less than a pack a day, has some liquid savings, or has more than two month’s income saved.”

The accuracy of the estimated elasticity of time sick with respect to pollution rests on the effectiveness of the independent variables in explaining the individual's level of health. This is difficult' to judge because no measure of the individual's overall health was available other than time spent sick. The success of the variables in explaining days ill in terms of significance and expected signs was mixed. Only the coefficient for existence of a chronic health condition was strongly significant and had the expected sign in every sample year. The pollution variable coefficient was probably the next strongest with marginal significance, the expected sign throughout, and a comparable magnitude each sample year. The other variables generally did not work very well, with low significance and/or mixed signs across the Sample years. This leaves the validity of the elasticity estimate in some doubt.

A potential measurement problem with the interpretation of the data comes from using days missed from work due to illness to calculate an estimate of total days spent ill. Whether or not an individual stays home from work due to illness is likely to depend on more than just how ill he is. For example, people who have paid sick leave may view the decision about whether to go to work differently than those who do not. There is therefor a potential for measurement error in assuming that total days spent ill during the year is proportional to work days lost due to illness.

Gerking et al. (1983) WTP Estimation

The model presented in Section 2.1 is essentially the same. as the Gerking et al. (1983) model. The only important difference is that the Gerking et al. model does not distinguish between defensive expenditures and medical expenditures. They define a variable called (M, the level of which the individual chooses in order to maintain or protect health (H). H influences utility directly and determines the amount of time spent sick, which in turn affects the full income budget constraint as in the other models. The authors argue that medical expenditures in response to acute illness are likely to be small compared to the opportunity cost of the time spent sick. Their M is therefore equivalent to the D defined in Section 2.1, with an emphasis on preventive medical care as the primary defensive effort. The term D is used in this discussion to maintain consistency with Section 2.1.

In their theoretical analysis, Gerking et al. derive an expression for marginal WTP for a change in pollution that is equivalent to:

$$\text{MWTP} = \frac{-(dH/dP)}{dH/dD} * Qd \qquad (2.11)$$

where:

H = the individual's health

P = pollution

D = preventive medical services

Qd = price of preventive medical services including time and dollar expenditures

This expression for marginal WTP equals equation 2.9 when the same model assumptions that were used to obtain equation 2.9 are used.[9] Gerking et al. attempt to estimate this expression for marginal WTP which appears to be observable now that the direct utility effects have been eliminated.

W~t this expression says is that the individual will be willing to pay an amount for a. reduction in pollution equivalent to what it would cost in defensive expenditures to obtain the same improvement in health as that associated with the reduction in pollution. This follows from the optimization conditions that were previously described. When defensive expenditures are less effective at improving H or when pollution has a more adverse affect on H, then WTP to prevent pollution will be higher. The individual will not be willing to pay any more to prevent an increase in pollution than it would cost to offset the associated deterioration in H with an increase in D. The validity of this expression for WTP depends on the existence of defensive efforts at some finite cost to the individual that he believes can offset the health effects of pollution. For example, if pollution causes more colds and there is nothing the person believes he can do to prevent this impact, then this expression for WTP is not valid.

'As with equation 2.9, the derivation of equation 2.11 requires that the first order condition for defensive efforts be met.

The health production function needs to be estimated in order to evaluate this expression for a specific change in pollution by providing estimates of the change in health associated with a change in pollution and the change in health associated with a change in preventive medical care. The health production function described in the model is:

$$H = H(D,P,Z1) \tag{2.2}$$

Z1 represents a set of exogenous variables that influence the individual's ability to produce H using a given level of D. The authors point out that to estimate equation 2.2 requires a single measure **of** the individual's health. They suggest that a multi-dimensional measure of health would be more appropriate. They argue that given equation 2.2 it will also be true that:[10]

$$D = D(H,P,Z1) \tag{2.12}$$

The authors then demonstrate that:[11]

$$\partial D/\partial P = -(\partial H/\partial P) / (\partial H/\partial D) \tag{2.13}$$

The right hand side of equation 2.13 multiplied by Qd equals equation 2.11. The authors therefore estimate equation 2.12 and take the derivative with respect to P times Qd as an estimate of WTP.

The data for the estimation were taken from the St. Louis Health Survey from the years 1977 through 1980. Individuals were asked about health and medical care as well as other socioeconomic information. Data were used for employed respondents only because of the difficulty of determining an opportunity cost of time for people who are not employed. The total sample of employed individuals was 2197. A subsample of 824 chose to answer the question concerning hourly take home pay. Estimates were made with both samples. The mean wage for the 824 was used as an estimate of the wage for those who did not answer the wage question.

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[10]This is based on an assumption that the conditions of the implicit function theorem are satisfied.

[11]The authors **re-express** equation 2.2 as an implicit function F(H,D;P,Z1) = O, from which they show that $D_p = -(F_p/F_D) = -(F_p/F_H)(F_H/F_D) = -H_p/H_D$ (equation 2.13), where the subscripts denote partial derivatives.

Air pollution" data were matched to this health data set. Measures of mean levels of ozone, small particulate% sulfur dioxide, and nitrogen oxides were taken from 19 monitors throughout the area. For each monitor an average over 1975 to 1977 was calculated for each pollutant. The authors acknowledge the problem that the years for the survey and the pollution levels differ, but they argue that the pollution data available were more accurate for those years than for the later years. The individual was matched to the monitor closest to his or her residence.

The health measures used" were whether or not the individual has a chronic illness (CHRO) and if so how long the individual has had the illness (LENGTH). The measure of preventive medical care (D) was whether or not the individual usually sees a doctor at least once a year (the authors called this variable MED), a zero-one variable. A two-stage estimation procedure was used to account for the expectation that MED and the' health measures are simultaneously determined. Reduced form equations were estimated for CHRO and LENGTH. The variables used in the reduced form estimations were:

PMED	=	the out of pocket and time costs of a visit to the doctor's office
HWAGE	=	the individual's hourly wage
AGE	=	age of the individual
SEX	=	sex, 1 denotes male
RACE	=	race, 1 denotes black
SCHOOL	=	years of schooling completed.

A logit form was used for the CHRO equation and a tobit form was used for the LENGTH equation.[12] The predicted values of CHRO and LENGTH from these estimations were then used in the estimation of equation 2.12.

The results of the estimation of the MED equation (equation 2.12) are shown in Tables 2.2 and 2.3. One is with the entire sample and one is with the subsample of 824. A logit estimation was used because the dependent variable had values of only 0 and 1. This means that the coefficients predict the probability that the individual will have visited the doctor at least once a year. The independent variables were entered in log form. The definitions for the pollution variables are:

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[12] The authors do not report the results of these reduced form estimations.

Table 2.2

Estimates of the Health Production Function (824 Cases)
(Dependent Variable is MED)
(t-statistics in parentheses)

	1	2	3	4	5
CONSTANT	60.42*** (3.96)	57.26*** (3.56)	54.06*** (3.32)	57.45*** (3.59)	54.11*** (3.32)
LNOZONEM	10.24*** (4.75)	10.36*** (4.78)	10.04*** (4.60)	10.42*** (4.78)	9.95*** (4.50)
LNSULDIOM		-.059 (-.255)			
LNTSPSMLM		1.01 (.600)	1.17” (.715)	1.02 (.604)	1.07 (.632)
LNOZSULM				.016 (.272)	-.016 (-.242)
LNOZNITM			.153 (1.13)		.169 (1.12)
LNAGE	-3.49*** (-2.86)	-3.46*** (-2.84)	-3*53*** (-2 . 88)	-3.46*** (-2.84)	-3*53*** (-2.88)
LNSCHOOL	-.164 (-.331)	-.161 (-.326)	-.155 (-.315)	-.160 (-.325)	-.160 (-.324)
SEX	-1.93*** (-5.35)	-1.93*** (-5 . 34)	-1.95*** (-5 . 38)	-1.93*** (-5.34)	-1.95*** (-5.38)
RACE	.653** (2.49)	.659** (2.51)	.723*** (2.69)	.659** (2.51)	.730*** (2.71)
LNCHRO	2.01 (1.17)	1.97 (1.15)	2.00 (1.17)	1.97 (1.15)	2.01 (1.17)
$\widehat{\text{LNLENGTH}}$	1.28 (1.38)	1.29 (1.40)	1.30 (1.41)	1.29 (1.40)	1.31 (1.41)
x^2 (d.f.)	69.63(7)	70.00(9)	71.20(9)	70.00(9)	71.26(10)

*** denotes significance at 1% level
** denotes significance at 5% level
* denotes significance at 10% level

Source: Gerking et al. (1983)

Table 2.3

Estimates of the Health Production Function (2197 Cases)
(Dependent Variable is MED)
(t-statistics in parentheses)

	1	2	3	4	5
CONSTANT	30.20** (2.53)	26.03** (2.12)	26.53** (2.16)	26.92** (2.20)	26. 27** (2.14)
LNOZONEM	5.53** (3.21)	5.81*** (3.34)	5.81*** (3.34)	6.05*** (3.46)	5.95*** (3.40)
LNSULD1OM		-.253 (-1.70)			
LNTSPSMLM		1.54 (1.46)	1.36 (1.33)	1.55 (1.47)	1.60' (1.52)
LNOZSULM				.065* (1.81)	.039 (.983)
LNOZNITM			.177** (2.11)		.137 (1.47)
LNAGE .	-1.68** (-2.06)	-1.77** (-2.16)	-2.00** (-2.40)	-1.77** (-2.15)	-1.97** (-2.36)
LNSCHOOL	-.468* (-1.70)	-.425 (-1.54)	-.396 (-1.43)	-.425 (-1.54)	-.392 (-1.42)
SEX	-1.53*** (-5.83)	-1.57*** (-5.95)	-1.63*** (-6.09)	-1.57*** (-5.94)	-1.63*** (-6.08)
RACE	.719*** (4.70)	. 709*** (4.60)	. 792*** (5.06)	.710*** (4.61)	.767*** (4.83)
$\widehat{\text{LNCHRO}}$	-.339 (-.301)	-.193 (-.170)	.086 (.075)	-.200 (-.177)	.063 (.055)
$\widehat{\text{LNLENGTH}}$	(5.38)	2.10*** (5.23)	2,03*** (5.03)	2.10*** (5.24)	2.03*** (5.03)
x^2 (d.f.)	194..05(7)	198.20(9)	199.49(9)	198.29(9)	200.46(10)

*** denotes significance at 1% level
** denotes significance at 5% level
* denotes significance at 10% level

Source: Gerking <u>et al.</u> (1983)

OZONEM = mean ozone level in ppm

SULDIOM = mean sulfur dioxide in ppm

TSPSMLM = mean total of suspended particulate, small size, in micrograms per cubic meter

OXNITM = mean ixides of nitrogen in ppm

OZSULM = OZONEM • SULDIOM

OZNITM = OZONEM * OXNITM

The results of the estimation are problematic. The only pollution coefficients that are consistently significant are for ozone. Within each sample their values -are consistent, but the smaller" sample has ozone coefficients about twice the value of those in the larger sample. The coefficients for LENGTH are significant only in the larger sample. CHRO is insignificant in both samples. Even when the LENGTH coefficients are significant, the sign is opposite what the authors expected. Greater use of medical care is expected to be associated with higher health stock. A higher value for LENGTH implies a lower health stock, so the authors predicted a negative coefficient. This means that the results do not support the basic hypothesis of the model.

Based on the results, the authors calculate some estimates of annual WTP for 10 percent and 30 percent reductions in ozone. These are shown in Table 2.4. The authors point out that these are illustrative estimates only because MED is only an indicator of whether health care was received and does not measure the level of consumption of health care. These estimates were calculated by multiplying the change in ozone, times the derivative of MED with respect to OZONE,[13] times the full price of MED (PMED). PMED was calculated as the portion of an average office visit charge paid by the individual, plus the average time commuting and waiting valued at the wage rate. The estimates of PMED reported by Gerking and Stanley (1983) are (1980 dollars):

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[13]In a logit equation, $\partial MED / \partial OZONEM = b * p(1-p)$, where b is the estimated coefficient of OZONEM and p is the probability that MED = 1.

Table 2.4
Annual Willingness to Pay for Reductions
in Mean Ozone Levels (1980 dollars)

Equation	Percent Reduction	
	10%	30%
1 (Table 2.2)	$6.15	$18.45
5 (Table 2.2)	$8.16	$24.48
1 (Table 2.3)	$3.31	$9.92
5 (Table 2.3)	$5.36	$16.06

Source: Gerking and Stanley (1983)

Sample Size	
824	(($16.45) * (.65)) + $24.29 = $34.98
2196	(($16.83) * (.70)) + $28.55 = $40.33

Comments

This is an interesting estimation because the sim plicit y of the theoretically derived expression for WTP for changes in pollution builds hope that an empirical estimation may be fairly straightforward. Data limitations, however, make this estimation of WTP problematic, and as the authors acknowledge, the results are illustrative only and not directly useful for policy purposes. The authors clearly acknowledge the most important limitation, which is that the measure of health care used only gives whether **or** not health care was obtained, not how much health care was consumed. This provides very little information with which to estimate a relationship between health care and the individual's level of health. It probably also results in an inaccurate estimate of the price of health care. The price that was calculated was based on one office visit per year, but some people visit a doctor more than once a year. This could lead to a downward bias in the WTP estimate.

The positive coefficient on LENGTH (of chronic illness) in the medical care equation raises some questions about whether these variables have been appropriately defined, given their use in the model. The hypothesized relationship between health and medical care, as presented in the model, is that the individual uses medical care to help produce the desired level of health. A positive relationship between medical care and health is therefore expected, all other things being equal. However, it can also be expected that people who are more sick, for reasons other than how much medical care they consume, will seek more medical care. The empirical approach used in this study acknowledges the simultaneous relationship between medical care and health, but the results seem to reflect the positive effect of illness on the amount of medical care an individual seeks, rather than the positive effect of medical care on health. The confusion seems to stem from making no distinction between medical care that is preventive, and therefore health enhancing, and medical care that is made in response to an illness. The variable **MED** reflects both, but it may be that they need to be modeled separately.

There is a related problem with the use of LENGTH and CHRO as measures of health. The HPF model, as presented in Section 2.1, makes a distinction between health and time spent ill, and incorporates relationships between medical expenditures and time spent sick as well as between health and defensive expenditures. Using LENGTH and CRON in the same equation blurs this distinction. It is also questionable whether the HPF model as presented by Gerking et al. is appropriate for analyzing changes in chronic health conditions.

An additional concern about the estimation results was that ozone was the only pollution variable found to be significant. The authors note that the federal ambient air quality standards for ozone are seldom exceeded in St. Louis, which raised some question about the credibility of the results when only ozone shows a significant coefficient.

23 CONCLUSIONS

Cropper (198 1), Gerking et at. (1983) and Barrington and Portney (1982) have deeloped models of individual behavior that incorporate the concept that people make expenditures of time and money in order to protect and maintain their health. This means that the observed effects of pollution on human health reflects only part of the disutility of pollution. The other part is the opportunity cost of the resources devoted to avoiding or mitigating additional health effects. The HPF models show the different ways pollution can be expected to affect an individual's utility, through actual or potential effects on his health.

The results of the HPF analyses suggest possible ways to approach the estimation of marginal WTP (WTA) concerning pollution-induced morbidity and give criteria by which to evaluate the completeness of other WTP (WTA) estimates. This is the most useful contribution of these studies to date. The empirical estimates that have been made suffer from data limitations and restrictive assumptions. More work needs to be done before policy relevant estimates of WTP (WTA) can be obtained with this approach. The expression for WTP derived by Gerking et al. (1983) shows promise for empirical estimation because the direct effects of utility, which cannot be directly observed, have been eliminated from the expression but not dropped from the model. Their empirical estimation, however, suffers from data limitations and illustrates the diff in specifying a health production function that is useful for empirical analysis. Specification and statistical identification problems make it difficult to estimate a specific health production function. Future efforts might benefit from the use of survey data designed specifically for an HPF model.

3.0 COST OF ILLNESS STUDIES

Research on the cost of illness (COI) has been ongoing for over two decades. COI estimates typically include medical expenditures and income lost due to time spent sick (or premature mortality). The y provide an estimate of the out-of-pocket costs of illness. The emphasis of this research has been on estimating the economic burden of illness on society. Extensive public funding for medical care and for programs for protection and enhancement of health has motivated much of this research. COI studies have contributed to the evaluation of such programs and to analyses examining cost containment for medical care. Total costs are usually estimated regardless of who incurs the m. This differs from typical WTP studies that consider the costs only to the individual, and can confuse comparisons between the two types of studies.

Some COI studies have developed estimates of costs" associated with morbidity and mortality 'for all causes, while others have focused on specific diseases or. health care programs. Hu and Sandifer (1981) review the current COI estimation methods and summarize 238 COI studies for specific diseases that have been published, for' the most part, since 1960. They group these studies into 13 disease categories. It is beyond the scope of this report to summarize this extensive literature. The goals of this chapter are to summarize the current estimation methods used in COI studies and to discuss their application for health effects related to environmental pollution. To illustrate the methods used and the kind of information obtained, two specific COI studies are reviewed. The study by Cooper and Rice (1976) was selected because it has been widely referenced as a source for national COI estimates for broad categories of diseases and has been the basis of several COI estimates associated with pollution induced illnesses. Hartunian et al. (1980, 1981) break new ground with the development of incidence based COI estimates, which may be more applicable for pollution related illnesses.

Before the reviews of these studies are presented, two sections discuss general issues related to CO1 estimates. Section 3.1 describes the costs that typically are included in COI estimates and discusses a few key issues with regard to application of COI estimates for pollution induced illnesses. Section 3.2 discusses the relationship between COI estimates and the cwi:ept of WTP (WTA) that was introduced in Chapter 1 as the appropriate measure of benefits for changes in pollution induced morbidity for use in bene f it-cost analysis. Although COI estimates are not equivalent to WTP (WTA), they are in many cases the only quantified information available concerning the benefits of reducing or preventing morbidity and will continue to be used extensively. It is therefore important to understand what they do and do not include, how they are derived, and how they can best be used.

3.1 COI ESTIMATION METHODS

Rice (1966), is referenced frequently as having laid the foundations for the current state of the art in COI estimation. She developed estimates of the total costs of illness in the U.S. in 1963 and allocated these costs among 16 disease categories. The 1972 update of these estimates (Cooper and Rice, 1976) is reviewed in Section 3.3. This section describes the costs typically covered in COI studies and discusses issues concerning application of COI estimation procedures for pollution induced health effects. The discussion draws upon Rice (1966), !+ and Sandifer (1981) and Institute of Medicine (1981).

3.1.1 **Typical Coverage of COI Estimates**

Three categories of costs are discussed in the COI literature:

1. Direct cos'ts are for preventive medical care, medical treatment, extended care and rehabilitation related to illness.

2. Indirect costs are resources that do not get produced due to morbidity and premature mortality.

3. Psychological, costs are the pain, suffering and emotional distress incurred by patients, family and friends.

Direct Costs '

Direct costs cover all medical and illness related medical expenditures made by patients, insurance companies and government agencies. “Core costs” in this category include:

- o hospital care (inpatient and outpatient)
- o nursing home care
- o home health care
- o services of physicians and specialists
- o services of dentists and other health professionals
- o drugs and drug sundries
- o eye glasses and appliances

These core costs are for the most part disease specific and are proportional to the severity of illness that occurs. Estimates of direct costs of specific diseases typically include these core costs. The kinds of preventive medical care expenditures included here differ from defensive expenditures defined in Chapter 2 in that they would include such things as annual checkups but would not include such things as exercise or diet changes that are not typically considered medical. Defensive expenditures include both. Rice allocated estimates of total national expenditures in ‘these categories (reported annually by the Health Care Financing Administration) among 16 broad categories of diseases. [1]. COI studies concerning a specific disease often use additional sources of information about the typical treatment and progress of that disease. The widespread existence of multiple health problems, however, makes it difficult to avoid overstating the direct core costs for any one disease. The Rice approach at least ensures that the sum of the estimates for each disease category will not exceed the total expenditures, but it is not very accurate for narrowly defined diseases.

Additional direct costs are costs to government of financing capital expenditures, such as hospital construction not covered in service charges, health program administration costs not covered in service charges, net social costs of insurance (premiums minus claims paid), government financed research and training, and government public health activities. Typically, these have not been allocated among disease categories. In 1980 these additional direct costs made up about i 2 percent of total national health expenditures as reported by the Health Care Financing Administration.

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[1] The information used for this allocation is described in the discussion of Cooper and Rice (1976) in Section 3.3.

There are also non-health sector direct costs associated with illness. These include transportation to receive medical care, costs for domestic help, special diets, clothing or household equipment,physical alterations of the home, and counseling or training of patient or family members. COI studies vary considerably in whether and to what extent these non-health sector costs are included. They are more often considered in detailed studies concerning specific diseases than in more general COI studies.

hdract Costs

Productivity 'lost due to morbidity and disability for employed individuals is typically measured as the wage rate times the time lost from work. This assumes that workers are paid the value of their marginal products if this estimate is to reflect the value lost to society due to time missed from work. Estimates of the number of people affected by morbidity and disability and average wages by age and sex groups generally are used for this calculation. Data on how many of the affected individuals are employed are usually not available, so the standard approach is to use the labor force participation rate to estimate the number of employed people af fected. Sometimes unemployment rates are taken into consideration.

Wages used for calculating foregone earnings due to morbidity and disability are usually before taxes with an additional percentage sometimes added for supplemental benefits. This is in the spirit of estimating the total economic burden of illness on society. The loss to the individual alone would be better approximated by take-home pay and benefits for uncompensated sick time lost from work.

It has become common practice to include an estimate of the value of homemaker services that are lost due to morbidity and disability. Most studies use an estimate of the market value of domestic help for a comparable time period, although some efforts have been made to use an estimate of the wage foregone by the homemaker who is not employed. Some studies use estimates of homemaker services lost only for homemakers who are not employed and others use housework losses for employed and not employed men and women. Frequently referenced studies concerning the value of housework are Walker and Gauger (1973) and Brody (1975). Neither the market value of domestic help nor foregone earnings is an entirely satisfying estimate of the opportunity cost of a homemaker's time, and there is some debate as to which is better. For a discussion of these issues, see Chiswick (1982) and Hawrylyshyn (1976).

Psychosocial Costs

Most COI studies acknowledge that direct and indirect costs do not reflect the full impact of illness. " Psychosocial costs that are frequently mentioned include the pain and suffering of the individual who is ill and the psychological effects on friends and family. Hu and Sandifer (1981) suggest that some unmeasured economic costs fall into this category, such as productivity losses for individuals who continue to work but are less productive and productivity losses due to emotional distress over a sick friend or relat ive. Hu and Sandifer reference Weisbrod (1961), Klarman (1965) and Abt (1975) for their discussions of psychosocial costs and suggestions for quantifying them in dollar terms, but satisfactory estimates of these costs have not been made.

