VALUING TIME LOSSES DUE TO ILLNESS

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Safe Drinking Water Act

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EXECUTIVE SUMMARY

In the 1996 amendments to the Safe Drinking Water Act, Congress increased the role of benefit-cost analysis in determining appropriate standards for drinking water contaminants. As a result, the staff of the Office of Ground Water and Drinking Water in the U.S. Environmental Protection Agency (EPA) have undertaken a number of projects to improve the approaches used in these analyses. This report focuses on one aspect of the assessment of human health-related benefits: valuing time losses associated with illness. These time losses result when ill individuals cannot engage in their normal work and leisure activities or when participation in these activities is less productive or less enjoyable than usual.

Valuation of time losses is useful in those benefit-cost analyses where EPA relies on cost of illness estimates to value risk reductions for nonfatal illnesses. The preferred approach for valuing these benefits is to determine individual willingness to pay for the risk reductions of concern. For fatal risks, EPA has a well-established framework for implementing the willingness to pay approach. For nonfatal risks, EPA often lacks empirical estimates of willingness to pay for the specific health risks of concern. In such cases, analysts may at times rely on estimates of the medical costs of illness. However, these estimates may understate the value of risk reductions because they exclude consideration of many attributes of the illness -- such as avoiding the associated activity restrictions as well as related pain and suffering.

In these cases, analysts may wish to add an estimate of the value of time losses to the estimates of the medical costs of illness to come closer to a complete accounting of the effects of the health risks of concern. While accounting for time losses does not fully capture the value associated with pain and suffering, it increases the extent to which activity restrictions are included in the benefits estimates. Traditionally, cost of illness studies have used the human capital approach to estimate the indirect costs of illness. The human capital approach focuses on lost productivity, including both time lost from paid work and, in some cases, from unpaid work (such as housework and volunteer activities). However, this approach excludes consideration of the effects of illness on nonwork activities and hence is an incomplete measure of the social welfare costs of activity restrictions.

To address this deficiency, EPA has developed an approach for valuing time losses that more broadly considers the impact of illness on all types of activities. This approach is based on consideration of the opportunity costs of time, consistent with the framework underlying the use of willingness to pay estimates to value health-related benefits. For paid work, this approach assumes that total compensation (wages and benefits) is equal to the employers' valuation of the workers output. Hence if a worker is absent due to illness, society loses this output and the time losses can be valued using compensation data. For time spent on nonmarket work and leisure activities, this approach assumes that an individual will engage in such unpaid activities only if, at the margin, the value of these activities is greater than the wage that he or she can earn if employed. Thus after-tax wages can be used to estimate the value of nonwork time.

When used in benefit-cost analysis, this approach has several limitations that can be addressed in a variety of ways. In particular, this report suggests that analysts may wish to assign a "zero" value to losses associated with sleep time, due to problems related to estimating the impact of illness on sleep and to determining the dollar value of this time. In addition, valuing time losses is difficult for segments of the population that do not engage in paid work, such as children, retirees, and others out of the labor force. Finally, imperfections in the labor market may also mean that wage and benefit rates over- or understate the value of time losses. At minimum, analysts will need to discuss the impacts of these limitations qualitatively; related uncertainties also can be addressed by sensitivity analysis or probabilistic assessment.

1.0 INTRODUCTION

In 1996, Congress amended the Safe Drinking Water Act (SDWA) to increase the consideration of benefit-cost analysis in regulatory decision-making. Prior to the amendments, the U.S. Environmental Protection Agency (EPA) was required to establish Maximum Contaminant Levels (MCLs) for drinking water contaminants at the lowest feasible level, regardless of the relative benefits and costs associated with achieving these levels. Under the 1996 amendments, the EPA Administrator may, at his or her discretion, establish less stringent MCLs if the costs of achieving the lowest feasible level exceed its benefits. Hence developing improved estimates of regulatory benefits, including the value of reducing risks to human health, has become a priority for EPA's Office of Ground Water and Drinking Water.[1] This report addresses one aspect of the valuation of risks to human health: determining the value of time losses associated with nonfatal illnesses.

Health risk reductions have many attributes that individuals value. For example, decreasing health risks diminishes the expenditures on disease prevention and treatment; the need to divert time from normal activities to bed rest, doctor's visits, or hospitalization; and the experience of pain and suffering. In general, economists prefer to use measures of value that address the combined effects of all of these attributes; i.e., that estimate the total value of the decrease in the risk of incurring a particular health effect. Such an approach avoids problems related to sorting out the contributions of different attributes and potential double-counting. However, this holistic approach is not always possible in benefit-cost analysis, given the available empirical research, and at times analysts may find it necessary to separately assess different components of the value of health risk reductions.

The preferred methodology for valuing human health-related benefits is to apply estimates of individual willingness to pay for risk reductions. EPA has well-established methods for implementing this methodology for fatal risks. For nonfatal risks, EPA often lacks empirical estimates of willingness to pay for the specific health effects of concern. In these cases, analysts may at times build values by estimating the medical costs of illness from the health economics literature and adding the value of lost time based on the approach discussed in this report. Such an approach may understate total willingness to pay to avoid the health risk of concern because it may not fully address the value of avoided pain and suffering as well as other attributes of the risk reduction.

The types of time losses discussed in this report are sometimes referred to as indirect costs or lost productivity. However, this report takes a more comprehensive approach than most of the indirect cost literature. That literature focuses on the effects of time usage on the production of goods and services, whereas this report is focused more broadly on the welfare effects of time use -- considering the value of leisure as well as work time to the individual and society. This report

[1]Drinking water regulations may result in a variety of other benefits, including aesthetic improvements (e.g., better water taste, odor, or color), reduced materials damages (e.g., decreased pipe corrosion), or ecological improvements (e.g., due to source water protection measures).

generally uses the term "time losses" rather than "indirect costs" or "lost productivity" to emphasize this different focus.

1.1 VALUATION FRAMEWORK

The practice of benefits assessment at EPA is based on the theory of welfare economics. The following sections briefly describe EPA's approach to valuation to provide context for this report. and discuss the relationship of cost of illness estimates to this framework.[2]

When determining the value of benefits such as those resulting from drinking water regulations, welfare economists begin with the assumption that individuals derive utility (or a sense of satisfaction or well-being) from the goods and services they consume. Individuals can maintain the same level of utility while trading off different bundles of goods and services and their willingness to make these trade offs can be measured in dollar terms. In so doing, individuals seek to maximize the utility they receive from the goods and services they consume given relevant budget constraints. This approach recognizes that, in choosing which activities to pursue, individuals are subject to a variety of economic and social constraints. These constraints interact with personal preferences to influence how individuals allocate their time among various types of activities -- including activities that earn income (which then can be expended on goods and services or invested) and activities that are not income-generating.

The dollar value of the benefits of drinking water regulations would be most directly measured by determining the change in income (or compensation) that has the same effect on utility as the regulatory requirements. In practice, economists generally rely on the concept of opportunity costs in valuing both costs and benefits. The opportunity cost approach recognizes that, because resources are limited, any decision to use resources for one purpose means that they cannot be used for other purposes. Hence the value of the resource can be determined based on the value of its next best use.

Willingness to pay is the approach applied to measure opportunity costs most often in regulatory analysis. For example, in its guidance on the practice of regulatory benefit-cost analysis in the Federal government, the Office of Management and Budget (OMB) notes that "[t]he principle of "willingness to pay" (WTP) captures the notion of opportunity cost by measuring what individuals are willing to forego to enjoy a particular benefit."[3] Individual willingness to pay represents the

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[2]EPA's approach to valuation is discussed in detail in: U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, September 2000, EPA 240-R-00-003, Chapter 7. For a more detailed and technical explanation of the underlying theory and methods, see: Freeman, A Myrick III, *The Measurement of Environmental and Resource Values: Theory and Methods*, Second Edition, Washington, D.C.: Resources for the Future, 2003.

[3]As OMB notes, willingness to accept compensation can also provide a "valid measure of opportunity costs" under some conditions, but is rarely used to due practical problems related to its empirical

maximum amount of money an individual would voluntarily exchange to obtain an improvement; e.g., in drinking water quality or in health status.

Willingness to pay is a different concept than cost or price. Cost generally refers to the resources needed to produce a good or service; it may not measure the full value of the good or service to consumers. Price is determined by the interactions of suppliers and consumers in the marketplace. An individual's willingness to pay may exceed the current price, in which case he or she benefits from the fact that the market price is less than he or she is willing to pay. If price instead exceeds willingness to pay, the individual would presumably choose to not purchase the good. The amount by which willingness to pay exceeds price is referred to as consumer surplus by economists, and aggregate changes in this difference (i.e., across all consumers) can be used to measure the dollar value of the social welfare effects of government policies. For example, consumers generally benefit from price decreases because the decrease means that, for those purchasing the good, willingness to pay will exceed the price by a larger amount.

1.1.1 Fatal Risk Valuation

EPA has developed standard practices for applying the concepts of welfare economics to value changes in fatal risks, based on estimates of the "value of statistical life." The value of statistical life does not refer to identifiable lives, but instead to small reductions in mortality risks throughout a population. A "statistical" life hence can be thought of as the sum of small individual risk reductions across an entire exposed population. For example, if 100,000 people would each experience a reduction of 1/100,000 in their risk of premature death as the result of a regulation, the regulation would "save" one statistical life (i.e., 100,000 * 1/100,000). If each member of the population of 100,000 was willing to pay $60 for this risk reduction, the corresponding value of a statistical life would be $6 million (i.e., $60 * 100,000). Value of statistical life estimates are appropriate only for small changes in risk; they do not value saving an individual life.

EPA's approach for valuing fatal risks is described in its *Guidelines for Preparing Economic Analysis*.[4] This approach has been subject to substantial peer review and implemented in numerous regulatory analyses. It was originally derived in the early 1990s from evaluation of the then-available empirical research, which yielded 26 estimates from value of statistical life studies suitable for consideration in the context of environmental policy analyses. Of these estimates, 21 are derived from studies that assess the increase in wages that workers demand for riskier jobs and five that are based on contingent valuation surveys. The best estimates from these studies (in 2000 dollars) range from $0.8 million to $17.5 million per statistical life saved, with a mean of $6.3 million. Analysts often adjust these values to reflect differences between the scenarios considered in the studies and the scenarios associated with a particular regulation, such as the growth in real income over time.

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measurement. U.S. Office of Management and Budget, *Regulatory Analysis (Circular A-4)*, September 2003, p. 18.

[4]U.S. Environmental Protection Agency (September 2000), pp. 87 - 94.

Given the uncertainty in these estimates, analysts generally present a range of values for fatal risk reductions, based on sensitivity analysis or probabilistic modeling.

EPA is currently conducting a number of projects to improve the approach for valuing fatal risks. While the approach will continue to evolve as new research is completed, its basic framework is reasonably well established and generally accepted for use in EPA analyses. Hence this report does not address the valuation of fatal risks in any detail. Rather, it is concerned with issues related to valuing nonfatal risks, as introduced below.

1.1.2 Nonfatal Risk Valuation

As noted earlier, EPA's preferred approach for valuing health risk reductions is to determine individual willingness to pay for related improvements.[5] These estimates are generally developed through stated preference methods (e.g., using surveys to collect information on reported values) or revealed preference methods (e.g., using data on related behaviors -- such as purchases of home water filters -- to estimate these values). Unfortunately, such studies have been completed for only a small subset of the illnesses associated with exposure to drinking water contaminants, and completing additional studies often requires more substantial time and resources than are available given regulatory deadlines and budgetary constraints.

As a result, analysts often transfer benefits estimates from existing studies rather than conduct new primary research. Benefit transfer involves reviewing the relevant valuation literature, selecting studies that address effects similar to those addressed by the regulations, and applying the estimates from these studies to the regulatory analysis. Key issues in conducting these transfers include ensuring that the studies used are of reasonable quality (e.g., adhere to best practices for the particular type of research) and are applicable to the policy of concern (e.g., consider similar health effects and similar populations). In some cases, it may be possible to adjust the primary research results to address differences between the study scenario and the regulatory scenario.

Such benefit transfers may not be appropriate for some health effects or may result in highly uncertain estimates. For example, the primary research literature may not include willingness to pay estimates for health effects that are sufficiently similar to the risk reductions resulting from the regulation, or the available studies may not be of adequate quality for use in regulatory analysis. Uncertainties stemming from the benefit transfer process may lead analysts to be interested in presenting more than one estimate of related values, or in using a different approach for valuation.

Faced with these uncertainties, EPA analysts may choose to consider estimates from the cost

[5] EPA's *Guidelines for Preparing Economic Analyses* provide more information on the valuation of nonfatal risks and on the use of benefit transfers. See: U.S. Environmental Protection Agency (September 2000), pp. 85-87 and 94-98.

of illness literature.[6] This literature is extensive and includes estimates for a wide range of health effects. It generally focuses on estimating expenditures associated with medical treatment, including doctor's visits, hospitalization, medications, and other medical goods and services. Some cost of illness studies also consider indirect costs, particularly the work time lost due to doctor's visits, hospitalization, and (in some cases) disability. However, as discussed below, this approach does not provide an ideal measure of value from a welfare economics perspective.

1.1.3 Relationship of Willingness to Pay to Cost of Illness

Although cost of illness estimates may be used for valuation in cases where willingness to pay estimates are not available, these estimates are not the preferred measure of value from a welfare economics perspective for a variety of reasons. First, they address a health outcome that differs significantly from that associated with drinking water or other environmental regulations. Such regulations lead to future changes in risk; e.g., a rulemaking might provide a 1/100,000 decrease in an individual's risk of incurring a particular disease by decreasing future contaminant levels. Cost of illness estimates instead reflect incurred costs to an individual and society for specific cases of diagnosed illnesses. Hence the scenarios assessed in cost of illness studies differ in both the perspective (past vs. future) and the level of certainty (diagnosed cases vs. risk of incidence) from the scenarios of regulatory concern. Medical treatment also may not return an ill individual to his or her original health state, whereas regulatory action may allow some individuals to avoid the illness entirely.

Second, cost of illness estimates usually exclude several types of impacts that are important from a social welfare perspective, including averting or defensive expenditures, indirect costs, and pain and suffering. Averting or defensive expenditures refer to costs that individuals incur to avoid illness, such as the use of water filters. To the extent that individuals discontinue these practices as

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[6]Health economists often advocate an alternative approach -- the use of quality adjusted life years (QALYs) or other types of health utility indices. This approach generally involves ranking the impacts of different health effects, then using this ranking to determine the relative value of a year in poor health (due to a specific health effect) compared to a year in good health. Traditionally, EPA has not applied this approach in benefit-cost analyses due to concerns about its inconsistency with welfare economics theory and the concept of willingness to pay. (For a discussion of related issues, see, for example, U.S. Environmental Protection Agency, *Benefits and Costs of the Clean Air Act, 1990-2020: Revised Analytical Plan for EPA's Second Prospective Analysis,* prepared by Industrial Economics, Incorporated, May 2003, pp. 8-11 to 8-12, and Advisory Council on Clean Air Compliance Analysis, *Review of the Revised Analytical Plan for EPA's Second Prospective Analysis-Benefits and Costs of the Clean Air Act 1990-2020,* prepared for the U.S. Environmental Protection Agency, May 2004, Chapter 11 and Appendix F.) EPA is now considering the use of these methods in cost-effectiveness analysis in response to new OMB guidance. As requested by OMB, an Institute of Medicine expert panel is now addressing several issues related to this approach (Office of Management and Budget, September 2003, p. 13).

the result of a regulation, related savings can be counted as a benefit of the rule.[7] However, these practices are often motivated by a range of concerns, not all of which may be affected by a particular regulation. For example, individuals may purchase water filters due to their concerns about a number of contaminants as well as their desire to improve water taste. A regulation that addresses only a few contaminants is not likely to noticeably affect the purchase of filters by these individuals. Hence, in the context of regulatory analysis, the exclusion of averting expenditures from cost of illness estimates may be of lesser concern than the other considerations raised in this section.

Cost of illness estimates also often exclude indirect costs. Conceptually, these indirect costs include any type of impact of illness on the economy other than direct medical expenses; however, this term is most often applied in practice to the consideration of productivity losses. Some cost of illness studies incorporate consideration of the loss in productivity that results when ill individuals are unable to engage in their normal schedule of paid work; a few also consider the lost productivity associated with unpaid work activities, such as housekeeping or volunteer efforts. These studies suggest that indirect costs can be significant. For example, a study of all chronic conditions in the U.S. indicated that the indirect costs of morbidity (time lost from paid work and housekeeping) totaled $72.9 billion in 1990.[8] These costs were approximately 17 percent of the medical costs, which were estimated at $425.2 billion in the same year.[9] Other studies (several of which are referenced later in this report) report indirect costs that equal or exceed the direct costs for certain illnesses.

Finally, cost of illness estimates do not address the value of avoiding the pain and suffering associated with illness.[10] Studies comparing cost of illness and willingness to pay estimates for a variety of health effects suggest that the exclusion of pain and suffering and other impacts leads to cost of illness estimates that understate willingness to pay by a significant amount.[11] The degree of

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[7]Care must be taken to ensure that the assumptions regarding defensive behaviors are consistent between the risk assessment and the benefits valuation portions of the benefit-cost analysis. If averting behaviors are taken into account in the risk assessment (e.g., because the analysis is based on data from a population that undertakes such activities), the resulting risk estimates will be lower than if the risk assessment considered the risks that result when no averting actions are undertaken. In the latter case, adding an estimate of decreased defensive expenditures to the value of the risk reductions could overstate actual benefits.

[8]Hoffman, C., D. Rice, and H. Sung, "Persons with Chronic Conditions: Their Prevalence and Costs," *Journal of the American Medical Association*, Vol. 276, No. 18, November 1996, pp. 1473-1479.

[9]Medical cost figure includes costs for fatal and nonfatal conditions.

[10] For a summary of relevant studies, see: U.S. Environmental Protection Agency, *Handbook for Non-cancer Health Effects Valuation*, December 2000, Appendix B.

[11]In some cases, medical expenditures may be greater than individual willingness to pay if third parties (i.e., insurance) finance treatments that individuals would not be willing to fund more directly from their own income.

understatement varies depending on the characteristics of the health effect, the types of costs considered, and the nature of the study design.[12] Available comparisons result in willingness to pay to cost of illness ratios ranging from about a factor of two to a factor of 79; most of the ratios are between three and six. In other words, in these studies the costs of illness are typically one-third to one-sixth of the willingness to pay estimates.

This result is consistent with theoretical work comparing willingness to pay and cost of illness approaches. For example, Harrington and Portney show that the medical costs of illness plus the value of lost earnings and defensive expenditures are likely to be less than willingness to pay for a change in pollution-induced illness under most conditions, due to the exclusion of the value of lost leisure time and of avoiding the disutility (e.g., pain and suffering) associated with illness.[13] They conclude that the cost of illness approach (including medical costs and lost wages) can be used as a lower bound estimate of the true value of benefits in most cases.

In this context, it is important to note that even empirical estimates of individual willingness to pay may understate societal values, in particular if the methods used in the study do not address costs borne by third parties or altruistic concerns about the health of others.[14] The issue of third party costs is addressed in the current OMB guidance on valuing morbidity impacts, which recommends that these values include both: "(1) the private demand for prevention of the nonfatal health effect, to be represented by the preferences of the target population at risk, and (2) the net financial externalities associated with poor health such as net changes in public medical costs and any net changes in economic production that are not experienced by the target population."[15] Later in the guidance, OMB also notes that economic analyses should include monetary values of "gains or losses of time in work, leisure, and/or commuting/travel settings" if they are significant.[16]

Despite its limitations, EPA analysts may, at times, rely on the medical cost of illness literature for valuation when willingness to pay estimates are lacking or are subject to enough uncertainty that comparison to other measures is desirable. As discussed above, such estimates are likely to understate true willingness to pay in most cases. The goal of this report is to address one

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[12]For example, these studies consider health effects that differ in severity and duration, use cost of illness estimates that vary in the extent to which they include forgone earnings or insurance-paid expenses, and estimate willingness to pay using different contingent valuation and averting behavior methods -- the contribution of each of these factors to the overall degree of understatement found in the comparison studies is uncertain.

[13]Harrington, W. and P. Portney, "Valuing the Benefits of Health and Safety Regulations," *Journal of Urban Economics*, Vol. 22, 1987, pp. 101- 112.

[14]Inclusion of altruism can lead to double-counting if not carefully addressed; see U.S. Environmental Protection Agency (September 2003), p. 92.

[15]U.S. Office of Management and Budget (September 2003), pp. 28 - 29.

[16]U.S. Office of Management and Budget (September 2003), p. 36.

of the several factors that contribute to this understatement -- the need to consider the effects of illness on activity restrictions (i.e., time losses).

1.2 APPLICATION TO REGULATORY ANALYSIS

The purpose of this report is to develop estimates of the value of lost time that can be added to estimates of the medical costs of illness in to develop improved measures of the welfare effects of reducing nonfatal health risks. To date, researchers largely have been interested in assessing the costs of illness as part of the determination of the relative cost-effectiveness of alternative resource allocations, both at the individual patient level (e.g., evaluating treatment options) and at the institutional or national level (e.g., evaluating options for investing health care or research dollars).[17] As such, these studies often are not directly suited for use in benefits valuation for drinking water or other regulations.

In contrast, EPA regulatory analyses focus on estimating the total national costs and benefits of various options for regulating a particular contaminant (e.g., arsenic) or group of contaminants (e.g., microbial pathogens), as well as the distribution of the costs and benefits across different sub-populations of interest. Hence they generally require information on lifetime costs per case, whereas cost of illness researchers may be more interested in the costs associated with different treatments for a particular symptom or in national illness-related expenditures for a particular year. The following sections explore how the differences between these two types of analyses affect the choice of data and methodologies used to estimate the value of time losses.

1.2.1 Data Needs for Regulatory Analysis

The benefits portions of EPA regulatory analyses generally start with an assessment of the human health risks attributable to each regulatory option, considering each major health effect associated with the contaminant of concern.[18] For example, an analysis of the effects of arsenic exposure may separately address lung and bladder cancer, as well as ischemic heart disease and diabetes or other relevant health endpoints. Estimated post-regulatory risk levels are compared to a "no action" baseline -- under which analysts predict future risks in the absence of the regulatory changes under consideration. The risk changes attributable to each regulatory option are then summed across the affected population to determine the number of statistical cases avoided

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[17] For a discussion of best practices from this perspective, see: Gold, M.R., J.E. Siegel, L.B. Russell, and M.C. Weinstein (eds.), *Cost-Effectiveness in Health and Medicine*, Oxford: Oxford University Press, 1996.

[18] EPA provides guidance on risk assessment in a number of other documents and hence issues related to this part of the analysis are not addressed in detail in this report.

nationally.[19] Depending on the characteristics of the rulemaking, the available health science research, and other factors, these estimates may be disaggregated by gender and/or by age group affected, by type of water system, by geographic location, or by other categories of concern.

A simplified example of this process is as follows. Risk assessors may estimate that a specific MCL (e.g., of 10 µg/L) will reduce the annual average individual risk of incurring a particular type of kidney disease by 1/10,000, compared to the baseline risk prediction. If this risk reduction is experienced by a total population of 50,000 persons, the number of statistical cases avoided would be five cases (1/10,000 * 50,000) per year.[20] Risk assessors may also note that about half of these cases would be fatal, and that the fatalities averted by the regulation would primarily be among elderly members of the population. Furthermore, uncertainty analysis may indicate that the number of cases averted may be understated or overstated by a factor of four.

The outcome of this risk analysis is usually an estimate of the number of fatal and nonfatal statistical cases avoided, possibly disaggregated by age group or other key attributes. This estimate is often reported as a range or probability distribution that reflects uncertainties in the analysis. The estimate of cases avoided then becomes the input for the valuation of related benefits. Hence economists working on benefit-cost analyses are generally interested in "per statistical case" values that can be applied to these risk estimates.

1.2.1 Data Provided by the Cost of Illness Literature

In contrast to the need for "per statistical case" estimates in regulatory benefit-cost analysis, much of the cost of illness literature has been developed to support decisions on medical treatment or on the allocation of health care resources. These studies may be based on the "prevalence" or "incidence" of the conditions of concern. Prevalence-based studies assess the costs of all cases existing in a given year, whereas incidence-based studies consider costs per new case diagnosed. Either method can be used to estimate direct (medical) and/or indirect (e.g., time) costs.[21]

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[19]Cost of illness studies often address all the cases of the illness found in the population studied regardless of cause. In contrast, regulatory analyses usually address only the risks associated with the contaminants of concern. Because most environmental contaminants are only one of many potential causal factors contributing to the overall incidence of adverse health effects, regulatory analyses usually address a smaller number of cases than would a cost of illness study focused on the same population. Cases associated with environmental contaminants may also have different characteristics than cases associated with other causes; e.g., may be more or less severe or affect different age groups.

[20]This type of analysis is more difficult for noncancer health effects than for most cancers, due to the availability of generally accepted practices for cancer dose-response assessment. Developing such practices for noncancer health effects is an active area of research because the lack of dose-response functions severely limits the quantification of most noncancer health endpoints in many benefit-cost analyses.

[21]Examples of these studies are provided in Appendix A as well as in footnoted references provided throughout this report.

To illustrate this difference, consider a hypothetical study designed to estimate the costs associated with a specific illness in a given year (e.g., 1998). Statistics characterizing the prevalence of the illness would estimate the costs for all individuals suffering from that illness in that year, regardless of the year of diagnosis. The use of incidence statistics, on the other hand, would yield an estimate of the costs over the entire period assessed (discounted back to the base year -- 1998), by those individuals who were first diagnosed with the illness in that year.

