Valuing the Economic Consequences of Work Injury and Illness: A Comparison of Methods and Findings

David Weil, PhD*

Background *Workplace injuries and fatalities in the US create significant economic costs to society. Although economic costs should measure the opportunity cost to society arising from injuries and fatalities, estimating them often proves difficult as a practical matter. This leads to a range of estimates for valuing these costs.*
Methods *This paper compares methods of economic valuation, focusing in particular on how different methods diverge to varying degrees from measuring the "true" economic costs of injuries and illnesses. In so doing, it surveys the literature that has arisen in the past 25 years to measure different aspects of economic consequences.*
Results *Estimates of the costs of injuries and fatalities tend to understate the true economic costs from a social welfare perspective, particularly in how they account for occupational fatalities and losses arising from work disabilities.*
Conclusions *Although data availability often makes estimation of social welfare costs difficult, researchers should attempt to more fully integrate such approaches into estimation procedures and interpretation of their results.* Am. J. Ind. Med. 40:418–437, 2001. *© 2001 Wiley-Liss, Inc.*

KEY WORDS: occupational injury and illness; economic valuation; benefit/cost analysis; value of human life; social welfare costs

INTRODUCTION

The economic costs arising from the more than six million workplace injuries and 6000 occupational fatalities in the US are significant and have given rise to a large number of studies. Each year, for example, the National Safety Council (NSC) releases an estimate of these costs, which they placed at about $128 billion in 1997 [NSC, 1998, p 51]. An important and widely cited study by Leigh et al. [1997] estimates costs of $171 billion for 1992, suggesting significantly higher economic costs than found by the NSC. These estimates and others found in public health, occupational medicine, and economic literatures—as well as in private and public policy discussions—rest on a combination of methodological assumptions, extrapolation methods, and known and unknown biases.

Some economic costs of workplace injury and illness are readily apparent. These include medical costs, lost time at work, and the administration of programs for those injured. Others, however, are more difficult to quantify: the loss of life, changes in the future work activity and earnings of the injured, impacts on households of injured or ill workers, diminishing quality of life. Actual expenditures on medical costs provide a reasonable measure of social costs related to injuries. Costs arising from diminished labor force

An earlier version of this paper was first presented at the NIOSH conference, "Integrating Social, Economic, and Health Services Research," Denver, CO, June 13–15, 1999.
Department of Finance/Economics, Boston University School of Management and Visiting Fellow, Taubman Center for State and Local Government, John F. Kennedy School of Government, Harvard University, Cambridge, MA.
Contract grant sponsor: NIOSH
*Correspondence to: David Weil, Visiting Fellow, Taubman Center, T-310, John F. Kennedy School of Government, Harvard University, Cambridge, MA 02138.
E-mail: David_Weil@ksg.harvard.edu

Accepted 1 April 2001

participation, earnings, or changes in household activity, in contrast, are more difficult to deal with in part because they are affected by the present and future behavior of employers, households, and—most importantly—the decisions of the injured parties themselves. As a result, any attempt to measure the economic consequences of workplace injuries and illnesses must address the complex question of how injury events affect behavior and how resulting changes in behavior affect social welfare [Chelius, 1974, 1982; Burton and Chelius, 1997].[1]

Economic costs in a so-called ''social welfare'' framework measure the opportunity cost to society for use of a resource, that is, the amount that individuals in their consumption decisions, and firms in their market activities indicate they value the goods relative to its next best alternative use. In some cases, market prices are reasonable estimates of social costs, particularly where consumers are well informed and markets competitive [Mishan, 1983]. In other cases, however, direct expenditure measures provide incomplete measures of social cost because of the absence of a direct market for the goods, the presence of market distortions, information problems, or because the true opportunity cost cannot be directly observed without holding constant the effects of other factors that are also reflected in prices. Thus, sometimes the cost directly observed and true social costs are similar (for example, in the case of administrative or medical costs).[2] However, the approaches diverge markedly as in the valuation of fatalities and in the long-term costs of work disabilities.