Estimating psychosocial costs raises the same kinds of difficulties as estimating WTP (WTA), in that they are difficult to observe in market behavior. The strength of the COI approach in the first place is that medical expenditures and income lost due to illness are more easily estimated from available data than are estimates of WTP (WTA).

Data sources

A wide variety of data sources are used in COI studies. The best sources of data depend on the purposes of the specific study, but some of the most frequently used sources can be mentioned. Table 3.1 shows the breakdown of data sources used in the 238 COI studies reviewed by Hu and Sandifer (1981). The first four on the list are from the U.S. Public Health Service, National Center for Health Statistics (NCHS) and are primarily sources of data on the incidence and prevalence of disease (defined on page 3-7). A frequently referenced source of data on national hospital utilization and expenditures is the American Hospital Association (AHA) in Chicago.

Mullner et al. (1983) have compiled an inventory describing 144 computer readable data bases containing current (1976 or more recent) national health care information collected by private and public sector organizations and available to outside researchers. This inventory is a valuable resource for finding COI data for studies of national scope, and provides information about who to contact for additional information on each data set.

Table 3.1

Data Sources Used in 238 COI Studies

Data Sources	Frequency of use
Health Interview Survey [1]	35
Health Examination Survey [1]	17
Vital Statistics [1]	45
Other U.S. Public Health Statistics	77
Study Survey	73
Onsite Data	60
Health Association Data (AMA, AHA, ADA)	33
Other Secondary Sources	153
Hypothetical Data	36

[1] National Center for Health Statistics data.

Source: Hu and Sandifer (1981) .

3.1.2 Issues Concerning Application of COI for Pollution Induced Health Effects

The kinds of COI Studies briefly described in the previous section typically estimate costs for all cases of a disease or group of diseases. Environmental pollution, however, usually causes some additional cases of an illness or aggravates the condition of some individuals who are already ill. This means that some procedure must be developed to determine what portion of the costs associated with the illness are attributable to changes in pollution. This will depend on the information available concerning the health effects of the specific pollutants under consideration.[2] The following issues should be considered in a COI study concerning pollution induced health effects, but the appropriate procedures will depend on the specific pollutants and health effects being studied and on what information is available to the researcher.

Prevalence versus Incidence .

COI estimates can be prevalence or incidence based. The prevalence of a disease is the number of cases existing in any given time period. The incidence of a disease is the number of new cases that occur in any given time period. Prevalence and incidence are essentially equivalent for short term i~lnesses, but they can be quite different for long term illnesses. Prevalence based costs are all the costs associated with a disease or illness in a given time period. Incidence based costs are all costs associated with the new cases of a disease or illness in a given time period from the start of the disease until recovery "or death occurs, and are usually discounted to a present value. Incidence based costs can extend several years beyond the time period in which the illness begins. For exam pie, consider lung cancer. Prevalence based costs for lung cancer in 1980 are all the costs incurred in 1980 associated with all cases of lung cancer that are active in 1980, regardless of when they were first diagnosed. Incidence based costs for lung cancer in 1980 are all costs associated with the new cases of lung cancer that are diagnosed in 1980, from the time they are diagnosed until death or recovery occurs.

[2] We are ignoring the considerable uncertainty about what the health effects of pollution are. This is a problem for all efforts to value changes in morbidity associated with environmental pollution, but is outside the scope of this report. We are assuming that the researcher knows what changes in morbidity he wants to value and we are addressing possible approaches for this valuation. See Institute of Medicine (1981) for a discussion of the problems in determining the health effects of pollution.

Since information for estimating prevalence based costs is more readily available, they are more common in the COI literature.

Whether a prevalence or incidence based cost estimate is preferable depends on the questions being addressed in the analysis. Hartunian et al. (1980) argue that incidence based costs are appropriate for evaluating programs concerned with disease prevention, while prevalence based costs are appropriate for programs concerned with overall cost containment or with assistance for individuals who are already ill. The Institute of Medicine (1981) suggests that incidence based costs are more pertinent to questions o pollution control because in most cases the result of pollution control is the prevention of additional incidence of disease or illness. In some cases, however, pollution is known to aggravate existing diseases or illnesses and prevalence based costs might be more appropriate.

When the "wrong" type of data are available, it may be possible to build a model of illness that relates the level of prevalence to the past and current levels of incidence of the disease. Such a model would require information on the average length of the illness in question. Then valid estimates of the benefits of reducing morbidity could be derived starting with either prevalence or incidence of a disease.

Marginal versus Average Coats

COI studies generally have not been concerned with the potential differences between marginal, average or total costs of illness, but the distinction could be important for some policy questions. For example, if air pollution causes people with asthma to have more frequent asthma attacks, a COI estimate for pollution induced asthma effects should reflect the incremental costs of an increase in asthma attacks. This could be different from the average cost of asthma attacks if, for example, asthmatics purchase the same kind of medical equipment whether they have 50 or 100 asthma attacks a year.

Many COI studies are based on total expenditures for a given medical service that are then allocated among different diseases. This does not provide enough information to estimate marginal costs for small changes in the incidence or severity of a disease. In many cases, the researcher will have to work with average costs, because the information necessary to estimate marginal costs is not available, but he should be aware of the circumstances for which marginal costs would be more appropriate and of the potential inaccuracy of using average costs instead.

Affected Populations

When COI studies use age and sex specific average wage rates and labor force participation rates to calculate indirect costs, they are assuming that the individuals affected by the disease are on average the same as others in their age and sex bracket. This can result in biased estimates if people in some socioeconomic groups are more likely to get sick. For national COI estimates for broad disease categories such bias is not likely to be severe. For pollution, however, there could be problems if socioeconomic characteristics of the individual are related to pollution exposures. For example, air pollution levels tend to be higher in central cities where the residents tend to have lower incomes than in the suburbs. This could produce an upward bias in COI estimates based on the average population. The researcher needs to consider the affected population group for the pollutant under consideration to determine the appropriate wage and labor market characteristics to use.

3.2 RELATIONSHIP BETWEEN COI AND WTP (WTA)

The concept of willingness to pay or willingness to accept compensation (wTP or WTA) for changes in health was introduced in Chapter 1 as, the appropriate dollar measure of the change in well-being associated with a change in health. The individual's WTP to prevent a deterioration in health, for example, can be expected to be a function of the out-of-pocket losses he would have incurred and the discomfort he would have experienced. A comparable COI estimate, on the other hand, would typically consider only his out-of-pocket losses.

Recent COI studies have acknowledged that WTP (WTA) estimates would be more appropriate for benefit-cost analysis of health programs (the "costs" of illness prevented are the benefits of such programs), but argue that reliable WTP (WTA) estimates are not available and that estimation' techniques are still in development stages (Mushkin, 1979b). it is often asserted that COI estimates can be expected to understate the total costs of illness, because "intangible" costs, such a pain and suffering, have not been included., If true, then COI estimates can provide a' lower bound estimate of the be~ef its of reducing or preventing pollution induced health effects.

Barrington and Portney (1982) have developed a model of individual utility maximization with respect to health and health related behavior that helps to clarify the expected relationship between WTP (WTA) and what is estimated in typical COI studies. This model was presented in Chapter 2. Barrington and Portney use the model to derive an expression for the individual's WTP (WTA) for a change in pollution (equation 2.9) that includes the following four components:

1. The opportunity cost of the change in time spent sick due to the change in pollution.

2. The change in medical expenditures associated with the change in time spent sick as a result of the change in pollution.

3. The change in defensive expenditures associated with the change in pollution.

4. The direct disutility (the pain and discomfort) associated with the change in pollution.

Barrington and Portne y (1982) argue that typical COI studies estimate only the first two components by considering only income lost and medical expenditures due to illness. They argue that under certain assumptions, WTP (WTA) can be expected to exceed COI because the third and fourth components can be expected to increase WTP (WTA). For example, an increase in pollution can be expected to cause the individual to increase defensive expenditures and to have a negative effect on the individual's utility due to the discomfort of increased illness.

This conclusion needs to be modified by clarifying the distinction between society's and individuals' costs or willingness to pay and by acknowledging some potential differences between typical COI estimates and the first two components of WTP defined above. An individual can be expected to respond only to those costs he will incur. The extensive availability of subsidized medical care, paid sick leave, and employer subsidized health insurance means that there can be a substantial difference between costs incurred by the individual who is ill and those incurred by society as a whole (including the individual) on his behalf.[3] WTP, to the extent that it is influenced by the costs of being ill, can be expected to be different if considered from the individuals' or society's point of view. Aggregate WTP or COI measures, reflecting the values to an entire group of individuals, can be the sum of individuals' WTP or COI, or the sum of society's WTP or COI.

Figure 3-1 illustrates the four measures for the same change in morbidity and how they can" be expected to compare to each other. The comparisons of individuals' WTP and COI and of society's WTP and COI are fairly straight forward; WTP can be expected to exceed COI because COI estimates do not inclu& the value of preventing all pain and discomfort and of all defensive expenditures and activities. The comparison between individuals' WTP and society's COI is more ambiguous. This comparison is important because COI estimates typically cover all costs to society and WTP estimates are often based only on the values to individuals who are ill. The comparison is ambiguous because society's COI contains some things not included in individuals' WTP and visa versa. This can be clarified by considering each of the four components of WTP explicated by Barrington and Portney, and comparing them to what is typically included in a social COI estimate.

1. Opportunity cost of time sick: Whether society's COI is greater or less. than individuals' WT P is uncertain because COI includes the costs of paid sick leave but considers only time lost from work.

2. Medical expenditures: Society's COI is greater than or equal to individuals' WTP because COI includes costs incurred by others.

3. Defensi~e expenditures: Society's COI is less than or equal to individuals' WTP because COI does not include non-medical expenditures.

4. Direct disutility: Society's COI is less than or equal to individuals' WTP because COI does not include values for direct disutility.

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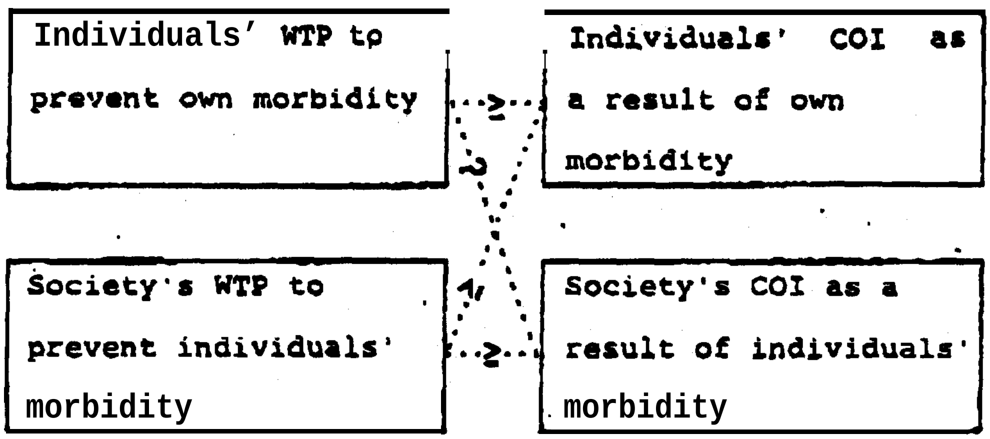
[3] Rice (1983) notes that third party payments comprised 68 percent of total national health expenditures in 1981, with private health insurance 'representing 26 percent, government 40 percent, and philanthropy 1 percent. Some of the costs of insurance and taxes are borne by the individuals who are ill and will therefore be reflected in the individuals' WTP to prevent morbidity, but these figures illustrate the extent to which medical care costs are spread across society.

Figure 3.1

Comparison of COI and ~



Society's COI will therefore be less than or equal to individuals' WTP unless the medical costs incurred by others (second term) and the work loss costs incurred by others (first term) are large enough to offset the understatements in the first, third and fourth terms.

3.3 REVIEWS OF TWO COI STUDIES

The two studies selected for review in this section cover a lot of ground in terms of the methods and data used and give an idea of the kind of information that might be useful for developing COI estimates for pollution induced health effects. The first study reviewed is Cooper and Rice (1976), an update of the estimates developed by Rice (1966). It is a widely referenced source for national COI estimates for major disease categories. The Cooper and Rice estimates have been used as the basis for pollution related COI estimates and other applications. Manuel et al. (1983) and Lute and Schweitzer (1978) are discussed as examples of the use of the Cooper and Rice (1976) estimates. The second study reviewed is Hartunian et al. (1980, 1981). This study provides an example of a detailed incidence based cost analysis for four categories of diseases or injuries: cancer, coronary heart disease, stroke and motor vehicle injuries.

3.3.1 Cooper and Rice (1976)

This study provides estimates of total direct and indirect costs associated with all illness in the U.S. for 1972. Cooper and Rice allocated national total cost estimates among 16 diagnostic categories. The methods used to obtain these estimates and the sources used are described below.

Direct Coats

The figure for total direct costs in each medical expenditure category (hospital care, physicians' service, etc.) was taken from the National Health Expenditures reported by the Social Security Administration for "1972. (These data are reported annually now by the Health Care Financing Administration.) All personal health care expenditures (about 83 percent of the total health care expenditures in 1972) were disaggregate into by diagnosis categories.. These are equivalent to the "core costs" defined in Section 3.1.

TABLE 3.2

Direct Costs, selected categories: Estimated moun and percentage distribution, by type of expenditure and diagnosis, 1972.

Diagnosis	Total	Hospital care	Physicians' services	Dentists' services	Other Professional services	Drugs and drug sundries	Eyeglasses and appliances	Nursinghome care
	Amount (in millions)							
ota	$75,231	$34,219	$16,916	$5,58	$1,717	$8,628	$1,896	$6,274
Infective and parasitic disease	,4 z	660	383		5	192		222
Neoplasms	3,872	2,957	528		47	186		154
Endocrine, nutritional, and metabolic diseases	3,436	920	1,294		25	869		328
Diseases of the blood and blood-forming organs	491	228	151		4	77		31
Mental disorders	6,985	5,261	685		9	434		596
Diseases of the nervous system and sense organs	5,947	1,033	1,294		655	594	1,896	475
Diseases of the circulatory system	10,919	5,271	1,676		86	1,305		2,581
Diseases of the respiratory system	5,931	2,473	1,851			1,460		117
Diseases of the digestive system	[illegible]	996	880	5,58	43	444		156
Diseases of the genitourinary system	4,471	2,699	1,089		34	571		78
Complications of pregnancy, childbirth, and the puerperium	2,607	2,331	151		39	86		
Diseases of the skin and subcutaneous tissue	525	488			6			21
Diseases of the musculoskeletal system and connective tissue	3,636	1,661	770		368	425		4. 2
Congenital abnomalies	38	313	44		3			3
Accidents, poisonings, and violence	5, z1	3,134	1,222		38	352		375
Other	7,398	794	4,292		325	,271		716

Note: All figures are in 1972 dollars.

Source: Cooper and Rice (1976)

Some national expenditures left unallocated were the costs of research, construction of medical facilities, program administration, net cost of insurance and government public health activites. **A** variety of sources were used to allocate direct costs by diagnosis. Table 3.2 shows the estimates of direct costs for 1972 allocated by diagnostic category.

Hospital Care. National expenditures for hospital care are broken down by type of hospital. The largest category is for community hospitals. The allocation of e xpenditures for community hospital care was based on days of hospital care by primary diagnosis reported for 1972 from the National Center for Health Statistics (NCHS) Hospital Discharge Survey (an annual survey). These were weighted by average daily costs by diagnosis f rorn Aema for their enrollees in the Federal Employees' Health Benefit Plan and from Medicare for patients over 65 years old. Data for federal hospitals were obtained from the Veterans' Administration, the Department of Defense and the Public Health Service. Expenditures for care at psychiatric and tuberculosis hospitals were classified under the diagnoses their names imply. Expenditures for long-stay hospitals" were treated like those for nursing homes, described below.

Physicians' Services. Expenditures for physicians' services were allocated according to the reported distribution of visits to physicians in 1972 by diagnosis. This distribution was reported by the National Disease and Therapeutic Index, a service of IMS American, Ltd., Ambler, Pennsylvania. Costs for each visit were assumed to be equal.

Dentists and Other Professional Services. Expenditures for dentists were all allocated to diseases of the digestive system. Expenditures for private duty nurses were allocated the same as hospital care. The National League of Nurses provided diagnostic data for visiting nurses. Optometrists' services were all allocated to diseases of the nervous system and sense organs. Chiropractors' services were all allocated to diseases of the musculoskeletal system and connective tissue.

Nursing Home Care. Expenditures for nursing home care were allocated according to the number of residents and average monthly charges for each diagnosis, reported by NCHS, "Charges for Care and Sources of Payment for Residents in Nursing Homes, U.S., June-August 1969." This is based on a survey of nursing homes that has been done every few years by NCHS. According to the most recent NCHS public use data tapes catalog, the most recent nursing home care data available are for 1977.

Drugs and Drug Supplies. The National Diseases and Therapeutic Index (used for physicians' services) also reported drugs prescribed by diagnosis. These were weighted according to prices from the National Prescription Audit of R.A. Gosselin & Company, Inc.

Indirect Costs

Losses of Income/Production Due to Morbidity. Losses of income or production for all individuals due to illness were estimated and allocated according to the 16 diagnostic categories. These are reported in Table 3.3. The non-institutional population considered for work loss due to morbidity was divided into those currently employed, women of all ages not employed but keeping house, and those individuals unable to work at all due to illness or disability. No work losses were considered for retirees and others who voluntarily choose not to work.

NCHS reports annual data on work-loss days due to illness for people who are employed by age, sex -and diagnosis. These data for 1972 were multiplied by mean 1972 wages for each age and' sex group from the Bureau of Census Current Population Survey to obtain estimates of morbidity losses for all employed individuals for each diagnostic category. NCHS also reports bed days for women not employed but keeping house by age and diagnosis and these were multiplied by mean housekeeping values based on Brody (1975).

The total number of people unable to work at all due to illness or disability is reported by age and sex by the Department of Labor, "Employment and Earnings" for 1972. Percentages of the general population who are employed or keeping house for 1970 (also from "Em ployment and Earnings") were used to estimate the portion of those unable to work who could be expected to have been employed or keeping house had they not been ill. These were then multiplied by mean earnings or mean housekeeping values by age and sex, and, for those 25 years and older, were allocated among the diagnostic categories according to the diagnostic distribution 'that was reported by NCHS for bed days for people retired due to health and people doing 'something else" (other than the employment categories listed in the NCHS question). The diagnostic distribution for those under 25 years old who were unable to work was based on information from disability allowance under Social Security since the NCHS "something else" category includes students.

TABLE 3.3

Morbidity Costs: Estimated amount and percentage distribution, by labor force status and diagnosis, 1972

Diagnosis	Total	Noninstitutional				Institutional
		Total	Currently Employed	Keeping house	Unable to work	
	Amount (in millions)					
Total	$42,323	$36,118	$17,619	$3,295	$15,204	$6,20[illegible]
Infective and parasitic diseases	1,200	972	669	119	184	228
Neoplasms	862	820	438	104	278	42
Endocrine, nutritional, and metabolic diseases	1,137	1,027	214	91	722	110
Diseases of the blood and blood-forming organs	220	208	7[illegible]	32	98	12
Mental disorders	6,179	2,210	39[illegible]	98	[illegible],716	3,969
Diseases of the nervous system and sense organs	3,944	3,752	850	137	2,765	192
Diseases of the circulatory system	6,4[illegible]7	5,589	1,781	495	3,313	828
Diseases of the respiratory system	7,089	7,040	5,085	845	1,110	49
Diseases of the digestive system	2,606	2,547	1,501	245	801	59
Diseases of the genitourinary system	1,249	1,226	745	234	247	23
Complications of pregnancy, childbirth, and the puerperium	245	245	79	166		
Diseases of the skin and subcutaneous tissue	460	456	355	18	83	4
Diseases of the musculoskeletal system and connective tissue	5,103	4,919	1,866	362	2,691	184
Congenital anomalies	238	232	12	12	208	6
Accidents, poisonings, and violence	3,883	3,794	3,058	242	494	89
Other	1,494	1,083	494	96	493	411

Note: All figures are in 1972 dollars.

Source: Cooper and Rice (1976)

The number of residents in each type of institution in 1970 was reported by age and sex by the Bureau of Census. The number was assumed to be the same for 1972. Employment rates and housekeeping rates for 1970 were used to estimate the portion of these people who could be expected to have worked had they not been ill. The 1972 mean wages and housekeeping values were applied. The diagnostic distribution was based on the type of institution. Chronic disease hospitals, nursing homes and homes for the aged were allocated according to the diagnoses of residents of nursing homes reported by NCHS.

Estimates of losses of income or production due to mortality in 1972 were also reported. These are not discussed because this report focuses on morbidity.

Comments on the Cooper and Rice COI Estimates

The frequency with which these estimates are referenced indicates that the authors have provided a great deal of useful information. They have pulled together data from many sources to come up with .a reasonable breakdown of the costs of illness in the U.S. according to major diagnostic categories. These data provide a picture of the costs associated with major categories of illness, but the Cooper and Rice estimation approach may not be as useful for developing COI estimates for much more narrowly defined diseases due primarily to the limitations of the data sources used.

The Institute of Medicine (1981) points out that a potential source of significant problems with these kinds of estimates is the presence of multiple conditions. Throughout their analysis, Cooper and Rice attribute all costs to the primary diagnosis. The Institute of Medicine suggests that more of an effort could be made to allocate costs among multiple conditions using data from Medicare hospital discharges and from the Commission on Professional and Hospital Activities. The y reference three Institute of Medicine studies concerning the reliability of the diagnoses reported with the NCHS Hospital Discharge Surveys. For broad disease categories, the disagreements with the primary diagnoses were about 14 percent, but for more specific diseases” (ICD four digit codes) they disagreed with 40 percent of the primary diagnoses. Cooper and Rice did not use these narrower disease categories, but these studies suggest that the data on diagnoses need to be used with caution.

Update and Extension of Cooper and Rice Estimates by Mushkin (1979b)

Mushkin (1979b) presents COI estimates for 1975 and projections to the year 2000 by major disease categories that are based on the same methodology as Cooper and Rice (1976). The reference for the 1975 estimates was Paringer and Berk (1977).

Mushkin (1979b) also expands on the Cooper and Rice (1976) estimates by including estimates of costs of debility (illness or impairment that does not necessarily cause a person to stay home from work, but may reduce his productivity), nonhealth sector costs of illness, and costs of pain. The author acknowledges that the estimates do not cover all the costs of illness, but argues that they are more complete than COI estimates that cover only work loss and direct medical expenditures.