Data sets characterizing the incidence and prevalence of an illness for a given year will contain overlapping observations but will yield different results. For example, an individual who contracts the disease in February 1998 will be represented by both incidence and prevalence data for 1998. However, a person who contracts the disease in November 1997 and is still sick in 1998 will only appear in the prevalence sample for 1998.

The decision to use prevalence or incidence statistics depends on the goal of a particular analysis and the availability of data. Any transfer of a benefit estimate from the original study to a different context is generally accompanied by careful consideration of the quality of the study and the similarity of the health endpoints and populations considered.[22] In a case where both prevalence- and incidence-based studies are available and suitable for transfer, incidence-based values are generally preferred for regulatory benefit-cost analysis. Such studies provide "per case" values that can be easily linked to the results of the risk assessment (i.e., the number of statistical cases avoided) as described above.

The available incidence-based studies may, however, have shortcomings that must be considered when used in regulatory analysis. For example, for some illnesses, the available studies may not track the full course of the illness. Ideally, the cost estimate would cover the complete time period over which the health effect is experienced, which may range from a few days (e.g., for certain gastrointestinal ailments) to the remainder of the individual's lifetime (e.g., for illnesses such as diabetes where the symptoms can be treated but the illness can not be "cured"). However, the available research may consider a shorter time frame (e.g., one, five, or 10 years) determined largely by the available data.

In addition, for some illnesses, the available incidence-based studies may provide disaggregate data that cannot directly be used to develop "per case" estimates. Such studies may track costs separately for individuals undergoing different types of treatment or experiencing different types of illness-related events, rather than providing estimates of the aggregate costs of all treatments and all events associated with a typical case. For example, such studies may track the costs associated with angina or heart attacks separately, without providing estimates of the likelihood that a typical patient with ischemic heart disease would experience events of each type. In addition, some studies may not separate the costs of fatal cases from the costs for nonfatal cases.

[22] Guidance on conducting benefit transfers is provided in: U.S. Environmental Protection Agency (September 2000), pp. 85-87.

To address many of these concerns, EPA developed "per case" cost of illness estimates for several health effects, separating costs for survivors and non-survivors.[23] These estimates do not include indirect costs, however. Hence analysts may wish to add the value of time losses (using the approach discussed in the subsequent chapters of this report) to these cost of illness estimates for a more complete accounting of the impacts of illness. For illnesses not covered in the EPA handbook, analysts will need to review the health economics literature to determine how to best estimate the medical costs of illness.[24]

The remainder of this document focuses on approaches for estimating the per case value of the time losses associated with nonfatal health effects. It is concerned primarily with time losses for persons living with the disease and their caregivers. Although health economists sometimes use estimates of lost lifetime earnings to value premature mortality, EPA instead values mortality by applying willingness to pay estimates from the wage-risk and contingent valuation literature as discussed earlier in this chapter. The approach discussed in this report may, however, be useful in assessing time losses due to morbidity prior to death as well as due to nonfatal health effects.

The next chapter first reviews the empirical literature that addresses the value of time in a number of different contexts, including studies of nonfatal health risks, transportation options, and recreational opportunities. It then describes the theoretical underpinnings of these studies and the relationship of this theory to the valuation of illness-related losses. Chapter 3 then describes the approach for valuing time diverted from paid or unpaid work, leisure, or sleep in more detail, provides an example of the suggested approach, and summarizes related limitations and the assessment of uncertainty. These chapters are followed by a list of references used in developing the report. The report concludes with two appendices: Appendix A summarizes selected examples of time valuation from the indirect cost literature, while Appendix B discusses data sources that can be used to conduct the analyses described in this report.

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[23]U.S. Environmental Protection Agency, *Cost of Illness Handbook,* February 2001.

[24]EPA has not yet developed general guidance for working with the available cost of illness literature, beyond the approaches applied to the particular studies used in the *Cost of Illness Handbook*. Analysts will need to assess the quality of individual studies, consider their suitability for use in regulatory analyses, and determine how to best convert prevalence estimates, or incidence-based per treatment or per event estimates, to estimates of lifetime costs per case. In addition, because EPA is interested in using these studies primarily for valuing nonfatal health effects, approaches for separating out the costs of fatal versus nonfatal cases may be needed.

2.0 THEORETICAL AND EMPIRICAL APPROACHES

Review of the available empirical literature suggests that few researchers have fully addressed the value of time losses due to illness in a social welfare context. Researchers concerned with the availability of goods and services focus on the loss in productivity that results when ill individuals are unable to engage in normal work activities. These studies do not fully capture the effect of time losses on individual or social welfare, because they do not address the impacts on time normally used for leisure or other uncompensated activities nor do they address the utility (or satisfaction) potentially associated with work beyond its effect on production.

Researchers who are instead concerned with valuation within a social welfare context generally do not provide separate or comprehensive values for all types of time losses. While many studies of willingness to pay for risk reductions consider the effect of illness on normal activities, they do not provide a value for time losses that is separate from the value of other attributes of the illness. Several researchers have estimated the value of time spent traveling in the context of studies of transportation options and recreation opportunities. However, these estimates focus on the allocation of time to specific types of activities; not on its allocation to the full range of work and leisure activities that could be affected by illness.

While the available empirical research is of limited usefulness in providing specific dollar values that can be applied to illness-related losses, these studies involve substantial research into the factors that can affect these values. Hence these studies, and the theoretical framework that supports them, have a number of interesting implications for the valuation of both work and nonwork time.

This chapter reviews these studies and their advantages and limitations in the context of valuing time losses due to illness. It then discusses the key tenets of economic theory that underlie these studies and their implications. The chapter concludes by introducing an approach that uses compensation data to estimate the opportunity costs associated with illness-related time losses, which is discussed in more detail in the following chapter.

2.1 METHODS FOR VALUING LOST PRODUCTIVITY

Most of the available empirical studies of the effects of illness on time use are concerned with the potential loss in productivity; i.e., the decrease in the goods or services produced as a result of disability or absenteeism from work. The most common approach for valuing this lost productivity is the human capital approach, which uses compensation data to measure the value of a worker's product. An alternative is the friction cost method, which focuses on the loss in productivity that occurs prior to replacement of absent workers. Both methods provide an incomplete accounting of the value of time losses from a social welfare perspective because they exclude consideration of the utility an individual gains from involvement in both work and nonwork activities. The main differences between the two methods are the assumptions they make regarding the functioning of the labor market, particularly regarding the impact of unemployment. Both approaches are briefly summarized below.

2.1.1 Human Capital Method

The most frequently used approach for estimating the value of time losses due to illness is the human capital approach, which is concerned with the effects of illness on the production of goods and services. (A number of examples of this approach are referenced later in this report, and selected studies are reviewed in Appendix A.) This well-established approach focuses on individual productivity, defined as output over time, and assumes that workers are paid the value of their marginal product. As a result, worker compensation can be used to estimate the costs associated with absenteeism or reduced output. Underlying this approach are a number of standard theoretical assumptions regarding the functioning of labor markets, particularly that: (1) these markets are competitive; (2) firms seek to maximize profits; and (3) unemployment is insignificant. The last assumption is relevant because, for example, if an absent worker is replaced by a worker who would be otherwise employed at a different job, the net national change in output is still equivalent to the effects of having one less worker. If instead an absent worker is replaced by an unemployed individual, the net change in output may be small and temporary, resulting largely from the time needed for the transition to a new worker.

The human capital approach is closely linked to the approaches used to estimate the medical costs of illness. In both cases, researchers are interested in the effects of related costs -- in terms of dollar expenditures (medical costs) or decreased production of goods and services (lost work time) -- on the wealth of the nation. Hence a number of cost of illness studies, including several discussed later in this report, use the human capital approach to estimate the indirect costs of illness.

Applications of the human capital approach typically focus on paid work time, because compensation for this work provides a straightforward measure of the marginal value of this time to society. However, several analysts have extended this approach to encompass unpaid productive work; e.g., in the household or as volunteers. Although individuals engaged in nonmarket labor are not paid a wage, many observers consider such activities productive because they could be performed by a professional in return for compensation. To estimate the value of time associated with nonmarket labor, a "wage rate" must be derived, generally based on information on market rates for similar activities (e.g., for paid domestic workers).

The human capital approach is generally not used to value lost nonwork (leisure or sleep) time because researchers assume that related productivity losses are reflected at least in part in lost earnings; e.g., an illness-related decrease in rest or relaxation would manifest itself in part in decreased productivity during work hours. In addition, the effects of illness on individuals who do not engage in productive market or nonmarket work are not considered. However, some human capital studies consider time losses during childhood to the extent that they affect future earnings; for example, a child who misses a substantial amount of schooling due to illness may earn less as an adult.

Implementation of the human capital approach for valuing productivity losses is relatively straightforward. It relies on fairly simple calculations that involve well-defined variables and use established, readily available data sources of known quality. The literature includes completed studies for a number of illnesses, and analysts can construct their own estimates relatively easily. As a result, this approach can be applied across a wide range of illnesses.

2.1.2 Friction Cost Method

The friction cost approach is a comparatively new method for assessing productivity losses due to illness.[1] This approach was developed largely to address the mitigating effects of unemployment and other market conditions on productivity losses. It assumes that productivity will decrease temporarily while the employer implements measures to replace the ill individual, rather than over the full course of the illness. Proponents of this approach note that, when the labor market is not at full employment, it is possible to replace affected workers (after a period of adaptation), by: (1) hiring qualified unemployed individuals; (2) utilizing existing labor reserves within the firm; or (3) reallocating employees to different functions and postponing non-urgent tasks. The "friction period" is defined as the time it takes to find and train a new employee or reallocate duties among existing employees.

Implementation of the friction cost method is relatively complex because it requires estimates of the length and frequency of illness-related friction periods as well as the loss in productivity that accrues during these periods.[2] (The costs associated with finding replacement workers, including advertising and interviewing candidates, may also be included.) Generally, the duration of job vacancies is used to estimate the friction period; this vacancy rate presumably decreases as unemployment increases and reflects the efficiency of the labor market.[3]

One example of this approach is a study by Hutubessy et al. that addresses the indirect costs of back pain in the Netherlands in 1991.[4] This study is of interest both because it assesses friction costs for a single, nonfatal condition and because it compares the effects of using the human capital approach to the friction cost approach. In the human capital portion of the study, the researchers

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[1]Koopmanschap, M.A., F.F.H. Rutten, B.M. van Ineveld, and L. van Roijen, "The Friction Cost Method for Measuring Indirect Costs of Disease," *Journal of Health Economics,* Vol. 4, 1995, pp. 171-189.

[2]Koopmanschap, M.A., and F.F.H. Rutten, "A Practical Guide for Calculating Indirect Costs of Disease," *PharmacoEconomics,* Vol. 10, No. 5, 1996, pp. 460-456.

[3]Researchers also argue that, by affecting the labor costs per unit of output and hence competitiveness in the world market, absenteeism can have macroeconomic impacts. Because the reductions in the risks of nonfatal illnesses attributable to drinking water regulations are not large enough to have noticeable macroeconomic impacts, such impacts are not discussed in this report. See: Koopmanschap, M.A., and F.F.H. Rutten, "Indirect Costs in Economic Studies," *PharmacoEconomics,* Vol. 4, No. 6, 1993, pp. 446-454.

[4] Hutubessy, R.C.W., M.W. van Tulder, H. Vondeling, and L.M. Bouter, "Indirect Costs of Back Pain in the Netherlands: a Comparison of the Human Capital Method with the Friction Cost Method," *Pain,* Vol. 80, 1999, pp. 201-207.

multiply the number of sick days attributable to back pain by the mean costs (paid wages or disability pension) per day. In the friction cost portion, they both limit the number of sick days included to the friction period (estimated as equal to the average vacancy duration) and add in consideration of the estimated elasticity of work time vs. work output.[5] They find that the human capital approach leads to estimates over three times larger than the friction cost approach.

This result is to be expected because the friction cost method estimates productivity losses over a shorter time period than does the human capital approach. However, the friction cost approach could significantly understate the effects of illness on output if replacement of ill workers diverts other workers from productive tasks. For short-term or relatively mild conditions, productivity losses will depend on the extent to which any loss attributable to illness is counterbalanced by greater-than-usual productivity by co-workers or by the ill worker upon his or her return to work. For conditions with more severe or longer term impacts, net national losses will depend on the extent to which ill workers are be replaced by someone who is currently unemployed (compensating at least in part for the productivity loss), or by moving someone from another job (shifting the loss from one location to another). In either case, researchers must address difficult questions regarding the net effects of illness on productivity, which often require understanding conditions at the level of the individual firm.

The assumption that ill workers will be replaced by unemployed or otherwise underutilized individuals may not be true in economies with low unemployment rates or in industries that require highly specialized skills. In addition, productivity may not return to its previous level if the ill individual was in a position where factors that are not easily offset by training (such as tenure) have a significant effect on output. Thus while the friction cost method suggests that the human capital approach may overstate the effects of illness on productivity, the extent of overstatement is uncertain and will vary depending on the nature of the illness, the characteristics of the job, and the conditions in labor market at the time when the absence occurs. Finally, because the friction cost method does not account for the opportunity costs of working (i.e., the trade-off between labor and leisure time) and does not assign value to labor beyond the friction period, it is an incomplete measure of the value of lost work time.[6]

The friction cost method is less well established than the human capital approach and its

[5]This elasticity may represent less than a one-to-one correspondence; e.g., one day of absence from work may lead to less than a one day loss in output, if other workers produce at higher than normal rates to compensate for the absent worker. In the case of the Netherlands in 1991, Hutubessy et al. assume a elasticity of 0.8 for annual labor time vs. labor productivity.

[6]For discussion of these and other concerns regarding the consistency of the friction cost approach with neoclassical welfare economic theory, see: Johannesson, M. and G. Karlsson, "The Friction Cost Method: A Comment," *Journal of Health Economics*, Vol. 16, 1997, pp. 249 - 255. For commentary on the use of the friction cost approach in cost-effectiveness analysis, see: Weinstein, M.C., Siegel, J.E., et. al, "Productivity Costs, Time Costs and Health-Related Quality of Life: A Response to the Erasmus Group," *Health Economics*, Vol. 6, 1997, pp. 505-510.

implementation in the context of regulatory analysis would present a variety of challenges. Friction cost estimates are available for only a few health effects, and many of the available studies address countries other than the U.S.[7] In addition, these studies usually address losses within a given year. It would be difficult to convert these annual estimates to the types of estimates of lifetime costs per case required for regulatory analysis, especially because the level of unemployment (and hence the likelihood that an ill worker will be replaced with an unemployed individual) is likely to vary over time.

Like the human capital method, the friction cost approach focuses on productive work and does not address other types of activities. While proponents of the friction cost approach believe that it could be used to estimate the effects of illness on reduced productivity while working, on unpaid productive activities (such as household tasks or volunteer work), and on leisure time, they have not yet developed an approach for quantifying friction-related costs in these areas.[8] In addition, using this method to assess the future impacts of illness (such as in the case of childhood illnesses that affect adult productivity) presents difficulties due to the need to predict unemployment levels as well as the duration and costs of friction periods over time. Finally, while both the human capital and friction cost methods exclude consideration of the impact of illness on the individual utility associated with work and nonwork activities (beyond the impact on productivity), the friction cost method also does not address the effects of lost compensation on the ill individual and his or her family.

2.1.3 Relationship of Productivity Losses to Social Welfare Losses

The human capital and friction cost approaches to valuing lost productivity differ in terms of the underlying assumptions regarding the operation of labor markets and the value of labor as well as in terms of practical application. However, the most significant deficiency of both approaches is their narrow focus on production and the exclusion of other aspects of social welfare.

The goal of EPA regulatory analyses is to develop as complete an accounting as possible of the social welfare impacts of alternative policies. Both of the methods discussed above fall short of this goal because they focus on goods and services and do not consider other factors that affect individual well-being. As discussed by A. Myrick Freeman III in his seminal work on benefits valuation:

> *The economic concept of value employed here has its foundation in neoclassical welfare economics. The basic premises of welfare economics are that the purpose of economic*

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[7]For example, a recent search of the MEDLINE bibliographic database identified 11 studies that apply the friction cost method, many of which were completed in countries other than the U.S. and address symptoms (such as neck pain) or health effects (such as mental illness) not usually associated with reductions in drinking water contamination

[8]Koopmanschap and Rutten (1993).

activity is to increase the well-being of individuals who make up society, and that each individual is the best judge of how well off he or she is in a given situation. Each individual's welfare depends not only on that individual's consumption of private goods and of goods and services produced by the government, but also on the quantities and qualities each receives of nonmarket goods and service flows...[9]

In this context, analysts are concerned with the effect of illness on foregone market production (paid work), foregone nonmarket production (e.g., volunteer or household activities), and any additional diminished utility (or sense of well-being) associated with both work and nonwork activities (including leisure and sleep time). Analysts are also concerned with the impacts of illness on other individuals such as dependent children or unpaid caregivers.[10]

In contrast, as discussed above, most of the work on valuing time losses has been completed in the context of estimating the market impacts of illness, focusing on the ill individual. In this context, individuals are viewed as mechanisms of production. The analyst is generally not concerned with other (nonmarket) factors affecting individuals' sense of well-being, except, of course, if they affect market productivity. For example, in his discussion of the use of the human capital approach to value premature mortality, Freeman notes:

The human capital approach is fundamentally at odds with the individualistic perspective of welfare economics and the theory of value. By in effect asking what the individual is worth to society, the human capital approach ignores the individual's own well being, preferences, and WTP [willingness to pay]. It defines the social worth of an individual in a narrow way, that is, as the individual's market productivity, thereby ignoring the value of that person's health and well-being to loved ones.[11]

Similar concerns have been voiced regarding the friction cost method, which takes an even narrower view of the value of lost work time. For example, Johannesson and Karlsson note that "the friction cost approach is based on implausible assumptions not supported by neoclassical economic theory." Economic theory suggests that "[a] firm can be expected to hire labour until the marginal cost of labour equals the marginal value of the products produced by the worker. If a worker is absent this would represent a marginal loss of labour, whose value for the firm equals the gross income of the worker."[12] Furthermore, the authors note the friction cost approach does not take into account the loss in leisure time that accrues when short term absences are offset by greater-than-

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[9]Freeman, A.M. III, *The Measurement of Environmental and Resource Values: Theory and Methods*, Second Edition, Washington, D.C.: Resources for the Future, 2003, p. 7.

[10]Paid care is included in the medical cost component of the analysis and hence is not included in the valuation of time losses.

[11]Freeman (2003), p. 302.

[12]Johannesson and Karlsson (1997).

normal productivity by others or by the ill worker upon his or her return. For long term absences, they note that, after the friction period, the price (i.e., opportunity cost) of work time is set close to zero, which is inconsistent with both economic theory and empirical evidence.

2.2 METHODS FOR VALUING SOCIAL WELFARE LOSSES

The generally preferred method for valuing social welfare losses due to illness would be to rely on estimates of individual willingness to pay, as discussed earlier in this report.[13] Such estimates could directly address the limitations of the human capital and friction cost methods described above by providing a broader measure of the impact of illness on individual welfare. For goods and services that are not directly bought and sold in the market place, economists generally rely on stated or revealed preference methods to estimate these values. Stated preference methods typically involve asking individuals what they would be willing to pay, whereas revealed preference methods use information on the price of market goods to estimate willingness to pay for related nonmarket goods.

While it would be possible to use revealed or stated preference methods to value illness-related time losses, few, if any, such studies have been completed. As discussed below, most empirical work provides a total value for all attributes of an illness, without separating out the value of time losses.[14] These studies suggest, however, that illness-related activity restrictions are an important influence on individual willingness to pay for risk reductions.

The value of time has been studied extensively, however, in the literature on willingness to pay for transportation and recreation options. While this literature focuses somewhat narrowly on particular types of time use rather than the full range of leisure and work activities potentially affected by illness, the underlying theory and the results of related empirical studies have a number of implications for the valuation of illness-related losses, as described in the following sections.

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[13]Estimates of willingness to accept compensation may be appropriate in some cases, but are rarely applied in practice, as discussed in U.S. Office of Management and Budget, *Regulatory Analysis (Circular A-4)*, September 2003, p. 18 and U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, September 2000, EPA 240-00-003, p. 60. Freeman (2003) provides detailed discussion of related theoretical and practical issues.

[14]More information on these methods is available in U.S. Environmental Protection Agency (September 2000) and Freeman (2003).

2.2.1 Willingness to Pay for Risk Reductions

A number of researchers have used stated or revealed preference methods to assess the value of risk reductions without separating out the value of related time losses. This holistic approach is undertaken largely because it is the preferred approach to valuation. As discussed in Chapter 1 of this report, separate valuation of time losses is needed only when the existing literature does not provide suitable estimates of willingness to pay for the risk reductions of concern and analysts lack the time or resources necessary to undertake new willingness to pay studies.

Available research suggests that the effect of illness on time usage is an important component of individual willingness to pay for risk reduction. Several willingness to pay studies include lost time explicitly in the valuation scenario.[15] For example, in a survey of willingness to pay for a program to reduce bad asthma days, Rowe and Chestnut elicited information on the effects of asthma on work, school, chores, and leisure activities.[16] However, the authors did not ask respondents to report their willingness to pay to avoid these time losses separately; rather, they asked respondents to report their total willingness to pay for the program.

Researchers also have found that time losses are a key factor affecting the magnitude of individual willingness to pay for health risk reductions. For example, Magat, Viscusi, and Huber found that "must restrict recreational activity" was one of the consequences of nerve disease to which respondents were most adverse.[17] Even for minor symptoms (coughing spells, stuffed up sinuses, etc.), Berger et al. found that a small percentage of respondents ranked loss of work at home or loss of recreation as the most important reason for their value for relief of symptoms.[18] In their study of angina, Chestnut et al. found that "subjects said that the most bothersome effects of a worsening of their condition ...would be decreased ability to do desired activities (recreation, chores, or work), and pain or discomfort."[19]

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[15]The cited studies generally use stated preference methods. Revealed preference methods that consider averting behavior or defensive expenditures also implicitly involve the valuation of time, since engaging in these behaviors (e.g., installing and maintaining a water filter) has a time cost as well as a monetary cost.

[16]Rowe, R.D. and L.G. Chestnut, *Valuing Changes in Morbidity: WTP vs. COI Measures*, prepared for the U.S. Environmental Protection Agency and the California Air Resources Board, undated.

[17]Magat, W.A., W. K. Viscusi, and J. Huber, *The Death Risk Lottery Metric for Valuing Health Risks: Applications to Cancer and Nerve Disease*, prepared for the U.S. Environmental Protection Agency, 1992, Table 4.

[18]Berger, M. C., G. C. Blomquist, D. Kenkel, G. S. Tolley, "Valuing Changes in Health Risks: A Comparison of Alternative Measures," *The Southern Economic Journal*, Vol. 53, 1987, pp. 977-984.

[19]Chestnut, L.G., S.D. Colome, L.R. Keller. W.E. Lambert, et al., *Heart Disease Patients Averting Behavior, Costs of Illness, and WIllingness to Pay to Avoid Angina Episodes*, EPA Report 230-10-88-042, October 1988, p. 4.

In addition, researchers have used stated preference methods to assess the value of restricted activity days, which are generally defined as time periods when individuals find that their activities are more limited than normal. This approach is closely related to the concept of lost time, but (as applied in the available literature) generally results in a value for all of the restrictions associated with a particular illness, rather than in a value of time losses that could be adjusted for application across different illnesses.

The restricted activity day approach is often used in the air pollution context. For example, researchers have linked self-reported data on activity restrictions to data on air pollution levels to determine the effects of this pollution on normal activities. They then apply estimates of willingness to pay for avoiding these restrictions (derived from stated preference studies of minor respiratory symptoms) to the estimates of the number of activity restricted days to determine their value.[20]

2.2.2 Willingness to Pay for Transportation and Recreational Options

In its simplest form, neoclassical economic theory suggests that individuals will allocate time between paid work and other activities so that, at the margin, the value of paid work is equal to the value of uncompensated activities. If individuals receive no utility from work (beyond the effects of income on consumption), then wage rate can be used to estimate the opportunity cost, or shadow price, of time. Research on the value of travel time, within the context of evaluating transportation and recreation options, thus often uses the wage rate as a reference point for comparing results across studies. Researchers are not always consistent in the basis for this comparison (e.g., in whether they compare their findings to individual or household income and in whether they include or exclude taxes and benefits). Such comparisons indicate, however, that the empirical results of these studies vary greatly.

Travel time has been studied extensively by researchers interested in assessing different transportation options.[21] Some of these studies focus on the relative value of different modes of transport (e.g., airplane, car, walking) taking into account comfort and convenience as well as speed and related economic costs.[22] Other studies focus more on the value of each time increment spent in travel for different purposes, such as business or leisure activities.

The variation in the resulting values is evident in the U.S. Department of Transportation's

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[20]See, for example, the approach applied in: Abt Associates, *Final Heavy Duty Engine/Diesel Fuel Rule: Air Quality Estimation, Selected Health and Welfare Effects Methods, and Benefits Results*, prepared for the U.S. Environmental Protection Agency, December 2001.

[21]For a review of these studies and the underlying theory, see: Small, K., *Urban Transportation Economics*, Luxembourg: Harwood Academic Publishers, 1992, pp. 36-45.

[22]MVA Consultancy et al., "Research Into the Value of Time," in R. Layard, R. and Glaister, S.(eds.), *Cost-Benefit Analysis*, Second Edition, Cambridge: Cambridge University Press, 1994, pp. 235-272.