This paper describes the ''true'' social welfare costs arising from occupational injuries and compares them with the approaches to valuation that have been employed in practice, paying particular attention to the extensive literature that has arisen over the past 25 years. While acknowledging the practical problems entailed in making estimates, the article focuses on the significant divergences between theoretical and actual valuations in the areas of occupational fatalities, workplace disabilities, and nonworkplace disabilities.

We begin in the following section by examining the pathways that lead from workplace injury events to economic consequences. This provides a framework in which to examine the different methods used for valuation of each pathway. The next three sections look in detail at the methodological issues surrounding economic valuation of fatalities, workplace disabilities, and nonworkplace disabilities (including household activities, social participation, and quality of life). The final section discusses how research might move forward in expanding our understanding of the economic consequences of occupational illness and injury across all pathways.

INCIDENCE OF INJURED WORKERS ACROSS PATHWAYS

One of the first problems encountered in assessing the economic consequences of occupational injury and illnesses is defining the appropriate time dimension for analysis. Some economic consequences are immediate: traumatic fatalities occur at a point in time and the consequences of the fatality can be evaluated at that time. On the other hand, exposures to workplace toxins may not give rise to physical problems until a much later time. The diagnosis of an illness may not signal the beginning of the economic consequences associated with that illness. The same is true for injuries where first return to work may not signal a long-term reattachment to the labor market.[3]

In order to capture these complexities, the economic consequences of occupational illness and injury can be usefully depicted as a flow or set of pathways. The overall ''disability pathway'' is portrayed in Figure 1. The ''inputs'' into the pathway are injuries or illness diagnoses. Workers leave the stream in Figure 1 either by fatality, or by returning to work (RTW) on a permanent basis. In between these entrances into and exits out of the pathway, workers will be distributed across a variety of states, each with associated economic consequences. Valuing the economic consequences of injury and illness can be thought of as summing the costs associated with the stream given the cross section of workers in the stream at that point in time.[4]

Figure 1 incorporates the important distinctions between *impairments*, *functional limitations*, and *disabilities* in defining the state of injured workers. An impairment refers to a physiological or anatomical loss or abnormality. An impairment may in some instances give rise to a functional limitation, defined as a restriction of a person's capacities. Finally, functional limitations may—but again

1 Unless otherwise noted, for simplicity in this paper, I will use the term ''injuries'' to denote workplace injuries and illnesses.

2 Even in the case of medical costs, the approaches diverge in that the market for medical services have areas of considerable market concentration and there are a variety of information problems for consumers and firms. As a result, observed prices of medical services in many cases will not reflect true social opportunity costs. For a discussion of whether direct medical costs are reasonable proxies for underlying social costs, see Baker and Krueger [1995].

3 The fact that many of the social costs occur over time raises the problem of assigning the correct discount rate in calculating the present value of future losses. From a social welfare perspective, one should select a discount rate that reflects the opportunity cost of capital, much as one would do in selecting the appropriate rate for a public investment. For example, Leigh et al., [1997] use a real discount rate of 4% in their calculation of the cost of occupational injuries, which would be regarded by some public finance theorists as below the appropriate opportunity cost of capital for this type of evaluation [Mishan, 1983].

4 There are also economic costs associated with the medical treatment of injuries and illnesses both in terms of hospitalization and ongoing treatment. The NSC estimates these costs at $20.7 billion in1997 (or 16% of their overall injury cost estimate). In addition, there are the administrative expenses, including those associated with private and public insurance, legal costs, and other administrative procedures relating to injuries. These amount to $26.5 billion in 1997, or 21% of total costs of work injuries [NSC, 1998, pp. 50–51; 146–147).