The expanded estim~tes for all illness in 1975 are reported in Table 3.4. Note that these include costs for premature death as well as for morbidity. The consumer outlays reported as part of nonhealth sector costs include transportation to health care facilities and property losses due to alcohol and drug abuse. The costs of pain are based on expenditures on painkillers, the use of medical care that originates in pain symptoms, the price of pain clinics, and the value given -to pain and suffering in court awards. Overall, the traditional COI estimate for morbidity and premature death (the first three subitems in Table 3.4) has been increased by 30 to 98 percent.

Applications of the Cooper and Rice Estimates

Coorxw and Rice (1976) give a suggestion of an approach for developing a quick estimate for costs associated with a specific disease based on their estimates and data available from NCHS. They illustrate this for strokes, a condition that falls into the category of diseases of the circulatory system. Cooper and Rice argue that a reasonable approximation of the portion of total direct costs associated with strokes could be obtained by using the percentage of people whose circulatory diseases are strokes to adjust the circulatory disease cost estimates. They suggest using NCHS data concerning the days of community hospital care, number of outpatient physician visits, and number of nursing home residents by diagnosis (detailed enough to give strokes as a disease category) to estimate this percentage.

Table 3.4

An Expandec Estimate of the Burden of Illness, 1975
(1975 dollars)

	Burden of illness (in billions)
Total	$419.6440.3
Traditional count of burden of illness	32'2.6
Direct health expenditures	118.5
Cost of premature death (at Z. S-percent discount)	146.2
Loss in work time and product due to sickness	57.8
Cost of debility	42.0-5 1.3
Acute temporary conditions	34.5-41.5
Impairments following major illness	0.7-2.8
Static impairments	5.5
Other losses in industrial accidents	1.3-1.5
Nonhealth sector cost of illness	29.2-37.8
Consumer outlays (e.g., transportation. property losses)	3.94.3
Government expenditures (e.g.. extra education costs, counseling, aid to handicapped, costs of antisocial behavior)	8.0-14.5
Time costs of health care	4.5-6.2
Industry	12.8
Costs of pain	25.8-22.6

Source: Mushkin (1979b)

NCHS also provides data on disability related to strokes. The percentage of circulatory disease related work-loss days due to strokes provides an estimate of the percentage of indirect losses for the employed population. Cooper and Rice (1976) suggest that housework losses are insignificant due to the older age of the average individual with stroke. NCHS reported bed days due to strokes for those unable to work gives the percentage of morbidity losses for those unable to work. The authors suggest using a slightly lower percentage of morbidity losses for those unable to work due to the higher average age of those with strokes. The percentage of nursing home residents with circulatory diseases who have strokes provides an estimate of the percentage of the institutionalized population with strokes.

This approach for a quick estimate of the costs associated “with a specific disease assumes that the mix of people with and average costs for the specific diseases are comparable to those of all other diseases in that major disease category. Cooper and Rice note the different age mix of individuals who have had strokes is a problem. It is also important to note the questions raised by the Institute of Medicine (1981) concerning the accuracy of the NCHS diagnosis data for more specific disease categories.

Manuel et al. (1983) provide one example of how the Cooper and Rice estimates have been used for estimating the benefits of reducing pollution-induced morbidity. They estimated the benefits, quantified in dollar terms, of ambient air quality standards for particulate matter. They used current epidemiological evidence to develop estimates of the changes in acute and chronic illness (measured in terms of work-loss days, restricted activity days, and bed days) associated with different levels of ambient particulate matter. These were then valued in terms of income lost and an associated change in direct medical expenditures.. The estimate of the change in direct medical expenditures was based on the Cooper and Rice estimates.

All health effects related to particulate matter were assumed to fall under diseases of the circulatory system or diseases of the respiratory system. To obtain a 1980 estimate of direct expenditures for these disease categories, the 1972 ratio of direct, expenditures for circulatory and respiratory diseases to all direct expenditures was applied to total direct expenditures in 1980. This assumes that the relative incidence and prevalence of diseases and relative medical costs have remained the same. Only those expenditure categories with non-zero values for circulatory or respiratory diseases in 1972 were used in this calculation. The percentage of these estimated direct medical expenditures for

1980 attributable to the effects of particulate matter was assumed to be the same as the percentage of acute and chronic illness associated with the different levels of particulate matter. Separate estimates were made for expenditures associated with acute and chronic illness by using the percentage breakdown of work-loss days, restricted activity days and bed days attributed to acute and chronic illness in the NCHS data.

A crucial assumption underlying the use of the percent: 'e of illness as the percentage of costs, is that the circulatory and respiratory illnesses associated with ambient particulate matter are not, on average, any different from other circulatory and respiratory illnesses in terms of medical expenditures and work loss. This means average medical costs are assumed to be a reasonable approximation of marginal medical costs associated with pollution and the affected population is assumed to be representative of the general ill population. Whether these assumptions are valid is questionable, but improving upon them would require more information about who is affected by pollution and exactly what kinds of morbidity are caused, and would require more disaggregate medical cost information.

Lute and Sweitzer (1978) estimated the direct and indirect costs associated with smoking for 1976. They used the Cooper and Rice estimates of total direct and indirect costs for four categories of diseases that are related to smoking: neoplasms, diseases of the circulatory system, diseases of the respiratory system, and accidents (in this case, smoking related fires). The costs for these four categories were multiplied by estimates of the percentage of each attributable to smoking. The authors reference Boden (1976) for these "smoking factors." The costs were adjusted to 1976 levels with the medical care component of the Consumer Price Index.

3.3.2 Harunian et al. (1980. 1981)

This study developed incidence based COI estimates for 1975 for four major categories of illnesses in the U.S.: cancer, motor vehicle injuries, coronary heart disease, and stroke. The COI estimates are the direct and indirect costs for the cohort who acquired all the cases of these diseases that began in 1975 until cure or death was predicted to occur. This is the first study that offers incidence based COI estimates for a range of disease categories. A great deal of information was gathered about each specific disease in order to develop the COI estimates, including initial and long term treatment, typical developments of the disease over time, chances of recovery, and likelihood of permanent disability. The study provides a good example of an approach for estimating incidence based COI.

Direct Costs

The direct cost estimates included the costs of the initial treatment, the present value of future treatment costs, insurance administration costs, and court and legal costs for motor vehicle injuries. The treat ment costs included:

- emergency assistance
- initial inpatient hospital care
- inpatient physicians' and surgeons' services
- vocational and physical rehabilitation following hospital discharge
- nursing home and home attendant care
- drugs, medical supplies and appliances
- outpatient medical and surgical care
- rehospitalization (owing to recurrence)
- home modifications .
- paramedical and miscellaneous expenses

These cover all the categories of direct costs typically included in the "core costs" with the addition of home modifications. Direct costs expected to be incurred in future years (after 1975) were discounted to a present value using a 6 percent discount rate. The authors acknowledge that it is not possible for these projections of future costs to reflect potential changes in treatment technologies or relative prices of medical care, since they are based on current practice.

Costs of health insurance administration is a category of costs that Cooper and Rice (1976) did not allocate among specific diseases. Hartunian et al. estimated that variable costs of insurance administration are about 4.5 percent of total treatment. related expenditures. They reference several studies for information about total health insurance administration costs and made some best guess assumptions about what portion of these are fixed and what are variable. To justify using the same figure for each disease category, they argue that the distribution of treatment costs (among hospital care, physicians' services, drugs, etc.) is roughly comparable for each of the diseases analyzed in this study and that these distributions are roughly comparable to the distribution of total treatment costs in the U.S.

Legal and court expenses were included for litigation related to motor vehicle injuries that are not already covered in the health insurance administration costs. The authors mention that a considerable amount of litigation concerning cancer cases also occurs, but this has not been included because data are sparse. Data that do exist indicate that these costs are relatively insignificant, and much of these costs are covered as part. health insurance administration costs (unlike those for motor vehicle injuries).

Indirect Costs

The estimates of indirect costs cover the lost productivity due to temporary and permanent disability and premature mortality as a result of the disease, from its onset until the condition is cured or death occurs. Morbidity and premature mortality effects were not reported separately. The expected economic product of a person with the condition was subtracted from the expected economic product of a person in the same age and sex group without the condition to obtain foregone production.

Average annual productivity values estimated for men and women in each age group in the general population are shown in Table 3.5. Productivity values using the market value approach for household labor values and using the opportunity cost approach are reported.

These estimates for the general population were used to represent productivity values for individuals without the condition.[4] Mean wages and labor force participation rates were used in these estimates. Estimates of value for household labor lost were taken from Brody (1975), supplemented with data from Paringer and Berk (1977) concerning household productivity for employed people. Market value estimates of household labor lost were used in the main analysis with opportunity cost estimates used to test the sensitivity of the results to different assumptions.

[4]The authors acknowledge that this is not entirely accurate since the general population includes some individuals who have the condition, but they argue that the potential bias is minimal because the incidence of any one condition represents only a small portion of the general population.

Table 3.5

Mean Annual Productivity Values (Using Market-Value Approach), 1975
(in 1975 dollars)

Age Group	*Males*	*Females*
16-19	$ 4,506	4,216
20-24	9,677	7,752
25-29	13,444	9,877
30-34	16,087	10,136
35-39	17,043	9,833
40-44	17,105	10,050
4s-49	17,027	9,422
50-54	16,690	9,534
55-59	14,909	7,323
60-64	13,413	5,763
65-69	8,884	3,532
70-74	6,156	2,233
75-79	4,569	1,426
80-84	2,562	•a 08
85	1,37s	452

Mean Annual Productivity Values (Using Opportunity-Cost Approach), 1975
(in 1975 dollars)

Age Group	*Males*	*Females*
16-19	4,481	3,479
20-24	9,797	7,311
25-29	14,054	9,971
30-34	17,204	10,194
35-39	18,449	10,130
40-44	18,697	10,376
45-59	18,756	10,418
50-54	18,449	10,516
55-59	16,732	9,720
60-64	15,689	8,769
63-69	10,886	5,587
70-74	8,052	4,375
75-79	5,998	3,580
80-84	4,411	2,989
85	2,%8	2,516

Source: Hartunian et al. (1981).

Average life ‘expectancies and mean annual productivity values for each age and sex group were used to calculate present values of expected future earnings per person for the gene ral population. A 1 percent average annual increase in productivity was assumed and a 6 percent discount rate was used for the present value calculation. These are reported in Table 3.6.

Expected future earnings for those with each of the conditions were estimated by subtracting the productivity impacts of temporary and permanent disability and premature mortality from the expected future earnings for the general population. The estimated average foregone earnings per person are listed in Table 3.7 for each of the four conditions. These are average earnings foregone throughout the entire course of the condition or disease. They are presented by age group for men and women. This is the age at the onset of the condition. These estimates are based on market values for household services and include the effects of premature mortality, as well as morbidity.

Survival rates for the affected population for each year after the onset of the condition were used to calculate loses due to premature mortality Temporary disability is primarily associated with the initial onset of the condition. The authors value all restricted activity days at the average annual wage (or household labor value) divided by 365, since both work days and non-work days are affected. This assumption is likely to overstate lost productivity since the individual is not necessarily unable to work at all on restricted activity days. These estimates of lost productivity for restricted activity days are shown in Table 3.8.

Permanent disability can mean a partial or total inability to work throughout the remainder of the individual’s life. The calculation for expected future earnings of an average individual with the condition inc Iuded the possibility y of a lower labor force participation rate and a lower productivity for those who do work (part-time work, etc.). Only two different productivity rates were used: one for the first year of the condition and another for all subsequent years.

Data Sources

The authors have taken information from a great many studies in order to develop the incidence based COI estimates. They specifically mention 63 studies that were most heavily relied on for information about the four conditions under consideration.

Table 3.6

Average Expected Future Earnings per Person by Age and Sex, 1975 (Discounted at 6% and in 1975 dollars)

	Us. General Population. 197s	Cancer	Coronary Heart Disease	Motor Vehicle Injuries	Stroke*
Melee					
0-14 years	$130,863	S 40.542	s 71,199	$219,152	$48,660
15-24	225,992	64,566	137,392	222,263	67,028
25-34	247,661	105,40s	159,746	224,030	71,666
35-44	205,667	66,631	136,766	201,463	59,994
45-54	135.972	42,685	95,420	132,997	41,596
55-64	52,192	19,421	33,517	50,641	17.610
65-74	5,754	2,450	3,092	5,466	1,658
≥ 75	533	242	302	493	233
All Males	157,030	16,327	46,136	166,464	9,170
Females					
0-14 years	92,241	36,433	61,606	91,464,	30,591
15-24	156,059	76,S63	113,636	154,661	40,366
25-34	153,131	63,9s1	112,326	151,s62	38,415
35-44	126,642	67,166	93,762	125,425	31 ,6s0
4S54	67,150	46.562	64,312	66,129	24,266
55-64	39,950	21,158	31,440	39,378	12,636
6$74	11,662	6,091	7,698	11,352	3,2U
≥75	2,556	1,384	1,786	2,451	1,166
All Females	97,016	23.183	23,600	119.196	5,250
All Persons	126,299	19,740	37,667	1 58,387	7,274

* Excluding Transient Ischemic Attacks

Source: Hartunian et al. (1980)

Table 3.7

Average Foregone Earnings per Person by Age and Sex, 1975
(Discounted at 6 Per Cent and In 1975 Dollars)

	Cancer	Coronary Heart Disease	Motor Vehicle Injuries	Stroke*
Males				
0-14 years	$ 90,321	$59.664	$1,771	$ 62,203
15-24	141,407	66,600	3,709	158,964
25-34	142,472	66,136	3,661	176,195
35-44	137,056	66,922	4,224	146,693
45-54	93,287	40,544	2,975	94,376
55-64	32,778	18,662	1,556	34,569
65-74	3,304	2,662	266	4,096
● 75	291	231	40	300
All Males	29,972	22,557	3,233	19,981
Females				
0-14 years	55,608	30.436	757	61,660
15-24	79,076	42,424	1,178	115,8s3
25-34	69,160	40,605	1,169	114,716
35-44	59,477	32,660	1,217	94,752
46-54	40,568	22,63s	1,021	62.665
55-64	10,792	6,510	572	27,315
65-74	5,591	3,664	330	8,43s
● 75	1,172	770	105	1,371
All Females	20,654	7,696	998	11,964
M Persons	2s,334	17,010	2,263	16,102

*Excluding Transient Ischemic Attacks

Source: Hartunian <u>et al.</u> (1980)

Table 3.8

Value of a Day of Restricted Activity (Using Market-Value Approach), 1975
(in 1975 dollars)

(Dollars)

Age	Male	Female
0-14	0	0
15-24	14	12
25-34	37	26
35-44	44	26
45-54	42	25
55-64	30	17
65-74	6	7
75+	1	2

Value of a Day of Restricted Activity (Using Opportunity-Cost Approach), 1975
(in 1975 dollars)

(Dollars)

Age	Male	Female
0-14	0	0
15-24	14	11
25-34	39	26
35-44	47	26
45-54	46	27
55-64	34	24
65-74	8	12
75+	1	6

Source: Hartunian et al. (1981)

Table 3.9 shows the studies and data sources referenced as primary sources of information on incidence, direct costs and indirect costs (including disability and mortality rates) for each of the four conditions.

Results

Tables 3.10 and 3.11 show the estimates of incidence of each condition in 1975. Table 3.10 shows the distribution of incidence by age and sex groups. Table 3.11 shows the distribution of incidence by subcategories of the four conditions. MAIS1 to MAIS5 are severity ratings for motor vehicle injuries that are not immediately fatal, the highest severity being MAIS5.

Table 3.12 gives the total direct and indirect costs estimated by the authors for the four conditions and their subcategories. Average per person costs can be calculated using these results and the incidence estimates reported in Tables 3.10 and 3.11.

Sensitivity analyses were conducted to test the ranges of likely error and their impact on final results for several data components, including incidence data, recurrence and mortality data, direct cost figures, and data on work incapacity, employment rates, and wage rates. The authors conclude "the current state of the art in estimating the economic costs of illness has limited numerical precision." The results of the sensitivity analyses did, however, show that the relative costs across the different health conditions were reasonably consistent and that for many applications, the numerical accuracy of the estimates is acceptable. The authors recommend continued use of sensitivity y analyses and care to maintain methodological consistency.

Comments

This study is an important contribution to the methodological development of procedures for estimating incidence based COI. The cost estimates developed are relevant for policy decisions regarding programs designed to reduce the incidence of any of these conditions. For exam pie, if a pollution con trol program could be expected to reduce the incidence of respiratory system cancers by 10 percent, an estimate of the reduction in costs of illness that would be associated with this reduction in cancer incidence could be obtained from the results of this study. If the 1975 incidence levels were an appropriate

Table 3.9: Primary Data Sources Used by Hartunian et al. (1981)

Condition	idence	Direct Costs	Indirect Costs
Coronary Heart Disease	Framingham Heart Study (U.S.DHEW 1977)	Commission on Professional and Hospital Activities (1976)	Framingham Heart Study (U.S.DHEW 1977) Weinblatt et al. (1966)
Stroke	Furlan et al. (1979) Garraway et al. (1979)	Blue Cross of Massachusetts National Nursing Home Survey (NCHS 1979) Emlet et al. (1973)	National Survey of Stroke (U.S.DHEW, 1980) Matsumoto et al. (1973) Gresham et al. (1979)
Cancer	Third National Cancer Survey (Cutler and Young 1975) Young, et a . (1978)	Third National Cancer Survey (Cutler and Young 1975) Abt Associates & Boston University Cancer Research Center (1976)	Axtell et al. (1972) Axtell and Myers (1974) Third National Cancer Survey (Cutler and Young 1975)
Motor Vehicle Injuries	Fatal Accident Reporting System (U.S. DOT 1976) Health Interview Survey (NCHS 1977) National Crash Severity Study (U.S. DOT 1980)	Smart and Sanders (1976) Faigin (1976) Wuerdemann and Joksch (1973) DeLorean (1975) National Crash Severity Study (U.S. DOT 1980) Automobile Insurance and Compensation Study (U.S. DOT 1970)	Smart and Sanders (1976) National Crash Severity Study (U.S. DOT 1980) Dresser et al. (1973)

Table 3.10

Annual Incidence of Cancer, Coronary Heart Disease, Motor Vehicle Injuries and Stroke by Age and Sex, 1975

	U.S. General Population, 1975	Cancer	Coronary Heart Disease	Motor Vehicle Injuries	Strew
Males					
0-14 years	27,366,000	3,585	119	275,520	354
15-24	20,375,000	4,6[illegible]	500	887,434	502
25-34	15,35S,000	6,150	5,939	492,651	962
35-44	11,163,000	11,2[illegible]0	34,730	229,600	2,322
45-54	11,491,000	37,964	81,184	165,683	9,512
55-64	9,345,000	60,555	150,464	127,720	26,086
65-74	8,027,000	104,340	20,043	73,346	43,191
a75	3,146,000	83,366	47,269’	34,166	47,668
Total Males	104,238,000	331,821	410,246	2,416,162	130,518
Females					
0-14 years	26,264,000	2,9[illegible]4	23	227,206	206
15-24	19,913,000	4,502	88	667,827	274
25-34	15,560,000	10,8[illegible]6	1,218	342,608	564
35-44	11,671,000	22,8[illegible]	7,345	196,149	1,353
45-54	12,260,000	54,8[illegible]1	28,514	172,422	3,805
55-64	10,425,000	73,9[illegible]4	62062	131,664	22,637
65-74	7,647,000	60,3[illegible]2	77,261	76,430	33,34s
• 75	5,382,000	78,4[illegible]2	53,136	42,017	59,961
Total Females	108,392,000	328,859	249,676	1,654,243	122,346
Total Population	213,630,000	660,640	659,926	4.270,395	252.666

*Stroke incidence figures do not include Transient Ischemic Attacks.

Source: Hartunian, et al. (1980)

Table 3.11

Estimated Incidence of Diseases and Injuries, 1975

Disease/Injury	Incidence	Average Age at Incidence: Male	Female	Both sexes	Proportion of Incidenc
Cancer					
Digestive System	168,411	66.8	6S.6	67.7	.522
Respiratory System	99,889	64.0	63.2	63.8	.796
Buccal Cavity	23,562	61.9	61.7	61.6	.710
Reproductive System	214,7S8	69.9	59.6	62.7	.263
Urinary System	43,577	6S.7	66.3	65.9	.698
Nervous System	10,570	48.5	46.0	4s.3	.54s
Leukemias	21 ,2s3	5s.4	60.6	59.3	.566
Lymphomas	29,338	56.4	60.5	58.3	.542
Other Sites	49.282	56.3	57.7	58.0	.460
Ail Cancers	660,660	64.7	62.2	63.5	.502
Coronary Heart Disease					
Sudden Death	68,967	59.1	68.4	62.2	.671
MI	231,642	61.3	66.1	62.4	.777
CI	75,151	56.9	64.0	59.7	.610
. APU	“ 283,866	60.6	65.0	62.9	.466
All CHO	659.926	60.3	65.5	62.3	.622
Motor Vehicle Injuries					
Fatalities	44,995	33.8	37.0	34.7	.734
*MAIS 1	3,053,035	28.7	30.4	29.5	.555
*MAIS 2	702.923	30.4	33.0	31.5	.56S
*MAIS 3	353,569	31.4	39.7	34.7	.602
*MAIS 4	67,262	30.4	34.6	31.6	.676
*MAIS 5	28.611	28.8	22.7	29.0	.739
All MVI	4,270,395	2s.3	31.6	30.3	.566
Stroke					
Hemorrhage	35,485	61.3	63.7	62.5	.516
infarction	217,381	71.3	74.7	72.9	.516
All Stroke**	2s2.666	69.9	73.1	71.5	.516

*MAIS 1 through MAIS 5 injuries that are non-fatalities.