(DOT's) recommendations for valuing changes in travel time attributable to its programs, which are based on detailed review of the literature.[23] For business travel (during paid work hours), DOT indicates that a plausible range is 80 to 120 percent of the total hourly compensation rate (including wages and benefits), and recommends a best estimate of 100 percent. For personal travel (commuting, shopping, recreation, etc.), DOT suggests a plausible range of 35 to 90 percent of pre-tax wages, with a best estimate of 50 to 70 percent depending on whether the travel is local or intercity. These ranges reflect, in part, the fact that travel has both desirable and undesirable attributes which may have counterbalancing effects in determining total value. For example, a trip may include time spent on relaxing scenic routes as well as in stressful urban congestion. Business travelers may devote some of their travel time to productive work, or may find that their productivity suffers if a travel delay leads them to miss meetings or other work activities.

Travel and related uses of leisure time also have been studied extensively in the context of valuing recreation opportunities; e.g., the availability of public lands for activities such as fishing or hiking.[24] The fundamental assumption is that the value of a recreational opportunity is at least as great as the value of what one is willing to give up (e.g., the opportunity costs of money and time expenditures) in order to participate in related activities.[25] For example, a simple travel cost model may use market data and survey information to determine the money costs (e.g., fuel, tolls, and access fees) and the time costs (e.g., spent traveling and on-site) to make inferences about individual willingness to pay. Some models, such as random utility models (sometimes referred to as discrete choice models), consider environmental quality variables as well as travel costs that affect an individual's choice between different recreational sites. While the money costs considered in these studies are often observable, the value of time is more difficult to measure and there is no consensus regarding how it is best valued. Further, disagreement exists regarding the valuation of time spent in travel verses time spent on-site.

Several studies of recreation opportunities value travel time at some fraction of the wage rate, frequently one-third. The use of one-third of the wage rate is somewhat arbitrary and appears to have its origins in some of the early transportation literature.[26] For example, many economists

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[23]U.S. Department of Transportation, *Departmental Guidance for the Valuation of Travel Time in Economic Analysis* (Memorandum from F.E. Kruesi), April 1997, and U.S. Department of Transportation, *Revised Departmental Guidance, Valuation of Travel Time in Economic Analysis,* (Memorandum from E. H. Frankel), February 2003.

[24]For more detailed discussion of approaches for valuing recreational opportunities, see U.S. Environmental Protection Agency (September 2000), pp. 73 - 74, and Freeman (2003), Chapter 13.

[25]As noted by Wilman, under this approach "[i]t is assumed that a travel-cost increase would be viewed by the recreationalist as being equivalent to a fee increase for an on-site visit." Wilman, E.A., "The Value of Time in Recreation Benefit Studies," *Journal of Environmental Economics and Management*, Vol. 7, 1980, pp. 272- 286.

[26]Shaw, W. D., and P. Feather, "Possibilities for Including the Opportunity Cost of Time in Recreation Demand Systems," *Land Economics*, Vol. 75, No. 4, 1999, pp. 592-602.

reference a 1976 study by Cesario that examines the question of how to value time in recreational studies.[27] This study reviews the then-available literature, which focused almost exclusively on the value of commuting time and included several studies of the choice between private and public transport options. Cesario indicates that "[t]hese early studies were plagued by the usual methodological problems besetting research into any new area of inquiry." However, he goes on to note that "it may be tentatively concluded...that the value of nonwork travel is between one-fourth and one-half of the wage rate" for the average individual and trip. In his own analysis of recreation opportunities in several parks, Cesario then uses one-third of the wage rate to represent the results of his literature review, while noting that this value "is arbitrary."

Although some researchers subsequently used this value of one-third the wage rate in their own studies, a number of others began to more directly investigate the value of time in the context of recreational valuation.[28] The results of these studies vary greatly, due to differences in the modeling approaches used (and the simplifying assumptions they incorporate) as well as in the data sources and types of activities considered. For example, in a 1981 study of sportfishing, McConnell and Strand directly examine the value of travel time as a proportion of the wage rate.[29] Their simple travel cost model assumes that individuals have flexible work hours and that the ratio of the opportunity cost of time to income is constant. They find that, for the typical angler included in their survey, travel time is valued at approximately 60 percent of hourly income.

A study published in 1983 by Smith, Desvousges and McGivney then examined the assumption that the opportunity cost of time could be represented as a fixed percentage of the wage rate.[30] The researchers rely on a survey that collected relatively detailed socioeconomic information on respondents, but that did not report their wage rates. Hence the researchers predict wage rates for each individual, based on each respondent's reported characteristics and wage data for similar individuals from the Current Population Survey, using a hedonic model. Hedonic approaches are statistical methods for imputing missing values from available data, and are often useful when individual wage rates are unknown -- either because wage data were not collected or because the researcher is interested in estimating a wage (or a shadow price of time) for individuals not in the labor force.

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[27]Cesario, F.J., "Value of Time in Recreation Benefit Studies," *Land Economics*, Vol. 52, No. 1, February 1976, pp. 32-41.

[28]Shaw and Feather have published a number of articles (cited throughout this section) that review these and related studies as well as their implications for further research. See, for example, Shaw, W. D., "Searching for the Opportunity Cost of an Individual's Time," *Land Economics*, Vol. 68, No. 1, 1992, pp. 107-115.

[29]McConnell, K.E., and I. Strand, "Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sportfishing," *American Journal of Agricultural Economics*, Vol. 63, 1981, pp. 153-156.

[30]Smith, V. K., W. H. Desvousges, and M. P. McGivney, "The Opportunity Cost of Travel Time in Recreation Demand Models," *Land Economics*, Vol. 59, No. 3, 1983, pp. 259-278.

The Smith, Desvousges and McGivney study uses these hedonic results to estimate the value of travel and on-site time for 43 water-based recreation sites. They experiment with different model specifications that (1) include or exclude the value of on-site time, and (2) estimate the opportunity cost of travel time based on the predicted wage or one-third of this amount. They find that including the value of on-site time improves the model estimates for about half of the sites. Their tests of alternative values for travel time indicate that neither the full wage rate nor one-third the wage rate is "unambiguously superior to the other as an approach for approximating the opportunity cost" of travel time. They note that these results may largely reflect the impact of missing data (e.g., on the flexibility of work hours), and suggest that additional research is needed to better estimate these values.

Other researchers subsequently examined the effects of work hour flexibility on the value of leisure time, and found that these values vary depending on labor market status. For example, in a 1987 study, Bockstael, Strand, and Hanemann examine the effects of fixed work hours on the valuation of time.[31] Their study is based on a survey of sportfishers in Southern California and considers the value of both travel and on-site time. The researchers find that, for individuals with flexible work hours, the average opportunity cost of time was about equal to their wage rate. In contrast, for individuals with fixed work schedules, the opportunity cost of time was about 3.5 times the wage rate.

A more recent (1999) study by Feather and Shaw further examines the impact of inflexible work hours. The researchers first estimate the value of leisure time (referred to as the shadow wage) for each individual based on work force status and other attributes, and then use a random utility model to estimate the value of river recreation.[32] They build on a theoretic model developed by Heckman that considers whether an individual is underemployed (working fewer hours than desired) or overemployed (working more hours than desired) due to the prevalence of jobs with fixed work hours.[33] Of the employed individuals (who include both hourly and salaried employees), roughly one-third reported flexible hours, one-third were overemployed, and one-third were underemployed. The researchers find that the shadow wage or opportunity cost of time exceeds the market wage in cases where an individual is working more hours than he or she would prefer, but is less than the market wage in cases where an individual is working fewer hours than desired. Where work hours are flexible, the opportunity cost was reasonably close to the market wage rate.

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[31]Bockstael, N. E., I. E. Strand, and W. M. Hanemann, "Time and the Recreational Demand Model," *American Journal of Agricultural Economics*, Vol. 69, 1987, pp. 293-202.

[32]The authors compare the results of this approach with models that estimate the value of time as a fixed fraction of the wage rate or that apply a hedonic approach. Feather, P. and W.D. Shaw, "Estimating the Cost of Leisure Time for Recreation Demand Models," *Journal of Environmental Economics and Management*, Vol. 38, 1999, pp. 49-65; and, Feather, P. and W.D. Shaw, "The Demand for Leisure Time in the Presence of Constrained Work Hours," *Economic Inquiry*, Vol. 38, No. 4, October 2000, pp. 651-661.

[33]Heckman, J., "Shadow Prices, Market Wages, and Labor Supply," *Econometrica*, Vol. 42, No. 4, July 1975, pp. 679-694, as cited in Feather and Shaw (1999).

The variation in individual valuation of travel costs is explored further using a somewhat different approach in Englin and Shonkwiler's 1995 research on the value of boating, angling, and swimming trips to freshwater recreation sites.[34] To reflect the assumption that the different values that individuals assign to travel costs are unobservable, they build an econometric model that includes travel costs as a latent (unobserved) variable, and include data on various indicators of its value. They find that time spent traveling is valued at approximately 40 percent of the wage rate.

These studies are concerned with particular types of time use, such as travel, rather than the diverse types of activities potentially affected by illness. They suggest, however, that empirical measures of the value of time can vary greatly depending on the modeling approach used and the context within which it is studied, highlighting the complexities inherent in this endeavor. In each of the studies cited above, the researchers acknowledge related difficulties and explore some of the factors (such as the availability of flexible work hours) affecting estimation of these values. Despite these difficulties, the development of these studies provides a number of insights -- both theoretic and practical, that are broadly relevant to the valuation of time losses. The following section discusses these implications.

2.3 IMPLICATIONS FOR VALUING ILLNESS-RELATED TIME LOSSES

The empirical literature provides relatively little information on the dollar value of time losses due to illness that can be used directly in regulatory analysis. This literature tends to focus narrowly on particular types of time use (e.g., productivity or travel) or yields estimates (e.g., of the overall value of risk reduction) that combine consideration of activity restrictions with consideration of other impacts. This literature is, however, a rich source of information on the factors that influence the value of time, that is useful in considering how to best value time losses in cases where more complete measures of willingness to pay for risk reductions are not available. The pursuit of the types of studies discussed earlier has led to a number of developments in the theoretical models considered in time valuation that have wide-ranging implications.

As noted in Chapter 1, the practice of benefit-cost analysis is based in welfare economic theory. The following sections review certain aspects of that theory that have particular relevance to the valuation of time. This discussion is not intended to be a comprehensive review of the extensive literature related to this topic; rather, it provides a brief overview of key considerations as well as references for those interested in more information.

The first section discusses the complex role that time plays in individual welfare maximization as both a "commodity" and a "resource." The second section describes the valuation of leisure time based on individual decisions regarding paid work. Each section begins by summarizing the key related tenets of the simple neoclassical economic model and then briefly

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[34]Englin, Jeffrey, and J.S. Shonkwiler, "Modeling Recreation Demand in the Presence of Unobservable Travel Costs: Toward a Travel Price Model," *Journal of Environmental Economics and Management,* 1995, Vol. 29, No. 3, pp. 368-377.

discusses the theoretical and empirical research on the effects of relaxing some of these assumptions. The final section then introduces an approach for using compensation data to value the opportunity costs of time use, based on the framework that results from the research summarized previously in this chapter.

2.3.1 Time as a Commodity and as a Resource

The basic neoclassical economic model assumes that individuals will consume a mix of goods and services that maximizes their utility (or sense of satisfaction or well-being), subject to their income constraint. In the simplest form of this model, time does not enter the utility function directly, although income clearly depends on the amount of time spent working (as well as on other factors such as education and the availability of investment assets). In addition, the consumption of goods and services also requires the use of time; e.g., to eat a meal, go to the movies, or participate in other activities.

A number of researchers have explored the implications of incorporating time more directly into this model, in particular, by considering both the "commodity" value and "resource" value of time. The commodity value of time is associated with the level of utility, or pleasure, one gains while participating in an activity (i.e., from consumption of goods or services). The resource value of time is related to its scarcity -- because the total number of hours per day is fixed, time saved in one activity can be used to engage in other activities which may generate a higher or lower level of utility.

One frequently cited early model that formalizes these relationships was developed by DeSerpa, who expands the neoclassical model to include three essential features:

> *...(1) utility is a function not only of commodities but also of the time allocated to them; (2) the individual's decision is subject to two resource constraints, a money constraint and a time constraint; and (3) the decision to consume a specified amount of any commodity requires that some minimum amount of time be allocated to it, but the individual may spend more time in that activity if he so desires.*[35]

Under this model, the difference between the commodity value (time in its current use) and the scarcity or resource value (the value of time in its an alternative use -- which may be higher or lower) represents the value of time saved. A positive value of time saved suggests that it could be devoted to an alternative activity of greater value to the individual.

DeSerpa notes that one implication of this model is the need to differentiate between time spent in various types of activities. Economists normally define leisure as time spent on activities

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[35]DeSerpa, A. C., "A Theory of the Economics of Time," *The Economic Journal*, Vol. 81, No. 324, December 1971, pp. 828-846.

other than work, but DeSerpa suggests that it may be more useful to consider a distinction made by Tipping between leisure and intermediate goods.[36] Leisure involves free choice in the consumption of goods and services (such as recreation), while intermediate goods are activities (such as travel to a recreational site) that make the consumption of this leisure possible. Variations on this conceptual model underlie several of the approaches applied in the recreation literature examined earlier in this chapter, as well as the related debate over the appropriate valuation of travel and on-site time.[37]

This model also suggests that it is important to consider the choices of activities considered by individuals in determining their opportunity costs of time. For example, as Cesario notes:

> *The value of time for an individual in a given situation is conditioned by what activities are being traded off. If the individual is trading off travel time for work time and there is no marginal utility or disutility associated with work or travel, then there is some basis for valuing travel time at the wage rate. However, it seems farfetched to assume that the recreational tripmaker is trading off time for travel with time for work. It seems much more likely that the trade off is between time for travel and time for leisure activities... The value of travel time in a recreational tripmaking context thus reflects the value placed on alternative uses of leisure time by the individual, for this is the relevant opportunity cost. If we posit that travel per se carries with it a marginal utility or disutility, then it can be shown that the value of saving travel time will diverge from the value of leisure time.*[38]

This theoretical framework, as well as the results of empirical studies (such as the 1983 Smith, Desvousges and McGiverny study discussed earlier) suggests that the value of time is likely to vary across individuals and activities, and that researchers need to carefully consider the context for valuation. For example, illness may force an individual to involuntarily participate in activities (such as bed rest or doctor visits) in lieu of his or her preferred normal activities. The implied trade off is different than in the case of a individual choosing among of variety of recreational opportunities.

2.3.2 The Labor-Leisure Trade Off

As noted earlier, the basic neoclassical economic model assumes that individuals will allocate time between paid work and other activities up to the point where, at the margin, the value of compensation received is equal to the value of uncompensated activities. The assumptions behind

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[36]Tipping, David G., "Time Savings in Transport Studies," *Economic Journal*, December 1968, pp. 843-854, as cited in DeSerpa (1971).

[37]See, for example, Wilman (1980) for an early theoretical analysis of the implications of this approach for recreation studies.

[38]Cesario (1976).

this approach are summarized in the Gold et al. study of "best practices" for cost-effectiveness analysis:

> *...The fundamental assumption of this literature is that people will take their opportunity cost into account when allocating their time, choosing to devote it to the activities that produce the greatest utility. They will work an extra hour, for example, if the compensation they receive exceeds the value they place on their time in other activities...*
>
> *...The labor-leisure trade off, which is at the heart of the theory of labor supply, illustrates the method used to value time which is not spent at work: if there is perfect competition; if workers and employers are perfectly well informed; if the worker has declining marginal utility of leisure time (i.e., the more time spent away from work, the lower the value of each incremental increase in leisure time) and diminishing marginal utility of income; and if the quantity of labor supplied in the market is continuously variable, then the worker "consumes" leisure time up to the point at which the value of an additional hour of leisure equals the (hourly) wage that he or she can receive by working.*[39]

As indicated by this quote, the use of wage data to estimate opportunity costs is based on a number of simplifying assumptions regarding the operations of labor markets and the process by which individuals choose among different activities, many of which have been investigated in the theoretical and empirical literature.

One key assumption that affects this trade-off is the ability to work as many, or as few, hours as desired. The wage rate may over- or understate the value of leisure time when individuals do not have complete flexibility in work hours. If this inflexibility causes them to work more hours than desired (i.e., they would prefer to spend time, at the margin, in leisure rather than work), the marginal value of leisure is likely to be greater than the marginal wage. If they are working less than desired, the opposite is likely to be true. This assumption has been investigated in empirical work, such as in the Bockstael, Strand, and Hanemann 1987 study and the Feather and Shaw 1999 study discussed earlier. These studies find that the shadow price of time may be higher or lower than the wage rate in cases where individuals do not have flexible work hours, but that time is valued close to the wage rate when hours are flexible.

Building on the work of Bockstael, Strand, and Hanemann and others, Larson notes that the degree of flexibility in work hours also depends on whether the perspective is short term or long term.[40] He describes the two stage budgeting model, where in the first stage the individual decides how to allocate his or her time between work and nonwork activities, and in the second stage the individual decides how to allocate the resulting nonwork time across different activities. As noted

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[39]Gold, M.R., L.B. Russell, J.E. Siegel, and M. C. Weinstein (eds.), *Cost-Effectiveness in Health and Medicine*, New York: Oxford University Press, 1996, p. 40.

[40]Larson, D.M., "Separability and the Shadow Value of Leisure Time," *American Journal of Agricultural Economics*, Vol. 75, August 1993, pp. 572-577.

in the prior section (in the discussion of Cesario's approach), recreation demand modeling generally focuses on decisions in this second stage. However, over the long run, individuals may have more flexibility in choosing the hours worked, if they can choose among different jobs offering varying wages or work schedules. From this long run perspective, at the margin, the wage rate than may be the appropriate measure of the value of leisure time.

These theoretical constructs and related empirical work suggest that the wage rate may represent the opportunity costs of leisure time under short-term or long-term conditions where there is flexibility in work schedules and income. It also provides some indication of the extent to which such opportunity costs may diverge from the wage rate in cases where labor market choices are more constrained than in the simple neoclassical model; for example, suggesting that wage rates will understate the value of leisure time when work hours are inflexible and greater than desired.

The utility maximizing behavior that underlies the neoclassical model also suggests that individuals will allocate their time across all nonwork activities so as to equalize the marginal value of time spent in each activity, and that this marginal value will equal the marginal wage rate; i.e. the amount that one would earn from working an additional hour. However, as Winston has noted, the use of time is constrained by the time period considered -- limited options exist for working at night or during the weekend, golfing may be possible only during the day and in good weather, etcetera.[41] This limited availability may lead to variations in the value of time over different periods. Valuing time spent in discrete individual activities presents a number of practical challenges, however, and has been infrequently attempted in the empirical literature. Many activities are bundled (e.g., one may listen to the radio while vacuuming, or one must travel to go fishing), making it difficult to value them separately.

In addition, it is often hard to separate marginal from average values. The standard assumption of decreasing marginal utility suggests that the last, or marginal, unit will be valued less than the preceding units. (In other words, an individual would value the second hour of leisure time received less than the first hour, and the average value of an hour spent in that activity will exceed the value of the final hour.) However, separating and defining activities in a manner that allows the switch point (or marginal unit) to be identified can be quite complex. The advantage of focusing on the overall labor-leisure trade off is that the presence or absence of wages can be used to define the marginal unit.

The focus on marginal trade offs in the labor-leisure decision is similar to the focus of the human capital model on marginal decisions by the employer, as discussed earlier in this chapter. The human capital approach assumes that employers hire workers up to the point where, at the margin, the value of the worker's output is equal to the value of his or her cost to the employer. In this case, total compensation (pre-tax wages plus benefits) can be used to value marginal changes in output.

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[41]Winston, G. C., "Activity Choice: A New Approach to Economic Behavior," *Journal of Economic Behavior and Organization*, Vol 8, 1987, pp. 567-585.

2.3.3 Conclusions

The discussion in this chapter suggests that there are no "off-the-shelf" readily available estimates of the value of illness-related time losses. It does suggest, however, that the neoclassical economic model provides a framework for valuing the opportunity costs of time in a social welfare context, arguing that compensation or wages can be used to value time at the margin. However, theoretical and empirical investigation of the assumptions underlying this model suggests that there are cases where the value of time will diverge from these rates, and argues for careful consideration of related uncertainties. The following chapter discusses the use of compensation data to measure the opportunity cost of time in more detail -- considering paid work, unpaid work, leisure, and sleep separately -- as well as the limitations of this approach.

The preceding discussion also indicates the need to take into account the differences between the context for regulatory analysis and the context underlying much of the available empirical research. When valuing time losses due to illness, the analyst is concerned with a condition that may force an individual to spend time in activities (such as bed rest or doctor's visits) other than their preferred, normal activities. This differs from the situation generally modeled in the recreation or transportation literature, where the analyst is concerned with the choices an individual makes in determining how to "normally" spend his or her time; e.g., in selecting modes of transportation or recreational opportunities.

In addition, in the context of regulatory analysis, analysts are not able to identify the specific individuals who might be affected by the risk reductions nor are they likely to have detailed information on the types of time use affected. The risk assessment may provide limited information on the characteristics of affected individuals; e.g., the age range of individuals most likely to incur the risks (e.g., the very young or very old). The analysis of contaminant occurrence may, in some cases, suggest that certain geographic regions will be disproportionately affected. Whether the analyst has detailed information on the extent to which the health effects of concern curtail different types of activities or on the duration of these restrictions is likely to vary from illness to illness. The analyst generally will need to estimate values based on the general characteristics of the potentially affected population, rather than on detailed characterization of each potentially affected individual.

This contrasts sharply with the context for most of the transportation and recreation studies described above, which survey identifiable individuals and value more discrete activities. Thus while the recreation literature supports the notion that different activities will have different values and that these values will vary across individuals, the regulatory analyst is often looking for values that provide averages or expected values that cover a range of individuals and activities. The following chapter discusses approaches for developing these values in more detail, and includes an example of the calculation of the value of time losses in the context of regulatory benefit-cost analysis.

3.0 CALCULATING THE VALUE OF LOST TIME

The available empirical literature reviewed in the prior chapter provides little information on the specific dollar values individuals place on avoiding the effects of illness on their ability to pursue normal activities. It does, however, provide a framework for determining the value of time in a social welfare context, based on the concept of opportunity costs. Neoclassical economic theory includes two key related tenets: (1) employers hire workers up to the point where, at the margin, the value of the worker's output is equal to the value of his or her cost to the employer, and (2) individuals allocate time between paid work and other activities up to the point where, at the margin, the value of compensation received is equal to the value of the uncompensated activities.

While these tenets are based on a number of simplifying assumptions regarding the functioning of labor markets and the factors influencing individual choices, they provide a starting point for valuing time losses. They suggest that compensation data can be used to estimate the value of time (i.e., its opportunity cost) in its preferred, or normal, use. This value of time in its normal use can then be compared to illness-related time use to estimate the value of the losses that occur when an individual's activities are restricted by illness. Uncertainty analysis then can be applied to assess the effects of simplifying assumptions on the resulting values.

This chapter extends the discussion of the value of time by breaking time use into four categories: paid work, unpaid work, leisure, and sleep. The first section discusses different approaches for valuing each type of time use based on the available theoretical and empirical literature, suggests an approach for valuation in the context of regulatory analysis, and notes some of the key limitations of the approach. The following section discusses the valuation of time for individuals not currently employed (including children, the elderly, those seeking employment, and those not in the labor market).

The next section then discusses how the extent of loss can be assessed, considering both complete losses (e.g., where the individual is unable to participate in normal activities due to illness) and partial losses (e.g., where the individual continues to participate in normal activities but finds them less productive or enjoyable than usual due to illness). In other words, it considers the impact of illness on the *quantity* of time spent on normal activities, as well as its effect on the *quality* of the experience. In addition, it discusses the impacts of illness on caregivers. The chapter concludes with an example of the calculation of the value of time lost due to illness, and describes the limitations of the approach that can be explored through uncertainty analysis.

3.1 VALUING TYPES OF TIME USE

From a social welfare perspective, the value of time depends in part on the type of activities in which an individual is engaged. The available valuation literature varies in the ways in which it categories these activities. For example, much of the human capital research focuses on the productivity of paid (market) and unpaid (nonmarket) work time, while recreational studies often consider only the difference between the value of travel time and other nonwork or leisure time --

defining leisure broadly to include any uncompensated activity. In reality, individuals may value each specific activity differently. This variation may result from the need to engage in a less desirable activity (e.g., travel) to participate in a highly desirable activity (e.g., outdoor recreation) or because the choice of activities may be constrained at a particular point in time (e.g., by time of day or weather conditions). However, a comprehensive system for estimating the variation in the value of time across the full range of work and nonwork activities is not available. Hence this chapter focuses on four major time use categories discussed in the available literature: market work, nonmarket work, leisure, and sleep.

Market labor involves an explicit transaction between the buyers (employers) and sellers (employees) of the labor to compensate the worker. Nonmarket labor includes all forms of uncompensated activities that produce output for internal household consumption rather than for external buyers. Housekeeping, childcare, auto repair, lawn care, and similar activities are examples of these nonmarket labor activities. In addition, volunteer work and other productive, unpaid activities undertaken outside the home constitute nonmarket activities. Nonmarket labor may be pursued by students, retirees, homemakers, and others, as well as by individuals who spend part of their time in the paid workforce. This chapter defines leisure as all time not spent working or sleeping, hence all activities (other than sleep) not classified as market or nonmarket labor are assigned to this category.[1] These categories are summarized in Exhibit 3-1 below.