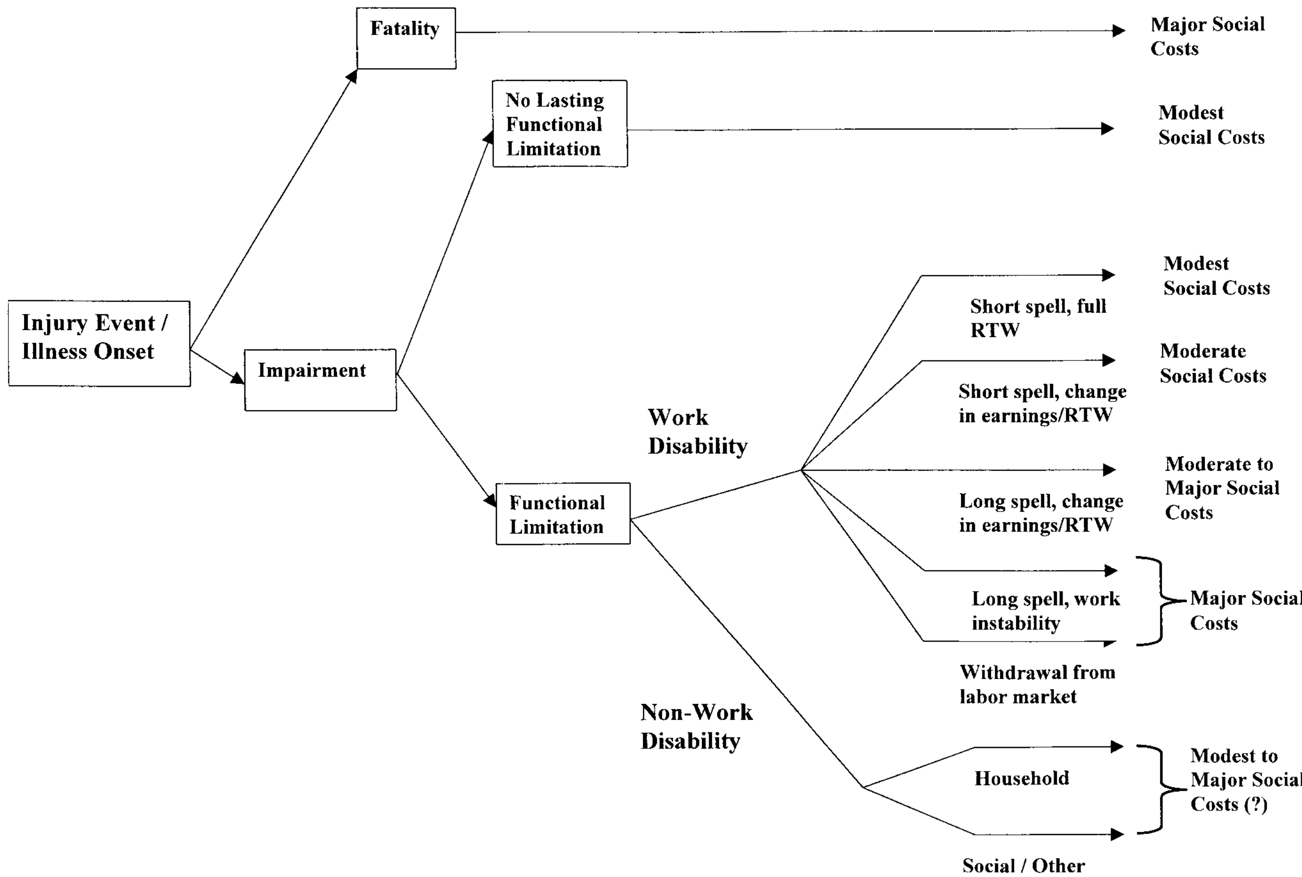

FIGURE 1. Disability Pathways and Economic Outcomes.

do not always—lead to a disability if they limit the individual's ability to engage in activities at home, work, and/or society [see Nagi, 1969; Baldwin and Johnson, 1998].[5] Occupational injuries will result in economic consequences of appreciable magnitude in those cases where the impairments associated with injuries result in a functional limitation that, in turn, have consequences on work and/or nonwork activities. The research on economic consequences can therefore be thought of as methods to value the losses on the different branches depicted in Figure 1.