**Stroke incidence figures do not include Transient ischemic Attacks.

Source: Hartunian et al. (1980)

Table 3.12

Estimated Direct and Indirect Costs Associated with the Incidence of Cancer, Coronary Heart Disease, Motor Vehicle Injuries, and Stroke, 1975 (Discounted at 6 Per Cent and in 1975 dollars)

	Direct Costs (millions $)				Indirect Costs (millions $)	Total Costs (millions $)
Disease/Injury	Treatment during First Year	Future Treatment	Other*	Total Direct		
Cancer						
Digestive System	$1,172	$ 207	$ 62	$ 1,441	s 3,569	S 5,010
Respiratory System	690	102	36	828	3,760	4,588
Buccal Cavity	182	93	12	287	593	880
Reproductive System	1,111	1,030	96	2,237	3,711	5,946
Urinary System	267	137	18	422	781	1,203
Nervous System	67	49	6	142	917	1,058
Leukemias	157	50	9	216	944	1,160
Lymphomas	198	133	15	348	1,383	1,72s
other sibs	2s6	205	21	492	1,079	1,571
All cancers	4,130	2,006	276	6,411	16,737	23.148
Coronary Heart Disease						
Sudden Death	7	0	0	7	3,891	3,82S
MI	974	459	84	1,497	5,389	8.6SS
CI	328	248	26	603	1,956	2,561
APU	77	280	17	384	7	391
AU CHD	1,387	997	107	2.491	11.225	13.716
Motor Vehicle Injuries						
Fatalities	50	0	128	178	7,052	7,228
MAIS 1	561	0	71	632	111	743
MAIS 2	874	0	123	797	180	977
MAIS 3	727	15	228	970	314	1,2s4
MAIS 4	434	122	109	665	206	671
MAIS 5	412	733	38s	1,533	1,798	3,331
All MVI	2,868	870	1,045	4,773	9,662	14,435
Stroke						
Hemorrhage	168	64	10	239	1,470	1,708
Infarction	1,345	583	87	2,015	2,602	4,617
TIA	16	93	5	114	16	130
All STrokes	1,526	740	102	2,368	4,0s6	6,456
All Conditions	9,901	4,612	1,530	16,043	41,712	57,755

*"Other" costs include insurance administration costs and, in the case of motor vehicle injuries, legal and court costs as well. For motor vehicle injuries, legal and court costs constitute $878 million of the $1,045 million in "other" costs.

Source: Hartunian et al. (1980)

base level for the analysis (i.e., if current year incidence levels were comparable to those in 1975) a reasonable COI estimate might be 10 percent of $4,588 million (the total costs of respiratory system cancers reported in Table 3.12). Alternatively, a per incident cost estimate could be used ($4,588 million divided by 99,889 incidence in 1975).

3.4 CONCLUSIONS

The COI studies refer to an extensive research area that has been concerned with estimating the economic burden of illness on society. Typical COI studies estimate direct medical costs and indirect productivity losses due to illness. For the application of COI estimates to the evaluation of programs to prevent or reduce health related effects of environmental pollution, it is important to determine how direct and indirect costs of illness can be expected to be related to WTP (WTA) for changes in health. For the most part, they can be expected to be a lower bound on society's total WTP (WTA) for changes in pollution induced morbidity, because they do not include all the expenses of time and resources associated with the prevention or mitigation of health effects (such as exercise or changes in activities to reduce exposure to pollution), or the pain and inconvenience associated with illness for the patient, as well as family and friends. In this light, COI studies are a useful source of information for policy makers concerned with the health effects of environmental pollution. Comperisons of empirical WTP(WTA) and COI estimates need to consider whether all costs or only costs incurred by the individual are included, due to the extensive availability of medical care subsidies.

In many cases, there is enough information readily available to develop new COI estimates for a specific pollution related health effect under consideration. Hu and Sandifer (1981) review 238 COI studies for specific illnesses. Mullner et al. (1983) have compiled an inventory of national health care information data bases that might be of use for COI studies.

Specific applications of COI for environmental policy issues should consider whether to use incidence or prevalence based estimates. incidence based costs may be more relevant for pollution induced health effects if, for example, a reduction in pollution means that fewer people will come down with a specific illness. Incidence based costs estimates are, however, more difficult to obtain and have received less attention in the COI literature.

An important difference between standard COI estimates and pollution induced health issues is that the latter are typically conce med with a **change** in the incidence or prevalence of a condition, while COI estimates are typically for all cases of a given condition. This means that some procedure must be used to determine what part of the COI estimate would be associated with a given change in pollution. The appropriate procedure will depend on the pollution change being considered and the type of information available to the analyst.

Cooper and Rice (1976) and Hartunian et al. (1980, 1981) are two COI studies that illustrate current practice in COI estimation methods. Their results are potentially useful for pollution related COI studies. Cooper and Rice (1976) developed prevalence based COI estimates for all illness in the U.S. in 1972. These costs were allocated among 16 disease categories. Their results have been frequently applied to more specific COI questions, and they are useful for developing quick COI estimates for broad categories of morbidity, although they may soon be outdated. For example, Manuel et al. (1983) use the Cooper and Rice (1976) results to estimate the change in direct medical expenditures that could be expected to be associated with a change in work-loss days as a result of a change in ambient particulate levels.

et al. (1980, 1981) estimate incidence based COI estimates for 1975 for four types of conditions: cancer, motor vehicle injuries, coronary heart disease, and stroke. They set the methodological example for incidence based COI estimation and their results are potentially useful for environmental pollution applications for the disease categories covered.

4.0 CONTINGENT VALUATION STUDIES FOR CHANGES IN MORBIDITY

The contingent valuation (CV) methods of interest here use surveys to ask respondents through a structured procedure to place a dollar value on pollution-induced changes in morbidity, or on changes in pollution that cause morbidity.Such studies are said to use contingent valuation approaches because the values estimated are based on the contingent market (rather than a real market) established in the survey instrument. CV approaches have been used to estimate values related to health, wildlife, outdoor recreation, power plant siting, beach use, urban noise, and air quality aesthetics, among others. Reviews of CV techniques and applications include Cummings et al. (1984), Rowe and Chestnut (1982, 1983) and Schulze et al. (1981).

The most widely used CV approach is the contingent bidding method. In this approach, as applied to the valuation of morbidity, respondents are given information about the levels of morbidity, or factors that may affect morbidity. They also are presented with a hypothetical situation or market that describes how actions or payments may be made, such as through changes in taxes, to obtain changes in morbidity. Then they are asked to bid their maxim urn willingness to pay (WTP) for a specific change in morbidity. Alternatively, respondents may be asked to estimate the minimum compensation that they would be willing to accept (WTA) in order to agree to a specific change in morbidity.

The respondent usually is not asked to simply state his maximum WTP in an open-ended question, because this may be difficult to do for a good with which he has no market experience. A common approach in a personal interview is to use an iterative bidding question where the interviewer asks if the respondent is willing to pay (or accept) a specific dollar amount and then continues to change the amount until a maximum WTP (or minimum WTA) is determined. Another approach is to use a payment card with a number of alternative payment amounts listed from which the respondent is asked to select his maximum WTP.A third approach that has been used recently is called a referendum question. Respondents are asked whether they would pay one specific amount versus going without the good, or are asked to vote on a take it or leave it referendum, with a specified cost and health result. The amount is varied across different respondents so that a maximum WTP curve can be derived from the responses, although an individual response is only whether or not the individual would pay at least that much. These surveys also usually ask related questions on perceptions and attitudes as well as socioeconomic characteristics of the respondent in order to identify the underlying determinant ts of the bids. All studies discussed in this chapter have used one of these variations on the bidding method, but other CV approaches have been used for other kinds of applications.

Another CV approach that could be used for estimating values for changes in morbidity is the contingent ranking approach. (See Rae, 1983 and Desvousges et al., 1983, for examples). With this approach respondents would be presented with alternative situations, each re fleeting a different combination of dollar expenditures and states of health, and be asked to rank the alternatives according to their preferences. An implicit valuation can then be derived from these rankings.

The results of CV studies are sometimes viewed with skepticism because the hypothetical nature of the questions does not require that the respondent actually uncle rtake the transaction. The challenge of CV approaches is to design a survey instrument that will effectively elicit an accurate estimate of the respondent's WTP. Valuations received with CV approaches often have varied substantially with small changes in the application of the technique so that the procedure must be designed and monitored carefully. The way the questions are phrased will influence the respondent's perceptions of the decision he is being asked to make, so his answers are subject to subtle influences inherent in the design of the survey instrument.CV estimates often have shown a great deal of variation across individual respondents that is not very well explained by differences in individual characteristics such as income. Evidence indicates that the variation is lowest when respondents are asked about activities and concerns that are well defined and familiar to them, about occurrences that are proposed as certain and in the current time period, and when the consequences and responsibilities are clear and noncontroversial. For example, questions about common ailments such as sore throats or eye irritation would probably elicit more consistent responses than questions about diseases that few of the respondents have ever experienced. It is also important that the payment mechanism suggested in the CV questions be well defined and realistic.

When problems in the applications of CV approaches for valuing changes in health are minimized or resolved, they can provide information for environmental policy decisions that cannot be obtained with other approaches. CV approaches are very flexible.

Constrained" only by the necessary realism of the hypothetical scenarios, the approaches can be structured to address the specific question at hand. This means they can be used in circumstances when no appropriate market information is available. For health effects of environmental pollution, CV approaches allow exploration of the effects of pain and inconvenience on WTP (WTA) that may not be reflected in available market data concerning medical expenditures and income lost. They also could consider defensive expenditures and activities that are very difficult to identify in market data due to the frequent multiple purposes of these expenditures and activities (e.g. people play tennis, or ride bicycles because they enjoy it as well as because it helps keep them healthy). CV approaches also could help resolve some of the questions about the applicability of cost of illness (COI) estimates by exploring the effects of paid sick leave, disutility of time lost from work and of leisure time lost, and the effects of medical insurance coverage.

This chapter reviews five contingent valuation studies concerning air pollution related morbidity.[1] The first two studies (Loehman et al., 1979; Loehman and De, 1982; and Rowe and Chestnut, 1984) are given the most attention because they provide estimates of WTP to avoid specific symptoms. The other three studies (Brookshire et al., 1979, Loehman et al., 1981, and Schulze et al., 1983) provide estimates of WTP for changes in air pollution levels that would be expected to be associated with changes in morbidity. It is difficult to interpret the results of these latter three studies in terms of changes in morbidity because of the uncertainty in the relationship between air pollution and its effects on human health and because of the difficulty in separating the estimates into values for morbidity versus mortality, visibility, soiling, and other effects of air pollution.

4.1 THE FLORIDA STUDY (Loehman et al., 1979, Loehman and De, 1982, and Green et al., 1978)

Green et al. (1978) conducted an interdisciplinary study estimating the benefits and costs of pollution controls for sulfur oxides in Florida. As part of this study, dose response

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[1] A CV study underway at Duke University under the direction of. W. Kip Viscusi and Wes Magat, with funding from the U.S. Environmental Protection Agency, is examining WTP to prevent adverse health effects from dangerous substances used in the home, such as bleach, cleaning liquid and drain opener.Results of this study will be of interest to policy makers when they become available. The University of Chicago, also with EPA funding, is in the early stages of a CV study to value changes in morbidity.

functions were developed based upon information already available about the relationship between sulfur oxide levels and asthma attack rates and chronic bronchitis prevalence. These were used to estimate changes in risks of health effects expected to result from changes in ambient sulfur oxide levels. Then a CV survey was used to put a dollar value on the changes in symptoms expected to be associated with these changes in health effects. This review focuses only on the CV surve y, which is described in Green et al. (1978) Chapters 7 and 8, and summarized in Loehman et al. (1979) and Loehman and De (1982).

Survey Instrument and Procedure

A three page questionnaire and a cover letter was mailed to" 1977 randomly selected residents in the Tampa Bay area (see the Appendix). A reminder card was sent to all persons two weeks after the initial mailing and 396 (20%) were returned and complete for use in the analysis. As a test for response bias, the socioeconomic characteristics of the respondents were compared with those of the population" in the area as a whole. The respondents were slightly above average in income, but were typical of the area in. other respects.

The first section of the questionnaire asked background questions concerning health, smoking, age, income, medical insurance, and employ merit." Twenty-four valuation questions followed. These were introduced with an explanation that sometimes there is a tradeoff between money and discomfort due to illness, for example when one goes to a doctor for diagnosis or treatment of an illness. Each question addressed minor or severe symptoms. Minor symptoms were defined as allowing continuation of daily activities with little or no change, and severe symptoms were defined as restricting daily activities and possibly being con fined to bed. The questions covered three kinds of respiratory symptoms:

1) Shortness of breath/chest pains
2) Coughing/sneezing
3) Head congestion/eye/ear/throat irritations

Symptoms were described as lasting 1 day, 1 week, or 3 months per year. There were also questions about unpleasant odors and haze. " Each question was followed by a list of dollar amounts from which the respondent was asked to select the highest amount he would be willing to pay to avoid the indicated severity and duration of the specified symptom. The choices were the same for each question: $0, $.50, $1, $2, $10, $15, $50, $120, $250, and $1,000.

Survey Results and Analysis

Table 4.1 gives the mean and median responses for each of the questions. The results indicate that the most undesirable symptom was shortness of breath, followed by head congestion and then by cough ing/snee zing. WTP estimates for avoiding severe symptoms were slightly more than two times those for minor symptoms.

The very significant difference between the means and the medians indicates that the answers were not normally distributed over the possible responses. The authors' suggest this may reflect some protest answers from respondents who may have objected to the questions. For example, the majority of the respondents selected an answer of $15 or less as the maximum amount they would be willing to pay to prevent 1 day of minor coughing and sneezing, but a few (496) selected $120, $250, or $1,000. It "is difficult to evaluate these answers, because respondents were not asked to explain their choices. In a personal interview it is possible to probe unusual or unexpected answers to determine if they are true WTP estimates or an indication of an objection to the question.

The authors concluded that the median responses are more representative of the questionnaire results, and because they represent an amount that 50% of the respondents said they would be willing to pay, they argued that they may in some sense be inore politically relevant, since the majority of the population could be expected to support a program that would cost that much to prevent the specified symptoms. This is, however, a different decision making criterion than a comparison of total costs to total benefits for which WTP (WTA) estimates are typically obtained.

The authors also noted that the median responses concerning severe symptoms were considerably less than would be a comparable cost of illness estimate if time lost from work and medical expenditures were considered. They suggest that these responses may not re fleet costs for which the respondent is reimbursed, such as with medical insurance or paid sick leave. It should also be noted that the definition of severe symptoms given in

Table 4.1

Willingness to Pay to Avoid Health Effects (1977)

Average WTP

Days	Days of Health Effect/Year: 1	7	90
MSB	48.61	73.87	145.93”
SSB	79.15	136.12	251.84
MCS	26.40	44.67	86.03
SCS	45.77	72.29	147.48
MHC	32.50	41.51	90.37
SHC	53.42	80.32	179.94
H	28.29	41.38	82.59
O	28.05	43.36	89.25

Median WTP

Days	Days of Health Effect/Year: 1	7	90
MSB	4.90	13.64	35.96
SSB	10.92	35.93	97.80
MCS	2.31	7.84	22.85
SCS	6.95	19.90”	50.56
MHC	3.80	9.58	25.14
SHC	8.17	20.34	61.68
H	1.77	4.95	15.29
O	1.91	4.87	16.26

MSB - minor shortness of breath
SSB - severe shortness of breath
MCS - minor coughing/sneezing
SCS - severe coughing/sneezing
MHC - minor head congestion/eye/ear/throat irritation
SHC - severe head congestion/eye/ear/throat irritation
H - haze
O - odor

Source: Green et al. (1978)

the questionnaire would not necessarily have to be interpreted as equivalent to a day lost from work.

Another result indicated in Table 4.1 is that WTP does not increase in proportion with an increase in the number of days on which symptoms are avoided. The authors suggest that this is consistent with the expectation that the additional utility associated with each additional improvement in health will be declining. In this case, however, it is not clear whether the questions refer to a reduction in symptoms that already occur or to the prevention of additional symptoms. Declining marginal utility would be expected for additional improvements in health, but, not for prevention of additional deterioration in health.

The authors used the results of the willingness to pay questions and the other information obtained about each of the respondents to estimate a bid function for each of the sym p-terns. The bid function gives WTP as a function of the number of days of illness an characteristics of the respondents such as income and health status. The initial estimation reported by Green et al. (1978) was later revised (Loehman and De, 1982). The results discussed here are based on the revised estimation. The most significant difference was that responses were dropped when the answers were $1,000 for all the questions or when the answers were internally inconsistent (e.g. avoiding 3 days of shortness of breath was valued less than avoiding 1 day), indicating objection to or confusion with the questions.[2] The specification of the bid function was also changed somewhat.

The authors decided to analyze the results as a series of "paired comparisons} asking in each case whether paying each of the listed amounts would be preferred to having the indicated symptoms. A positive answer indicates that the respondent would prefer paying that amount or any smaller amount rather than suffer the symptoms. Based on this interpretation, the survey results were used to estimate a stochastic choice model, which predicts whether the payment or the illness would be preferred using the results of the paired comparisons. This accounts for the possibility that the respondents' true maximum WTP falls between the selected amount and the next highest choice.

[2] This was explained in personal conversation with Edna Loehman.

The authors chose to aggregate the responses into income and health status (days of illness during the preceding year) groups and estimated a logit function in the form:

$$\ln(P/1-P) = b1 + b2 \ln m + b3 \ln d + b4 \ln M + b5 \ln D + b6\, S \qquad (4.1)$$

where

P = the percentage of the group that preferred payment m to illness d.

m = the payment choice.

d = duration of symptoms in days.

M = average household income for the group.

D = average health status (days ill in past year).

S = other socioeconomic characteristics of the group including percentage female, employed, covered by medical insurance, and retired.

A median WTP function can be derived from this estimated logit function by setting P equal to .5. This is the point at which 50 percent of the respondents would choose the payment over the symptoms. This reduces the Ieft side of equation 4.1 to zero. Solving for m then gives the payment amount with a 50 percent chance of being selected as a. function of days of sym p toms and the other variables:

$$m = \left[d^{b3} M^{b4} D^{b5} \right]^{-\frac{1}{b2}} * e^{-\frac{b6}{b2} * S} \qquad (4.2)$$

When evaluated at some specific value for d and the other variables, equation 4.2 provides an estimate of an amount that 50 percent of the respondents would be willing to pay to avoid the specified level of d. Because this is a median WTP function, it cannot be used to estimate an aggregate WTP in the same way that a mean WTP function could. For this sample, the median is considerably below the mean so that multiplying the median WTP times the number of people affected would understate total WTP.

The estimated coefficients for equation 4.1 are presented in Table 4.2 Most of the variables show statistically significant coefficients in the equations for the different sym ptoms. The coefficients for m, d, M and D have the hypothesized signs, The m, d, and M coefficients are significant at the 99 percent level in every equation. The coefficient for D is significant at the 90 percent level for severe shortness of breath, minor and severe head congestion and minor coughing/sneezing, but is small in its effect on the median WTP.

Table 4.2

OLS Regression Results

Symptom Equation	Coefficients									
	ln m	ln d	ln M	ln D	% Retired	% Female	% Insured	% Employed	C	R^2
SSB	-0.7106	0.2809	0.4301	0.0464	2.943S	-0.1397	-1.9471	2. 12s1	-3.1291	
	(-42.09)	(1s.04)	(s.59)	(2.02)	(4.2s)	(-0.62)	(-s.74)	(4.24)	(- 4.37)	.674
MHC	-0.8654	0.2805	0.3067	0.0444	1.16s7	0.3031	-0.6967	0.9904	-2.3686	
	(-41.95)	(13.14)	(3.53)	(1.69)	(1.51)	(1.17)	(- 1.85)	(1 .72)	(-2.69)	.678
SHC	-0.7976	0.24%	0.2032	0.0464	2.0208		-1.3s34	1.8090	-1.0966	
	(-44. 14)	(12.6s)	(2.46)	(1.93)	(2.82)	(-0.11)	(-3.94)	(3.44)	(-1.4s)	.679
MCS	-0.6761	0.3274	0.234s	0.0s29	1.6784	0.0s11	-0.4691	1.2969	-2.2366	
	(-39.49)	(13.99)	(2.4s)	(1.66)	(1.96)	(o. 18)	(-1.19)	(2.11)	(2.52)	.869
0	-0.?891	0.2742	0.3169	-0.0103	2.0662	1.0585	-0.4191	1.2993	-3.5106	
	(36.s7}	(12.17)	(3.39)	(-0.38)	(2.s3)	(3.63)	(- 1.05)	(z 19)	(-4.02)	.84s
MSB	-0.8065	0.2S9	0.3010	0.0118	2.935S	0.0789	-1.122s	2.0280	-2.6799	
	(-42.70)	(12.56)	(3.39)	(0.46)	(3.88)	(0.31)	(-3.06)	(3.68)	(-3.23)	.677
H	-0.7637	0.2872	0.3287	0.03 18	2.2899	0.9006	-0.3322	1 .372a	-3.8996	
	(-34. 18)	(12.34)	(3.47)	(1.10)	(2.71)	(3.27)	(-0.82)	(2.23)	(-4.4s)	.83s
Scs	-0.7914	0.2737	0.3699	0.0346	2.6603	0.3046	-1.4973	1.7944	-3.0782	
	(-41.39)	(13.2s)	(4.46)	(1.35)	(3.57)	(1.24)	(-4.11)	(3.26)	(-3.60)	.072

Note: *SSB* . severe shortness of breath
MSB - minor shortness of breath
SHC = severe head congestion
MHC = minor head congestion
m = amount of money to be paid
M = income
"odds" = probability of a vote in favor of paying *m* to avoid *d* divided by one minus this probability

SCS - severe coughing and sneezing/eye irritation
MCS = minor coughing and sneezing/eye irritation
O = odor
H = haze
d = increase in days of illness
D - initial health index (a greater value indicates worse health).

t-statistics in parentheses

Dependent Variable is Log of the “Odds”

Source: Loehman & De (1982)

The coefficients for percentage retired and for percentage employed indicate a higher probability of people in. these categories being willing to pay a given amount to prevent symptoms. The authors suggest that a wealth effect could explain the positive coefficient for percentage retired, but poorer health and older age also could be factors. The negative coefficients for percentage insured indicate that having medical insurance coverage reduces the probability y of being willing to pay a given amount to prevent sym ptoms. This supports the authors' interpretation of the responses to the questionnaire as re fleeting individual willingness to pay and not necessarily re fleeting total social costs.

Table 4.3 gives some illustrative estimates of median individual WTP estimates for avoidance of the different symptoms for 1, 7, and 14 days. These are based on equation 4.2 evaluated at income (M) levels of $5,000, $15,000, and $30,000 and health status (D) levels of 2 days, 20 days, and 200 days.[3] Mean values were used for the other socio-economic variables throughout.The descriptive statistics for the sample groups indicate that about 75 percent of the sample had medical insurance, about 74 percent were employed, about 16 percent were retired and about 38 percent were female. However, using these values and the estimation results reported in Table 4.2 we derived slightly different, but similar, estimates to those reported in Table 4.3 To apply these results to a different population group it would be appropriate to' make these calculations using values for that group rather than using these sample characteristics.

The estimation results reported in Table 4.2 can be used to show what the median WTP would be for an individual without medical insurance. The differences are most significant for the severe symptoms. This makes sense in that medical care is more likely to be sought in response to these symptoms than for the minor symptoms. Using O percent for percentage insured instead of the 75 percent sample mean, the median WTP is about $80 to prevent one day of severe shortness of breath and about $30 each to prevent a day of severe head congestion or severe coughing and sneezing, as compared to values from Table 4.3 of about $10, $7, and $6. There was not enough information obtained in the survey to determine a precise relationship between the WTP estimates and cost of illness estimates that are based on time lost from work and medical expenditures, but it is clear from the effect of insurance that the WTP estimates do not re fleet the full costs of illness

[3] The mean days sick per year for the sample was about 21 days, so the estimates for D = 200 are based on very few observations.