Exhibit 3-1

DEFINITIONS OF TIME USE CATEGORIES

Category	Definition
Market work time	Time that an individual spends engaged in productive activity in exchange for a salary or wage at a price set in the labor market.
Nonmarket work time	Time spent on productive work without monetary compensation in the home (e.g., housework) or outside the home (e.g., volunteer work).
Leisure time	Time spent engaged in activities other than market work, nonmarket work, or sleep.
Sleep time	Time spent sleeping.

The rates (i.e., "dollar per hour" values) for these four categories are discussed below. For each category, the discussion first describes the major alternatives most frequently used in the available empirical literature. It then notes the approach that is likely to provide the best estimate of the opportunity costs associated with each category of time use, based on currently available data. Exhibit 3-2 below summarizes the base values suggested for each activity category; analysts will often wish to explore the effects of alternative assumptions in sensitivity or probabilistic analysis of uncertainty.

[1]This definition ignores the distinction between "pure" leisure (activities undertaken by free choice, such as time spent on recreational activities) and intermediate activities (such as time spent on travel to recreational areas) noted in the prior chapter because the data available on time use generally does not allow the analyst to distinguish clearly between these two categories of leisure activities.

Exhibit 3-2 OVERVIEW OF VALUATION APPROACH	
Category	**Valuation Approach**
Market work time	Gross (pre-tax) wage plus benefits, reflecting both the opportunity costs to both the individual (i.e., lost wages) and to the employer and society (i.e., lost product)
Nonmarket work time	Net (post-tax) wage, based on the opportunity costs to the individual
Leisure time	Net (post-tax) wage, based on the opportunity costs to the individual
Sleep time	Zero, due to lack of support for a specific dollar value and difficulties inherent in estimating the net impact of illness on sleep time

The rationale for selecting these values is discussed in more detail in the following sections.

3.1.1 Market Work Time

In the case of market labor or paid work, the selection of a rate for valuing time losses is relatively straightforward. The available data (discussed in Appendix B) support three choices for estimating the value of lost work time.

1. ***Total compensation***: This approach includes all compensation, such as taxes, wages, and benefits, and reflects the total costs of lost time from the perspective of the employer. The national data on benefits are less extensive and detailed than the data on wages or earnings, sometimes requiring the use of simplifying assumptions to implement this approach.

2. ***Pre-tax wage rate***: While this approach is an incomplete measure of compensation, extensive earnings data are available, both in the aggregate and broken out by age, gender, and occupation. Hence this approach is often applied in the empirical literature.

3. ***Post-tax wage rate:*** This approach reflects the value of lost time from the perspective of the individual. The national data on income taxes paid (including all Federal, state, and local taxes) are less detailed than the data on pre-tax earnings, hence simplifying assumptions may be needed to apply this approach.

Neoclassical economic theory suggests that total compensation is the preferred measure of value of lost market work time. This approach is consistent with the human capital method for valuing lost productivity, and is based on the assumption that the compensation provided by an employer equals the value of each worker's marginal output.[2] In other words, an employer would not pay an employee more, in salary plus benefits, than that employee is worth to the company (i.e., the value of the employee's marginal product) and hence to society.

In a social welfare context, the value of marginal changes in market work time is comprised of two components: (1) the value of the time loss to that individual, and (2) any additional value to the rest of society. Total compensation is the most representative measure of the full social welfare impact of lost work time because it incorporates both the loss to the individual (in terms of lost income) and the loss to society (in terms of reduced tax revenue and decreased production of goods and services).

The total compensation approach recognizes that, when an individual misses work or is less productive due to illness, he or she loses the utility (or sense of satisfaction or well-being) associated with working. Under standard neoclassical economic assumptions (where the marginal utility of paid work is equal to the marginal value of wages received), this loss is measured by the income which the individual can trade for goods and services. The total compensation approach also recognizes that the employer (and society) loses the value of the individual's productivity, and (again based on standard assumptions) this value is equal to total compensation (pre-tax wages plus benefits). From this perspective, the value of productivity (pre-tax wages and benefits) exceeds the value of the income (post-tax wages) received by the individual. Some of the total value of work-related time losses is thus reflected in the employee's take home pay and benefits and the remainder accrues in terms of taxes paid -- reflecting the value of product created above and beyond what is reflected in the employee's post-tax wages.

In this context, when illness forces an individual to miss work, the reduction in his or her compensation, discounted over the period of illness, can be used to estimate the value of lost work time. In some cases, an illness only causes an individual to perform at a reduced level of efficiency, rather than miss work altogether. In such cases, the wage rate can be fractionally adjusted to account for the reduced output associated with the illness in question.

Embedded in this approach are a number of simplifying assumptions regarding the operations of the labor market and the factors that influence individual choice, several of which were introduced in Chapter 2 of this report. Uncertainties related to these assumptions and their implications are discussed in detail in Section 3.5 below. In addition, the data sources used to implement this approach have some shortcomings that are discussed in Section 3.5 and Appendix B of this report.

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[2]A number of cost of illness studies use lost earnings to estimate the indirect cost of illness. For example, the total compensation approach is used in Rice, D.P. and W. Max, *The Cost of Smoking in California, 1989,* Sacramento, California: California State Department of Health Services, 1992; Buzby, J. C., T. Roberts, C.T.J. Lin, and J.M. MacDonald, *Bacterial Foodborne Illness: Medical Costs and Productivity Losses,* Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 741, August 1996; and Waitzman, N.J., R.M. Scheffler, and P.S. Romano, *The Cost of Birth Defects: Estimates of the Value of Prevention,* Lanham: University Press of America, Incorporated, 1996.

3.1.2 Nonmarket Work Time

The valuation of nonmarket work time varies depending on the goals of the analysis. Under the human capital approach, time spent engaged in nonmarket labor activities is considered productive due to the fact that activities such as childcare, cooking, and general home maintenance -- if not performed by a member of the household -- could be performed by a professional in return for compensation (i.e., as market labor). However, unlike individuals employed in the labor market, those engaged in nonmarket labor activities are not compensated for their work. As a result, the rationale for selecting a rate for valuing the time spent performing such activities is less straightforward than for market labor.

Researchers applying the human capital method generally use one of two approaches for deriving a rate to use in valuing the productivity of nonmarket labor.[3] The first approach uses the wage rate of domestic servants or housekeepers to estimate the value of household production.[4] This approach may undervalue the true productivity of nonmarket labor due to the wide range of activities undertaken in addition to housekeeping. A second approach uses a composite of the wage rates paid for the diverse range of activities associated with nonmarket work, such as the rates paid for cooks, childcare providers, gardeners and others.[5] Under this latter approach, it is possible to include the value of volunteer activities outside the home as well as the value of home-related nonmarket work.[6] Time use studies are applied to allocate nonmarket activities across different job categories to develop this composite. The composite approach, although more complex to implement, is likely to more accurately reflect the true productivity of this labor than the

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[3]For a survey of studies valuing nonmarket labor, see: Goldschmidt-Clermont, L, *Unpaid Work in the Household*, prepared for the International Labor Office, United Nations, 1982.

[4]A pioneering example of this approach is: Rice, D.P., "Estimating the Cost of Illness," *Health Economic Series No. 6, PHS Publication No. 947-6*, U.S. Government Printing Office: Washington, DC, May 1966. A more recent example that uses data on the value of housekeeping services based on Current Population Survey data from the Bureau of Labor statistics, is: Ray, N.F., M. Thamer, et al., "Economic Consequences of Diabetes Mellitus in the U.S. in 1997," *Diabetes Care*, Vol. 21, No. 2, 1998, pp. 296-309.

[5]One early demonstration of this composite market value approach is: Cooper, B.S. and D.P. Rice, "The Economic Cost of Illness Revisited," *Social Security Bulletin*, Vol. 39, No. 2, February 1976, pp. 21-36. A more recent approach is provided in Hoffman, C., D. Rice, and H. Sung, "Persons with Chronic Conditions: Their Prevalence and Costs," *Journal of the American Medical Association*, Vol. 276, No. 18, November 1996, pp. 1473-1479. This later study uses values based on research reported in Douglas, J., G. Kenny, and T.R. Miller, "Which Estimates of Household Production Are Best?," *Journal of Forensic Economics,* Vol. 4, 1990, pp. 25-45.

[6]See, for example, Trewin, D., *Unpaid Work and the Australian Economy: 1997*, Australian Bureau of Statistics, October 2000; and Robb, R., M. Denton, A. Gafni, A. Joshi, J. Lian, C. Rosenthal and D, Willison, "Valuation of Unpaid Help by Seniors in Canada: An Empirical Analysis," *Canadian Journal on Aging*, Vol 18, No. 4, 1999, pp. 430 - 446.

housekeeper approach.[7]

However, this focus on productivity ignores the utility that the individual gains from choosing to engage in nonmarket, rather than market, work. Under standard neoclassical assumptions, if (at the margin) the market wage exceeded the utility gained from nonmarket work, an individual would join the paid work force. In electing to engage in nonmarket labor, an individual is not necessarily forgoing a job involving similar activities. For example, a practicing physician may elect to engage in nonmarket labor on a full-time basis following the birth of his or her child. At a later date, this individual may choose to return to the labor market at a wage rate comparable to that received before the decision to leave the labor market. For such an individual, the opportunity cost of choosing not to participate in the labor market is clearly much higher than estimates generated using the average wage rate for various types of domestic occupations.[8] In addition, an employed physician will choose to spend some of his or her time on nonmarket, rather than market, work activities.

From the social welfare perspective, the post-tax wage an individual would receive for market work represents the value, at the margin, of nonwork time. Under this framework, individuals presumably choose to engage in nonmarket work themselves rather than hire a replacement worker because (1) the utility they gain from performing nonmarket tasks is greater than the utility they would gain from spending the time on paid work, and/or (2) the amount they would earn for paid work is less than the cost of hiring a worker to perform their nonmarket tasks (i.e., of hiring a replacement worker). Therefore, the individual must value a marginal hour of his or her nonmarket work time at a rate at least equal to the marginal post-tax wage per hour he or she could have earned in the job market.

In much of the economics literature that supports this opportunity cost perspective, nonmarket work time is not clearly distinguished from other uses of uncompensated time. However, Gronau and others have used a household production framework to explore the valuation of nonmarket work in more detail.[9] While Gronau notes that the line dividing nonmarket work and leisure may be difficult to define precisely, he distinguishes between household production (i.e., nonmarket work, which could be performed by someone else for pay) and household consumption

[7]The replacement cost approach will understate the cost of using market labor if it ignores the relatively high transaction costs related to hiring domestic workers, including the need to pay taxes and maintain and submit related records.

[8]In addition, an individual who chooses to engage in nonmarket work because the cost of hiring a replacement worker exceeds his or her market wage presumably values nonmarket work time at minimum at his or her market wage rate.

[9]Gronau, R., "Home Production - A Survey," *Handbook of Labor Economics, Vol. 1,* (O. Ashenfelter and R. Layard, eds.), New York: North-Holland, 1986.

(i.e., leisure, which is almost impossible to enjoy vicariously).[10] He reviews the arguments related to using market (replacement) costs or opportunity costs (foregone wages) to value home production, and concludes that market costs are likely to be an inappropriate measure because: (1) the utility gained from home production may exceed the costs of a replacement worker, and (2) the quality or quantity of the output of the nonmarket worker may be superior to that of a market substitute.[11] Thus the opportunity cost approach is more consistent with the social welfare model of individual utility maximization, since it takes into account both the productivity and utility associated with nonmarket labor.

This report suggests the use of post-tax wages for valuing nonmarket work time, consistent with standard neoclassical assumptions, since this approach takes into account the opportunity costs of decisions to engage in nonmarket work and the effects of this choice on individual utility. (Approaches for estimating this value for individuals who do not engage in paid work are discussed later in this chapter.) This value accounts for the wage rate an individual could command if he or she elected to spend more time in the labor market (either by taking a job or by increasing paid work hours) rather than engaging in nonmarket labor.

This approach is based on many of the same simplifying assumptions as the approach for valuing lost market work time, several of which were introduced in Chapter 2 of this report. These and other uncertainties related to the approach for valuing lost nonmarket work time are discussed in Section 3.5 below. Concerns related to available data sources are also explored in Appendix B.

3.1.3 Leisure Time

The valuation of leisure time is the area where there is the greatest divergence between the human capital approach and approaches that provide more complete consideration of impacts on social welfare. Analysts who value lost time using the human capital approach rarely, if ever, include a value for lost leisure time due to the emphasis of these studies on measuring productivity. While leisure time may affect an individual's productivity, some researchers believe this impact is at least partially captured in the valuation of market and nonmarket work.[12] Hence from the human

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[10]Gardening is an example of the problems related to defining particular activities as nonmarket work or leisure; it is an important leisure activity for many individuals but one could hire gardener at a market wage.

[11]Gronau suggests that analysts use both rates to value output. However, this conclusion appears to be based on the fact that (1) he is interested primarily in the value of output, not its utility, and (2) he notes that job satisfaction is rarely considered in valuing paid work. Thus his arguments for using a replacement cost approach are similar to those used in the human capital literature, and do not take into account the full social welfare costs of related decisions.

[12]For example, in the extreme case, an individual who has no leisure time is likely to be less productive than an individual with some leisure, due to the stress and exhaustion that could result.

capital perspective, including a separate value for leisure runs the risk of some degree of double-counting. Researchers using the human capital approach, however, note that the exclusion of the value of leisure time leads them to understate the full social welfare impact of illness.[13]

In contrast, from the opportunity cost perspective, the theory behind estimating the value of lost leisure time is the same as that used to value lost nonmarket work time -- in both cases the individual presumably chooses to engage in activities other than market work because, at the margin, the utility gained from these other activities is greater than the utility gained from market work. Hence under the opportunity cost approach, the value of leisure time can be estimated based on the after-tax wage rate, assuming that this rate represents the income an individual forgoes in choosing to engage in leisure rather than market work.[14] This approach is consistent with the approach applied in the recreational literature which suggests that desirable leisure time (i.e., on-site time) should be valued at the after-tax wage rate.[15]

In addition to its consistency with standard neoclassical assumptions regarding the labor-leisure trade-off and the concept of opportunity costs, this approach has a practical advantage. Using the same rate for both nonmarket work and leisure circumvents difficulties related to clearly defining different uncompensated activities as either nonmarket work or leisure, and then determining the extent to which illness affects the time spent in each type of activity. A number of activities (such as gardening) could be considered both nonmarket work and leisure.

Using the post-tax wage rate to value leisure time is subject to uncertainties related to the operation of the labor market and its effects on wage rates, such as those discussed in the section on valuing paid work time. In addition, as discussed in the section on valuing nonmarket time, individuals may consider factors other than wage rates (such as non-reimbursed work-related costs

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[13]For example, Ungar et al., in their analysis of asthma, use daily wages to calculate the value of lost work time but do not address other categories of time losses. They note that their approach may mislead policymakers regarding the real social costs of asthma by excluding consideration of the opportunity costs of nonmarket work time and leisure, as well as the impact on caregivers. Ungar, W. J., P. C. Coytem and the Pharmacy Medication Monitoring Board, "Measuring Productivity Loss Days in Asthma Patients," *Health Economics*, Vol. 9, 2000, pp. 37-49.

[14]Examples of the valuation of lost nonwork time are provided in two studies that are summarized in Appendix A: Harrington, W., A. J. Krupnick, and W. O. Spofford, *Economics and Episodic Disease: The Benefits of Preventing a Giardiasis Outbreak*, Washington, DC: Resources for the Future, 1991; and Kocagil, P., N. Demarteau, A. Fisher, and J.S. Shortle, "The Value of Preventing Cryptosporidium Contamination," *Risk: Health, Safety and Environment*, Vol. 9, pp. 175-196, 1998.

[15]As discussed in Chapter 2, under a two-stage model of time allocation, the recreation valuation literature subdivides nonwork time into necessary intermediate activities that may involve disutility (such as travel) and hence may be valued at less than the wage rate, and "pure" leisure (such as recreational activities) which are generally valued at post-tax wages. However, researchers assume that the total amount of nonwork time (including both intermediate and pure leisure activities) is chosen so that its marginal value is equal to post-tax wages.

and foregone benefits) in determining whether to engage in paid work. The implications of these limitations are discussed in more detail later in this chapter.

3.1.4 Sleep Time

Perhaps the most difficult type of time loss to value is the effect of illness on sleep. Similar to lost leisure time, sleep time is normally not valued under the human capital approach because of its lack of direct association with a "product." Because individuals generally perform work and leisure activities at a decreased level of efficiency when receiving inadequate amounts of sleep, under the human capital approach analysts often assume that the value of sleep manifests itself at least in part in the productivity associated with other activities.

As in other applications of the human capital method, this approach ignores any utility that the individual receives from sleep that may be above and beyond its productive value. The neoclassical approach, which assumes that an individual will trade-off time in different activities so as to equalize their value at the margin, implies that the value of changes in sleep time would be equal to post-tax wages, consistent with the valuation of nonmarket and leisure time. However, the fact that some minimum amount of sleep is a biological necessity limits the extent to which an individual can in fact exchange sleep time for time spent in other activities.

Biddle and Hamermesh explore this and related issues, noting that relatively little attention is paid to sleep in the economic literature that explores time allocation.[16] This literature tends to implicitly include sleep with other leisure activities or to focus solely on the allocation of waking time. Biddle and Hamermesh review several studies of sleep time and note that, while some minimum amount of sleep is needed, individuals also exercise choice in determining the amount of sleep they achieve beyond this minimum. This amount may vary due to economic incentives and other factors. For example, they examine the effects of wages on sleep time and conclude that changes in the time spent in market work affect the time spent in sleep as well as in nonmarket work and leisure, suggesting that sleep involves a choice between resting and engaging in other work or nonwork activities.

Illness may involve counterbalancing effects on sleep -- it can disrupt normal sleep patterns but can also lead one to nap rather than engage in normal waking time activities. Assuming that some minimal level of sleep is necessary, naps may compensate for any lost night sleep time associated with illness. Greater than normal nap or night sleep time may also be necessary simply to cope with the impacts of the illness. This need for sleep may in turn displace some of the time the individual would otherwise spend engaged in leisure, nonmarket work, or market work activities.

Given this complexity, analysts are likely to find it difficult to determine the amount of sleep

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[16] Biddle, J.E., and D.S. Hamermesh, "Sleep and the Allocation of Time," *Journal of Political Economy*, Vol. 98, No. 5, 1990, pp. 922-943.

time lost due to illness and its relationship to time spent in other types of activities. Empirical estimates of the net effects of illness on sleep time are not likely to be available in many cases. Hence this report suggests that analysts conservatively estimate the base value of sleep time as "zero," until more research is completed. Sensitivity or probabilistic analysis of uncertainty may be used to test the impacts of assigning a higher value.

3.2 VALUING TIME FOR INDIVIDUALS NOT ENGAGED IN PAID WORK

Several sub-groups of the population present specific valuation challenges because they often do not engage in paid work and hence wage rate data may not be available to estimate of the value of their time losses due to illness. These groups include the following.

- **Children**: Children do not generally engage in paid work, and wage rate data is not generally collected for those who do. The definition of "child" can vary, but the age cut-off is usually at 16 or 18 years of age. The Bureau of Labor Statistics does not collect employment data for individuals under the age of 16.

- **Elderly Individuals**: As individuals age, they generally leave the work force. However, retired persons may value their time differently than younger workers who are out of the labor force, due to the availability of pensions and Social Security. These individuals may in fact lose benefits if they increase their job-related income.

- **Unemployed Individuals**: Individuals not currently engaged in market work, but actively seeking employment, would prefer to earn a wage but are not currently doing so.

- **Individuals Not in the Labor Force**: Individuals not currently engaged in market work, and not seeking employment, presumably value their time at a rate higher than the earnings they could gain from paid employment. However, at times they may be engaged in necessary nonmarket work (such as child care) where the cost of hiring a replacement worker exceeds the amount they could earn as a member of the labor force.

The concerns related to the appropriate valuation of time losses are discussed for each of these groups below.

3.2.1 Children

Valuation of the effects of illness on children presents a number of difficult challenges related to the fact that children are not "economic actors" who can answer valuation questions or engage in market activities that reflect their own preferences. Under the human capital approach, the primary issue concerning the valuation of children's time losses is that of double-counting. Analysts assume that childhood time spent in school or other productive activities will be reflected in future adult earnings. Hence rather than directly value time losses during childhood, they consider the effects of childhood illness, if any, on future earnings.[17]

This approach contrasts to the social welfare perspective, which ideally would include the utility losses that accrue to children as well as adults. Children can be profoundly affected by illness in ways that have little relationship to the effects captured under the human capital approach. These effects may be direct, i.e., children may be unable to engage in normal activities because they are ill; or they may be indirect, i.e., children may receive a lessor quantity or quality of care due to the illness of their caregivers. The dollar values of these impacts are highly uncertain.

Freeman notes that risks to children may be valued from three different ethical or normative perspectives.[18] One option is to use children's own values (i.e., assume children's sovereignty) but these values are not likely to be well-informed. Children also do not control the financial resources necessary to make the trade-offs implicit in related decision-making. A second option is to use parental values. While parents are often presumed to have an altruistic interest in the well-being of their children, they may not always exercise good judgement in determining how to best ensure this welfare. The third option is to consider the child as an adult. While consistent with basic economic principles, this approach may be difficult to implement in practice since it involves predicting future values for individuals who are now children.

Both the OMB and EPA guidance on regulatory analysis suggest that, in the absence of better data, adult values may be applied to children. For example, the OMB guidance states: "[f]or rules where health gains are expected among both children and adults and you decide to perform a benefit-cost analysis, the monetary values for children should be at least as large as the values for adults (for the same probabilities and outcomes) unless there is specific and compelling evidence to suggest otherwise."[19] EPA's *Children's Health Valuation Handbook* notes that both the parental perspective and the child-as-adult perspective may be useful in valuing health risk reductions but, for practical reasons, analysts are more likely to transfer adult values to children.[20]

In assessing time losses due to illness, analysts have several choices for implementing this guidance. For example, the analyst could first calculate the value of time losses for the adult population potentially affected by a regulation, then assess the values for children based on the average adult value per statistical case of illness. For some health effects, it may be possible to

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[17] An example of this approach is summarized in Appendix A; see: Waitzman, N.J., R.M. Scheffler, and P.S. Romano, *The Costs of Birth Defects,* Lanham: University Press of America, Incorporated, 1996.

[18] Freeman, A.M. III, *The Measurement of Environmental and Resource Values: Theory and Methods*, Second Edition, Washington, D.C.: Resources for the Future, 2003, pp. 340-341.

[19] U.S. Office of Management and Budget, *Regulatory Analysis (Circular A-4),* September 2003, p. 30.

[20] U.S. Environmental Protection Agency, *Children's Health Valuation Handbook*, October 2003, p. 2-11.

compare these adult values to values calculated using the human capital approach (i.e., that consider effect of childhood health problems on adult earnings). However, as noted throughout this report, the human capital method is likely to significantly understate the value of these time losses from a social welfare perspective. As always, the limitations of the approach need to be carefully discussed in presenting the results and addressed by uncertainty analysis as appropriate.[21]

3.2.2 Elderly, Unemployed, or Out of the Labor Force

The opportunity cost of time for individuals who do not engage in paid work is, conceptually, the post-tax wage they would earn if they were employed -- sometimes referred to as the shadow wage. This approach is based on the assumption that these individuals do not participate in market work because they value nonwork time at a rate that is higher than the wage they would earn if employed. However, due to the lack of employment, this wage rate is not observable for these individuals.

Researchers generally impute a wage in this case by comparing these individuals to similar employed individuals. One such approach is the hedonic wage model, which is discussed in the context of the recreation valuation literature in the prior chapter. This model predicts wages based on the reported characteristics of each individual in a sample. In the context of regulatory analysis, the average or median post-tax wage for the employed members of the affected population may be used to estimate the shadow wage for those members of the population not engaged in market work. These approaches are based on the assumption that wage earners and nonwage earners do not differ in respects that would affect their wage rates. This simplifying assumption may under- or overstate the actual shadow wage depending on the characteristics of the groups of concern.

For example, many elderly individuals are not employed in the labor force for reasons not directly related to the wage rate. Several factors, such as forced retirement and Social Security, distort their employment decisions so that an imputed marginal wage rate (or the actual wage earned in any post-retirement employment) may not reflect their opportunity cost of not working.[22] It is not clear whether elderly individuals not engaged in market work are more likely to be similar to those who are technically unemployed (i.e., would still like to work) or to those not in the labor force (i.e., not working by choice).

By definition, the unemployed (i.e., individuals not in the paid work force, but actively seeking employment) would prefer to spend at least part of each day employed, rather than in seeking employment or in nonmarket work and leisure activities. For these individuals, the offered

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[21]EPA's *Children's Health Valuation Handbook* provides a detailed discussion of the uncertainties introduced when adult values are transferred to children.

[22]For a brief discussion of the impacts of social security on the employment decisions of elderly individuals, see: Gold, M.R., J.E. Siegel, L.B. Russell, and M.C. Weinstein (eds.), *Cost-Effectiveness in Health and Medicine*, Oxford: Oxford University Press, 1996, p. 202.

wage is presumably below the wage they would like to receive (i.e., their reservation wage) suggesting that they value nonwork time more than the wage they could currently command in the labor force. This assumption, however, ignores the complex set of factors that contribute to unemployment. In general, wage rates for the employed population may provide an upper bound estimate of the wage rates unemployed workers could command, given the potential differences in the characteristics of each group.