Figure 1 suggests several different ways of measuring the relevant incidence of occupational injuries and illnesses. In particular, one can measure the number of people entering or exiting the pathway and/or one can measure the number of people "within" the stream at a point of time. The number of workplace injuries and illnesses is a measure of the annual flow into the disability stream. In 1998, a total of 5.9 million injuries and illnesses were reported in private industry. This represented a rate of 6.7 cases per 100 equivalent full-time workers. About 46% of injury cases involved days away from work or days of restricted work activity [BLS/DOL, 2000].[6]

Individuals leave the disability stream either through fatalities or by complete return to work. Measuring return to work is complicated for a variety of reasons that will be discussed in a later section. Work fatality data is more readily available, and the accuracy of national reporting has been appreciably improved both by the National Traumatic Occupational Fatalities Surveillance System (NTOF) maintained by the National Institute for Occupational Safety and Health and more recently by the Census of Fatal Occupational Injuries (CFOI) collected by the Bureau of Labor Statistics. According to the CFOI, there were 6026 fatal

[5] To illustrate these distinctions, imagine a worker at a small machine shop. While using a grinder, the worker is hit in the eye by a small piece of metal, injuring her eye (and therefore causing an impairment). As a result of the impairment, the worker loses part of her peripheral vision (a functional limitation). This functional limitation might cause a nonwork disability in the form of a diminished ability to drive at night, and yet cause no work disability if she could continue to undertake her activities in the machine shop.

[6] These injury-estimates arise from the Survey of Occupational Injuries and Illnesses, a Federal / State program administered by the US Department of Labor, Bureau of Labor Statistics. Estimates are based on employer reports of nonfatal injuries and illnesses only, collected from 169,000 establishments.

occupational injuries in 1998 for the private and public sector. Of these events, 44% resulted from transportation incidents; 16% from assaults and violent acts; 16% from contact with objects; 12% from falls, 9% from exposures to harmful substances; and the remaining fatalities from fires and explosions and other sources [BLS/DOL, 2000, p. 102].[7]

The number of people at various stages within the pathways depicted in Figure 1 is a more difficult number to assess. Researchers use a variety of survey-based measures for these estimates, including the Current Population Survey (CPS); the Panel Study of Income Dynamics (PSID); and the Survey of Income and Program Participation (SIPP).[8] Ideally, one would like to measure those disabilities directly attributable to workplace injuries and illnesses. This is not possible, however, using most survey sources which provide estimates of work disability, whether work-related or not. Survey results from the above sources provide an upper-bound estimate in this respect of the number of people in the pathways depicted in Figure 1.

Because of differences in the way that survey questions measure disability and the different sampling procedures and universes of these series, estimates of the number of disabled workers vary across surveys.[9] Estimates given in the different surveys and methodologies are presented in Table I. Although the studies using PSID, CPS, and SIPP use different survey questions to identify workers with a functional limitation that results in some type of work disability, they result in remarkably consistent estimates ranging from about 9 to 11% of the population aged 25–61 years. As a result, it seems reasonable to estimate that roughly one in 10 people in the US are ‘‘inside’’ the pathways depicted in Figure 1.

ECONOMIC CONSEQUENCES OF FATALITIES

“True” Social Costs of Workplace Fatalities

Traumatic injuries or long-term occupationally-induced illnesses resulting in death represent the worst case outcomes and presumably the outcomes with the highest costs to society associated with them. From a social welfare perspective, the cost of fatalities can best be captured by the amount of resources the public would give up to reduce their risk of death. The willingness to pay for reduction in risk measures the trade-offs people would willingly make in current consumption and welfare to lower the chance of death in some future period.