Table 4.3

Predicted Median Bids for Symptom Days by Income and Initial Days of Illness

Days of Disease		D=2 Income 5,000	15,000	30,000	D=20 Income 5,000	15,000	30,000	D=200 Income 5,000	15,000	30,000
SSB	1	5.96	8.23	10.09	7.29	10.07	12.34	8.92	12.32	15.10
	7	13.79	19.05	23.35	16.87	23.31	28.57	20.65	28.52	34.96
	14	18.60	25.69	31.49	22.75	31.43	38.53	27.84	38.46	47.15
SHC	1	5.77	5.69	5.64	6.88	6.79	6.73	8.21	8.1.0	8.03
	7	11.45	11.29	11.19	13.67	13.48	13.36	16.31	16.09	15.95
	14	14.62	14.42	14.29	17.45	17.21	17.06	20.83	20.54	20.36
Scs	1	4.28	5.59	6.62	4.75	6.20	7.34	5.27	6.88	8.14
	7	9.04	11.81	13.97	10.03	13.10	15.50	11.13	14.53	17.20
	14	11.80	15.41	18.24	13.09	17.10	20.23	14.53	18.97	22.45
MSB	1	4.14	5.26	6.11	4.12	5.24	6.09	4.11	5.22	6.07
	7	8.15	10.35	12.03	8.12	10.31	11.99	8.09	10.27	11.95
	14	10.37	13.17	15.32	10.33	13.12	15.26	10,29	13.08	15.21
MHC	1	2.67	3.18	3.55	3.01	3.59	4.01	3.27	3.90	4.36
	7	5.28	6.29	7.03	5.96	7.10	7.93	6.48	7.72	8.63
	14	6.73	8.02	8.96	7.60	9.05	10.11	8.26	9.85	11.00
Mcs	1	2.16	2.43	2.62	2.47	2.78	3.00	2.82	3.18	3.42
	7	4.76	5.35	5.77	5.43	6.12	6.59	6.21	6.99	7.54
	14	6.30	7.09	7.64	7.20	8.10	8.73	8.22	9.26	9.98
‘o	1	2.12	2.88	3.49	2.04	2.77	3.36	1.96	2.66	3.23
	7	4.45	6.04	7.32	4.28	5.81	7.04	4.12	5.59	6.77
	14	5.79	7.86	9.53	5.57	7.56	9.16	5.36	7.27	8.11
H	1	1.85	2.73	3.48	1.88	2.77	3.54	1.91	2.82	3.59
	7	3.90	5.74	7.33	3.97	5.84	7.45	4.03	5.93	7.56
	14	5.09	7.49	9.56	5.17	7.61	9.71	5.25	7.73	9.80

Source: Provided by E. Loehman

Comments

This is a first effort to estimate WTP for specific health effects that are suspected of being caused or aggravated by air pollution. There are several limitations and problems with the survey design that reduce the applicability of the resulting WTP estimates for current policy and regulatory decisions. The approach used in this study shows potential for providing very useful information about WTP for reduction or prevention of morbidity, but future efforts will have to correct some of the specific problems in the application.

Transferring these results to other applications would be problematic for the various reasons discussed below, but the results do provide some information about WTP for these kinds of symptoms. They indicate that shortness of breath is almost twice as undesirable as coughing/sneezing, with head congestion in between. They also indicate that severe symptoms are somewhat more than twice as undesirable as minor symptoms, for the definitions of minor and severe that were given in the questionnaire. WTP responses were higher for both minor and severe symptoms than for haze and odor. Income was found to have a significant positive effect on WTP. The responses of men and women were not significantly different, Another important result was that having medical insurance had a significant negative effect on WTP.

A serious ambiguity in the wording of the WTP questions was whether the question was about a reduction in currently occurring symptoms or a prevention of additional symptoms. The direction of the hypothesized change in health can be expected to have a significant impact on the WTP estimates. Asking what they would pay to avoid symptoms does not make it clear which direction is being hypothesized. This could explain the surprisingly small increase in WTP for longer durations of symptoms. For example, the results suggest that three months of severe shortness of "breath is only ten times worse than one day of severe shortness of breath. This is hard to believe unless the respondents were thinking in terms of reductions in symptoms that they already experienced. Few of them would currently be experiencing three months of severe shortness of breath each year, so that a reduction of this amount would not be worth much to them. The authors interpreted the results as if they were for the prevention of additional symptoms, but this seems to have been inappropriate. More confidence probably can be placed in the responses concerning one day of symptoms than those for multiple days due to this ambiguity.

The authors' argument that median bids are more representative than **mean** bids is not entirely satisfying. WTP for changes in morbidity are not necessarily distributed normally across the population. It is possible that a small number of people (e.g., those who have chronic illnesses) could have much higher WTP than most people. Ambiguities in the survey questions about whether the change was a reduction in current days ill or a prevention of additional days ill could also have distorted the responses, as could have the range of choices and order of questions given. A switch to the use of median WTP does not seem appropriate unless these questions are addressed.

The goal of the study was to obtain WTP estimates for changes in symptoms of asthma or chronic bronchitis, but the results are probably applicable only for short term changes in respiratory symptoms, not for chronic changes in health. The questions referred to the frequency of common respiratory symptoms for specific amounts of time in a one year period. The responses might have been different if the respondents were told that the symptoms were associated with a chronic condition and could be expected to occur at some leve 1 throughout the ind ividual's lif etime. This implies a change in the individual% under lying health status, not just a short term change in symptoms. The survey questions seem to refer to short **term changes** in respiratory symptoms rattler than to effects related to chronic conditions.

Some additional comments should be made on the survey instrument itself. For each question the responders were to choose from ten diff erent dollar amounts. The first five ranged from $0 to $10 and the second five ranged from $15 to $1,000. This was necessary in order to keep the choices to a manageable number and provide a large range, but the change in the size of the increments between the choices could have distorted the responses. There were also many questions to answer, with each only a little different in the second part, which probably taxed the respondents' patience and concentration. Fewer questions probably would have been given better attention and possibly have improved the response rate. It was also not clear from the cover letter and introduction whether the household head or any family member should answer the questionnaire (it was not well designed for other family members) and there was some ambiguity in the introduction about whether WTP responses were to be for self only.

It is encouraging that a mailed questionnaire seemed to produce reasonable results in terms of completed and consistent responses, but more efforts need to be made to determine if respondents differ from nonrespondents. Follow-up calls to respondents and nonrespondents should be used to check for such things as differences in health that might cause some people to be more likely to respond than others. With such a difficult topic as WTP for health, respondents' reactions to the questionnaire should also be gauged in some way, in order to help interpret the results. This is more difficult in mailed questionnaires than in personal interviews, but needs to be explored before mailed questionnaires are accepted as an appropriate tool.

4.2 THE SOUTHERN CALIFORNIA ASTHMA STUDY (Rowe and Chestnut, 1984)[4]

This was a pilot study designed to supplement research underway at the UCLA School of Medicine concerning the effects of air pollution on people with asthma. The UCLA study was designed to determine the effects of day-to-day changes hi air pollution on the respiratory symptoms of asthmatics. Data on daily asthma symptoms were collected for about 90 subjects with diagnosed asthma from January 1983 through November 1983 in Glendora, California, a high pollution area east of Los Angeles. Subjects answered a background questionnaire, a daily diary and a brief bi-weekiy questionnaire. Rowe and Chestnut (1984) supplemented this information with two additional questionnaires for a subset of 82 subjects (64 adults and 18 children under 16 years old) during October and November 1983.

There were three primary goals of these additional questionnaires. The first was to estimate WTP (WTA) for changes in conditions that affect asthma symptoms. The second was to compare the components of WTP with estimates of the individual's cost of illness (COI). The third was to determine the importance of mitigating and defensive behavior as it affects WTP and as it may bias the results of epidemiological studies that are only able to observe health effects that actually have occurred.

Survey Instruments and Procedure

The first survey instrument was a daily diary completed for four weeks by each of the adult sub jects. The other instrument was a general questionnaire answered by each of

[4]This discussion is based on preliminary results since the final report had not been completed at the time of this writing.

the adult subjects and by the parents of the children subjects at the end of the observation portion of the study. Copies of both questionnaires are included in the Appendix.

Respondents were asked to select an asthma severity rating, on a seven point scale they were already using in the UCLA study, that represented the worst rating they would still consider a good day. Everything above this point they were told to consider a "bad asthma day" and several of the questions in the diary and in the general questionnaire referred to "bad asthma days." This allowed for differences between subjects in terms of what it meant to them for their asthma to be worse and provided a mechanism for asking questions about what individuals did in response to or in anticipation of what they considered to be worse asthma. Air pollution is expected to aggravate asthma, so asthma severity had to be defined in terms that made sense to the subject in order to ask questions about mitigating behavior and about marginal improvements in asthma. For interpersonal comparisons, another asthma severity measure was also defined based on respondent reported intensity and frequency of asthma symptoms.

The purpose of the daily diary was to supplement the information obtained in the UCLA study concerning daily asthma symptoms with information about how the sub jects may have changed their activities in response to or in anticipation of worse than normal asthma symptoms. The diaries were turned in to the UCLA staff at the regular biweekly meeting where questions were answered and ambiguous responses were clarified.

The general questionnaire was administered by the UCLA staff to adults and parents of children sub jects. The purpose of the general questionnaire was to identify ways in which asthma affects the subject's well-being and, where possible, to estimate economic measures of changes in well-being associated with changes in the frequency or severity of asthma symptoms. There were sections about the effect of asthma on:

- expenditures (medicine, equipment, medical care, etc.)
- work and school
- leisure activities
- household chores
- residential location

There were also WTP and WTA questions about changes in "bad asthma days" along with a question asking respondents to rank in importance a list of the five categories of benefits of having fewer bad asthma days that were covered in the preceding sections of the questionnaire. Parents of panel members who were under 16 years old were asked a shorter version of the general questionnaire, skipping the sections on work and household chores. (See Rowe and Chestnut, 1984, for this version).

There were two kinds of willingness to pay questions, one with regard to wages and working conditions that might affect asthma and the other with regard to taxes to support programs to reduce factors that aggravate asthma. Employed respondents who said that they believed their asthma could be affected by their working conditions were asked the wage reIated WTA questions. The questions referred to cutting in half or doubling the number of bad asthma days they currently experience. A payment card format was used. Respondents were given a list of 20 wage change amounts ranging from $0.00 to $10.00 per hour. They were instructed to select a listed amount or give any other amount. Zero bids and refusals were probed to determine whether they were true zero valuations or a reflection of objections to the question. For the tax program WTP question, all of the respondents were asked to estimate the maximum increase in taxes they would be willing to pay each year for a program to cut their bad asthma days in half by reducing pollens, dusts, air pollutants and other factors. They were shown a list of 29 dollar amounts ran&-ing from $0 to $10,000 and asked to select a listed amount or give any other amount. Zero bids again were probed.

Survey Results and Analysis

This study provides some quantitative information about the costs of asthma and what people would be willing to pay for a reduction in asthma. A considerable amount of qualitative information also was obtained about how asthma affects people% activities and behavior. This qualitative information does not translate into new WTP estimates, but suggests what might be important to consider in future WTP studies.

Medical and Related Expenditures. Asthma related expenditures, including doctor visits, hospitalization, medication, and special medical and household equipment purchased because of asthma were divided into one-time purchases and annual variable purchases. Since changes in air pollution are expected to cause marginal changes in asthma, it is the variable expenditures, which may fluctuate with asthma severity, that are of most interest. Mean variable expenditures re lated to the respondent's asthma were approximately $435 per year. When medical insurance coverage was considered, it was estimated that of this total amount the household paid an average of about $210 per year. Mean one-time expenditures were approximately $575, of which the household paid an average of about $485.

Regression analysis on variable medical costs paid by the household was conducted to determine how medical costs vary with asthma severity and other characteristics of the individual. Severity was measured as a combination of respondent reported frequency and severity of asthma symptoms. " The estimated elasticity of variable medical costs with respect to the severity variable was statistically significant and had a value of .92, indicating that variable medical costs can be expected to increase almost in proportion to an increase in severity. The coefficient on income was statistically insignificant indicating that these kinds of medical expenditures do not constitute a normal economic good, the consumption of which is expected to increase with income.

Work and School Loss. About 40 percent of the adult respondents said that their asthma has. affected their job choice or employment status, and the responses indicated" that about 60 percent of the students (children and adults) believed asthma affected their school performance. The employed respondents were asked if they thought that working conditions could affect their asthma and most of them said yes. WTP (WTA) questions were asked with regard to tradeoffs between changes in wages and changes in conditions that might be beneficial or detrimental to their asthma. The authors report that a high percentage of respondents objected to this question and concluded that this payment vehicle did not work very well.

Leisure Activities and Household Chores. Approximately 75 percent of the respondents said that their asthma affects their leisure activities. Eighty percent of the adults said that their asthma affects their ability to perform household chores.

WTP Estimates for a Reduction in Asthma Symptoms. The responses to the tax vehicle WTP question were checked for internal consistency and 65 of the 82 responses were retained for analysis. Based on this reduced sample, the mean annual bid for a 50 percent reduction in bad asthma days was about $400 , with a standard error of the mean of about $85. The average 50 percent reduction in the number of bad asthma days per year for this sample was 19 days, so this means an average of about $21 per bad asthma day reduced.

The tax bids were analyzed as a function of asthma severity and other characteristics of the respondent. A nonlinear functional form was used. The number of bad asthma days per year and the highest good day rating were both positively related to the individual's bid. income was insignificant. Table 4.4 gives the results of the estimated WTP function and some average WTP estimates per bad day reduced based on this analysis. The results indicate declining marginal utility of additional days reduced. The higher WTP estimates per day when the good day rating is higher are indicative of the more severe asthma symptoms implied by a bad day when the good day rating is higher.

Rankings of Benefits and Comparison of WTP and COI. The respondents were asked to rank five possible bene f its they might receive from having their asthma improve. The results are reported in Table 4.5. The reduction of discomfort and of leisure activity restrictions came out well ahead of medical expenditures and income effects. These latter two components were considered COI components because they represent medical expenditures and income lost due to illness, which are typically covered in COI estimates. The rankings for the two COI components were very close. The low ranking for the residential flexibility should be cautiously interpreted because it is based on the responses of a group of asthmatics who choose to live in an area with some of the highest ozone levels in the country. They obviously have not moved in order to reduce their exposure to factors that might aggravate their asthma and they may not be representative of other asthmatics in this regard.

The results of these rankings of possible benefits, the medical expenditure estimates, and the tax vehicle WTP responses were used to compare estimated average WTP for a 50 percent reduction in bad asthma days to an estimate of the average reduction in COI components only. It was estimated that medical expenditures incurred by the household on behalf of the individual would be reduced by about 46 percent if bad asthma days were reduced by 50 percent. (This was supported by an estimated elasticity of medical expenditures with respect to asthma severity of about .92.) Since income effects were ranked approximately the same as medical expenditures on average it was assumed that

Table 4.4

WTP for Reducing Bad Asthma Days

Dependent Variable = In (WTP tax bid)

Variable	Coefficient	t-ratio
Constant	.283	.078
In (# bad days reduced)	.565	4.25
In (highest good rating)	.973	1.43
in (variable medical expenditures)	-.043	-.280
In (income)	.292	.896
Sex	-.416	-.899
N ohs. 65		
F 5.276		
R2 .309		

Average WTP per Bad Day Redued*

		Number of Bad Days Reduced”			
Highest Good Day Rating**		1	5	15	50
1	(no symptoms)	$22	$11	$7	$4
2	(very mild symptoms)	43	21	13	8
3	(mild symptoms)	64	32	20	12
4	(moderate symptoms)	84	42	26	15

* Evaluated for males at the sample means of the other variables.

** This is the rating selected from a 7 point severity scale (7 = highest severity) that the respondent said was the highest rating he would still consider to be a good day. Bad days are days that would be rated more severe.

Source: Rowe and Chestnut (1984)

Table 4.5

Ranking of Benefits of Reducing Asthma

Benefit	Mean Implied Ranking[a]	SE of the Mean Ranking
Less discomfort	2.16	.16
Better chance to participate in leisure, recreation and social activities	2.89	.18
Lower expend iture on doctors, hospitals, medicines, special equipment and services	3.63	.20
Higher productivity y at work or ability to get higher wages and salaries	3.79	.20
More flexibility about where to live	4.88	.15

[a] This rating is based on value of 1 for the benefit ranked first, 2 for the second and so on, with 6 for those that were considered of no importance.

Source: Rowe and Chestnut (1984)

the dollar value of income effects would be about the same as the change in medical expenditures. The authors then compared the WTP bids from the tax question to these COI estimates using several different approaches and concluded that the WTP/COI ratio probably fell within the range of 1.6 and 2.3. This was based on a comparison of the average individual's WTP to the average individual's COL Using the rankings as the basis for the assumption that the component of WTP due to changes in medical expenditures equals the component of WTP due to income effects, presumes that because the rankings are about the same so would be the WTP for each of those two components.

Analysis of the Diary

The results of the daily diary indicate that many of the subjects accurately perceive air pollution conditions in that they indicated concern about air pollution on days when higher ambient levels did in fact occur. Many of the subjects also expected that their asthma might have been aggravated on days when air pollution was high, and these individuals were more likely to have worked less and spent less time on chores and activities on those days. This suggests that mitigation behavior is occurring.

Comments

An important result of this study is analysis concerning the relative importance of the different components of WTP. The results indicate that the individual's total WTP may be 1.6 to 2.3 times the individual's medical expenditures and income lost. This should be used cautiously since it is based on some rough approximations and assumptions about the appropriate interpretation of the ranking responses.

The medical expenditure estimates are fairly rough especially with regard to doctor's visits and hospitalization. They are more comprehensive than previous estimates, however, because they cover defensive expenditures that are not typically considered medical expenditures, such as air conditioning purchased because of asthma.

The transferability of the WTP estimates of this study is limited due to the subjective nature of the change in asthma severity used in the questions. The "bad asthma day" measure is not easily translated into an objective measure of severity and makes the WTP estimates difficult to transfer to other scenarios, since changes in "bad asthma days" is not a health effects measure used in other epidemiological studies.

The study was intended as a first attempt to explore WTP estimation and mitigation issues for a sample of individuals potentially sensitive to pollution. The sample is small and may not be representative of all asthmatics, nor of other groups sensitive to ozone or other air pollutants.

4.3 WTP SURVEYS FOR CHANGES IN AIR QUALITY

Three WTP surveys that have estimated values for" improvements in air quality have focused on health effects (Brookshire et al., 1979; Loehman et al., 1981; and Schulze et al., 1983). These studies are reviewed here because they provide evidence about factors that influence WTP (WTA) for changes in health and they provide examples of CV applications to health related topics, which can be instructive for future efforts. The WTP (WTA) results themselves are, however, not very useful in terms of providing estimates of value for changes in morbidity because respondents were asked to estimate WTP (WTA) for changes in air quality levels, not for specific changes in morbidity.

Valuing changes in air quality causes several problems. One is that air quality is associated with aesthetic and materials damage as we 11 as effects on human health. Even if respondents are told to focus on health effects, responses' to questions about changes in air pollution may still reflect their attitudes about all air pollution effects, not just health. Another problem is that the specific health effects of any particular change in air pollution are uncertain, especially with regard to an individual. It would be possible to use epidemiological evidence to estimate the change in risks of morbidity that could be expected to be associated with the change in air pollution.. Such an approach was suggested by Portney (1981) in order to derive an estimate of the value of a reduction in risks of mortality from the results of a property value study in which the implicit value of air quality was estimated. There are, however, several problems with this approach. One is that it assumes the average person knows the health effects of different levels of air pollution in order to say that. his WTP for a change in air pollution, or his willingness to pay a given price for a home, implies a bid for a specific change in health effects. Another is that typically there are several different kinds of health effects (including mortality) that could be expected to all be associated with a change in air pollution and it would be difficult to say what portion of the WTP estimate should be at tribu ted to each. A third is that changes in air pollution are associated with changes in risks of health effects, not certain changes in any individual's health, and it is not clear how the uncertainty will affect the responses to WTP (WTA) questions.

The reviews of these three studies describe the study design and the survey instrument, especially with regard to the characterization of health effects, and summarize the results that suggest something about WT P (WTA) for changes in morbidity.

Brookshire et al. (1979)

Brookshire et al. (1979) conducted a WTP survey in the Los Angeles area "concerning changes in visibility and health effects associated with different air pollution levels. This was a first effort to estimate WTP for reductions in air pollution in an urban area that could be compared with the results of a property value" study in the same area. Another focus of the study was to test for several different potential biases in the survey instrument design. Three levels of air quality that occur in the Los Angeles area were illustrated with photographs to show the cliff erences in visibility. Health effects were separated into acute and chronic effects and separate WTP estimates were obtained for each. Acute effects were described as:

Level A: 1/2 population experiences eye irritation
Level B: 1/4 population experiences eye irritation
Level C: no effects

Chronic effects were described as:

Level A: effects on respiratory and circulatory systems that could reduce life span up to 3 years

Level B: effects on respiratory and circulatory systems that could reduce life span up to 1 year

Level C: no effects

Respondents were asked first to estimate how much they would be willing to pay each month (on their utility bills or in an unspecified lump sum payment) to obtain a reduction in pollution levels. Respondents who lived in areas typified by pollution level A were asked their WTP for changes from A to B and A to C, those who lived in B areas were asked about changes from B to C, and those who lived in C areas were asked their WTP for changing the entire Los Angeles area to level C. The questions were asked in two different sequences: one started with visibility and then added acute health effects and then chronic health effects, and the other started with acute health effects and then added chronic health effects and then visibility. The change in the sequence of the questions did have an effect on the bids implied for each component, but the total bid appeared to be insensitive to the sequence of the questions. The mean bids are summarized in Table 4.6 The result that WTP for an improvement from B to C exceeds WTP for an improvement from A to C is unexpected but might be caused by the typically higher income levels in the less polluted areas.

The results indicate that on average the health effects bids make up about 65 percent of the total bids for changes in air quality, with the acute component being larger than the chronic component. The results in Table 4.6 show, however, that these proportions vary considerably across the different scenarios of air quality change. This variation and the differences in these proportions when the questions were asked in different sequence again point to the conclusion that it is difficult to separate the different categories of air pollution effects in this kind of WTP study.

The authors compared the property value study results and the CV study results. They found property value differentials associated with differences in pollution levels exceeded mean WTP from the CV study for comparable changes in pollution levels. This was what the authors had predicted.