In contrast, individuals not in the labor force include homemakers and other individuals (including many elderly) who are not actively seeking employment. As discussed earlier, these individuals presumably value the time spent in uncompensated activities at a rate greater than their potential take-home (i.e., post-tax) market wage, and therefore have chosen not to engage in paid labor. However, in some cases this decision may reflect constraints on individual choice. For example, individuals may engage in necessary nonmarket work (such as childcare) because the full cost of hiring someone else is greater than the wage they could earn in the job market. Another example is a severely mentally or physically handicapped person who may be unable to engage in market labor.

For individuals not engaged in paid work, the framework applied in this report suggests that the shadow price (or opportunity cost) of time should be estimated based on potential post-tax wages, and that this value should be used to estimate the social welfare effects of time losses due to illness. The limitations of this approach for each of the groups addressed above can be discussed qualitatively along with the results of any related quantitative analysis of uncertainty.

3.3 DETERMINING THE EXTENT OF TIME LOSSES

In addition to determining the value of time, analysts must estimate the amount of time lost due to illness. Some of the illness-related loss may be relatively complete; i.e., individuals may be forced to spend time in unpleasant activities that have little or no utility, rather than in their preferred normal activities. Other illness-related losses may be partial; e.g, individuals may find that the time spent in normal activities is less productive or pleasurable than in the absence of illness, or may need to substitute less desirable activities for those that they prefer. These effects may be long term as well as immediate. For example, illness may affect decisions to enter or leave the workforce, to select particular types of jobs, or to work full time or part time -- as well as whether to spend a particular day resting rather than engaged in normal activities. Time losses are not limited to the ill individual. For example, others may take time off from compensated or uncompensated work, or lose leisure time, to care for the ill individual. Children who are dependent on the ill individual for care may be affected as well. Approaches for estimating these impacts are discussed below.

3.3.1 Types of Time Losses

Ideally, estimates of time losses should be developed by comparing time usage when well to time usage when ill. These estimates of the amount of the loss (e.g., in terms of hours affected) can then be multiplied by the dollar values (e.g., post-tax wages) to determine the total value of time losses. This section provides a general description of the options for developing estimates of the amount of time lost, while Appendix A describes examples of some of the specific methods applied in the empirical literature. Appendix B discusses a number of data sources that can be used to estimate the normal allocation of time across market work, nonmarket work, leisure, and sleep, as well as sources of information on the effects of illness on this normal time use.

The approach used to estimate the amount of time losses will vary across different regulatory benefit-cost analyses depending on the characteristics of the illness and the affected population, the available data, the importance of the resulting estimates to the overall analytic conclusions, and the time and resources available. Some of the options an analyst might consider include the following.

1. First, he or she may use an existing empirical study of time losses that directly addresses the types of health risks and the populations affected by the regulatory options of concern. Because the match between the available research and the context of a particularly regulatory analysis is almost always imperfect, in most cases the analyst will need to choose an alternative approach.

2. Second, he or she may transfer estimates from a research study that addresses the same or similar health effects in a comparable, but not identical, population. For example, the available literature may include a study of time losses due to myocardial infarction for patients at a particular health maintenance organization. This study may be used as an indicator of the value of time losses due to ischemic heart disease (for which myocardial infarction is one of several symptoms) for a rulemaking with nationwide impacts. Factors related to assessing the quality and suitability of studies for transfer, as well as issues related to the limitations of the benefit transfer approach, are discussed in a number of other documents and hence are not explored in detail in this report.[23]

3. Third, the analyst may construct his or her own estimates based on survey data or other information sources. In this case, analysts may need to consult a variety of data sources -- e.g., on the frequency of hospitalization, doctors visits, and other illness-related activities -- and compile the results to determine the total time losses. In the case of nonfatal chronic illnesses that last for several years, the likelihood that an individual will survive the course of the illness (i.e., not die of other causes) must also be considered.

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[23]For example, information on conducting benefit transfers is provided in: U.S. Environmental Protection Agency, *Handbook for Non-cancer Health Effects Valuation,* December 2000.

In pursuing these options, the analyst may decide to rely on a single approach to estimate time losses, or to use more than one approach and compare the results.

Under each of these options, the amount and types of time losses may be determined from individual research studies or from large scale, national surveys. For example, the health economics literature includes several studies of specific populations (e.g., at a particular health maintenance organization or hospital) that may provide information on time allocation.[24] Alternatively, many studies rely on national self-reported data from the National Center for Health Statistics' National Health Interview Survey.[25] This survey provides data on lost time including the number of disability days, doctor's visits, and hospitalizations. Estimates for individuals with the illness of concern can be compared to those for individuals without the illness, to separate out the effects of other factors that affect time use.

An alternative approach involves compiling data from different sources to develop composite estimates. For example, one source can be used to estimate the number of doctor visits associated with the illness, another can be used for hospitalization rates, etcetera. Several national databases maintained by the National Center for Health Statistics and other agencies provide these types of data (see Appendix B). Because these data sources generally focus on specific treatment-related activities, they often lack information on time spent at home (i.e., bed rest days or days during which activities are restricted) and may need to be supplemented by other sources.

In some cases, the data sources noted above will identify the activities from which time is diverted; e.g., the number of hours lost from market work, nonmarket work, leisure, and (possibly) sleep activities. In other cases, the data sources may only indicate the duration of the illness-related activities. For example, information may be available on the number of days spent ill or on the number of hours spent on doctor visits, but not on what the individual would have been doing during these times in the absence of illness. In these cases, the analyst may need to compare this illness-related time allocation to the allocation found in studies of typical time use (see Appendix B). For example, if a study of typical time usage indicates that individuals spend three hours per day in paid work (averaged across employed and unemployed individuals and across seven days per week), then the analyst could assume that individuals too ill to engage in paid work lose an average of three hours of paid work time per day of illness.

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[24]For example, the Hartunian study summarized in Appendix A relies on a study by Weinblatt et al. to example the functional status of heart attack survivors (Weinblatt, E., S. Shapiro, C.W. Frank, and R.V. Sager, "Return to Work and Work Status following First Myocardial Infarction," *American Journal of Public Heath*, Vol. 65, No. 2, 1966, pp. 169-185). See: Hartunian, N.S., C.N. Smart, and M.S. Thompson, *The Incidence and Economic Costs of Major Health Impairments: A Comparative Analysis of Cancer, Motor Vehicle Injuries, Coronary Heart Disease, and Stroke*, Lexington, Massachusetts: D.C. Heath and Company, 1981.

[25]There are numerous examples of the use of the National Health Interview Survey to estimate time losses, including Ray et al. (1998) and Waitzman et al. (1996), which are described in Appendix A.

These comparisons raise difficult questions regarding whether the time loss is complete or partial. In some cases, illness may force an individual to substitute a less desirable activity (e.g., reading in bed) for a preferred activity (e.g., paid work or outdoor recreation). In this case, the substitute activity presumably has some utility that is less than the utility of the preferred activity. This partial loss could be reflected by assigning a value to the substitute activity that is less than the wage rate (i.e., the value of a complete loss) but greater than zero (the value of continued participation in normal activities). Another example of a partial loss is when an individual continues to engage in normal activities when ill, but is less productive or finds them less enjoyable than usual. These losses can be represented by prorating the value of time; for example, the loss associated with a day reported as 30 percent less productive would be 30 percent of the wage rate. In other cases, the loss may be complete. For example, an individual is likely to assign little, if any, utility to time spent suffering from a high fever, vomiting, or coping with diarrhea. In such cases, the time spent ill may have zero value compared to the normal use of time, and the loss would be represented by 100 percent of the wage rate.

3.3.2 Acute vs. Chronic Illness

The approach used to assess time losses depends in part on the duration of the illness. In the case of acute illnesses, such as nonfatal cases of giardiasis or cryptosporidiosis, the effects generally do not linger beyond the year of incidence and often may cover only a few days or weeks. Individuals suffering from such illnesses (as well as family or friends acting as unpaid caregivers) generally are able to return to their full schedule of normal work and leisure activities within the year of incidence and experience no permanent or long-term effects. In these cases, there is no need to adjust the calculations for year-to-year changes, e.g., in employment status or survival rates, nor is there a need for discounting to reflect the time value of money.

The time lost to these types of acute illnesses is sometimes characterized by defining day scenarios.[26] Such scenarios reflect the effect of a given illness on the daily allocation of time to labor and leisure activities. These days can be defined by the degree and type of time loss, including bed-rest days, work-loss days, and restricted activity days. For example, bed days may be defined as days an individual is unable to perform any type of normal activity, resulting in a relatively complete loss of the value of labor and leisure time. Low productivity days could be used to characterize days when an individual can participate in work at a reduced rate or for a reduced period of time, reducing the value of output for a given individual by a marginal amount, depending on the symptoms and severity of illness. During these time periods, individuals may also experience a loss in utility when engaged in leisure activities, as the illness reduces their ability to enjoy these activities or pursue them with the same degree of efficiency as normal. In some cases, the effects of the illness will vary by day; e.g., a few days of severe symptoms may be followed by several days of milder impacts. Time losses can then be computed for each day scenario then summed across the days.

[26] See, for example, Hartunian (1981).

More detailed survey data may be available to aid in defining these scenarios for some illnesses. For example, Harrington et al. collected information on time losses associated with giardiasis, including data on work loss days for the ill individual and his or her caregiver.[27] They also collected information on the extent to which the ill individual's productivity decreased while at work during the course of the illness. These examples suggest that the availability and nature of the data characterizing the particular health effect of concern will determine the degree of detail that can be applied using the day scenario approach.

For chronic illnesses, that may last for many years, estimating time losses is more complex. The ill individual may experience time losses associated with both labor and leisure activities throughout a significant portion of the remainder of his or her life. In some cases, the effects may be permanent and prevent return to a normal schedule of work and leisure activities. Even in cases where the individual is able to return to his or her former schedule of activities, he or she may not be capable of performing them at the same level of efficiency or of deriving the same level of utility from them.

For long term illnesses, estimating the number of years an individual lives with the illness generally requires consideration of life expectancy. For nonfatal cases, this life expectancy is defined based on when the individual is likely to die from causes other than the illness of concern. This life expectancy may be shorter for ill individuals than for the general population because the illness itself may contribute to premature mortality from other causes. For example, diabetics have a higher rate of heart and renal disease than the general population, and hence may die prematurely from these associated conditions rather than directly from diabetes.[28]

The life span of ill individuals should be compared to the life span of similar healthy individuals in calculating the value of time losses.[29] A simple approach would involve considering the average age at death for a person with the illness who dies of other causes, and comparing it to the average age at death for the general population. Times losses would then be calculated over the duration of the illness (if not life-long) or over the remaining life expectancy (if "incurable"). Data related to developing a more complex approach, which address survival rates for each year of age with and without the illness, are provided in Appendix B.

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[27]Harrington, W., A. J. Krupnick, and W.O. Spofford, "The Economic Losses of a Waterborne Disease Outbreak," *Journal of Urban Economics*, Vol. 25, No. 1, 1989, pp. 116-137.

[28]Addressing these issues requires clear communication between economists and risk assessors to ensure that both parts of the analyses apply the same definition of a fatal case. A case of diabetes that leads to death from an associated cause (such as renal failure) may be counted as either a fatal or nonfatal case of diabetes, depending on whether the risk assessment considers these types of associated conditions or focuses solely on deaths attributable directly to diabetes.

[29]An early example of this approach, which could be refined based on the valuation methods and data sources discussed in this report, is provided in Hartunian (1981).

3.3.3 Caregivers

Caregiver time losses may fall into the same four categories as discussed earlier for ill individuals.[30] A caregiver may take time from paid work, reduce the time spent on nonmarket work, or lose leisure or sleep time to care for sick family members or friends.[31] While caregiver losses are only occasionally quantified in human capital studies (due to data limitations and other factors), the importance of including these losses is often noted.[32] In its *Children's Health Valuation Handbook*, EPA states that the inclusion of caregiver losses is of particular importance when children are affected.[33]

Ideally, analysts would rely on data that specifically describes the duration and types of time losses for caregivers. In the absence of empirical data, analysts will need to develop a method to estimate these losses on a case-by-case basis. For some health effects, it may be possible to estimate caregiver losses in proportion to the time lost by the ill individual. For example, a parent who takes time off from work to care for an ill child at home may lose an amount of time equal to the time loss of the child. In contrast, a woman who takes time off to transport her sick husband to the doctor, but not to care for him while he is resting at home, will accrue only a portion of the time loss of the ill individual. In this case, the losses could be estimated from data on the number and length of doctor visits (including transport time) for the illness of concern.

As when evaluating the lost time of ill individuals, the use of wage data to estimate the value of lost caregiver time may under- or overstate the actual value of the losses. This is particularly true if caregivers are able to perform some of their regular activities while caring for the ill individual, such as working from home, completing household chores, or engaging in leisure activities. Again, it will be important to discuss the limitations of the chosen valuation approach and its implications

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[30]This section considers only unpaid caregivers such as friends and family. Paid caregivers, such as doctors and nurses, are covered in the medical cost component of the analysis and hence are not considered in the analysis of time losses.

[31]Caregivers may also become ill as a result of their caregiving activities. Communicable illnesses can be transmitted from the patient to the caregiver. In addition, caregivers may suffer from emotional distress or depression as a result of their responsibilities. The extent to which these effects are addressed (quantitatively or quality) will depend on the availability of related data as well as the likelihood of such effects given the illnesses addressed.

[32]An example of the inclusion of caregiver losses is provided in Buzby et. al (1996) which is summarized in Appendix A. Other studies discuss the need to include these losses (especially in cases where children are affected) such as: Rice, T.D., A. K. Duggan, and C. DeAngelis, "Cost-Effectiveness of Erythromycin versus Mupirocin for the Treatment of Impetigo in Children," *Pediatrics*, Vol. 89, No. 2, 1992, pp. 210-214. Inclusion of caregiver losses is also suggested in health economics texts, such as Dravove, D., "Measuring Costs," *Valuing Health Care*, (F.A. Sloan, ed.), Cambridge, England: Cambridge University Press, 1995, p. 74.

[33]U.S. Environmental Protection Agency (October 2003), p. 2-16.

when presenting the results of the analysis.

3.4 EXAMPLE OF CALCULATIONS

The previous sections discuss the process for estimating a dollar value per unit of time and for estimating the amount of time lost or degraded by illness. This section provides an example of an approach for deriving specific numerical values. While the actual approach will depend on the data and context for a particular analysis, this illustration provides some general information how the available data sources can be used in regulatory benefit-cost analysis.

Ideally, estimates of wages and total compensation and of the quantity of time lost would be developed for the specific population affected by the rulemaking.[34] However, it is generally not possible to identify this population in much detail. The risk analysis will provide an estimate of the number of statistical cases averted over time under each regulatory option, and may provide some information on distribution of these risk reductions by age and/or gender. In addition, if the regulation addresses contaminants that are prevalent only in a few geographic regions, certain parts of the country may be disproportionately affected. In cases where these types of information are available, the analyst will have some ability to tailor the valuation of time losses to fit the characteristics of the affected population. In other cases, even if some identifying features are known (e.g., that individuals with suppressed immune systems are more likely to contract the disease), data on wage rates and time losses may not be available for the particular group affected. Most often, the effects of regulations are dispersed across the nation and across different demographic groups to such an extent that national data will provide the most appropriate estimates.

If data are available on the specific population affected by the rulemaking, average values for this population will provide the best estimates of the central tendency or expected value. However, when using national data to estimate wages and compensation for the small proportion of this population that is affected by a rulemaking, analysts may wish to use median rather than average values if available.[35] The distribution of income in the U.S. is highly skewed due to the small number of people who are extremely highly compensated, hence the average is significantly higher than the median.[36] Using the median is consistent with the notion that the small fraction of

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[34]For consistency, the approach for valuing time use should reflect the same population as the approach for valuing the medical cost of illness. For example, if regional values are used, both compensation and medical costs will reflect regional economic conditions -- such as whether wage rates and the cost of living (including medical costs) are lower than national averages.

[35]See, for example: Abt Associates, *Final Heavy Duty Engine/Diesel Fuel Rule: Air Quality Estimation, Selected Health and Welfare Effects Methods, and Benefits Results,* prepared for the U.S. Environmental Protection Agency, December 2001, p. 3-15.

[36]In some cases, a regulation may disproportionately affect a group whose median earnings are less than the U.S. average (e.g., the elderly, minorities, women). Using the earnings rate specific to this group

the U.S. population affected by most rulemakings are likely to be better reflected by the median (which is in the center of the income distribution) than by the mean (which is closer to the upper tail of the distribution).

Often, these calculations will involve developing a profile of a "typical" individual affected by the regulatory option. In other words, if the regulation averts 100 nonfatal statistical cases of the disease throughout the United States, then the goal is to develop a value that can be multiplied by 100 to estimate the total national time losses averted throughout this population. Because the specific individuals affected by the illness are not known, the value would be a weighted average of the characteristics of the affected population. For example, if the population is 45 percent male and 55 percent female, this profile would weight the values for males and females accordingly to develop a composite (or weighted average) value. As described above, nationwide per capita values can be used to represent this composite individual in most cases, since risk reductions are often spread across a large population of unidentified individuals for whom the expected value of wages and compensation is best approximated by the national median.

For an individual in either well or ill status, the total value of time reflects the value of time spent in different activities.

Value of time (total) =
Value of market work time + Value of nonmarket work time
+ Value of leisure time + Value of sleep time

The total value of time is equivalent to the dollar value per unit of time (i.e., the measures of compensation or wages discussed earlier) times the amount of time spent in each activity, which then can be summed across the different types of time valued using the equation above. For example:

*Value of market work time = Time spent on market work * Market work rate*
*Value of nonmarket time = Time spent on nonmarket work * Nonmarket work rate*
*Value of leisure time = Time spent on leisure * Leisure rate*
*Value of sleep time = Time spent on sleep * Sleep rate*

To determine the value of time losses, the value of time use without illness is compared to time use with the illness for a typical individual. In other words:

Value of time losses =
Value of time in the absence of illness - Value of time with illness

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as a benefit measure is consistent with the focus of welfare economics on individual preferences and economic efficiency. However, this approach may raise concerns about equity, since it implies that society values benefits to these groups at a lower rate than benefits to other groups. In these cases, analysts may wish to explicitly recognize this concern in presenting the analysis, and possibly use the U.S. median (rather than rates specific to the age, sex, or minority group of concern) to address equity concerns.

An example of these calculations, for a representative individual experiencing a single day of illness, is provided below. This calculation conservatively assumes a zero value for lost sleep time, since (as discussed earlier) it is generally difficult to determine the amount of sleep time lost and to assign an appropriate dollar value. In addition, this example combines nonmarket work and leisure time in the calculations, since (as also discussed earlier) the same dollar per hour value is used to value losses in both categories. The basic equation for calculating time losses in this example is presented below, and compares the value of work and nonwork time (excluding sleep) when well to the value when ill.

$$\textit{Value of lost time per day} = ([W_{well} - W_{ill}]\cdot C) + ([N_{well} - N_{ill}]\cdot E)$$

(Equation 3-1)

where...

W_{well}	=	work time when well; the number of hours that an individual without the illness will be employed in the labor market
W_{ill}	=	work time when ill; the number of hours that an individual with the illness will be employed in the labor market
C	=	compensation (pre-tax wages and benefits); the hourly value of market work time
N_{well}	=	nonwork time when well; the number of hours that an individual without the illness will be engaged in nonwork (uncompensated) activities, including nonmarket labor and leisure but excluding sleep
N_{ill}	=	nonwork time when ill; the number of hours that an individual with the illness will be engaged in nonwork (uncompensated) activities, including nonmarket labor and leisure but excluding sleep
E	=	earnings (post-tax wages); the hourly value of nonwork (uncompensated) time including nonmarket work and leisure

The numerical values for these variables could be derived from a number of sources. For this example, the values for total compensation and post-tax wages are estimated from national data, discussed in detail in Appendix B.[37] The starting point for the development of these estimates is median weekly earnings for the year 2001 for full time workers ($597 per week) as reported by BLS (replicated in Appendix B, Exhibit B-3).[38] This value is derived from the Current Population Survey

[37]The example focuses on a typical or composite individual, but these values could be calculated separately for each gender and/or age group if data on the amount and type of time losses are available at this disaggregate level. In the latter case, the results for each gender or age group would need to be weighted to reflect the characteristics of the affected population (i.e., the overall proportion of the population of each age and sex) in determining the national impacts.

[38]This approach assumes that the hourly earnings for part-time workers will be the same as for full-time workers; analysts may wish to explore the extent to which this assumption introduces uncertainty into

and includes wages and salaries but not other costs (e.g., benefits) paid by the employer. The next step is conversion of this value to earnings per hour. Individuals usually working full time averaged 42.9 hours per week at work in 2001, again according to Current Population Survey data reported by BLS.[39] This means that median earnings per hour averaged $13.92 ($597/42.9).

For market work time, the measure of opportunity costs used in this example is total pre-tax compensation from the perspective of the employer. The earnings number reported above does not reflect employer paid benefits. To adjust this estimate upwards to reflect total compensation, this example uses the average ratio of wages and salaries to total compensation as reported by the Bureau of Labor Statistics for private industry workers for 2001. These data show that total compensation per hour averages 1.393 times wages and salaries for full time workers ($23.55/$16.91 per hour).[40,41] Using this factor to adjust median hourly earnings (as reported above) leads to an estimate of $19.39 per hour for total compensation.

For nonwork time (excluding sleep), the measure of opportunity costs used is post-tax earnings; i.e., the "take home" pay of the median individual. This example relies on Current Population Survey data on household income before and after taxes to determine the percent of earnings paid as taxes.[42] In 2000, the median before tax income was $42,151 and median after tax income was $34,667.[43] Thus after tax income was 82.2 percent of the pre-tax amount. Applying this factor to median hourly earnings leads to estimated after tax earnings of $11.44 per hour.

The results of these calculations are reported in Exhibit 3-3 below.

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the results.

[39] U.S. Bureau of Labor Statistics, "Table 19: Persons at work in agricultural and nonagricultural industries by hours of work," *Employment and Earnings*, undated (http://stats.bls.gov/cps/cpsaat19.pdf, as viewed September 2002).

[40]U.S. Census Bureau, "Table No. 626: Employer Costs for Employee Compensation Per Hour Worked: 2001," *Statistical Abstract of the United States: 2001*, Washington, D.C.: U.S. Government Printing Office, November 2001, p. 406.

[41]The earnings per hour estimates vary across data sources depending on sample characteristics, whether mean or median values are reported, and other factors.

[42]U.S. Census Bureau, "Table No. RDI-1, Household Income Before and After Taxes : 1979-2000", March 2002 (http:www.census.gov/hhes/income/histinc/rdi01.html as viewed September 2002).

[43]This median income estimate differs from the earnings estimates cited earlier because it reflects household income rather than individual earnings and relies on a different data source. It also represents data from the year 2000, because year 2001 data on pre- and post-tax earnings are not reported.

Exhibit 3-3 DOLLAR PER HOUR VALUES USED IN EXAMPLE CALCULATION			
Variable	**Time Loss Category**	**Basis for Estimate of Value**	**Dollar Value**
C	Market work time	Median gross (pre-tax) wage plus benefits.	$19.39 per hour
E	Nonwork (uncompensated) time (nonmarket work and leisure)	Median post-tax wage	$11.44 per hour

Notes:
See text for derivations of values.
Sleep time losses are conservatively valued at zero.

As discussed earlier, the source of estimates for the value of lost time will vary depending on the illness of concern and other considerations. For simplicity, this example assumes that the ill individual loses a full day of normal activities and is unable to engage in any sort of desirable leisure activities. Based on the data on normal time use provided in Exhibit B-1 of Appendix B, this loss will include 3.3 hours of work time and 12.6 hours of nonwork time (excluding sleep) for the typical individual (averaged across employed and unemployed individuals and seven days per week). In other words, in this example, zero time will be spent in work or nonwork activities while ill.

Equation 3-1 can be rewritten as follows using the above data

$$\textit{Value of lost time per day} = ([W_{well} - W_{ill}]\cdot C) + ([N_{well} - N_{ill}]\cdot E) \qquad \text{(Equation 3-1)}$$

$$= ([3.3 - 0] \cdot 19.39) + ([12.6 - 0] \cdot 11.44) = \$208.13$$

If the illness lasts for more than one day and the time loss is constant across days, then this value can be multiplied by the number of days of illness to determine the value of the time losses per case. (Adjustments will be needed if the time losses vary from day to day during the course of the illness.) This value then can be multiplied by the number of statistical cases averted by the regulation to determine the total value of the avoided time losses throughout the affected population. This calculation will become more complicated in cases where the losses vary over the time period of the illness, or where data limitations require the development of additional assumptions to complete the analysis.

The above example assumes that the loss is complete; i.e., that the affected individuals do not engage in any normal activities. This approach can be adjusted to estimate the value of partial losses; e.g., in cases where individuals continue to engage in normal activities while ill, but are less productive or find the activity less enjoyable. For example, if illness reduces productivity or enjoyment by 30 percent, then 30 percent of the hourly rate (represented by C and E in the example) can be used to estimate the value of the losses. This approach can also be applied when an ill individual is forced to substitute a less preferred, but somewhat pleasant, activity (e.g., reading) for a preferred activity (e.g., outdoor recreation).