Coments. As a first effort at a CV study concerning air quality in an urban area, this study contributed to the development of CV methods for estimating WTP for changes in pollution. The mean bids for each of the three components of the change in air quality effects for each community were not statistically different from zero in about 20 percent of the cases, but the small sample sizes (7 to 19 individuals in each of the 15 communities) could have been responsible. The defined change in health effects was limited because it only discussed changes in eye irritation and changes in life expectancy. The

Table 4.6

Mean Monthly WTP for Changes in Air Quality[a]

Air Quality Change	Mean Bid Acute Health	Mean Bid Chronic Health	Mean Bid All Effects (including visibility)
A to B	$4.66 (26)	$1.31 (26)	$9.96 (26)
A to C	$5.07 (28)	$3.23 (28)	$24.49 (28)
B to C	$10.20 (86)	$3.43 (85)	$ 20.32 (85)
C to C*	$12.96 (30)	$3.67 (30)	$24.53 (30)

[a] These are calculated from the community means reported in Brookshire et al. (1979), Table 4.4a. These are bids assuming a two-year cleanup. A ten-year cleanup was also considered, but was not found to significantly affect the bids. The number of respondents is given in parentheses. C* indicates area-wide improvement in air quality.

small sample size, wide variation in results, and incompleteness of the defined change in health effects indicate that the results should be considered illustrative, not useful for providing estimates of WTP for specific changes in morbidity.

Loehman et al. (1981)

Loehman et al. (1981) conducted a WTP survey in the San Francisco area concerning changes in air quality and focusing on human health and visibility. One goal of the study was to compare the results of a survey approach with the results of a property value method for estimating the value of reductions in air pollution, and to compare the study results with those of Brookshire et al. (1979). Several questions were asked concerning the respondents' perceptions of air pollution levels and related health effects to compare perceptions with physical measures. Perceived air quality levels were correlated with measured air quality levels, although measured levels did not explain all the differences in perceived levels.

The WTP questions were preceded by a description of the EPA Pollutants Standard Index (PSI) rating of air quality in terms of health. The respondents were given the information shown in Table 4.7. Photographs were used to illustrate non-polluted, moderate and poor levels of visibility. Six air quality areas were then defined in terms of the annual distribution of days with different levels of visibility and health. These are shown in Table 4.8. Areas A through E correspond to conditions *in* the respondents' areas of residence. Area F is a hypothetically worse area. Respondents were then asked the maximum amount they would be willing to pay each month to the Bay Area Air Quality Managemerit District to prevent or obtain a change in air quality in their area from its current level to each of the other levels. Note that some of the differences between areas were in. the distribution of health conditions only, some were visibility only and others were differences in both health and visibility conditions. The mean responses are shown in Table 4.9.

From the analysis of the differences in bids across respondents, the authors draw several interesting conclusions. One is that bids to avoid worse air quality were in most cases significantly higher than bids to obtain better air quality for the same size change. This highlights the concern raised in the discussion of the Florida study that the framing of the question can have a significant effect on the responses. The analysis also revealed

Table 4.7

Information Given to Respondents on Health Effects Related to Air Quality

Level of Air Quality	Health Effects	Likelihood of Effects and Limitations
Good	No health effects	None
Moderate	Eye irritation	Affects few persons
Unhealthful	Eye irritation Breathing problems	Affects some persons Persons with lung or heart disease should reduce physical activity
Very Unhealthful	Eye irritation Breathing problems Coughing Headaches Reduced alertness	Affects most persons Children, elderly, and persons with lung or heart disease should stay indoors and reduce physical activity
Hazardous	Eye irritation Breathing problems Coughing Headaches Reduced alertness Nausea Possible premature death for ill	Affects almost everyone Children, elderly and parsons with lung or heart disease should stay indoors and avoid physical activity. General population should avoid outdoor activity.

source: Loehman et al. (1981)

Table 4.8

Information Given to Respondents on Definition of Air Quality Areas

	Area A	Area B	Area C	Area D	Area E	Area F
Visibility						
Non-Polluted Days	330	265	330	265	265	205
Moderate Days	20	70	20	70	70	100
Poor Days	15	30	15	30	30	60
Health						
Good Days	294	294	232	232	191	161
Moderate Days	70	70	130	130	150	140
Unhealthful Days	1	1	3	3	20	50
Very Unhealthful Days	0	0	0	0	4	12
Hazardous Days	0	0	0	0	0	2

Source: Loehman et al. (1981)

Table 5.9

Average Monthly Willingness to Pay for Changes
By Air Quality Area, All Respondents

Change from \ to	A	B	C	D	E	F	(Number of Respondents)
A	•	12.5 (17.53)[a]	13.75 18.08)	21.11 (20.73)	38.33 (28.61)	60 (36.83)	(9)
B	5.80 (11.39)	•	6.13 (9.02)	7.70 (11.02)	12.23 (16.95)	16.63 (19.19)	(145)
C	10.78 (16.27)	6.36 (11.20)	•	7.98 ([illegible]2.51)	14.18 (15.06)	24.39 (25.71)	(64)
D	10.08 (13.94)	7.70 (12.46)	5.96 (12.56)	•	9.48 (12.77)	16.46 (19.18)	(83)
E	9.35 (15.97)	6.44 (9.84)	3.79 (6.37)	3 (5.53)	•	13 (21.09)	(43)

[a] Standard deviation in parentheses

NOTE: To obtain Standard errors of these mean bids, the deviations must be divided by the square root of the umb of that when health and visibility conditions were both changed, the bids were significantly different than the sum of the bids when the same changes in health and visibility conditions were considered separately. To obtain an improvement in air quality, the sums were greater than the combined bids. To prevent a deterioration in air quality, the sums were less than the combined bids. This supports the point that separating WTP for health from WTP for other air pollution impacts may not be as simple as just asking respondents to think about health.

Some characteristics of the respondents were also found to have a significant effect on the bids. Bids were found to-be significantly higher for those who smoked and for those who were in worse health. Both of these groups of people are likely to be at higher risk of suffering health effects from air pollution. Those with higher incomes also bid significantly more.

The results of the property value study were comparable to the CV study results. Average annual household WTP from the property value study for a 30 percent improvement in overall air quality was $63 to $98, depending on the pollution measure used. The average annual household WTP from the bid function estimated with the CV results varied considerably with the bid function specification, but was in the range of $51 to $81. The analysis of the CV results indicated that values for health effects comprised about half of the WTP bid, on average.

Comments. This was a carefully designed and executed study concerning WTP for changes in air quality, although questions remain about the adequacy of the presentation of air quality diff erences and about the representativeness of the respondents. The information provided concerning the different levels of health effects was an improvement over that used in the BrookShire et al. (1979) study.

The mean WTP estimates based on the property value study and the CV study are considerably lower than those from. Brookshire et al., indicating that values may not be transferable across different population groups and across areas with different air pollution problems. The variability in mean WTP estimations when specifications of WTP functions were changed are indicative of the imprecision in these estimation approaches.

The finding that WTP bids to prevent health and aesthetic effects are not strictly additive is important for future CV studies concerning WTP for air pollution related health effects. It indicates that individuals may value air quality as a whole and may have di f-ficulty separating concern about health effects from aesthetic effects.

Schulze et al. (1983)

Schulze et al. (1983) conducted a WTP survey in the Los Angeles area during December 1982, which focused on a widely publicized high ozone episode over the previous Labor Day holiday. interviews and mailed questionnaires were used, since one of the purposes of the study was to test whether consistent results would be obtained with a mailed questionnaire versus personal interviews. If so, this would support the use of much less expensive mailed questionnaires.

Respondents were shown a chart of daily maximum ozone levels during August and September 1982. The chart was divided into good, fair, poor and very poor ozone levels and the ozone induced effects that could be expected at each leve 1 were listed. The chart for the San Gabriel Valley, the area with the. highest "pollution levels covered in the study, is shown in Figure 4.1. Respondents were asked if they or any family member had experienced any of the "ozone-induced" effects listed on the chart during the Labor Day pollution episode. The y were then asked WTP questions which were worded as follows:

> What is the most your household would be willing' to pay to reduce the daily high ozone reading on that day from VERY POOR to POOR?

The, change in ozone levels they were asked to consider depended on how high the level had been in their area during that episode. For example, residents in the San Gabriel Valley were asked to value changes from VERY POOR to POOR, VERY POOR to FAIR, and VERY POOR to GOOD. Respondents were asked to select a value from a *list* of 32 dollar amounts that ranged from $0 to $100. A total of 114 interview and 177 mailed questionnaires were completed. Table 4.10 gives the ranges of the mean WTP responses for each community.

The results show no clear pattern of differences between interview and mailed responses and the analysis indicated the re were no statistically significant cliff erences bet ween

Figure 4.1

Illustration of Helath Effects Associated with Different Levels of Ozone

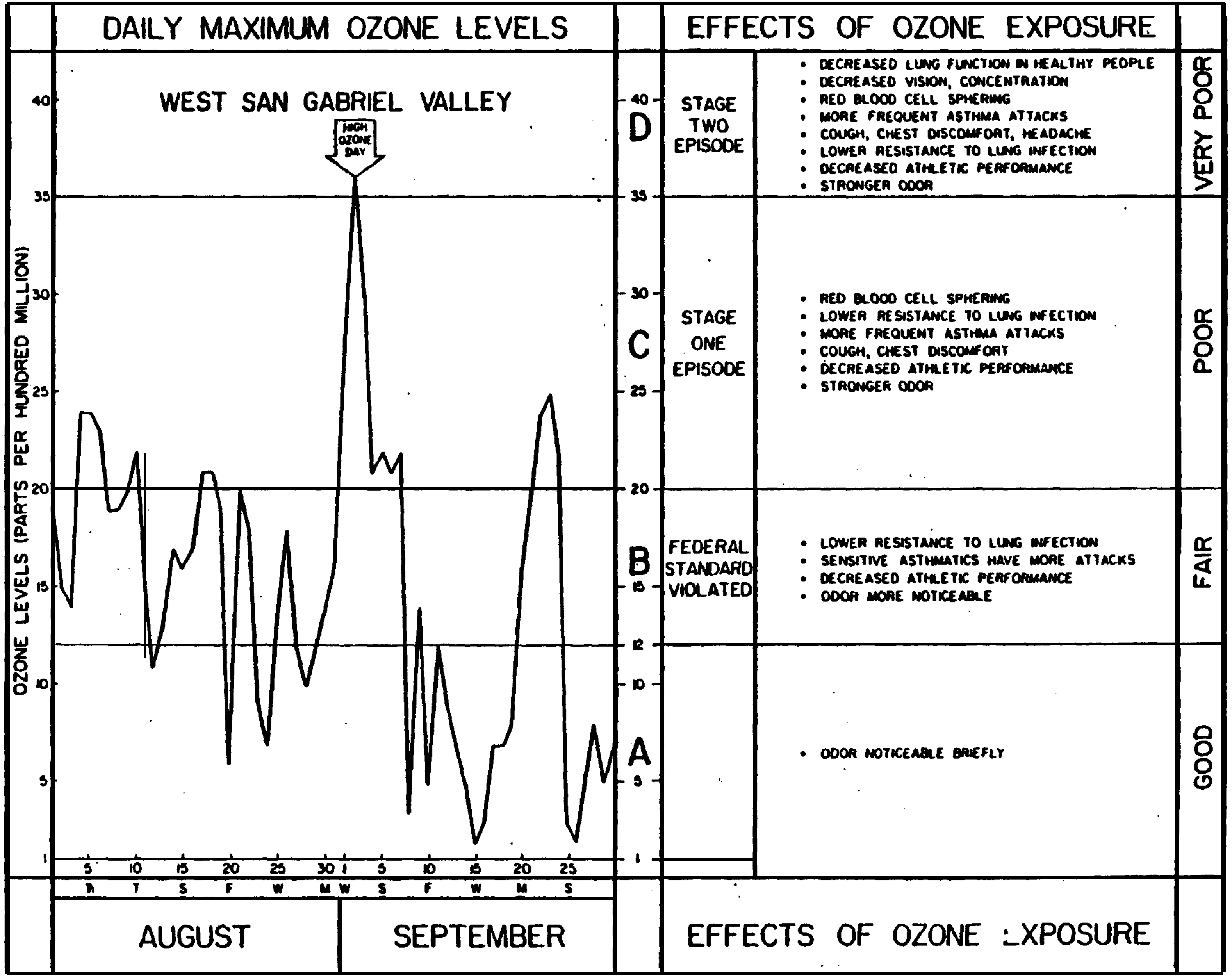

Table 4.10

Mean WTP Responses for Changes in Air Pollution in the Los Angeles Area

Air Pollution Change	Range of Mean Responses for Each Community	
Very Poor to Poor	$ 3.61 to	$15.92 (interview)
	$1.82 to	$9.70 (mailed)
Very Poor to Fair	$5.17 to	$16.92 (interview)
	$3.73 to	$13.66 (mailed)
Very Poor to Good	$11.30 to	$24.75 (interview)
	$15.86 to	$20.97 (mailed)
Poor to Fair	$2.57 to	$ 4.82 (interview)
	$7.53 to	$8.18 (mailed)
Poor to Good	$3.23 to	$8.59 (interview)
	$7.75 to	$12.21 (mailed)
Fair to Good	$9.83 to	$16.08 (interview)
	$4.46 to	$4.77 (mailed)

Source: Schulze et al. (1983)

them. This is, in part, a result of a very large variation in the responses for both types of instruments and is not particularly strong evidence in support of consistency. The socio-economic characteristics of the respondents explained, at best, about one-third of the variation in bids in each community. The most consistently significant variable was an index of outdoor activities which indicated that individuals who spent more time in outdoor activities had higher bids for reductions in pollution. Household income was generally not statistically significant.

Comments. This study provides some interesting results concerning factors that affect WTP for changes in air quality, but the WTP estimates themselves are not very useful due to ambiguities in the survey instrument. The most important problem with the survey instrument is that the change in air quality is not clearly defined. The differences in pollution levels are nicely illustrated as shown in Figure 4.1, but asking WTP for. a reduction in pollution for one day that has already passed introduces a great deal of confusion. Does it mean that pollution would "be lowered throughout the year in order to bring down the peak levels? Does the question ask what you would pay to have prevented that pollution incident or to prevent similar ones in the future, since obviously the past. cannot be undone? The lack of a clear payment mechanism by which funds would go toward pollution reduction also reduces the credibility of the question.

4.4 CONCLUSIONS

Two contingent valuation studies were reviewed in this chapter that have estimated values for specific pollution-induced changes in morbidity. Loehman et al. (1979) focused on prevention of three kinds of respiratory symptoms and Rowe and Chestnut (1984) focused on changes in the frequency of "bad asthma days." These do not provide a very comprehensive coverage of the types of morbidity that are of interest in environmental policy analysis and without verification of repeated estimation of similar values in different applications of contingent valuation techniques, the estimates should be viewed as preliminary.

The results of the Florida study (Loehman et al. 1979) may be applicable for evaluation of programs to prevent or reduce short term respiratory symptoms. Median WTP estimates obtained were highest for shortness of breath and lowest for coughing/sneezing.

Median WTP to prevent one day of minor symptoms ranged from about \$3 to \$8, and to prevent one day of severe symptoms ranged from about \$11 to \$18 (in 1983 dollars).

The results of the asthma study (Rowe and chestnut, 1984) indicate that WTP to reduce asthma symptoms may be 1.6 to 23 times medical expenditures and income loss incurred by the household as a result of asthma. Average WTP to reduce one bad asthma day was \$21 (in 1983 dollars).

Three additional contingent valuation studies (Brookshire et al. 1979, Loehman et al. 1981 and Schulze et al. 1983) have found people are willing to pay substantial amounts in order to improve air quality, where health and other effects were used to describe what improvements in air quality would mean. The changes in health effects were defined very broadly in these studies, so the results do not provide estimates of WTP for specific changes in morbidity. They do, however provide evidence that WTP for changes in health effects can be expected to be influenced by income, current health status and by whether the hypothesized change is an improvement or a deterioration in health related air quality conditions. They also provide evidence that health and aesthetic effects of air pollution may not be separable from the general population's point of view.

Table 4.11 provides a summary of factors found to influence individuals' WTP for changes in morbidity or health related air quality conditions. Several studies found that WTP was significant ly related to income, with WTP increasing with higher income levels. Several studies also found the current health status was related to WTP, with those in poorer health having higher WTP for reductions in health effects. Only one study included medical insurance in the WTP analysis, but it was found that having insurance was associated with significantly lower WTP, this confirms that individuals are giving WTP responses on the basis of costs they incur, which might be quite different from society's costs.

Table 4.11

Factors Affecting Individuals' WTP

Study	Income	Current Health	Age	Sex	Outdoor Activity Level	Medical Insurance Coverage
Loehman et al. (1979) & Loehman and De (1982)	Yes	Yes	Yes	No	N.T.	Yes
Rowe and Chestnut (1984)	No	Yes	N.T.	No	N.T.	N.T.
Schulze et al. (1983)	No	N.T.	N.T.	N.T.	Yes	N.T.
Loehman et al. (1981)	Yes	Yes	N.T.	N.T.	N.T.	N.T.
Brookshire et al. (1979)	Yes	N.T.	N.T.	N.T.	N.T.	N.T.

N.T. = Not Tested

5.0 HEALTH INDEX AND UTILITY FUNCTION APROACHES

Health status index studies involve a subjective weighting of different health outcomes. A numeric scale is typically developed, often a zero to one scale, that rates different health states in terms of their relative disutility. These indices have not been specifically applied to pollution-induced morbidity, but they may provide a useful starting point for environmental benefits studies. These health measures are disease independent and they are sensitive to the specific factors that affect quality of life. Having a health measure that is disease or cause independent is important since there is a wide variety of different health effects; as' well as differing degrees of severity and length. It would be a difficult, if not an impossible, task to obtain economic benefits estimates for all possible lengths of time and degrees of severity for each disease or ailment. It would be a considerable advantage to be able to construct a health status index where each health state of this one index is valued and then used to obtain values for the myriad diseases or ailments that resulted in" that health state. Also, it is intuitive ly appealing to base the monetary valuation of health effects on the reduced activity or function that results since these are the factors that influence the quality of life.

The emphasis of these health measures is on the function/dysfunction aspects of the illness or affliction. This functional approach includes such things as the performance of activities usual for an individual's social role as well as certain "quality of life" aspects. Health status can then range from optimal function to different levels of dysfunction. Factors to be condidered could include the individual's independence, mobility, ability to communicate and work effectively, and other deviations from what would be considered normal well-being.

To date, the efforts to measure health status have explicitly avoided using dollar values as the unit measure. Instead, the procedure has been to scale subjective preferences for health status into a function or index that typically ranges between 0 and 1 using psy-chometric methods or the von Neumann-Morgenstern standard gamble approach. The indices produced by these techniques can be used to perform cost-effectiveness analyses;

that is, they can be used to maximize the derived health status index given a fixed level of resources to be devoted to this purpose. However, as they currently stand they cannot be used to address what is often the more pressing question of how many resources should be devoted to environmental health protection, the benefit-cost question of interest.

This chapter presents several different methods that have been used to characterize health status and then discusses how these characterizations could be used in a benefits framework. Section 5.1 discusses the instruction of health indices using techniques common to the psychometric scaling literature. These indices are based on rankings of several attributes of health (commonly called health dimensions) that would occur with certainty. The problem is to combine these rankings of individual attributes or dimensions into a multi-dimensional index that reflects the relative contribution of each attribute to overall health. Of the many published applications of health indices, applications by Sintonen (1981) and Rosser and Kind (1978) are selected to illustrate these techniques. Section 5.2 of the chapter presents an application of the multi-attribute utility (MAU) method for constructing preference orderings of health states. The primary difference between the MAU method and the psychometric methods is that the MAU method uses a scaling technique that evaluates health states that are not certain, i.e., are associated with probabilities less than one. Torrance et al. (1982) is used as an example. Section 5.3 discusses different approaches for evaluating alternative durations of health states. Section 5.4 summarizes the conclusions that can be drawn from the work in these research areas and discusses how they can be used for benefits studies.

5.1 PSYCHOMETRIC TECHNIQUES FOR MEASURING HEALTH STATES

Reviews of the literature pertaining to the construction of health state indices can be found in Rosser and Kind (1978), Mushkin (1979a), and Kaplan and Ernst (1983). Also, the National Center for Health Statistics maintains a bibliography of research on health indices through a research clearing house. Two approaches using psychometric scaling techniques will be presented in this section. Rosser and Kind (1978) define 29 different health states. This manageable number of health states allows for an index value to be directly estimated for each state. In contrast to the Rosser and Kind approach, Sintonen (1981) uses twelve health dimensions each with between four and seven levels. This framework results in several million health states (i.e., combinations of health dimensions and levels). As a result, Sintonen (1981) must use an indirect approach to constructing a health index that allows a value to be placed on each possible health state.

5.1.1 Discussion of* Rosser and Kind (1978) Direct Health State Index Approach

The goal of the Rosser and Kind (1978) effort was to obtain a ratio scale of different health states, that is, a scale that represents the relative undesirability of each state. A two dimensional health state classification was used:

Dimension 1- Disability

1. No disability
2. Slight social disability
3. Severe social disability and/or slight impairment of performance at work. Able to do all housework except very heavy tasks.
4. Choice of work or performance at work very severely limited. House-wives and old people able to do light housework only but able to go out shopping.
5. Unable to undertake any paid employment. Unable to continue any education. Old people confined to home except for escorted outings and short walks and "unable. to do shopping. House-wives able only to perform a few simple tasks.
6. Confined to chair or to wheel chair "or able to move around in the home only with support from an assistant.
7. Confined to bed.
8. Unconscious.

Dimension 2- Distress (Pain)

1. No Distress
2. Mild
3. Moderate
4. Severe

This classification resulted in 29 health states since only one level of distress was felt to be appropriate for the disability state 3- unconsciousness.

The subjects for the experiment were selected to encompass individuals with different experiences of illness. The subjects came from six groups:

Group 1: Ten patients from medical wards

Group 2: Ten psychiatric in-patients

Group 3: Ten experienced state registered general nurses.

Group 4: Ten experienced state registered psychiatric nurses

Group 5: Twenty healthy volunteers

Group 6: Ten doctors sufficiently experienced to have gained a Membership or Fellowship of at least. one Royal College.

Additional socioeconomic data and experience of illness were collected for each individual.

The procedure used to develop the ranking scale was to present the subject with two cards each depicting a health state such as those in Table 5.1. The subject was asked "How many times more ill is a person described as being in state A as compared with state 0?" To assist the subject in their rankings, several assure ptions were specified:

a) The descriptions are of people who are all of the same age - either young adults or middle aged.

b) All states have the same prognosis. All can be cured if the sufferer is treated, but if left untreated will remain static until some other condition supervenes.