Calculation of the impacts of nonfatal chronic illnesses require consideration of a number of other factors. For example, chronic illness may require consideration of changes in status (e.g., employment and survival rates) from year-to-year, as well as of the time value of money (i.e., using discounting to estimate the present value of future losses). As in the example above, the calculation of time losses for nonfatal chronic illness compares an ill individual to a similar well individual to determine the net loss over the duration of the illness. In this case, however, the duration is determined by the interaction of two factors: (1) the likely duration of the health effect (i.e., the number of days or years with the illness), and (2) the likelihood that an individual will survive (i.e., will not die from other causes) throughout the period of the illness.[44] In cases where the time loss is expected to accrue over a multi-year period, the analyst will need to discount the results so as to estimate the present value of the time losses in the base year, using the discount rates applied elsewhere in the analysis.[45] These factors will need to be considered in assessing time losses for unpaid caregivers as well as for the ill individual.

The assessment of chronic illness requires more data than the assessment of acute illness, examples of which are provided in Appendix B and elsewhere. For valuation, in addition to data on total compensation and post-tax wages (C and E in Equation 3-1 above), data are needed on the expected change in these earnings over time, the variation in the fraction of time spent in market work and other activities, and the discount rate. To estimate the amount of time lost, data are needed on age at onset, the duration of the illness, and survival probabilities, as well as on the effect of the illness on normal work and nonwork activities over time.[46]

Application of this approach is relatively straightforward for illnesses that strike in adulthood, but may be more difficult for illnesses that begin in childhood.[47] As discussed earlier in

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[44]As noted earlier, nonfatal cases can contribute to premature mortality if the definition of fatal cases (based on the risk assessment) includes only deaths directly attributable to the illness. For example, fatal cases may include only deaths directly attributable to diabetes, whereas nonfatal cases may include deaths from associated conditions (e.g., premature mortality from diabetes-related ischemic heart disease).

[45]A detailed explanation of the concept of discounting, as well as the rates recommended for use in EPA analyses of social costs, is provided in: U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, September 2000, EPA 240-00-003, Chapter 6.

[46] Because EPA expects to use this approach only in the valuation of nonfatal illnesses, the "with illness" survival probabilities should be based on data for individuals who survive the disease (i.e., die of other causes).

[47]All values should be real values (net of inflation) indexed to a common base year that is used throughout the regulatory analysis. For example, for an analysis conducted in 2004, all cost and benefit estimates may be based on year 2003 dollars since that would be the most recent year for which inflation data are available. In cases where the age at onset is after this base year, an annual productivity factor would be used to adjust the compensation and wage rate values from the base year to the year at onset.

this chapter, adult values may be used when calculating time losses during childhood years in the absence of better data.[48] In general, calculations will end at age 85, because most life tables assign a value of zero to the probability of a member of the general population surviving beyond that age. The market work time proportions can be adjusted to reflect employment rates at each age; the amount of time spent in paid work drops in the years after age 65 as many members of the population retire. In some cases, there may be a need to adjust the rates used for total compensation and post-tax wages to reflect the fact that individuals with the illness, while continuing to engage in paid work activities, are no longer able to be employed in occupations with earnings equivalent to those they received when well.

As noted previously, these approaches for valuing time losses for acute and chronic illnesses can be applied to caregivers as well as to ill individuals, and limitations related to applying this approach to children, the unemployed, and those out of the labor market should be discussed in presenting the results. For simplicity, the example does not include assessment of uncertainty or variability, which can be addressed quantitatively through sensitivity analysis of the effects of changes in key assumptions or through probabilistic analysis.

Finally, the example uses a combination of hypothetical assumptions and real data for demonstration purposes. EPA regulatory analysts should use the most current sources of data rather than the information in the examples. Many of these data are periodically updated and will need to be tailored for the health effects and populations considered in each individual analysis.

3.5 LIMITATIONS AND ASSESSMENT OF UNCERTAINTY

Analysts may be interested in characterizing three types of uncertainty related to this approach: uncertainty in the relationship of the resulting estimates to the preferred measure of willingness to pay for risk reductions, uncertainty in the estimates of the amount and types of time losses due to illness, and uncertainty in the unit dollar values assigned to these losses. The effects of these limitations should be clearly stated in the analysis, and can be explored through sensitivity analysis or probabilistic analysis using lower or higher rates, applying methods that are discussed in detail elsewhere.[49]

Relationship to willingness to pay: As discussed in Chapter 1, estimates that add the direct medical costs of illness to the indirect costs associated with lost work time are generally expected to understate willingness to pay in most cases for a variety of reasons. A major contributing factor is the lack of consideration of the value of averting the pain and suffering associated with illness, which is manifested at least in part in restrictions on nonwork activities. The approach discussed in this report addresses this deficiency by proposing an approach for valuing losses in nonwork time.

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[48]Data on earnings and employment rates are generally not available for individuals 16 years and younger.

[49]See, for example, U.S. Environmental Protection Agency (September 2000).

It is conceivable that this enhanced approach will still understate true willingness to pay; e.g., because it does not address the value of avoiding pain and suffering beyond its impact on normal activities. However, the extent of understatement is uncertain and difficult to quantify.

Estimates of time use with and without illness: The uncertainty in the estimates of the amounts and types of time losses associated with illness will depend on the approaches and data sources used in the particular analysis. Because these approaches are likely to vary greatly, it is difficult to generalize about the potential magnitude or direction of any bias or to develop any specific suggestions for addressing it quantitatively.

In many cases, data on time use with illness will be more uncertain that estimates of time use in the absence of illness. As discussed in Appendix B, a number of surveys collect data on normal time use. While different sources do not yield identical estimates, the estimates are relatively similar. For example, estimates of average sleep time appear to be in the range of 8 hours per night, and estimates of paid work time suggest that full time employees in the U.S. tend to work slightly more than 40 hours per week.

Information on the effect of illness on these normal activities is less prevalent and more uncertain, in part because of the vast variety of possible health effects and the diverse ways in which individuals respond to their symptoms. While data may be available on the likely duration of illness (e.g., the average number of days that elapse between when symptoms appear and disappear, or less ideally, between diagnosis and "cure"), information on the change in activities over this time period may be relatively general and incomplete. In particular, it may be difficult to differentiate between periods when the time loss is complete (i.e., the illness prevents any participation in enjoyable activities) and when the time loss is partial. Partial losses may occur when a less preferable activity (e.g., watching TV in bed) is substituted for a preferred activity (e.g., paid work or outdoor recreation), or when an individual continues to engage in normal activities but is less productive or finds them less enjoyable than usual. Hence in many cases the analyst may wish to test the assumptions regarding the degree of loss using sensitivity analysis or other approaches. Regardless, it is important that analysts clearly discuss the limitations of the data and assumptions.

Estimates of dollar values per unit time: Uncertainty in the dollar values per unit of time may stem from two sources: (1) uncertainty in the data used to estimate the value of wages and compensation, and (2) uncertainty that underlies the assumptions related to the use of these data to estimate the opportunity costs of time. The first source of uncertainty is probably less significant than the second. Data on U.S. wages and compensation are plentiful and (as in the case of normal time use) different sources provide reasonably similar values. Hence the estimates of post-tax wages and total compensation are likely to be subject to less uncertainty than other aspects of the analysis.

The uncertainty related to the assumptions that underlie the use of these data to value time losses requires consideration of more complex issues. The use of total compensation (wages and benefits) to estimate the value of paid work time, of post-tax wages for the value of uncompensated work and leisure time, and of a "zero" value for sleep time are based on a number of simplifying assumptions regarding the operations of the labor market and the factors that influence individual choice. The key uncertainties are summarized in Exhibit 3-4 and discussed below.

Exhibit 3-4

SUMMARY OF IMPACTS OF KEY ASSUMPTIONS RELATED TO DOLLAR VALUES FOR TIME USE

Time use category	Valuation Approach	Key Limitations	Comments
Market work time	Gross (pre-tax) wage plus benefits, reflecting both the opportunity costs to both the individual (i.e., lost wages) and to the employer and society (i.e., lost product)	• Based on a number of simplifying assumptions regarding the relationship between wages and productivity.	Effect is indeterminate, however, approach is widely accepted for valuing lost work time.
Nonmarket work and leisure time	Net (post-tax) wage, based on the opportunity costs to the individual	• May be reasonably accurate for individuals with flexible work schedules, but may understate or overstate values for individuals with inflexible work schedules. • May exclude some costs and benefits that affect employment decisions. • May understate or overstate values for individuals who do not engage in paid work.	Effect is indeterminate, but impacts appear to be counterbalancing to some (unknown) extent.
Sleep time	Zero, due to lack of support for a specific dollar value and difficulties inherent in estimating the net impact of illness on sleep time	• Value may be similar to that of other nonwork activities.	Likely to underestimate value by a potentially significant amount.
All	Average values may differ from marginal values Excludes consideration of involuntary nature of losses	• Theory suggests average values may exceed marginal values, but constraints on activity choice leads to variation in this relationship • Available research suggests avoidance of involuntary adverse effects may be more highly valued.	Effect is indeterminate, but may underestimate value.

The approach for valuing *paid work time* is based on two assumptions: (1) that the marginal value of an employee's output is likely to be equal to the marginal value of his or her total compensation; and (2) that the value of this output is likely to be greater than the utility an individual gains from working. The first assumption is based on the basic neoclassical model of profit-maximizing behavior on the part of firms. Underlying this model are a number of simplifying assumptions such as perfectly competitive markets and complete information, and the extent to which total compensation will under- or overstates the actual value of the worker's output to society is uncertain. For example, the friction cost approach (discussed in the previous chapter) suggests that this approach may overstate net national productivity losses if illness-related absenteeism results in the employment of previously unemployed workers.[50]

In addition, as discussed in Appendix B, the data sources used to estimate total compensation are likely to provide median or average rather than marginal values; i.e., to report total values for a given time period rather than values for small changes in the number of hours worked within that time period. Under standard neoclassical assumptions, marginal productivity is expected to decrease with each unit of labor (in simple terms, the first hour spent in production is expected to provide greater output than the second hour), implying that average values may exceed marginal values as long as this assumption holds. Under this assumption, use of median values may overstate the value of relatively small changes in time use, but may be accurate for larger changes.

Under the second assumption, the difference between the value of work to the individual and the value of work to the employer and society is equal to the costs of benefits and taxes. If an individual gains utility from work that exceeds post-tax wages but is less than the value of total compensation, using total compensation to measure the societal value of illness-related losses should not introduce additional bias into the analysis. If, however, individuals gain utility from paid work that is greater than total compensation, then this approach may understate the value of related social welfare losses. Despite these limitations, the use of total compensation as an estimate of the value of lost work time is widely accepted in the cost of illness literature and is likely to be subject to less debate than the approaches used to value uncompensated time.

The approach for valuing *nonmarket work and leisure* is based on the assumption that, at the margin, individuals allocate their time between work and leisure so that the value of leisure time is equal to the wage rate. Work by Bockstael, Strand, and Hanemann, and by Feather and Shaw (summarized in Chapter 2) suggests that the wage rate provides a reasonably accurate estimate of the value of uncompensated time when an individual can choose the number of hours he or she spends in paid work.[51] Where hours are inflexible, the marginal value of uncompensated time may be more than the wage rate (if a worker is forced to work more hours than desired), or less than the wage rate (if a worker is forced to work fewer hours than desired). While Feather and Shaw found that their sample of employed individuals was split roughly into thirds (one-third with flexible hours,

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[50]While the friction cost approach suggests that this approach may overstate the value of lost output in cases where unemployed workers replace ill workers, more research is needed to determine the extent to which such replacement actually occurs. In addition, the friction cost approach does not take into account other factors that contribute to the uncertainty inherent in the approach.

[51]Bockstael, N.E., I.E. Strand, and W.M. Hanemann, "Time and the Recreational Demand Model," *American Journal of Agricultural Economics*, Vol. 69, pp. 293-202, 1987; Feather, P. and W.D. Shaw, "Estimating the Cost of Leisure Time for Recreation Demand Models," *Journal of Environmental Economics and Management*, Vol. 38, pp. 49-65, 1999; and, Feather, P. and W.D. Shaw, "The Demand for Leisure Time in the Presence of Constrained Work Hours," *Economic Inquiry*, Vol. 38, No. 4, pp. 651-661, October 2000.

one-third overemployed, and one-third underemployed), Bockstael, Strand, and Hanemann found that individuals with inflexible hours generally valued leisure higher than the wage rate. These results suggest that it is possible that overemployment is more prevalent than underemployment and hence post-tax wages may understate the value of nonwork time.

The focus on marginal values introduces uncertainty into the valuation of uncompensated time, as well as compensated time (as discussed earlier). Neoclassical economic theory suggests that average values will exceed marginal values. The standard assumption is that each hour spent in an activity has decreasing utility, and hence the marginal hour may have a lower value than the average. In reality, as discussed in Chapter 2, the value of activities is likely to rise and fall depending on a number of factors -- such as constraints on an individual's ability to engage in certain activities at certain times (e.g., to golf at night, or to enjoy the beach in the winter) -- and the relationship between average and marginal values is uncertain. In addition, the time losses associated with many illnesses may lead to greater than marginal changes in time use, and use of the average or median value per hour may provide more accurate estimates than relying on the marginal value for the last hour.[52] As noted above, the available data sources generally provide median or average rather than marginal estimates of both total compensation and post-tax wages.

Other factors also influence the accuracy of post-tax wages as a measure of the value of nonmarket work and leisure time. In particular, this approach ignores some costs that may a necessary part of the decision to engage in paid work, such as those associated with commuting or childcare, as well as the potential utility (or disutility) associated with these activities. For example, commuting imposes dollar costs that decrease an individual's disposable income, and may be a source of discomfort or inconvenience. Childcare also imposes costs, however, an individual may gain substantial utility from taking care of his or her own child. Presumably, these costs would be netted out from post-tax wages in an individual's consideration of the impact of work on income, and the individual would also consider any utility gains or losses associated with these activities.

This approach also ignores the impact of employer paid benefits on individual utility -- working fewer hours will decrease the receipt of any benefits that are tied to hours worked, and deciding to not work at all will eliminate any benefits. In addition, illness-related absence may not reduce the disposable income of the employee due to the availability of sick pay and disability benefits (as long as the absence does not exceed the time period covered by these benefits), and small changes in hours (or short absences from work) may not affect total compensation particularly for salaried employees.[53] The net direction and magnitude of these effects is difficult to determine,

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[52] This factor may be one explanation for Gronau's findings, as discussed earlier, In his work on the effects of the wage rate on the hours of home work for employed wives, Gronau found that the value of output was almost twice as high as would be predicted under the opportunity cost approach. Gronau (1986), p. 299.

[53]If the individual has access to paid sick leave, a marginal loss of work time (within certain limits) will not result in an immediate loss of income. However, a loss will accrue to the employer, who pays wages without the benefit of the worker's productivity. The individual also loses the ability to save this sick leave for another time.

especially since many of these concerns have counterbalancing effects.

The approach of using estimates of post-tax wages for *individuals not engaged in paid work* raises a number of other concerns. This approach assumes that individuals who do not engage in paid labor are similar to those who do. For children, there are clear differences, and applying adult values introduces significant uncertainty into the calculations. Adults who are involuntarily unemployed may differ from the working population in ways that suggest that wage rates will overstate the value of their time. Those not seeking employment may be forced to do so by retirement policies (in the case of the elderly) or by the cost of childcare (for homemakers), rather than by choice, and factors such as the availability of Social Security or welfare benefits complicate these decisions. The net effects of using wage rates to estimate the value of time for these individuals is unclear.

The approach used to value *sleep* is conservative and likely to undervalue related losses. Available literature suggests that sleep may be valued at approximately the same marginal rate as nonmarket work and leisure, but there a number of difficulties related to estimating the net effect of illness on sleep time. Hence analysts may wish to test the effects of assigning a larger value to sleep-related losses if it is possible to estimate the net change in sleep time due to illness.

Finally, two sources of uncertainty have *cross-cutting* effects. As described in the previous paragraphs, the use of marginal vs. average values has implications for the valuation of all of the time loss categories. In addition, the approach for valuing lost time is based on the theory of consumer choice, where individuals are able to make decisions regarding the allocation of time across different activities. However, illness limits this choice, and the activity restrictions involved are generally involuntary. Available research on risk perception suggests that individuals may place a higher value on avoiding involuntary or uncontrollable adverse effects than on avoiding such effects voluntarily. For example, voluntariness and controllability are among the nine major risk dimensions that Slovic, Fischhoff, and Lichtenstein identify as influencing individuals' perceptions and rankings of risks.[54] In addition, Cropper and Subramanian find that individuals tend to choose programs that address risks that are more difficult to avoid (i.e., less controllable) when selecting among public health and environmental programs with different risk characteristics.[55] In addition, two recent reviews of the risk perception literature interpret it as suggesting that the combined effects of dread, lack of voluntariness, and lack of controllability in environmental risk reduction settings compared to a typical accidental death risk scenario could increase willingness to pay

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[54]Summarized in: P. Slovic, B. Fischhoff, and S. Lichtenstein, "Perceived Risk: Psychological Factors and Social Implications," *Proceedings of the Royal Society of London. Series A: Mathematical and Physical Sciences*, Vol. 430, No. 1878, 1981, pp. 17-34. Also evaluated in P. Slovic, "Perception of Risk," *Science*, Vol. 236, April 1987, pp. 280-285.

[55]M.L. Cropper and U. Subramanian, "Public Choices Between Lifesaving Programs: How Important Are Lives Saved?" *Policy Research Working Paper 1497*, The World Bank, 1995.

estimates derived from accidental risk scenarios by a factor of two or more.[56] These studies suggest that the value of involuntary time losses attributable to illness may exceed the value of time reflected in the normal allocation of time between labor and leisure activities.

[56]R.L. Revesz, "Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives," *Columbia Law Review*, Vol. 99, No. 4, 1999, pp. 941-1017; and P. Rowlatt et al., *Valuation of Deaths from Air Pollution*, prepared for the (British) Department of Environment, Transport and the Regions and the Department of Trade and Industry, 1998.

REFERENCES

Advisory Council on Clean Air Compliance Analysis. May 2004. *Review of the Revised Analytical Plan for EPA's Second Prospective Analysis – Benefits and Costs of the Clean Air Act 1990-2020.* Prepared for the U.S. Environmental Protection Agency. EPA-SAB-COUNCIL-ADV-04-004.

Abt Associates. December 2001. *Final Heavy Duty Engine/Diesel Fuel Rule: Air Quality Estimation, Selected Health and Welfare Effects Methods, and Benefits Results.* Prepared for the U.S. Environmental Protection Agency.

Berger, M., Blomquist, G., Kenkel, D., and Tolley, G. 1987. "Valuing Changes in Health Risks: A Comparison of Alternative Measures." *The Southern Economic Journal*. Vol. 53. Pages 977-984.

Biddle, J.E. and Hamermesh, D.S. 1990. "Sleep and the Allocation of Time." *Journal of Political Economy.* Vol. 98, No. 5. Pages 922-943.

Bockstael, N.E., Strand, I.E., and Hanemann, W.M. 1987. "Time and the Recreational Demand Model." American Journal of Agricultural Economics. Vol. 69. Pages 293-202.

Brody, W.H. August 1975. *Economic Value of a Housewife*. Research and Statistics Note 9. DHEW Publication No. SSA 75-11701. Washington: Social Security Administration, Office of Research and Statistics.

Buzby, J.C., Roberts, T., Lin, C.T.J., and MacDonald, J.M. 1996. *Bacterial Foodborne Disease: Medical Costs and Productivity Losses.* Food and Consumer Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 741.

Cesario, F.J. February 1976. "Value of Time in Recreation Benefit Studies." *Land Economics.* Vol. 52, No. 1. Pages 32-41.

Chestnut, L.G., Colome, S.D., Keller, L.R., Lambert, W.E., et al. October 1988. *Heart Disease Patients Averting Behavior, Costs of Illness, and Willingness to Pay to Avoid Angina Episodes*. EPA Report 230-10-88-042.

Cooper, B.S. and Rice, D.P. February 1976. "The Economic Cost of Illness Revisited." *Social Security Bulletin*. Vol. 39, No. 2. Pages 21-36.

Cropper, M.L. and Krupnick, A. 1999. "The Social Costs of Chronic Heart and Lung Disease." *Valuing Environmental Benefits: Selected Essays of Maureen Cropper*. (M.L. Cropper, ed.). Cheltenham, UK: Edward Elgar Publishing.

Cropper, M.L. and Krupnick, A. June 1990. *The Social Costs of Chronic Heart and Lung Disease*.

Resources for the Future Discussion Paper QE89-16-REV. Washington, DC.

Cropper, M.L. and Subramanian, U. 1995. "Public Choices Between Lifesaving Programs: How Important Are Lives Saved?" *Policy Research Working Paper 1497*. The World Bank.

DeSerpa, A. C. December 1971. "A Theory of the Economics of Time." *The Economic Journal*. Vol. 81, No. 324. Pages 828-846.

Douglas, J., Kenny, G., and Miller, T.R. 1990. "Which Estimates of Household Production Are Best?" *Journal of Forensic Economics*. Vol. 4. Pages 25-45.

Dravove, D. 1995. "Measuring Costs." *Valuing Health Care*. (F.A. Sloan, ed.). Cambridge, England: Cambridge University Press.

Englin, J. and Shonkwiler, J.S. 1995. "Modeling Recreation Demand in the Presence of Unobservable Travel Costs: Toward a Travel Price Model." *Journal of Environmental Economics and Management*. Vol. 29, No. 3. Pages 368-377.

Feather, P. and Shaw, W.D. 1999. "Estimating the Cost of Leisure Time for Recreation Demand Models." *Journal of Environmental Economics and Management*. Vol. 38. Pages 49-65.

Feather, P. and Shaw, W.D. October 2000. "The Demand for Leisure Time in the Presence of Constrained Work Hours." *Economic Inquiry*. Vol. 38, No. 4. Pages 651-661.

Freeman, A. M., III. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*. Second Edition. Washington, DC: Resources for the Future.

Gold, M.R., Siegel, J.E., Russell, L.B., and Weinstein, M.C. (eds.). 1996. *Cost-Effectiveness in Health and Medicine*. Oxford: Oxford University Press.

Goldschmidt-Clermont, L. 1982. *Unpaid Work in the Household*. Prepared for the International Labor Office, United Nations.

Gronau, R. 1986. "Home Production - A Survey." *Handbook of Labor Economics,* Vol. 1. (O. Ashenfelter and R. Layard, eds.) New York: North-Holland.

Harrington, W., Krupnick, A.J., and Spofford, W.O., Jr. 1991. *Economics and Episodic Disease: The Benefits of Preventing a Giardiasis Outbreak*. Washington, DC: Resources for the Future.

Harrington, W., Krupnick, A.J., and Spofford, W.O., Jr. 1989. "The Economic Losses of a Waterborne Disease Outbreak." *Journal of Urban Economics.* Vol. 25, No. 1. Pages 116-137.

Harrington, W. and Portney, P. 1987. "Valuing the Benefits of Health and Safety Regulations." *Journal of Urban Economics.* Vol. 22. Pages 101 - 112.

Hartunian, N.S., Smart, C.N., and Thompson, M.S. 1981. *The Incidence and Economic Costs of Major Health Impairments. A Comparative Analysis of Cancer, Motor Vehicle Injuries, Coronary Heart Disease, and Stroke.* Lexington, Massachusetts: D.C. Heath and Company.

Heckman, J. July 1975. "Shadow Prices, Market Wages, and Labor Supply." *Econometrica*. Vol. 42, No. 4. Pages 679-694.

Hoffman, C., Rice, D., and Sung, H.Y. November 1996. "Persons With Chronic Conditions: Their Prevalence and Costs." *Journal of the American Medical Association.* Vol. 276, No. 18. Pages 1473-1479.

Hutubessy, R.C.W., van Tulder, M.W., Vondeling, H., and Bouter, L.M. 1999. " Indirect Costs of Back Pain in the Netherlands: A Comparison of the Human Capital Method with the Friction Cost Method." *Pain*. Vol. 80. Pages 201-207.

Johannesson, M. and Karlsson, G. 1997. "The Friction Cost Method: A Comment." *Journal of Health Economics*. Vol. 16. Pages 249 - 255.

Kocagil, P., Demarteau, N., Fisher, A., and Shortle, J.S. 1998. "The Value of Preventing Cryptosporidium Contamination." *Risk: Health, Safety and Environment.* Vol. 9. Pages 175-196.

Koopmanschap, M.A. and Rutten, F.F.H. 1993. "Indirect Costs in Economic Studies." *PharmacoEconomics.* Vol. 4, No. 6. Pages 446-454.

Koopmanschap, M.A., and F.F.H. Rutten. 1996. "A Practical Guide for Calculating Indirect Costs of Disease." *PharmacoEconomics.* Vol. 10, No. 5. Pages 460-456.

Koopmanschap, M.A., Rutten, F.F.H., van Ineveld, B.M., and van Roijen, L. 1995. "The Friction Cost Method for Measuring Indirect Costs of Disease." *Journal of Health Economics*. Vol. 4. Pages 171-189.

Landefeld, J.S. and Seskin, E.P. 1982. "The Economic Value of Life: Linking Theory to Practice." *American Journal of Public Health*. Vol. 6. Pages 555-566.

Larson, D.M.. August 1993. "Separability and the Shadow Value of Leisure Time." *American Journal of Agricultural Economics*. Vol. 75. Pages 572-577.

Magat, W.A., Viscusi, W. K., and Huber, J. 1992. *The Death Risk Lottery Metric for Valuing Health Risks: Applications to Cancer and Nerve Disease.* Prepared for the U.S. Environmental Protection Agency.

McConnell, K.E., and Strand, I. 1981. "Measuring the Cost of Time in Recreation Demand Analysis: An Application to Sportfishing." *American Journal of Agricultural Economics*. Vol. 63. Pages 153-156.