The second of these proved difficult to maintain and had to be frequently reiterated.

The subject was told that this was the most difficult stage in the entire interview and that he should consider the time spent on it as unlimited. Because there were a variety of im plications in his decision, it was suggested that he might like to consider these before he chose a number. The im placations described were:

a) The ratio will define the proportion of resources such as time of trained personnel, money, equipment, etc. that you would consider it was justifiable to allocate for the relief of a person in the more severe state as compared with the less ill.

Table 5.1

Health State Descriptions used in Rosser and Kind (1978)

Health State Description	Dimension Levels: Disability Level	Dimension Levels: Distress Level
A. Can work normally, do everything at home and have a normal social life. In moderate pain which is not relieved by aspirin.	1	3
B. Can work normally and do all household tasks. Illness interferes with some hobbies and leisure activities. In severe pain for which heroin is prescribed.	2	4
C. Too ill to work but can move around independently. At home can only do a few light jobs. In moderate pain. which is not relieved by aspirin.	5	3
D. Can only move around in a wheelchair. Has slight pain which is relieved by aspirin.	6	2
E. Confined to bed. Has slight pain which is relieved by aspirin.	7	2
F. Confined to bed. In severe pain for which heroin is prescribed.	7	4

Source: Rosser and Kind (1978).

b) The ratio will define your point of indifference between curing one of the more ill people or a number (specified by the ratio) of the less ill people.

Once ratios were determined for all 29 states using this procedure, the subject was then asked to change the assure ptions regarding treatment. None of the states would be treated -- they were permanent states. The subject was asked to adjust the scale given this new information. The subject was also asked to place the state of death on the scale of permanent states.

The interviews ranged from 1.5 to 4.5 hours. Rosser and Kind (1978) also incorporated a number of internal consistency checks into their elicitation that could be used to test the reliability of the index. These included the re-testing of ten subjects. In addition, methods other than the ratio method were employed on some subjects. These included the method of fractionation. This method first has the subject identify the worst state, then identify a state half as severe as the worst state. The next step is to find the state that lies halfway between these two states.

Interview Results

Rosser and Kind (1978) reported that the subjects found the interview experience to be both painful and relevant. The subjects indicated that they felt that their perceptions had changed as a result of the experiment. This indicates that the individuals may not have had well formed values prior to participating in the experiment. The ten subjects who were subjected to retesting on six selected states showed a correlation of 97.2 percent. The internal consistency checks also showed most subjects were internally consistent.

The results of the ranking method are shown in Table 5.2 by subject groups. Two subject groups – psychiatric patients and psychiatric nurses - constructed scales that were much steeper (i.e., the worst states were rated as many times worse than relatively healthy states) than those constructed by the other groups. Table 5.3 presents the median scale-values derived from all 70 subject rankings.

Table 5.2

Median Scale Values for Six Subject Groups

	Medical patients	Psychiatric patients	Medical nurses	Psychiatric nurses	Healthy volunteers	Doctors
1.2	1.00	1.00	1.00	1.00	1.00	1.00
1.3	1.75	3.17	2.00	2.25	2.00	7.00
1.4	2.90	7.50	5.06	8.75	9.75	26.88
2.1	1.68	3.60	1.55	2.14	2.00	2.50
2.2	2.30	4.00	2.00	3.17	2.47	3.50
2.3	4.00	6.83	3.31	7.25	4.65	17.50
2.4	8.00	20.00	8.86	25.83	11.00	30.47
3.1	2.51	6.50	3.70	5.42	3.00	7.00
3.2	4.25	7.25	4.10	6.75	3.67	11.25
3.3	5.25	10.00	5.27	8.75	8.25	19.75
3.4	10.67	37.50	11.00	51.25	15.22	43.13
4.1	5.75	10.75	4.60	8.66	4.40	10.00
4.2	6.17	12.25	5.20	10.00	7.50	14.50
4.3	7.92	17.00	6.90	11.21	10.75	31.25
4.4	13.33	45.63	16.67	55.00	20.67	105.63
5.1	9.50	19.75	8.26	13.33	6.83	16.50
5.2	11.25	21.50	9.61	16.43	9.70	17.60
5.3	12.17	25.00	22.67	17.62	22.25	40.00
5.4	20.00	115.00	49.00	62.50	106.67	181.25
6.1	17.17	63.33	20.60	31.67	26.00	26.00
6.2	19.00	75.00	23.25	65.50	32.00	29.50
6.3	30.00	157.50	51.67	85.00	60.00	91.25
6.4	70.00	1050.00	94.50	2 50.00	284.13	234.38
7.1	45.00	227.50	7100	160.00	46.75	64.38
7.2	78.67	225.00	78.20	193.18	49.63	71.26
7.3	125.00	700.00	187.50	378.57	175.00	130.00
7.4	310.00	1710.00	384.00	1107.64	576.00	427.50
8.1	177.78	1800.00	423.33	460.71	232.14	270.00

Table 5.3

Median Scale Values for All 70 Subjects

		Distress State: 1.	2.	3.	4.
Disability State	1.		1.00	2.00	6.67
	2.	2.00	2.70	5.45	13.50
	3.	4.00	5.53	8.75	17.50
	4.	7.25	8.70	11.67	26.00
	5.	10.85	13.03	20.00	60.00
	6.	25.00	31.00	64.00	200.00
	7.	64.50	87.20	200.00	497.14
	8.	405.71			

Note: When scale refers to permanent states. Score for death is 200.00.

Source: Rosser and Kind (1978)

Comments

The procedures used by Rosser and Kind (1978) were carefully and thoughtfully implemented. A ratio scale was constructed that provided an index measure of relative disutility for different health states. The ratio measures were found to vary with current experience of illness, but were not found to vary with other socioeconomic or personal data. The rankings were independent of age, sex, socioeconomic group, religion and past medical history.

The ratio based health index constructed by Rosser and Kind (1978) could be used to evaluate the cost ef festiveness of expenditures but cannot be used to assess the magnitude of total benefits obtained from health expenditures. There still remain some questions concerning whether theirs is an adequate consensus index. Several of the subject groups produced much steeper indices that rated bad health states as many more times worse than the better health states. There remain practical questions regarding what should be done with this variability, such as whether an average or median value is adequate for policy decisions.

It is of interest to note that the results reported in Table 5.3 indicate that two states were considered worse than death. These were 1) unconscious with no distress and 2) confined to bed with severe distress. This suggests that WTP to avoid increased likelihood of severe morbidity might in some cases exceed WTP to avoid increased likelihood of death.

5.1.2 Discussion of the sintonen (1981) Indirect Health state Index Approach

Sintonen (1981) applies two standard psychometric scaling techniques to a sample of 120 individuals. The use of a general public sampIe makes the Sintonen (1981) study unique. Other identified studies used samples of college students or health professionals rather than the general public.

Sintonen (1981) uses three methodological steps to construct a health index:

(1) the selection of the dimensions in which health is to be measured;

(2) the division of each dimension into a number of discrete levels (or descriptive statements) which can be used to characterize better or worse health states within that dimension;

(3) the relative valuation (i.e. non monetary indexing) of the combinations of levels in the dimensions that comprise the different health states.

The dimensions were selected by Sintonen (1981) to reflect three major components of health: perceived health, psycho-physical functioning, and social functioning. The end result was 12 dimensions in which health was to be measured:

(1) perceived health
(2) breathing
(3) seeing
(4) sleeping
(5) moving
(6) communicating
(7) eating
(8) mental functioning
(9) incontinence
(10) hearing
(11) working
(12) social participation

Each health dimension was then divided into discrete levels. These dimensions and levels are shown in Table 5.4. The estimated weights for the dimensions and levels are also shown in Table 5.4. The development of these weights is discussed below.” Twelve dimensions each with between four and seven discrete levels results in several million possible combinations which form the individual health states. This large number of health states makes a direct valuation approach, i.e., a state by state valuation, impossible. instead Sintonen uses an indirect, two stage approach. Following work by Fishbum (1967) on the estimation of additive utility functions, Sintonen assumes that the dimensions are independent and that the index value to be assigned to each combination of levels (i.e. each health state) can be expressed as a weighted sum of the index values placed on each dimension. This assumption of additivity is questionable, yet Sintonen argues that it is better to proceed recognizing that the results are an approximation rather than not attempting to address the issue.

The additive model used by Sintonen is:

$$V^i = \sum_{j=1}^{m} I_j^i \, w_j^i \, (X_j) \qquad (5.1)$$

Table 5.4

Levels of Health Dimensions end w^i_j (Xj) Weights for Each Level

	Magnitude		Category	
Moving	Mean	SD	Mean	SD
—is able to move (walk) normal: i.e. without difficulties indoors. outdoors and on stairs	Loo	0.00	0.99	0.02
—is able to move (walk) without difficulties indoors. but outdoora and/or on stairs with difficulties	0.72	0.24	0.61	0.33
—is able to move (walk) without help indoors (with or without appliances). but outdoore and/or on stairs only with help from others	0.51	0.25	0.45	0.30
—u able to move (walk) only with help from others indoors ako	0.34	0.23	0.25	0.25
—conscious.but completely bed-ridden and unable to move about: if helped may sit on a chair	0.15	0.20	0.09	0.20
—unconscious	0.04	0.05	0.04	0.11
—dead	0.02	0.06	0.07	0.18
Hearing				
—hears normally(i.e. well) normal voice (with or without a hearing aid)	1.00	0.00	0.99	0.03
—hears normal voia with difficulty, in conversation louder than normal voice has to be used	0.65	0.25	0.56	0.31
—hears even loud voice poorly. almost deaf	0.37	0.23	0.29	0.25
—conscious,but completely deaf	0.20	0.18	0.14	0.17
Speaking				
—is abk 10 speak normally. i.e. clearly and fluently	1.00	0.00	0.99	0.03
—is abk to speak incoherently. but understandably, voice trembles or changes pitch, stuttering speech	0.60	0.28	0.49	0.30
-speech so slurred and confused that others have difficulties in understanding	0.32	0.21	0.22	0.22
—conscious, but dumb or speech not at all understandable, communicates only by gestures	0.17	0.16	0.15	0.18
Seeing				
—sees normally. I.e. sees to read a paper without difficulty either with or without glasses	1.00	0.00	0.99	0.03
—sees to read a paper with difficulty either with or without glassess	0.69	0.24	0.63	0.29
-does not see 10 read a paper with or without glasses. but seas to move about without a guide	0.42	0.22	0.42	0.28
—conscious. but does not see to move about without a guide. i.e. almost or completely blind	0.17	0.16	0.17	0.18
Working				
—is abk to do paid work or household work normally	1.00	0.00	0.98	0.08
-is abk to do paid work or household work with slightly reduced efficiency or with slight difficulty	0.74	0.23	0.73	0.22
—is able to do paid work or household work with considerably reduced efficiency or with considerable difficulty. abk to accomplish only ● put of usual teaks at work or ● t home	0.45	0.19	0.46	0.24
-is abk to accomplish only a small part of usual tasks at work or at home, almost unable to work	0.27	0.17	0.32	0.24
—completely unabk to work	0.15	0.15	0.13	0.14
Breathing				
-k abk to breathe" normally, i.e. no shortness of breath or other difficulty in breathing	Loo	0.00	0.99	0.03
—*shortness of breath* when quickening one's pace 0ss even ground	0.68	0.24	0.62	0.27
—shortness of breath on even ground at the walking pace of other of the same age	0.53	0.23	0.49	0.26
-must atop because of shortness of breath when walking ● t one's own pace on even ground	0.36	0.19	0.35	0.24
—shortness of breath when dressing, washing or at rest	0.21	0.16	0.21	0.21
Incontinence				
-is abk to control the bladder and bowels normally, never "accidents'	Loo	0.00	0.99	0.03
—occasional difficulty in controlling the bladder and/or bowels, sometimes 'accidents'	0.57	0.26	0S0	0.30
-regular difficulty in controlling the bladder and/or bowels, quite often 'accidents'	0.30	0.20	0.24	0.22
—conscious, but completely incontinent	0.13	0.13	0.07	0.10
Sleeping				
—is able to sleep normally, i.e. no problems with sleeping	1.00	0.00	0.98	0.08
—slight difficulty m sleeping, e.g. difficulty in falling asleep, wakes up too early. wakes up occasionall y e.g. because of shortness of breath	0.69	0.24	0.51	0.28
—considerable difficult y in sleeping e.g. must use often or regularly sleeping pills wakes up regularly 1-2 times a night e.g. because of shortness of breath	0.41	0.20	0.25	0.21
—suffers from serious sleeplessness. e.g. difficulty in sleeping even with sleeping pills, is ● wake moat of the night e.g. because of shortness of breath	0.20	0.17	0.11	

Table 5.4 (Cont'd.)

Eating				
—is able to eat normally by oneself without any difficulty or help	Loo	0.00	1.00	0.00
—is able to eat by oneself without help, but with difficulty (e.g. slowly or with special appliances)	0.70	0.23	0.55	0.33
—needs some help from others in eating	0.49	0.22	0.40	0.28
—unable to eat by oneself at all, must be fed by others	0.26	0.19	0.16	0.15
—conscious, but unable to eat by oneself at all, must be fed through tubes or intravenous fluids	0.11	0.14	0.06	0.08
Intellectual or mental functioning				
—intellectual or mental functioning normal, i.e. is able to think dearly, rationally and logically ● nd make needed decisions end pkna without difficulty	1.00	0.00	0.99	0.03
—slow-thinking difficulty in tasks and activities involving thinking end cocentration, difficulty in thinking logically	o.%	0.23	0,s2	0.29
—slight memory loss, confused at times	0.35	0.21	0.32	0.2s
—confused at all times, marked memory loss, partially disorientated	0.16	0.15	0.13	0.14
—conscious, but completely disorientated	0.09	0.18	0.0s	0.08
Social participation				
—is able to participate normally (ss usual) in social interaction ● nd activities e.g. club meetings, visits, eta.	0.99	0.04	o.%	0.14
-because of one's health. has had to restrict slightly one's usual participation m social interaction aad activities	0.76	0.21	0.66	0.22
-because of one's health, has had to restrict considerably one's usual participation in social interaction and activities	0.52	0.19	0.47	0.21
—because of one's health has had to give up almost entirely one's usual participation in social interaction and activities	0.34	0.14	0.32	0.17
—because of one's health, has had to give up completely one's participation in social interaction and activities	0.17	0.14	0.17	0.17

Note: The author did not report the weights for perceived health.
SD = standard deviation

Source: Sintonen (1981)

where:

v^i = the value of the index for the health state, i.e., the value for that particular combination of levels for each health dimension.

X_j = the different levels of health dimension j.

w_j^i = a function representing the value the individual places on the different levels within a health dimension.

I_j^i = a positive constant for the jth dimension representing the importance the individual attaches to that particular dimension.

This method for the valuation of health states requires individuals to make two assessments. First, the individual assigns a w_j^i weight to each of the "i" levels within the jth health dimension. For example, in Table 5-4 the w_j^i weights for the hear ing dimension are $w^1 = 1.0$, $w^2 = .65$, $w^3 = 937$ and $w^4 = .2$ for the four levels within that dimension. These w_j^i weights for each dimension are scored from zero to one. The second set of weights, the importance weights, are used to provide information on the relative importance of the different dimensions. They provide information on, for example, whether the hearing or the moving dimension is more important overall. These weights allow the dimensions to be summed to a single health status index. For example, from Table 5.7 one can see that the hearing dimension is less important than the moving dimension with weights of 74.8 and 80.2 respectively. As a result, when combining these two health dimensions the following equation is used:

$$\text{Aggregate Health Index} = 74.8 \times (w^i_{\text{hearing}}) + 80.2X\,(w^i_{\text{moving}}).$$

Therefore, the aggregate health index, assuming only these two health effects and assuming level 2 for the hearing dimension and level 3 for moving dimension would be:

$$\text{Aggregate Health Index} = 74.8\ (.65) + 8002\ (.51) = 89.52$$

To elicit the values for the health states, self administered questionnaires were used. Magnitude and category types of questions were used to determine the two sets of weights. The magnitude approach attempts to assign relative values to the health dimensions. The category approach is slightly different in that the respondent places each health dimension into a preset scale. Each sub ject was given only one type of question. The questions used to elicit the importance weights placed on each dimension using the magnitude method are presented in Table 5.5. The category questions used to elicit the importance weights are shown in Table 5.6. The importance weights resulting from these questions are shown in Table 5.7. Recall that the importance weights are designed to give the correct weighting to each overall health dimension. Individual levels within each health dimension are weighted by a separate set of questions. Examples of the questions used to derive the w_j^i values for the different levels within a dimension are shown in Tables 5.8 and 5.9. Results from such questions were used to calculate the transformed (to a 1 to 0 scale) weights reported in Table 5.4 presented earlier. Sintonen also asked questions regarding the comprehensibility of the questions and the difficulty in answering the questions. Table 5.10 summarizes those results.

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Comments

Conclusions from these indices are difficult to draw. They simply reflect the subject's ranking of different health states. h the absence of any monetary valuation of these health states, the index could be used as part of a cost effectiveness analysis. Given a fixed amount of resources, the index can be used to determine how these resources should be allocated to produce the highest level of overall health. This is done by using equation 5.1 to determine the relative preferability of changes in health states associated with different program expenditures. The parameters of equation" 5.1 are the importance weights shown in Table 5.7 and the weights on the levels within each dimension shown in Table 5.4.

The two health indices - one by the magnitude method and the second by the category method - constructed by Sintonen (1981) showed a high correlation with an r-square of .92. Roughly half of the subjects found the questions easy to understand, but that did not mean they were easy to answer (see Table 5.10). Still, very few subjects felt the questions were impossible to answer. This general acceptability indicates some potential for the construction and ranking of health states based on functional/dysfunction def initions in future benefits studies. However, this particular application does have weaknesses. In particular, the assumption of utility independence between the different health dimensions is unlikely to hold in practice. There also may be a problem in the category method interpretation since respondents could designate ties except for the most and feast important characteristics.

Table 5.5

Magnitude Method for Determining Importance Weights

A number of characteristics have been listed below, which are associated with a healthy person. Various paopk may have different views of what health is about and how important various characteristics are xx far as health is concerned. Hare we are interested in your personal view.Evaluate first, which of the characteristics below ix in your opinion the most important ax far ax health is concerned. that is, the one which you would give up last. and draw a line from the box following it (o)10 100 on the adjacent scale. Then evaluate the importance of all the other characteristics in relation to this moat important characteristic. If. for example. some characteristic is in your opinion haff (1/2) ax important as the most important characteristics, draw a line from the boa following it 10 SO on the scale. If some characteristic in your opinion is not at ● ll important xx far ax health is concerned. draw ● line from its box 100. For clarity. write in each box the number ● t which the line drawn from the box ia aimed (e.g. (50)). In evaluation you may use all numbers between 0 ● nd 100 as you tae fit. The characteristics are:

that one is able to sleep normally ▭

that one is able 10 move (walk) normally ▭

that oae IS abk to control the, bladder and bowels normally . ▭

that one is abk to hear normally . ▭

that one is able to sea normally ▭

that one IS abk 10 breatha normally . . . . ▭

that ona is abk to speak normally . . . . ▭

that one IS able to participate normally in social interaction and activities. e.g. clubs, meetings, visits, et . . . . ▭

that one is abk 10 do paid work or household work normally . . . . ▭

that owe feels completely healthy . ▭

that one is ● bk to eat normally ▭

100 ← The most Important characteristic

90 ← 9/10 as important ax the most important characteristic

80

← 3/4 as important ax the most important characteristic

70

← 2/3 ax important as the moat important characteristic

60

50 ← 1/2 ax important ax the moar important characteristic

40

← 1/3 as important ax the most important characteristic

30

← 1/4 ss important ss the moat important

20

10 ← 1/10 xx important ax the most important characteristic

0 ← 1/100 ax important ss the moat important characteristic

Source: Sintonen (1981)

Table 5.6

Category Method for Determining Importance Weights

A number of characteristics have been listed below, which are associated with a ehalthy person. Various people may have different views of what health is about ● nd how important various characteristic are as far as health is concerned. Here we are interested in your personal view. Each characteristic is followed by a seek ranging from 0 to 10. Circle on the scale the number which, in your opinion, reflects the importance of the characteristic in question as far as health is concerned. Number 10 w labelled "most important". Give it tothe characteristic whkh in your opinion is the moat important as far as health ra concerned. that is, the osss whkh you would give up last. If you do not regard some characteristic as at all important as far as health is concerned give it number 0. labelled "not ● t all important". The other characteristics fall between 0 and 10 and you may use all numbers as you see fit The characteristics are:

	Not at All important									Most important
that one is able to sleep normally..	0	1	2	3	4	5	6	7	8	9	10
that one is able to move (walk) normally	0	1	2	3	4	5	6	7	8	9	10
that one is able to control the bladder and bowels normally	0	1	2	3	4	5	6	7	8	9	10
that one is able to hear normally	0	1	2	3	4	5	6	7	8	9	10
that one is able to see normally	0	1	2	3	4	5	6	7	8	9	10
that one is able to breath normally	0	1	2	3	4	5	6	7	8	9	10
that one is able to speak normally	0	1	2	3	4	5	6	7	8	9	10
that one is able to participate normally in social interaction and activities, e.g. clubs, meetings, visits, etc.	0	1	2	3	4	5	6	7	8	9	10
that one is able to do paid work or household work normally.	0	1	2	3	4	5	6	7	8	9	10
that one feels completely healthy	0	1	2	3	4	5	6	7	8	9	10
that one is able to eat normally	0	1	2	3	4	5	6	7	8	9	10

Source: Sintonen (1981)

Table 5.7

Means & Standard Deviations of the Importance Weights of Dimensions Obtained by the Magnitude & Category Methods

Dimension	Magnitude method			Category method		
	Original Mean	Original SD	Transf.* Mean	Original Mean	Original SD	Transf.* Mean
1. Intellectual or mental functioning	93,6	11.7	0.101	9.12	1.39	0.096
2 Breathing	69.7	13.8	0.097	a93	1.71	0.094
3. Seeing	84.6	16.2	0.091	8.15	230	0.086
4. Perceived health	80.9	25.0	0.067	7.64	2.65	0.062
5. Moving	80.2	18.0	0.086	8.03	2.40	0.084
6. Speaking	78.6	19.0	0.085	8.1s	214	0.086
7. Incontinence	78.1	21.1	0.084	8.13	221	0.085
8. Hearing	74.8	22.8	0.080	7.67	259	0.081
9. Working	721	25.5	0.078	7.43	290	0.078
10. Sleeping	69.5	25.9	0.075	7.63	206	0.080
11. Eating	68.3	23.5	0.074	7.66	2.04	0.080
12. Social participation	58.4	29.0	0.063	6.44	2.74	0.068

*To satisfy $\sum_{j=1}^{n} l_j = 1$.