MVA Consultancy et al. 1994. "Research Into the Value of Time." *Cost-Benefit Analysis* (R. Layard, and S. Glaister, eds.). Second Edition. Cambridge: Cambridge University Press. Pages 235 - 272.

National Research Council. 2000. *Time Use Measurement and Research: Report of a Workshop.* Commission on Behavioral and Social Sciences and Education, Committee on National Statistics (M. Ver Ploeg, J. Altonji, N. Bradburn, J. DaVanzo, W. Nordhaus, and F. Samaniego (eds.)). Washington, D.C: National Academy Press.

Revesz, R.L.. 1999. "Environmental Regulation, Cost-Benefit Analysis, and the Discounting of Human Lives." *Columbia Law Review*. Vol. 99, No. 4. Pages 941-1017.

Ray, N.F., Thamer, M., Gardner, E., Chan, J.K., and American Diabetes Association. 1998. "Economic Consequences of Diabetes Mellitus in the U.S. in 1997." *Diabetes Care*. Vol. 21, No. 2. Pages 296-309.

Rice, D.P. May 1966. "Estimating the Cost of Illness." *Health Economic Series No. 6, PHS Publication No. 947-6*. Washington, DC: U.S. Government Printing Office.

Rice, T.D., Duggan, A.K. and DeAngelis, C. 1992. "Cost-Effectiveness of Erythromycin versus Mupirocin for the Treatment of Impetigo in Children." *Pediatrics*. Vol. 89, No. 2. Pages 210-214.

Rice, D.P. and Max, W. 1992. *The Cost of Smoking in California, 1989.* Sacramento: California State Department of Health Services.

Ries, L.A.G., et al. (eds). 2001. *SEER Cancer Statistics Review, 1973-1998.* Bethesda, MD: National Cancer Institute.

Robb, R., Denton, M., Gafni, A., Joshi, A., Lian, J., Rosenthal, C., and Willison, D.. 1999. "Valuation of Unpaid Help by Seniors in Canada: An Empirical Analysis." *Canadian Journal on Aging.* Vol 18, No. 4. Pages 430 - 446.

Rowe, R.D. and Chestnut, L.D. undated. *Valuing Changes in Morbidity: WTP vs. COI Measures.* Prepared for the U.S. Environmental Protection Agency and the California Air Resources Board.

Rowlatt. P. et al. 1998. *Valuation of Deaths from Air Pollution*. Prepared for the (British) Department of Environment, Transport and the Regions and the Department of Trade and Industry.

Shaw, W. D. 1992. "Searching for the Opportunity Cost of an Individual's Time." *Land Economics*. Vol. 68, No. 1. Pages 107-115.

Shaw, W. D. and Feather, P.. 1999. "Possibilities for Including the Opportunity Cost of Time in Recreation Demand Systems." *Land Economics*. Vol. 75, No. 4. Pages 592-602.

Slovic, P. April 1987. "Perception of Risk." *Science.* Vol. 236. Pages 280-285.

Slovic, P., Fischhoff, B., and Lichtenstein, S.. 1981. "Perceived Risk: Psychological Factors and Social Implications." *Proceedings of the Royal Society of London. Series A: Mathematical and Physical Sciences*. Vol. 430, No. 1878. Pages 17-34.

Small, K.. 1992. *Urban Transportation Economics*. Luxembourg: Harwood Academic Publishers.

Smith, V. K., Desvousges, W.H. and McGivney, M.P. 1983. "The Opportunity Cost of Travel Time in Recreation Demand Models." *Land Economics.* Vol. 59, No. 3. Pages 259-278.

Statistics Canada. 1999. "Average time spent on activities, total population, and participants, by sex." *General Social Survey, 1998*.

Tipping, D. G. December 1968. "Time Savings in Transport Studies." *Economic Journal*. Pages 843-854.

Trewin, D. October 2000. *Unpaid Work and the Australian Economy: 1997*. Australian Bureau of Statistics.

Ungar, W. J., Coytem, P.C., and the Pharmacy Medication Monitoring Board. 2000. "Measuring Productivity Loss Days in Asthma Patients." *Health Economics.* Vol. 9. Pages 37-49.

U.S. Census Bureau. November 2001. *Statistical Abstract of the United States: 2001 (121st edition).* Washington, DC: U.S. Government Printing Office.

U.S. Department of Transportation. April 1997. *Departmental Guidance for the Valuation of Travel Time in Economic Analysis* (Memorandum from F. E. Kruesi).

U.S. Department of Transportation. February 2003. *Revised Departmental Guidance, Valuation of Travel Time in Economic Analysis* (Memorandum from E.H. Frankel).

U.S. Environmental Protection Agency. October 2003*. Children's Health Valuation Handbook.*

U.S. Environmental Protection Agency. May 2003. *Benefits and Costs of the Clean Air Act, 1990 – 2020: Revised Analytical Plan for EPA's Second Prospective Analysis.* Prepared by Industrial Economics, Incorporated.

U.S. Environmental Protection Agency. February 2001. *Cost of Illness Handbook.*

U.S. Environmental Protection Agency. December 2000. *Handbook for Non-cancer Health Effects Valuation.*

U.S. Environmental Protection Agency. September 2000. *Guidelines for Preparing Economic Analyses*. EPA 240-R-00-003.

U.S. Environmental Protection Agency. August 1997. *Exposure Factors Handbook (Final Report),* Washington, D.C.: Office of Research and Development.

U.S. Office of Management and Budget. September 2003. *Regulatory Analysis (Circular A-4).*

Waitzman, N.J., Scheffler, R.M., Romano, P.S. 1996. *The Cost of Birth Defects: Estimates of the Value of Prevention*. Lanham: University Press of America, Incorporated.

Weinblatt, E., Shapiro, S., Frank, C.W. and Sager, R.V. 1966. "Return to Work and Work Status Following First Myocardial Infarction." *American Journal of Public Heath*. Vol. 65, No. 2. Pages 169 -185.

Weinstein, M.C., Siegel, J.E., et. al. 1997. "Productivity Costs, Time Costs and Health-Related Quality of Life: A Response to the Erasmus Group." *Health Economics.* Vol. 6. Pages 505-510.

Wilman, E.A.. 1980. "The Value of Time in Recreation Benefit Studies." *Journal of Environmental Economics and Management.* Vol. 7. Pages 272- 286.

Winston, G.C.. 1987. "Activity Choice: A New Approach to Economic Behavior." *Journal of Economic Behavior and Organization.* Vol 8. Pages 567-585.

APPENDIX A: EXAMPLES FROM THE EMPIRICAL LITERATURE

The preceding chapters of this report provide detailed information on calculating the value of lost time, and include footnoted references to existing studies that illustrate particular aspects of the approach. This appendix provides more information on some of the studies referenced previously. It is not intended to be a comprehensive review of the literature; rather it provides selected examples of alternative approaches to the valuation of time losses due to illness. As indicated by these examples, much of the existing literature applies the human capital approach and focuses on lost work time. Few researchers have considered the social welfare losses associated with the effects of illness on other types of time use (e.g., leisure) using the approach described in this report.

The studies selected as examples are listed in Exhibit A-1, which provides information on the types of time losses costs assessed, the health effects studied, and the type of estimates developed. These studies are summarized to reflect the variety of methods and results within the body of relevant literature. The first two studies provide examples of the human capital approach, while the remaining studies provide examples of alternative approaches to estimating indirect costs. Descriptions of each study, as well as a summary of the results, are provided in the following pages.

Exhibit A-1

EXAMPLES FROM THE LITERATURE

Authors and Publication Date	Time Losses Assessed	Health Effects Assessed	Type of Estimates
Hartunian et al., 1981	Lost earnings and housekeeping time for ill individuals	Cancer, ischemic heart disease, stroke, and motor vehicle injuries	Lifetime costs of U.S. cases identified in 1975
Ray et al., 1998	Lost earnings and housekeeping time for ill individuals	Diabetes mellitus	Annual costs for U.S. cases in 1997
Cropper and Krupnick, 1999	Changes in earnings and labor force participation rates for ill individuals	Various chronic heart and lung diseases	Predictive model based on 1977 national sample of males
Buzby et al., 1996	Lost earnings for ill individuals and caregivers	Various bacterial diseases	Lifetime costs per case using a 1993 base.
Waitzman et al., 1996	Lost earnings and housekeeping time for ill individuals	Various birth defects	Lifetime costs of California cases identified in 1988
Harrington et al., 1989	Lost earnings, household work, and leisure time for ill individuals and caregivers	Giardiasis	Per case losses due to 1983-1984 contamination incident
Kocagil et al., 1998	Lost earnings and nonwork time for ill individuals	Cryptosporidiosis	Per case losses due to 1996 contamination incident

Sources:
See footnotes and reference list at the end of this report for full citations.

Hartunian et al. (1981): This study uses an incidence approach to estimate direct and indirect costs of cancer, motor vehicle injuries, coronary heart disease, and stroke.[1] The authors separate each condition into a number of sub-conditions to distinguish between those with different cost impacts. The direct costs considered vary somewhat by health effect, but generally include: emergency assistance; initial inpatient hospital care; physical and surgeon services; vocational and physical rehabilitation; nursing home and home attendant care; drugs, medical supplies, and appliances; outpatient medical and surgical care; re-hospitalization (due to recurrences); home modifications; paramedical and miscellaneous expenses; insurance administration; and legal and court expenses.

For nonfatal cases, the authors estimate the indirect costs of lost market work, reduced

[1]Hartunian, N.S., C.N. Smart, and M.S. Thompson, *The Incidence and Economic Costs of Major Health Impairments: A Comparative Analysis of Cancer, Motor Vehicle Injuries, Coronary Heart Disease, and Stroke*, Lexington, Massachusetts: D.C. Heath and Company, 1981.

productivity at work, and lost nonmarket work due to morbidity in surviving patients. For fatal cases, they estimate morbidity prior to premature mortality (the morbidity increment) as well as lost earnings due to death. Data on employment and housekeeping rates are from the Department of Labor. For employed individuals, lost time is valued at market wage rates, however, it is unclear whether these rates include taxes (or benefits). The value of household labor is estimated in two ways: (1) based on Brody (1975) which uses a composite market-value approach, and (2) based on the opportunity cost of household labor, valued at the average earnings of same-age and same-sex peers in the labor force.[2]

This study is an early and precedent-setting example of an incidence-based approach to valuing indirect costs; much of the available literature focuses on annual estimates rather than on lifetime costs per case. It provides the foundations for several aspects of the valuation methods discussed in this report, including the valuation of reduced productivity as well as more complete work-related losses, the valuation of nonmarket work based on earnings (i.e., opportunity costs) compared to replacement costs, and the calculations used to estimate the value of time losses associated with both acute and chronic illnesses. While the authors do not estimate the value of caregiver losses, they note that including such losses would improve their estimates.

Ray et al. (1998): This study provides a more recent example of a straightforward application of the human capital method, and illustrates how the data sources discussed in Appendix B can be used to estimate the amounts and types of illness-related time losses. It assesses the direct medical expenditures and indirect costs attributable to the roughly 7.5 million estimated cases of diabetes in 1997.[3] The direct cost estimates include nursing home stays, hospital stays, physician visits, emergency room care, medication, and related professional services. The indirect costs estimated include lost earnings and housekeeping time due to disability and premature mortality.

Ray et al. estimate three types of time losses. First, they consider short-term disability, using self-reported data on bed days, restricted activity days, and work loss days from the National Health Interview Survey. They compare estimates of lost days for persons with and without diabetes, to estimate the net impact of diabetes. For employed individuals, lost work days were valued at median gross (pre-tax) earnings for full time workers from the Bureau of Labor Statistics; bed days and disability days were valued based on median gross earnings for housekeepers from the same source. Second, Ray et al. also consider long term permanent disability time losses. These losses are estimated based on lost earnings data (exclusive of disability payments) from the Social Security Administration. Third, the analysis also considers time losses due to premature mortality.

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[2]Brody, W. H. *Economic Value of a Housewife*. Research and Statistics Note 9, DHEW Publication No. SSA 75-11701. Washington: Social Security Administration, Office of Research and Statistics, August 1975.

[3]Ray, N.F., M. Thamer, et al., "Economic Consequences of Diabetes Mellitus in the U.S. in 1997," *Diabetes Care*, Vol. 21, No. 2, 1998, pp. 296-309.

Cropper and Krupnick (1999): This study applies a different and somewhat unusual approach to valuing time losses, using an econometric model to estimate the effects of illness on earnings and labor force participation.[4] Cropper and Krupnick characterize the effects of chronic respiratory and circulatory disease on labor force participation and earnings for men aged 18 to 65. Data used in the model are from the Social Security Survey of Disability and Work, and include individuals with and without illness. Annual losses in expected earnings are estimated at different ages, by age at onset, for different health conditions. The independent variables include data on earnings, household characteristics, age, level of education, location, and other characteristics as well as health status. To capture an individual's decision to remain in the work force, additional variables are added to the model, including whether the individual is aware of Social Security benefits, whether the individual is a veteran, and the size of the individual's debt. The study also estimates direct medical costs from the National Medical Care Expenditure Survey for some conditions, including the costs of medical visits, hospitalization, and drugs.

The researchers note that the theoretically correct measure of social benefits from reducing the incidence of a disease is the sum of ill individuals' willingness to pay to avoid the disease plus the costs of the disease borne by others. This study focuses on only the second half of this equation; estimating costs (e.g., of hospital stays and lost productivity) that are often borne by others (such as insurance companies or employers) rather than directly by the ill individual. Therefore, the authors suggest that the results of this study could be added to an individual willingness to pay measure to better estimate the social welfare benefits of risk reductions.

Buzby et al. (1996): This study assesses medical costs and productivity losses for a number of bacterial diseases, and provides an example of an approach for assessing caregiver losses. For four bacterial diseases (salmonellosis, campylobacteriosis, staphylococcus aureus, and clostridium perfringens), the authors rely on previous research that does not separate out medical costs from the costs of lost time. For the remaining two health effects, *E. coli* disease and listeriosis, the authors separate medical costs from the value of lost productivity. In addition to assessing lost time due to morbidity, they assess mortality costs by relying on adjusted value of statistical life estimates based on a study by Landefeld and Seskin.[5] The discussion below focuses on the approach for valuing lost time for acute cases of these latter two illnesses, because chronic cases are valued in part based on adjusted value of statistical life estimates.

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[4]Cropper, M.L. and A.J. Krupnick, "The Social Costs of Chronic Heart and Lung Disease," in *Valuing Environmental Benefits: Selected Essays of Maureen Cropper,* M.L. Cropper (ed.), Cheltenham: Edward Elgar, 1999. (A previous version of this study was published as: Cropper, M.L. and A.J. Krupnick, *The Social Costs of Chronic Heart and Lung Disease*. Resources for the Future Discussion Paper QE89-16-REV, Washington, DC. June 1990.)

[5]Buzby, J.C., T. Roberts, et al., *Bacterial Foodborne Disease: Medical Costs and Productivity Losses*, Food and Consumer Economics Division, Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 741, 1996; Landefeld, J.S. and E. P. Seskin, "The Economic Value of Life: Linking Theory to Practice," *American Journal of Public Health*, Vol. 6, 1982, pp. 555-566.

For acute *E. coli* disease, the authors estimate time lost from paid work both for caregivers of ill children and for ill adults. The number of days a child is home from school is estimated based on the severity of the condition. For ill adults, days lost due to illness, physician visits, and hospitalization and subsequent recuperation are considered. For both caregivers and ill adults, time losses are valued using average weekly gross (pre-tax) earnings, including fringe benefits. These estimates are based on data for production of non-supervisory workers in private nonagricultural jobs, collected by the Bureau of Labor Statistics. A similar approach is used for acute cases of listeriosis. However, in this case, only time losses due to hospitalization and subsequent recuperation are considered. Costs are estimated separately for pregnant women and other adults, and for cases of differing severity. The amount of lost time is based on estimates of the length of the hospital stay and of the subsequent recuperation time at home. Lost work time is valued using the same approach as described above for *E. coli* disease.

The researchers acknowledge limitations of their approach to valuing these illnesses. In particular they note that in the case of the salmonellosis study, if the value of lost leisure were included in their estimate and valued at the prevailing wage rate, the cost estimate of salmonellosis would more than double their current estimate. The authors state, "[w]hen using the COI estimates presented here, one should bear in mind that they underestimate the true economic value of bacterial foodborne illnesses to society because they exclude such costs as: (1) pain, suffering, and lost leisure time of the victim and her/his family, (2) lost business and costs and liabilities of lawsuits affecting agriculture and the food industry, (3) the value of self-protective behaviors undertaken by industry and consumers, and (4) resources spent by Federal, State and local governments to investigate the source and epidemiology of the outbreak."

Waitzman et al. (1996): This study provides an example of the valuation of the impact of childhood illnesses on future market and nonmarket work; it estimates the lifetime costs of several types of birth defects for children in California.[6] Indirect costs of morbidity are separated into two categories based on the severity of the lifelong effects: (1) the affected individual is totally unable to work, or (2) the affected individual is limited in the type and amount of work he or she can perform. The percent of individuals with work limitations of each type was estimated largely from the National Health Interview Survey, supplemented by data from the Survey of Income and Program Participation. The authors consider both market work and household production, and assume that time losses for household work will be concomitant with the reductions in market work. The authors combine these data with information on survival rates to determine the time periods over which losses occur.

Waitzman et al. use information from Rice and Max (1992) to value time losses.[7] They value lost market work time at gross wage rates that include earnings and benefits, assuming a

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[6]Waitzman, N.J., R.M. Scheffler, and P.S. Romano, *The Costs of Birth Defects,* Lanham: University Press of America, Incorporated, 1996.

[7]Rice, D.P. and W. Max, *The Cost of Smoking in California, 1989*, Sacramento: California State Department of Health Services, 1992.

one percent increase in market productivity per year. The Rice and Max study is also used to value lost household production, applying a composite rate that reflects the market costs for different household activities.[8] Waitzman et al. provide estimates discounted at rates of two, five, and ten percent. In addition, the researchers estimate lost earnings from premature mortality, medical costs (such as inpatient and outpatient care, pharmaceuticals, laboratory tests, x-rays, appliances, and long-term care), and the costs of developmental and special education services. Waitzman et al. acknowledge that excluding caregiver costs, as well as the impacts of pain and suffering, results in a conservative estimate of the social costs of birth defects.

Harrington et al. (1989): These researchers estimate the losses associated with giardiasis due to a drinking water contamination episode in Luzerne County, Pennsylvania.[9] Their study is somewhat unusual in that it includes the valuation of lost leisure time and provides a more complete estimate of the effects of illness (on both caregivers and ill individuals) than the previously cited studies. The medical cost component of the analysis considers visits to doctors, the hospital, and the emergency room, as well as laboratory tests and medication. Time costs include time spent on these activities and associated travel. In addition, the indirect cost component of the analysis considers work time losses, reduced productivity while at work, and lost leisure and housework time from the perspective of affected individuals and their caregivers. The researchers also assess losses due to averting actions.

To determine the direct and indirect costs of illness, the authors surveyed individuals with reported cases of giardiasis. They collected information on work days lost for the employed and for homemakers, including both the ill individual and his or her caregiver. In addition, they collected data on the self-reported reduction in productivity due to illness while at work for employed individuals and homemakers. Leisure time was calculated as time not spent working or sleeping.

For the employed, the researchers value lost time at the before-tax hourly wage rate for survey respondents. Leisure time losses are valued at the after-tax wage, calculated from gross wages by netting out an amount equal to the U.S. average income tax rate (including federal, state and local taxes and FICA). Three different methods are used to value the lost nonmarket time of homemakers, retirees, and unemployed persons: (a) the after-tax wage rate for employed respondents, (b) the after-tax minimum wage rate, and (c) zero.

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[8]This approach in turn is based on a methodology developed in: Douglas, J., G. Kenny and T.R. Miller, "Which Estimates of Household Production Are Best?," *Journal of Forensic Economics*, Vol. 4, No. 1, pp. 25-45.

[9]Harrington, W., A.J. Krupnick, and W.O. Spofford, Jr., "The Economic Losses of a Waterborne Disease Outbreak," *Journal of Urban Economics*, Vol. 25, No. 1, 1989, pp. 116-137. (More detailed information on this study is available in: Harrington, W., A.J. Krupnick, and W.O. Spofford, Jr., *Economics and Episodic Disease: The Benefits of Preventing a Giardiasis Outbreak*, Washington, DC: Resources for the Future, 1991.)

Kocagil et al. (1998): The Kocagil study is similar to the Harrington study in that it considers the value of averting actions, medical costs, and time losses associated with a contamination event.[10] However, this team of researchers uses a slightly different approach for valuing time losses. Kocagil et al. assess the impacts of cryptosporidiosis, using a 1996 outbreak in Lancaster County, Pennsylvania as a case study. The medical cost component comprises over-the-counter medications, physician or emergency room visits, and hospitalization (in severe cases). Time losses for ill individuals include both work and leisure time. (Leisure is defined as including both nonmarket work and other nonwork activities.) The researchers also include time losses in their analysis of averting behavior, including boiling water (electricity and time), hauling water from outside the contaminated region (travel time), and purchasing bottled water.

For ill individuals, Kocagil et al. present two estimates that vary in the approach used to estimate the value of time losses (medical costs are the same under both approaches). First, they value all time losses at the after-tax wage rate to reflect the cost of these losses from the individual perspective. Second, to reflect the societal perspective, they value lost work time at the average before-tax wage rate, and lost leisure time at the after-tax wage rate. They assume that individuals sleep for eight hours per day, and that 2/7 of the remaining 16 hours are spent in leisure and 5/7 in work. Alternative assumptions are explored through uncertainty analysis. The researchers also estimate the value of cryptosporidiosis-related mortality based on different estimates of the value of statistical life. The researchers describe their results as providing a lower bound estimate of the value of preventing these contamination events, since they do not include the potential costs associated with pain and suffering.

Exhibit A-2 below provides the estimates of the value of *morbidity* time losses from each study, both in dollars and as a percentage of medical costs.[11] Many of the studies in the exhibit address time losses associated with mortality as well as morbidity, however the table excludes post-mortality losses unless otherwise indicated. For all illnesses, the estimates of morbidity losses include both fatal and nonfatal cases. In other words, the exhibit includes the costs associated with morbidity prior to death for those who die of the disease, as well as morbidity costs for those who die of other causes. In cases where the study reports total (e.g., national) estimates, the estimates are converted to per case values based on information reported on the number of cases. Note that data from Hartunian et al. (1981) are not provided in this exhibit because the researchers do not report time losses for morbidity separate from time losses from mortality.

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[10]Kocagil, Patricia, Nadia Demarteau, Ann Fisher, and James S. Shortle, "The Value of Preventing Cryptosporidium Contamination," *Risk: Health, Safety and Environment*, Vol. 9, 1998, pp. 175-196.

[11]The studies do not provide adequate information to convert the cost estimates to a comparable metric (e.g., average value of time losses per day of illness in year 2001 dollars).

Exhibit A-2

MORBIDITY-RELATED COST ESTIMATES

Authors and Date of Study	Value of Time Losses	Time Losses as a Percent of Medical Costs (medical costs in parentheses)
Ray et al., 1998 (1997 dollars, annual costs per case)	Diabetes: $4,947	Diabetes: 67% ($7,402)
Cropper and Krupnick, 1999 (1977 dollars, annual losses per case)	Allergies: $742 - $1,300 Chronic bronchitis: $1,770 - $3,083 Emphysema: $4,212 - $5,336 Other lung disease: $961 - $1,647 Arteriosclerosis: $2,921 - $7,226 Heart attack: $607 - $5,744 Hypertension: $556 - $983 Stroke: $5,369 - $6,635 Other heart disease: $1,149 - $2,358	Chronic bronchitis: 1,830% -3,187% ($97) Emphysema: 666% -843% ($633) Hypertension: 258%-455% ($215) Other health effects: comparable medical costs not reported
Buzby et al., 1996 (1993 dollars, total costs per case, 3 % discount rate)	Acute E. coli: $175 - $2,815 Acute listeriosis: $1,166 - $1,469	Acute E. coli: 8%-219% ($160-$36,185) Acute listeriosis: 10%-12% ($12,117)
Waitzman et al., 1996 (1988 dollars, total costs per case, 5 percent discount rate)	Spina bifida: $53,000 Truncus arteriosus: $16,000 Transposition/DORV: $26,000 Tetralogy of fallot: $32,000 Single ventricle: $20,000 Cleft lip or palate: $30,000 Upper limb reduction: $24,000 Lower limb reduction: $88,000 Down syndrome: $171,000 Cerebral palsy: $92,000	Spina bifida: 53% ($99,000) Truncus arteriosus: 8% ($210,000) Transposition/DORV: 37% ($69,000) Tetralogy of fallot: 30% ($108,000) Single ventricle: 20 % ($99,000) Cleft lip or palate: 265% ($11,000) Upper limb reduction: 456% ($5,000) Lower limb reduction: 551% ($16,000) Down syndrome: 313% ($55,000) Cerebral palsy: 125% ($74,000)
Harrington et al., 1989 (1984 dollars, total costs per case)	giardiasis: $604 - $1,001	giardiasis: 238 - 394% ($254)
Kocagil et al., 1998 (1998 dollars, total costs per case)	cryptosporidiosis: $460 - $547	cryptosporidiosis: 78% - 81 % ($129)

Notes:
See Exhibit A-1 and preceding text for information on methods used and types of costs assessed.
Kocagil et al. estimates exclude time losses related to averting actions.
Excludes Hartunian (1981) due to lack of per case data.
Sources:
See footnotes and reference list for full citations.