Source: **Sintonen** (1981)

Table 5.8

Magnitude Method for Weighting the Different Levels within a Specific Health Dimension

Ott this and the next 10 pages different health states arfe presented. Your task is to evaluate the desirability of the states presented on each page in relation to each other. Read these instructions carefully. since they apply to each of the following 10 pages. Think only at any time of the health states presented on the page at hand. Evaluate which of the states ott each page is irt your opinion tba meet desirable and draw ● line from the box following it to 100 on the adjacent scale. Then evaluate the desirability of all other states in relation to this most desirable state. If. for example. some state is in your opinion half (1/2) as desirable ax the moat desirable state, draw a line from the box following it to SO on tbe scale. For clarity. write in each box the number ● t wbkb the line drawn from the box is aimed, In evaluation, you may use all numbers between O and 100 as you sax fit. The states are:

—one is ● bk to move (walk) normally, i.e. without difficulties indoors, outdoors and on stairs

—one is abk to move (walk) without difficulties indoors, but outdoors and/or on stairs with difficulties . . . .

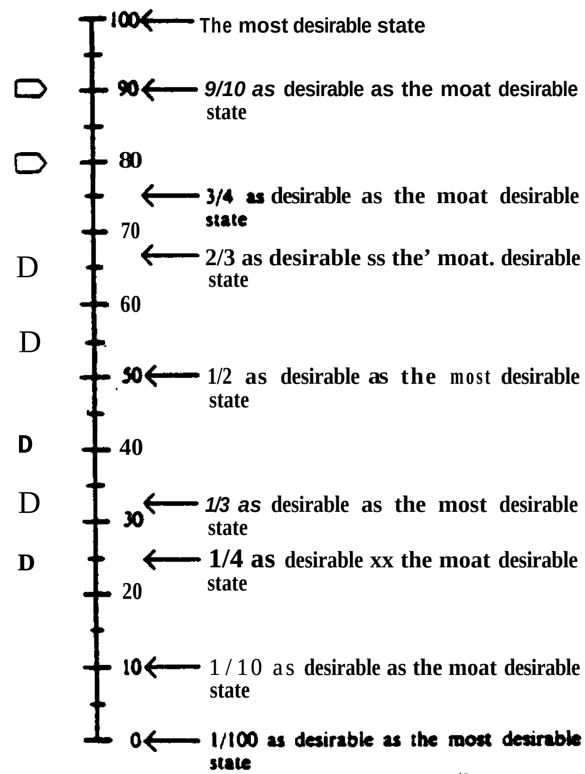
—one is abk to move (walk) without help indoors (with or without appliances) but Outdoors and/or on stairs only with help from others . . . .

—one is ebk to move (walk) only with help from others, indoors also . . . .

—conscious, but completely bed-ridden and unable to move about; if helped may sit on ● chair . . . .

—unconscious, ...

—dead . . . .



Source: Sintonen (1981)

Table 5.9

Category Method for Weighting the Different Levels within a Specific Health Dimension

On this ● nd the next 10 pages different health states are presented. Your task is to evaluate the desirability of the states presented on each page in relation to aadt other. Reed these instructions carefully, since they apply to each of the following 10 pages. Think only ● t any time of the health states presented on the page at hand. Each state is followed by ● scale ranging from Oto 10. Circle on the scale the number which, in your opinion, reflects the desirability of the state in question. Number 10 is labelled "most desirable". On each page, give 10 to the state whkh in your view is the moat desirable on that page. Number 0 is labelled "least desirable". On each page, give 0 to the state, whkb in your view is the least desirable on that page. The other states fall between 0 and 10 and you may use all numbers as you sea fit. The states are:

	Least desirable										Most desirable
—one is able to move (walk) normally, i.e. without difficulties indoors, Outdoors and on stairs	0	1	2	3	4	5	6	7	8	9	10
—one is ● bk to move (walk) without difficulties indoors, but outdoors and/or on stairs with difficulties	0	1	2	3	4	5	6	7	8	9	10
is abk to move (walk) wihtout help indoors (with or without appliances), but outdoors and/or on stairs only with help from others	0	1	2	3	4	5	6	7	8	9	10
—one is ● bk to move (walk) only with help from others indoors also. .	0	1	2	3	4	5	6	7	8	9	10
—conscious, but completely bad-ridders and unable to move about; if helped, may sit on a chair	0	1	2	3	4	5	6	7	8	9	10
—unconscious . . . .'.... . . .'	0	1	2	3	4	5	6	7	8	9	
. . . .	0	1	2	3	4	5	6	7	8	9	10

Source: Sintonen (1981)

Table 5.10

Comprehensibility & Difficulty of Questions

Comprehensibility of the Questions

	Magnitude sample (%)	Category sample (%)
Easy to understand	49.1	50.8
Slightly difficult to understand	38.6	35.6
Quite difficult to understand	8.8	10.2
Very difficult to understand	3.5	1.7
Impossible to understand	0.0	1.7

x^2 = 1.48; d.f. = 4.

Difficulty with Answering the Questions

	Magnitude sample (%)	category sample (%)
Not at all difficult to answer	25.9	28.8
Slightly difficult to answer	39.7	424
Quite difficult to answer	24.1	20.3
Very difficult to answer	6.9	5.1
Impossible to answer	3.4	3.4

x^2 = 0.50; d.f. = 4.

Source: Sintonen (1981)

5.2 MULTI-ATTRIBUTE UTILITY FUNCTION

A four dimension classification system is used by Torrance et al. (1982) to construct a social preference function for alternative health states. As with the previously discussed indices, the index is based on a functional classification system allowing the derived health states to be disease independent. The approach used to construct the multi-attribute utility function (or index) is similar to the method used by Sintonen, but with some attempt to incorporate risk aversion and allow for less restrictive, non-additive functional forms.

The four health dimensions (or attitudes) used by Torrance et al. (1982) are:

(1) Physical Function: Mobility and physical Activity
(2) Role Function: Self Care and Role Activity
(3) Social-Emotional Function: Emotional Well-Being and Social Activity
(4) Health Problem

Each of these health dimensions are then subdivided into between 4 to 8 levels as shown in Table 5.11. Since each feasible combination of the levels across health dimensions defines a unique health state, this system allows for 960 health states.

Multi-attribute utility methods are-concerned with expressing the utility associated with a multi-dimensional outcome as a function of the utilities associated with each dimension calculated separately. Several functional forms are typically considered including additive and multiplicative functions. ” The conventional method for obtaining a measure of the utility associated with a given level for a health dimension is the von Neuman-Morgenstern (1953 standard gamble technique. This method first establishes two reference outcomes, usually one is a favorable outcome (X^*) and the second is a relatively bad outcome (X^o). Given these reference points, the utility of an intermediate outcome (X) is calculted by asking the subject to determine the probability p such that he is indifferent between the lottery - outcome X^* with probability p and outcome Xo with probability 1- p - and an intermediate outcome X with certainty. The utility index for this attribute is then $U(X^*) = 1$, $U(X^o) = O$ and $u(X) = p$. Using this process, a utility function can be constructed for each health dimension taken separately. The next step is to combine the utility functions on each dimension into a multi-attribute utility function.

Table 5.11

Health State Classification System

Level x_1	Code	Description
X_1 PHYSICAL FUNCTION: MOBILITY AND PHYSICAL ACTIVITY		
1	P1	Being able to get around the house, yard, neighborhood or community WITHOUT HELP from snot her person; AND having NO limitat ion in physical ability to lift, walk, run, jump or bend.
2	P2	Being ● ble to get around the house, yard, neighborhood or community W ITHOUT HELP from another person; AND having SOME limitations in physical ● bifity to lift, walk, run, jump or bend
3	P3	Being able to get around the house, yard, neighborhood or community WITHOUT HELP from another person; AND NEEDING mechanical aids to walk or get around.
4	P4	NEEDING HELP from another person in order to get around the house, yard, neighborhood or community; AND having SOME limitations in physical ● bifity to lift. walk run, jump or bend.
5	P5	NEEDING HELP from another person in order to get around the house, yard, neighborhood or community; AND *NEEDING me.* chanical aids to walkor get around
6	P6	NEEDING HELP from another person in order to get around the house, yard, neighborhood or community, AND NOT being able to uee or control the arms and legs.

Level x2	Code	Description
X_2 *ROLE FUNCTION:* SELF-CARE AND ROLE ACTIVITY”		
1	R1	Being able to eat, dress, bathe and go to the toilet WITHOUT HELP AND having NO limitations when playing, going to school, working or in other activities.
2	R2	Being able to eat, dress, bathe and go to the toilet WITHOUT HELP: AND having SOME limitations when working going to school, . playing or in other activities.
3	R3	Being able to eat. dress, bathe and go to the toilet WITHOUT HELP; AND NOT being able to play, attend school or work.
4	R4	NEEDING HELP to eat, dress, bathe or go to the toilet; AND having SOME limitations when working. going to school, playing or itr other activities.
5	R5	NEEDING HELP to eat, dress, bathe or go to the toilet; AND NOT being able to play, attend school or work.

Level x_3	Code	Description
X_3 *SOCIAL-EMOTIONAL FUNCTION:* EMOTIONAL WELL-BEING AND SOCIAL ACTIVITY		
1	S1	being happy and relaxed most or all of the time, AND having an ● verue number of friends and contacts with others.
2	S2	Being happy and relaxed most or all of the time. AND having very few friends and little contact with others.
3	S3	Being anxious or depressed some or a good bit of the time, AND having an ● vermgw number of friends and contact with others.
4	S4	Being anxious or depressed some or a good bit of the time, AND having very few friends end litt le contact with others.

Table 5.11 (Contd.)

Health State Classification System

*X_4 HEALTH PROBLEM**		
~t.cl:,	Code	Description
1	H1	Having no health problem.
2	H2	Having a minor physical deformity or disfigurement such as scars on the face.
3	H3	Needing a hearing aid.
4	H4	Having ● medical problem which causes pain or discomfort for ● few days in ● row ● very two months.
5	H5	Needing to go to a special school because of trouble learning or remembering things.
6	H6	Having trouble seeing *even when wearing glasses*
7	H7	Having trouble beingunderstood by othera.
8	H8	Being blind OR deaf OR not ● ble to speak.

" Multiple choices within each description are applied to individuals as ● -te for their age. For ● xample, a 3-year-old child is not expected to be able to get around the community without help from another person.

*Individuals with more than one health problem are classified according to the problem they consider the moat serious.

Source: Torrance <u>et al.</u> (1982)

There are several candidate multi-attribute utility functions. Two of the most common are the additive form and the multiplicative form. The additive form is:

$$U(X_{ij}) = \sum_{i=1}^{4} k_i \, v_i \, (X_{ij}) \tag{5.2}$$

where:

X_{ij} = the j^{th} level of the i^{th} dimension

k_i = is similar to Sintonen's "importance" weight and is determined by calculating the utility associated with the highest (best) level in dimension i holding the levels of the other dimensions at their lowest levels, e.g.:

$$k_1 = U1 * (X_1 \bullet, X2°, X3°, X_4^0) \tag{53}$$

$v_i(\ )$ = is the value function for rating the level within each independent dimension.

Rather than simply assuming additive independence, there are several methods that can be used to test for it. The simplest is a two-step procedure where first the utility index for a given health dimension is determined holding the levels of the other attributes con stant at their worst level. The second step evaluates the utility index for the sa health dimension holding the levels of the" other dimensions constant at their highest level. If the utility index associated with each attribute does not vary with the level at which the other attributes are held constant, then additive independence is an appropriate assumption.

There are a number of multiplicative functional forms for combining the utility indices derived for each attribute separately. They each embody a different set of assumptions regarding separability of the health dimensions. Keeney and Raiffa (1976) discuss the properties of these different functional forms in detail. The multiplicative **functional** form chosen by Torrance et al. (1982) embodies a less restrictive separability assumption than additive independence, but it is still one of the more restrictive multiplicative functional forms.[1] It is, however, more general than the additive form because it allow attributes to be either substitutes or complements.[2]

The major difference between Sintonen's health value function discussed in the prev section and the multi-attribute utility function is that the utility function directly in porates probabilities within the construction of the utility index. This allows individual's risk preferences to be taken into account.[3]

Torrance et al. (1982) used this conceptual approach to estimate a multi-attribute ut function for the health dimensions and states presented previously in Table 5.11. A dom survey of 112 households was conducted in Hamilton, Ontario. Torrance et al. (1 modified the conventional multi-attribute utility method by not using the standard Neuman-Morgenstern gamble method for determining the utility indices for each a bute. They felt that given the project time and budget constraints as well as the c plexity of the gamble method for application to a general public sample, a sim approach better suited their needs. Instead of the gamble approach, which is time su ming and requires extensive interviewer-subject interaction, Torrence et al. use category scaling approach similar to Sintonen (1981) and then adjusted these values b on previous work using the standard gamble technique.

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[1] See Keeney and Raiffa (1976) for more information on the properties of ut functions. The specific function used in Torrance et al. is:

$$U(X_{ij}) = (Y_c)\left\{ \prod_{i=1}^{4} (1 + CK_i U_i(X_{ij}) - 1 \right\} \quad (-.$$

where:

X_{ij} - the jth health level of the i^{th} dimension
K_i = is an "importance" weight as defined in eq. S-3
$\bar{C}$ = is a constant solved from:

$$C = -1 + \left\{ \prod_{i=1}^{4} (1 + CK_i) \right\}$$

[2] See Keeney and Raiffa (1976) chapter 6, p. 289 for a discussion of the properties assumptions of this form for the utility function. To **summarize,** the independence sumption embodied in this function is that the utility associated with a subset of at butes is independent of its complementary set. This functional form allows for attribu that are either substitutes or complements.

[3] The concept of risk preferences such as risk aversion seems to have less meaning these applications since the levels within each health dimension cannot be ea interpreted. One definition of risk aversion is an unwillingness to accept a "fair bet", a bet when the expected values of the outcomes are equal; however, it is not clear w is a fair bet between alternative health levels.

The category scaling method used by Torrance et al. (1982) used a scale from O to 100. The interview subjects were asked to place the most desirable level for the health dimension under consideration at 100 and the least desirable at O. The other levels **were** placed in between, in order of desirability and spaced such that the relative distance between levels corresponds to the relative difference in desirability. Because the category scaling technique does not incorporate probabilities, it produces what psychologists term a "value function" as opposed to a utility function and the individual's attitudes towards risk are not captured. To convert **the** value function to a utility function that would have been produced by a lottery technique like the standard gamble method, Torrance et al. used results from other work [4] where the standard gamble method was used to adjust the value function. These earlier studies found the following relationship between value and utility $U=V^{1 \bullet 6}$ indicating risk aversion with respect to poor health outcomes.

The four single attribute **value** functions that resulted from the category scaling method are shown in Table 5.12. These can then be combined in either the additive (equation 5.2) or multiplicative functions discussed previously to yield the multi-attribute utility function. The k_i parameters (equation 5.3) also need to be determined using a category or similar scaling method.

Two methods of aggregating the individual's utilities to yield a social preference function were used. The first method constructs a separate utility "function for each individual; then social utility for health state j is defined as the average of the utilities for each individual. This approach yields a tabular set of data with 960 averaged utility entries, one entry for each "combination of health dimension levels (ie. health state). The second **method** of aggregation uses the means from the value functions shown in Table 5.12, the calculated means for the k_i parameters, and equation 5.2 or the multiplicative function to. produce an average social welfare function.

Both methods of aggregation produce similar results. The simple correlation between the two methods was .995. The testing for additive independence showed that a simple additive function was not appropriate and the multiplicative functional form was used. Out of the 87 individual utility functions that were calculated, the parameters indicated that in 79 cases the health attributes were viewed as complements.

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[4] The studies used were Torrance, 1976; Torrance et al., 1973 and Wolfson et al., 1982.

Table 5.12

Single-Attribute Value Functions (N = 87)

Physical Function			Role Function			Social Emotional Function			Health Problem		
Level	Mean Value	Standard error	Level	Mean value”	Standard error	Level	Mean value	Standard error	Level	Mean value	Standard error
P1	1.00	0.000	R1	1.00	0.000	S1	Loo	0.000	H1	1.00	0.000
P2	0.62	0.082	R2	0.71	0.021	S2	0.65	0.027	H2	0.49	0.040
P3	0.38	0.101	R3	0.32	0.019	S3	0.25	0.026	H3	0.47	0.047
P4	0.37	0.021	R4	0.30	0.022	S4	0.00	0.000	H4	0.46	0.037
P5	0.10	0.085	R5	0.00	0.000				H5	0.30	0.062
P6	0.00	0.000							H6	0.25	0.064
									H7	0.22	0.074
									H8	0.00	0.000

Source: Torrance et al. (1982)

Comments

The work by Torrance (1976 and 1982) and Torrance et al. (1982) indicated, according to the authors, that the multi-attribute utility function approach was quite promising. A high proportion of eligible subjects participated and few broke off the interview even when told they should do so if they did not feel they understood what was being asked. The conditions for additive independence were strongly rejected for all individuals and in most cases positive health attributes were complements. The complimentary relationship among attributes indicated that if a healthy individual were to experience a worsening of health states along more than one dimension the utility loss is not much worse than if the reduction had occurred in only one health dimension.

Other work on multi-attribute utility functions for health status has shown the reference health level of the subject to be very important. Krischer (1976) sampled individuals in poor health and found health attributes to be substitutes. Torrance et al. (1982) sampled healthy individuals and found the health attributes to be complements. This stems from unhealthy subjects viewing the various. health outcomes as gains, while the healthy subjects viewed the outcomes as losses. Fischer and Kamlet (1981) discuss this general finding and indicate that individuals tend to exhibit multivariate risk seeking behavior for losses and multivariate risk aversion for gains.

5.3 LENGTH OF HEALTH STATE VERSUS QUALITY OF LIFE ISSUES

The previous sections on health indices and utility functions have focused only on the quality of life. The quantity issue, i.e., the time spent in a health state, has not been addressed. The relationships between length of time, different health states, and utility have received little study. The conventional approach has been to use the estimated values from a specific health index or the utilities from a von Neuman-Morgernstern utility function and multiply them by the length of time in that health state. For example, a life-year in a health state judged to be .75 on a utility scale would represent .75 quality-adjusted life years (QALYs) The use of von Neuman-Morgernstern calibrated utilities to adjust the value of a life year has been suggested by Zeckhauser and Shepard (1976) and applied by Weinstein and Stason (1976) and Boyle et al. (1983). Still, this concept seems to be missing a key issue. In particular, the utility assigned to a health state may not be independent of the amount of time spent in that state and, as a result, it may be inappropriate to simply multiply a utility level for a health state times the number of years in that state. For example, one day of bed confinement due to illness may not be viewed as much of a burden where 5 days may be viewed as a considerable hardship. The loss in utility from the 5 day illness may be greater than 5 times the loss associated with one day's confinement.

Limited empirical data available on this are provided by Torrance et al. (1972) and Torrance (1971). In these papers, the authors developed a time trade-off method where the subject was asked to choose between two health states with different periods of time in each state. The respondent's indifference point was found by varying the time factor of one state. In general, Torrance found that individuals typically had declining utility levels per unit time as the length of time ill increased. This information indicates that it might be useful to recalibrate the health indices or utility function for different time periods. Candidate time periods could be one day, one week, one year and five years. A five year time period is probably sufficiently long to approximate a permanent condition. No work was found where separate health. indices were estimated for health states of different durations during the literature search.

5.4 CONCLUSIONS

The work to date on health status indices and utility functions does not provide numbers that are immediately useful for benefit-cost analysis but this work could be useful for cost-effectiveness' analysis. Still, this research is potentially important for benefits studies in that it provides a method for constructing health status measures that are disease independent. This could be very important since the number of possible health effects from environmental causes is large. Also, the nature of effects vary from skin rashes and eye irritation to long term illnesses such as cancer and heart disease. A benefits analysis of each of these potential health effects would be a truly herculean task.

A more tractable approach may be to define a discrete number of health attributes similar to those developed by Rosser and Kind (1978), Sintonen (1981) or Torrance et al. (1982). Health states could then be characterized as combinations of these attributes. Methods similar to the methods used to construct health indices or the techniques used to develop multiattribute utility functions could be used. to estimate WTP for changes in

Step 5 - Place values in monetary terms on movements between health states using either direct valuation if the number of health dimensions and resulting states is small, or using multiattribute techniques if the number of states is large.

This type of organization could be very useful and prevent benefit: studies from having to conduct a separate willingness-to-pay study for each health effect. This aggregation is flexible in that different subcategories of individuals could have different valuations. Rosser and Kind (1978) found no significant differences in health state valuation across different socioeconomic or demographic subgroups, but they did find that the current health state of the individual influenced health state valuations.

health states. The utility function approach would be preferred if it were desirable to capture the individuals' attitudes towards risk. However, it remains questionable whether social policy decisions should be based on individuals' risk preferences which can be extremely risk averse or whether a risk neutral expected value approach should govern social policy discussions. If expected values are felt to be appropriate due to the "spreading of statistical risks across large populations, then the health index methods are more appropriate and simpler to apply.

The construction of a suitable health status index need not be as complicated or include as many health states as the Sintonen (19S1) and Torrance et al. (1982) indices. Rosser and Kind (19~8) used a simple two-dimension health state classification that resulted in a maximum of 32 health state combinations. This number of health state combinations could be evaluated directly in a contingent valuation survey and the multiattribute techniques with their associated assumptions would not be needed. The multiattribute methods must be used when the final number of health states is so large "that they cannot be valued directly. These methods allow one to place values on the levels of the individual dimensions (i.e., attributes) and then provides a framework for combining the individual values to 'yield a value for the combination of attributes.

The valuation of health states is only a portion of the research that would halve to be conducted before health indices could be used in benefits studies. In particular, the following additional steps are envisioned:

Step 1 - Determine the environmentally caused illnesses that are expected to be important in evaluating health policy issues.

Step 2 - Categorize the function/dysfunction effects of each illness.

Step 3 - Define the health **dimensions and** levels within the dimensions needed to represent the health states. It may be appropriate to have several separate sets of health dimensions- for example, different dimensions and levels could be used for acute and chronic health effects.

Step 4 - Develop a mapping between environmentally caused illnesses and the functionally defined health states so that changes in the incidence of illness can be translated into the number of people whose health states change.

Step 5 - Place values in monetary terms on movements between health states using either direct valuation if the number of health dimensions and resulting states is small, or using multiattribute techniques if the number of states is large.

This type of organization could be very useful and prevent benefit: studies from having to conduct a separate willingness-to-pay study for each health effect. This aggregation is flexible in that different subcategories of individuals could have different valuations. Rosser and Kind (1978) found no significant differences in health state valuation across different socioeconomic or demographic subgroups, but they did find that the current health state of the individual influenced health state valuations.