As can be seen from the exhibit, the estimates of the value of time losses vary greatly due to the types of time losses considered (e.g., work vs. nonwork time), the approach used to value these losses, and the differences in the effects of each illness on time use. While the studies exhibit some agreement in how they account for direct medical costs, they diverge in their analyses of indirect costs. All incorporate estimates of lost work time for ill individuals, and several include valuation of losses in nonmarket work time. Two of the seven studies include the valuation of lost leisure time, and two include caregiver losses. Some of the studies account for productivity losses for ill individuals who continue to engage in normal activities in addition to accounting for more complete losses of normal time use. In general, the researchers note that their approaches are likely to understate the full value of related social welfare losses, due to the exclusion of some types of time losses as well as the incomplete consideration of the value of avoiding pain and suffering.

The precise estimates derived in these studies are not entirely comparable because of the differences in approaches as well as in the overall goals of each study. Exhibit A-2 suggests, however, that the value of time related-losses can be substantial. Hence ignoring these effects could lead an analyst to significantly understate the value of risk reductions.

Analysts interested in valuing time losses for the health effects listed in the table should consult the original studies rather than relying solely on the materials in this appendix. The brief summaries provided do not include the sort of detailed information needed to determine the suitability of individual studies for use in a particular regulatory context. In addition, as noted earlier, these studies were selected to represent different methodological approaches and hence do not represent a complete review of the approaches applied in the literature. More recent and/or more complete estimates of time losses may be available for many of these illnesses.

APPENDIX B: DATA SOURCES

This appendix provides additional information on some of the data sources that can be used when valuing time losses. It first discusses data sources that provide information on daily time usage both with and without illness. It then presents U.S. data on: (1) the probability of employment and labor force participation; (2) earnings and benefits, including tax impacts; and (3) growth in productivity over time. It concludes by describing an approach for assessing survival probabilities for illnesses that last for more than one year. Most of the data sources reported in this appendix are frequently updated, and analysts may wish to consult the sources cited for more recent information.

As discussed in the main text of the report, regulatory analysts may transfer data from an existing study of time losses rather than construct estimates from the types of national data sources referenced in this appendix. In this case, the national data sources may provide a means of verifying the values in particular research studies, or may allow the analyst to adjust the values in the studies to reflect estimates for the population of concern. For example, for a rulemaking with national impacts, the analyst may wish to use the national earnings data from the sources cited in this appendix rather than the local values applied in a research study of a particular population.

The national databases referenced in this appendix are typically administered by government agencies and involve large sample surveys. Data from such sources usually can be disaggregated in a number of different ways (e.g., by age, race, sex, or region). The agencies that maintain these databases are staffed by individuals with detailed knowledge of the data sets, who are available to answer questions or provide more detailed data than are reported publicly. This appendix includes website addresses for most of the data sources; information on people to contact for further information is generally posted on these sites.

B.1 TIME LOSS DATA

The Center for Disease Control's National Center for Health Statistics (NCHS) publishes several national databases containing information on work loss days, doctors visits, and hospital stays for a variety of illnesses (for a list of all NCHS surveys, see: http://www.cdc.gov/nchs /nhcs.htm). Published reports may provide summary statistics that are useful for the analysis of time losses; however, in many cases analysts will need to acquire and analyze the raw data (often for a fee) to derive the information needed. Key databases include the following.

- The **National Health Interview Survey (NHIS)** is a national cross-sectional household interview survey of illnesses, injuries, impairments, and chronic conditions (see http://www.cdc.gov/nchs/nhis.htm). It contains information on a variety of medical costs, as well as data on activity limitations caused by chronic conditions, utilization of health services, and other health topics. It is designed to collect data that can be used to understand disability, to develop public health policy, to produce simple prevalence estimates of selected health conditions, and to provide descriptive baseline statistics on the effects of disabilities. The NHIS is conducted on an annual basis and covers hundreds of diseases.

- The **National Hospital Discharge Survey (NHDS)** provides information annually on the inpatient use of hospitals in the United States (see: http://www.cdc.gov/nchs/about/major/hdasd/listpubs.htm). Data are collected on diagnoses, surgical and nonsurgical procedures, and patient characteristics from a national sample of approximately 500 non-Federal, short-stay hospitals. The information is abstracted from a sample of medical records from each sample hospital for a total of about 270,000 records each year.

- The **National Nursing Home Survey (NNHS)** is a continuing series of national sample surveys of nursing homes, their residents, and their staff which provides information on nursing homes from two perspectives -- that of the provider of services and that of the recipient (see: http://www.cdc.gov/nchs/about/major/nnhsd/nnhsd.htm). Data about the facilities include characteristics such as size, ownership, Medicare/Medicaid certification, occupancy rate, number of days of care provided, and expenses. For recipients, data are obtained on demographic characteristics, health status, and services received. Data for the survey have been obtained through personal interviews with administrators and staff and occasionally through self-administered questionnaires in a sample of about 1,500 facilities.

- The **National Hospital Ambulatory Medical Care Survey (NHAMCS)** is designed to collect data on the utilization and provision of ambulatory care services in hospital emergency and outpatient departments (see: http://www.cdc.gov/nchs/about/major/ahcd/ahcd1.htm). Findings are based on a national sample of visits to the emergency departments and outpatient departments of noninstitutional general and short-stay hospitals, exclusive of Federal, military, and Veterans Administration hospitals.

- **National Survey of Ambulatory Surgery (NSAS)** is designed to meet the need for information about the use of ambulatory surgery services in the United States (see: http://www.cdc.gov/nchs/about/major/hdasd/nhds.htm). Data are available on patient characteristics including age and sex; administrative information including patient disposition, expected sources of payment, and region of the country where procedure was performed; and medical information including diagnoses and procedures performed coded using the *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM).

- **National Home and Hospice Care Survey (NHHCS)** is a continuing series of surveys of home and hospice care agencies in the United States (http://www.cdc.gov/nchs/about/major/nhhcsd/nhhcsd.htm). Information is collected on agencies that provide home and hospice care and about their current patients and discharges. Data are collected on referral and length of service, diagnoses, number of visits, patient charges, health status, reason for discharge, and types of services provided.

The health economics literature includes a number of examples of how these data can be used to estimate time losses, including the examples cited in Appendix A of this report. For example, analysts can use the NHIS data to compare time losses for individuals with the illness of concern to other individuals, to determine the time losses attributable to the particular illness. Alternatively, data from these sources can be used to compile information on the number of doctor visits and hospital stays associated with the illness to be used in estimating time losses attributable to these activities.

In some cases, analysts may have data on the quantity of time lost (e.g., on the total duration of the illness, or on the days of associated bed-rest), but not on the types of activities affected (e.g., work vs. nonwork time). In these cases, data on normal time use allocation can be used to infer the allocation of losses across each usage category. For instance, if data are available on the number of days lost to illness, analysts can use normal time use allocation data to estimate the allocation of these losses across market work, nonmarket work, leisure, and sleep activities.

The allocation of normal time across different types of activities is an active area of research and a number of time use studies have been completed internationally. Time use researchers have developed detailed schemes for categorizing different uses of time. For example, the categorization scheme for created by the National Research Council for a proposed U.S. survey includes nine major groupings (personal care, employment activities, education activities, domestic activities, care for dependent household members, purchasing activities, voluntary work and care, social and community interaction, and recreation and leisure) which are further subdivided into 99 subgroups, each of which is then subdivided into a number of discrete categories.[1]

The National Research Council study lists over 50 major time-use surveys that have been completed internationally.[2] However, the majority of the studies completed in recent years address countries other than the U.S., including Australia, the European Community, Japan, New Zealand, and Canada. The most recent U.S. studies were completed by the University of Michigan in 1981-1982 and by the University of Maryland in 1985; the U.S. Bureau of Labor Statistics (BLS) is in the process of developing a new time use study and expects the results to be available late in 2004.[3]

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[1]For an overview of available time use research as well as information on the proposed U.S. survey, see: National Research Council, *Time Use Measurement and Research: Report of a Workshop*, Committee on National Statistics, M. Ver Ploeg, J. Altonji, N. Bradburn, J. DaVanzo, W. Nordhaus, and F. Samaniego, (eds.), Commission on Behavioral and Social Sciences and Education, Washington, DC: National Academy Press, 2000.

[2]National Research Council (2000).

[3]See www.bls.gov/tus/ for more information.

Ideally, time allocation would be determined based on a recent U.S. study because the allocation of time can vary significantly across cultures and over time. However, the most recent comprehensive U.S. study was conducted over 15 years ago and is not likely to reflect recent trends.[4] In contrast, Statistics Canada has completed a recent study that addresses a population which may have time use patterns that are similar to the U.S.[5] It seems reasonable to expect that Canadian time use patterns will be similar to U.S. patterns due to the proximity of the two countries and the extent of interaction between their populations. Thus analysts may wish to use the Canadian results until more recent U.S. data are available.

Exhibit B.1 summarizes the results of the Canadian study, which provides national estimates for all individuals ages 15 and older (regardless of employment status) in 1998. The hours per day estimates are based on a seven day week for all time categories. The study allocates time usage across numerous categories, which are aggregated in the exhibit into the three major categories (market work, nonmarket work and leisure, and sleep) used for the calculations in this report.

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[4] EPA's National Human Activity Pattern Survey, conducted in 1992-1993, also provides data on time use (see http://www.epa.gov/heasd/herb/hap.htm for more information). However, the easily accessible data from this survey focus on time spent in selected activities and micro-environments for the purpose of exposure assessment, and do not provide the comprehensive summary data necessary for the analysis of time losses. For more information on this and related exposure studies, see: U.S. Environmental Protection Agency, *Exposure Factors Handbook (Final Report),* Washington, D.C.: Office of Research and Development, August 1997, Chapter 15 - Activity Factors.

[5] Statistics Canada, "Statistics Canada, "Canadian Time Allocation: Average time spent on activities, total population and participants, by sex," *General Social Survey, 1989,* 1999.

Exhibit B-1 AVERAGE DAILY TIME ALLOCATION IN CANADA (1998)			
Time Category	**Women**	**Men**	**Total Population**
Market Work	2.8 hours (11.67 percent)	4.1 hours (17.08 percent)	3.3 hours (13.75 percent)
Nonwork (nonmarket work and leisure)	13.0 hours (54.17 percent)	11.9 hours (49.58 percent)	12.6 hours (52.50 percent)
Sleep	8.2 hours (34.17 percent)	8.0 hours (33.33 percent)	8.1 hours (33.75 percent)
Total (all activities)	24.0 hours (100.00 percent)	24.0 hours (100.00 percent)	24.0 hours (100.00 percent)

Notes:
Detail may not add to totals due to rounding.
Market work includes paid work time only. Nonmarket work and leisure includes all other activities except sleep, including unpaid work-related activities such as commuting time. Sleep includes night sleep only.
Includes all individuals aged 15 and older (regardless of employment status).
Source:
Statistics Canada, "Canadian Time Allocation: Average time spent on activities, total population and participants, by sex," *General Social Survey, 1989*, 1999.

B.2 EMPLOYMENT AND WAGE DATA

The U.S. Bureau of Labor Statistics (BLS) provides well-established, detailed, and widely used data on national employment and compensation. Because BLS collects data throughout the year, these data can be used to calculate long-term averages or describe seasonal employment patterns. BLS collects data on a number of different characteristics of the labor market, including wage rates, employment rates, and employee benefits, by age, sex, race, and occupation (see: http://www.bls.gov).

The Current Population Survey (CPS), a joint project of BLS and the Census Bureau, is a monthly survey of approximately 50,000 households that provides data characterizing the labor force (see: http://www.bls.census.gov/cps/cpsmain.htm). CPS includes information on the number of employed and unemployed individuals in the civilian labor force, the number of individuals not in the labor force, and average earnings.

The level of demographic detail available in on-line data sources and in print publications tends to vary over time. CPS data are typically provided by age, sex, race, marital status, and level of educational attainment. However, data broken out by age and sex are generally published online only for the current year. Similar tables are available in written form in *Employment and Earnings*, a periodical published by BLS. Additional data are collected and compiled internally by BLS and can be obtained by calling the Division of Labor Force Statistics.

In interpreting these data, it is important to consider the definitions of the following terms used in the CPS, which is the source of most of the data presented in this section.[6] The CPS is conducted monthly, and addresses the status of respondents in the week prior to the week during which the survey interviews were conducted.

- **Employed**: all persons who, during the reference week...(a) did any work at all (at least 1 hour) as paid employees, worked in their own business, profession, or on their farm, or who worked 15 hours or more as unpaid workers in an enterprise operated by a member of the family, and (b) all those who were not working but...were temporarily absent, whether or not they had paid time off.

- **Unemployed**: all persons who had no employment during the reference week, were available for work, except for temporary illness, and had made specific efforts to find employment in the 4-week-period ending with the reference week.

- **Labor force**: all persons classified as employed or unemployed in accordance with the criteria described above in the definitions of "employed" and "unemployed."

- **Not in the labor force**: all persons...who are neither employed nor unemployed; includes the retired, students, discouraged workers, people keeping house, the ill, and the disabled.

Exhibit B-2 presents BLS data on employment rates and rates for nonparticipation in the labor force. These rates do not include the unemployed; however, the rate of unemployment can be estimated by subtracting the sum of the rates in the table from 100 percent [i.e., for males ages 16 to 19, 42.6 percent (employed) + 49.3 percent (not in labor force) = 91.9 percent; 100 percent - 91.9 percent = 8.1 percent (unemployed) for males in this age group].

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[6] Detailed information on these and other definitions used by BLS is provided at http://www.bls.gov/bls/glossary.htm.

Exhibit B-2

U.S. EMPLOYMENT AND LABOR FORCE PARTICIPATION RATES, 2001
(as a proportion of the civilian noninstitutional population ≥ 16 years of age)

Age Interval	Proportion Employed			Proportion Not in the Labor Force		
	Male	Female	Combined	Male	Female	Combined
All ages (16 +)	0.708	0.573	0.638	0.256	0.399	0.331
16 to 19	0.426	0.427	0.427	0.493	0.506	0.500
20 to 24	0.742	0.674	0.708	0.185	0.271	0.229
25 to 29	0.871	0.722	0.795	0.084	0.239	0.163
30 to 34	0.900	0.718	0.807	0.064	0.245	0.156
35 to 39	0.895	0.731	0.811	0.071	0.239	0.157
40 to 44	0.889	0.753	0.820	0.079	0.220	0.150
45 to 49	0.874	0.759	0.816	0.097	0.215	0.157
50 to 54	0.837	0.721	0.778	0.135	0.260	0.199
55 to 59	0.748	0.599	0.670	0.227	0.384	0.309
60 to 64	0.545	0.413	0.475	0.435	0.576	0.509
65 to 69	0.293	0.194	0.240	0.697	0.800	0.753
70 to 74	0.176	0.105	0.137	0.819	0.892	0.859
75+	0.082	0.033	0.052	0.916	0.966	0.946

Notes:
Annual averages for the year 2001.
Source:
Derived from data from the Current Population Survey, conducted by the Bureau of Census for the Bureau of Labor Statistics, http://www.bls.gov/cps/cpsaat3.pdf as viewed September 2002.

Exhibit B-3 provides data on compensation rates. The starting point is BLS data on median pre-tax weekly earnings in 2001 for full time employees from the Current Population Survey. These data are adjusted to reflect employee benefits (the second set of columns) using the average ratio of total compensation to wages and salaries in 2001 from the BLS. These data are reported by BLS for private industry workers based on a sample of establishments. In the third set of columns, pre-tax weekly earnings are adjusted downwards to net out taxes, using an estimate of the year 2000 average tax rate based on data on household income before and after taxes from the Current Population Survey (at the time this exhibit was prepared, year 2001 data were not yet available for this variable).

Exhibit B-3 MEDIAN WEEKLY EARNINGS BY AGE AND SEX, 2001 (Full-Time Wage and Salary Workers)									
Age Interval	**Median Pre-Tax Weekly Earnings**			**Median Pre-TaxWeekly Earnings Plus Benefits**			**Median After-Tax Weekly Earnings**		
	Male	**Female**	**All**	**Male**	**Female**	**All**	**Male**	**Female**	**All**
All ages (16 +)	$672	$511	$597	$936	$712	$832	$553	$420	$491
16 to 19	319	287	304	444	400	423	262	236	250
20 to 24	410	375	395	571	522	550	337	308	325
25 to 29	589	505	546	820	703	761	484	415	449
30 to 34	657	523	601	915	728	837	540	430	494
35 to 39	735	539	647	1,024	751	901	604	443	532
40 to 44	773	551	669	1,077	768	932	636	453	550
45 to 49	788	585	683	1,098	815	951	648	481	562
50 to 54	811	592	705	1,130	825	982	667	487	580
55 to 59	793	551	659	1,105	768	918	652	453	542
60 to 64	714	518	610	995	722	850	587	426	502
65 to 69	575	372	478	801	518	666	473	306	393
70+	512	372	459	713	518	639	421	306	378

Notes:
Pre-tax wages plus benefits are derived using an average ratio of wages to wages plus benefits of 1.393.
After-tax wages are derived using an average tax rate of approximately 17.8 percent.
Source:
Pre-tax weekly wages: Personal communication between Michel Woodard Ohly, Industrial Economics, Incorporated and Mary Bowler, Bureau of Labor Statistics, unpublished tabulation from the Current Population Survey, September 2002.
Benefits adjustment: U.S. Census Bureau, "Table 626. Employer Costs for Employee Compensation Per Hour Worked: 2001," *Statistical Abstract of the United States: 2001*, November 2001.
Average tax rate: U.S. Census Bureau, "Table RDI-1. Household Income Before and After Taxes: 1979 to 2000," March 2002 (http://www.census.gov/hhes/income/histinc/rdi01.html as viewed September 2002).

The exhibit reports median rather than average earnings (although both are available from BLS) because in most cases analysts may wish to use the median values in regulatory analysis. The distribution of income in the U.S. is highly skewed, due to the small number of people who are extremely highly compensated, hence the average is significantly above the median. Using the median is consistent with the notion that the small fraction of the U.S. population affected by most rulemakings are likely to be better reflected by the median (which is in the center of the distribution) than by the mean value (which is closer to the upper tail of the distribution).

Because of differences in the level of aggregation in the reported data, the employment rates in Exhibit B-2 include part time workers whereas the compensation data in Exhibit B-3 are for full time workers only.[7] Combining these data in the calculations will overstate earnings as a result. In contrast, the data on hours worked in Exhibit B-1 include all individuals regardless of whether they are employed, unemployed, or out of the labor force.[8] Analysts should take care to consider these differences when combining data from different sources and determine the appropriate level of aggregation on a case-by-case basis, depending on the level of detail desired and the time and resources available for the particular analysis. Any potential bias introduced by the data limitations would be discussed in presenting the results of the analysis.

Analysts should also note that the result will be median value per hour across all hours worked during the reporting period (e.g., a week or a year). The theory of decreasing marginal utility (discussed in the main text) suggests that, in a perfectly functioning competitive labor market, marginal values will be less than median or average values. However, illness often leads to greater than marginal changes in activities. Hence the impact of using the median to value time losses is unclear and may vary depending on the magnitude of the losses.

BLS also collects information that characterizes national trends in the prices of various goods and services and in the productivity of labor. Data on the annual change in labor productivity is available on the BLS website. Exhibit B-4 contains the BLS data on the historical rate of growth in output per hour, which can be used to predict the increase in real wages over time if needed for long term illness or for regulatory analyses that predict impacts far into the future.

Exhibit B-4

ANNUAL PERCENT CHANGE IN OUTPUT PER HOUR

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Ten-Year Average
3.7	0.5	1.3	0.9	2.5	2.0	2.6	2.4	2.9	1.1	2.0

Notes:
10 year average is for 1992-2001; the 40 year average (1962 - 2001) is also 2.0 percent.
Data reflect annualized rates for output per hour for nonfarm business.
Source:
Derived from data from the Major Sector Productivity and Costs Index, maintained by the U.S. Bureau of Labor Statistics, http://www.bls.gov/lpc/ as viewed September 2002.

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[7] For Exhibit B-3, the ratio of total compensation to wages is for full-time workers, consistent with the data on median earnings. However, the same data source also includes information on part-time workers and for all workers.

[8] Data on hours worked for employed individuals only are available in: U.S. Census Bureau, "Table 582. Persons At Work by Hours Worked: 2000," *Statistical Abstract of the United States: 2001,* November 2001.

B.3 SURVIVAL STATISTICS

The period over which time losses accrue will depend on the life span of affected individuals as well as the duration of the illness, particularly in cases where the health effects are experienced over a multi-year period. A simple approach to determining this time span could involve estimating the time that elapses between incidence and death on average for members of the affected population (e.g., based on national U.S. data).

A more complex approach involves considering the probability that affected individuals are likely to survive for different time periods after the onset of illness. This approach requires considering both the likelihood of death at a particular age and the likelihood of surviving to that age. For example, assume an illness starts at age 30 and continues for the remainder of an individual's life. Whether the individual accrues related time losses at age 70 depends on (a) the likelihood that he or she survives *to* age 70; and (b) the likelihood that he or she dies *at* age 70.

Regardless of whether a simple or complex approach is used, the analysis should compare the life expectancy of a healthy individual to the life expectancy of an ill individual to estimate the net time loss. If losses were to be assessed for a fatal case of illness, the life expectancy for the ill individual should be that for individuals who die of the disease. For nonfatal cases, this life expectancy should be based on individuals with the disease who die of other causes. Even for these nonfatal cases, life expectancy differ from that of an individual without the illness, if the illness is associated with other conditions that can result in premature mortality.[9]

EPA has developed an approach for calculating these survival probabilities which is described in detail in its *Cost of Illness Handbook*. These calculations are quite complex, and analysts interested in using them should consult the *Cost of Illness Handbook* for detailed information. An example of these calculations for stomach cancer is provided below.[10]

For cancers, the survival rate calculations rely largely on data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program.[11] Data on other

[9]Care must be taken to ensure that the definition of a fatal case used in the analysis of lost time is the same as that used in the risk assessment. In some cases, fatal cases may be estimated based only on the disease of concern; in other cases, fatalities from associated diseases may also be considered.

[10]U.S. Environmental Protection Agency, *Cost of Illness Handbook*, February 2001, pp. II.2-7 to II.2-16.

[11]See, for example, Ries, L.A.G., et al. (eds.), SEER Cancer Statistics Review, National Cancer Institute, 1973-1998, Bethesda, MD, 2001. More information on this data source is available at http://seer.cancer.gov/.

illnesses are available in the *Cost of Illness Handbook*, the general health science literature, and data sources maintained by non-profit health research institutions (such as the American Diabetes Association).

The starting point for these calculations is the relative survival rate for the illness of concern. This rate is the number of observed survivors among patients, divided by the number of "expected" survivors among persons with the same age and gender in the general population (observed divided by expected). The relative survival rate takes into account competing causes of death, which increase with age. For example, the relative survival rate for stomach cancer patients during the first year post-diagnosis is 46 percent. This value indicates that a person with stomach cancer would have, on average, a one-year survival probability that is 46 percent of someone of the same age and gender in the general population. Because these survival rates are comparative (i.e., the analyst needs to know the survival rate for the general population to estimate the likelihood that a stomach cancer patient will die in a particular year), a number of calculations are needed to translate these rates into estimates that can be used in a particular analysis of the costs of illness or time losses.

The results of such calculations are presented below for stomach cancer. For this illness, the average age at diagnosis is approximately 70 years, and survival rates are estimated for the first 10 years post diagnosis; i.e., for affected individuals aged 71 to 80. The data indicate that most stomach cancer patients who die of the disease will do so by the tenth year, whereas stomach cancer patients who die of other causes have slightly lower survival rates than the U.S. population. Stomach cancer is fatal in over 80 percent of all cases.

These survival rates are provided in Exhibit B-5. Column (1) provides the survival rates for members of the general population. Columns (2) and (3) provide the probabilities that should be used for ill individuals; the rates in Column (2) apply to fatal cases (persons with the disease who die of the disease) and the rates in Column (3) apply to nonfatal cases (persons with the disease who die of other causes). Each column provides two estimates, one for the likelihood of surviving that year and one for the likelihood of dying in that year.

Exhibit B-5

CONDITIONAL SURVIVAL AND MORTALITY PROBABILITIES

Years Post-Diagnosis	(1) General Population Conditional probability of:		(2) Stomach Cancer Non-Survivors (fatal cases) Conditional probability of:		(3) Stomach Cancer Survivors (nonfatal cases) Conditional probability of:	
	Surviving through the *n*th year	Dying during the *n*th year	Surviving through the *n*th year	Dying of stomach cancer during the *n*th year	Surviving through the *n*th year	Dying of some other cause during the *n*th year
1	0.973	0.027	0.343	0.657	0.894	0.106
2	0.945	0.028	0.188	0.155	0.834	0.060
3	0.915	0.030	0.121	0.067	0.787	0.048
4	0.884	0.031	0.082	0.039	0.745	0.042
5	0.852	0.032	0.057	0.026	0.706	0.039
6	0.817	0.035	0.039	0.018	0.669	0.037
7	0.782	0.035	0.025	0.014	0.634	0.035
8	0.745	0.037	0.015	0.010	0.600	0.034
9	0.707	0.038	0.007	0.008	0.567	0.033
10	0.667	0.040	0.000	0.007	0.535	0.032

Source:
U.S. Environmental Protection Agency, *Cost of Illness Handbook*, February 2001. General population probabilities are derived from data presented in Table II.2-3. Probabilities for stomach cancer patients are taken directly from Table II.2-7.