Cast in this way, the ‘‘value of human life’’ for workplace fatalities reflects the trade-offs between earnings and risk of death and includes losses of earnings and consumption, psychic costs, and the ancillary costs born by family members from loss of life. Casting the question in this way also makes a clear distinction between the value of life to an individual when faced with a certainty of death (which may be infinite) from that of a ‘‘statistical life’’ where the individual trades off consumption for small changes in the risk of death.[10]

Estimating the Economic Costs of Fatalities

Not surprisingly, measuring the economic costs of fatalities has been highly controversial among academics and policy makers primarily because it poses the question of setting a ‘‘price on life.’’ Three basic valuation approaches have arisen to value the cost of fatalities. The first approach, often used in legal proceedings uses the present value of foregone earnings as the principal measure of social cost. In this framework, foregone earnings measure social costs in that they represent lost productivity to society. The magnitude of these social costs is a function of the factors determining productivity of the lost workers, in particular human capital attributes, including education, experience, and ability; their expected longevity; and the selection of an appropriate discount rate to determine the present value of the foregone lifetime earning stream.[11]

The NSC employs this method of valuing fatalities in their annual estimates of consequences of injuries and illnesses [NSC, 1998, Technical Appendix, pp. 146–147]. Using this framework, the NSC set the value of the median life lost to occupational fatalities in 1997 at $890,000. Leigh et al. [1997] also draw on this method to value fatalities in their study (see pp. 1560–1561).

This procedure provides a very poor proxy for the social welfare costs of fatalities as described above. The present value of earnings does not represent a measure of the

7 CFOI estimates are one of the most comprehensive methods for tracking workplace-related fatalities. In most cases, estimates reflect fatalities caused by traumatic events, rather than from the latent effects of occupational exposures where the causality of fatality is complex. There is a large literature regarding estimating the incidence of occupational injuries and fatalities and the problems associated with different data sources and survey methods. Although important to establishing overall estimates of the cost of injuries, it is beyond the scope of this article.

8 Reville et al., [1999] provide a detailed discussion of these data sources.

9 Even within a survey such as the CPS, the use of different subsets of questions to estimate the population with work disabilities leads to a range of estimates. For example, Bennefield and McNeil [1989, Table B] arrive at somewhat different estimates of the number of disabled workers for the same years and same breakdown as those reported by Haveman and Wolfe [1990], even though both studies use the same CPS extracts.

10 This important distinction was first made by Schelling [1968].

11 Usually, assumptions are made about the median worker in the fatality group as the basis for estimates [NSC 1998]. More sophisticated analyses attempt to estimate losses based on the expected work life for workers in different demographic, occupational, and / or industry groupings. Gilbert et al. [1998] develop a more sophisticated methodology for determining years of potential life lost by occupational grouping. Their estimates allow computation of expected work life by gender, race, occupation, and industry.

TABLE I. Estimates of the Population With Work Disabilities

Data source	Year	Survey question/method	Population	Estimated percent of population with disabilities
PSID[a]	1989	Do you have any nervous or physical condition that limits the type or the amount of work you can do? (Must have responded "yes" in both 1988 and 1989).	Aged 25 to 61	
			Men	9.2
			Women	10.6
			Aged 62+	
			Men	23.0
			Women	38.1
CPS[a]	1990	Do you have a health problem or disability which prevents you from working or which limits the kind or amount of work you can do?; or Main reason did not work in 1989 was ill; or Disabled or current activity reason not looking for work ill or disabled.	Aged 25 to 61	
			Men	8.1
			Women	7.8
SIPP[a]	1990	Do you have a physical, mental, or other health condition which limits the kind or amount of work you can do?	Aged 21 to 64	
			Men	11.7
			Women	11.6
CPS[b]	1962 - 1984	Work disabled classified as those who report being unable to work or unable to work full time–full year, because of the presence of limiting health conditions and/or receive benefits from SSDI, Workers' Compensation or other disability program.	Aged 25 to 61	
			Total (1962)	7.0
			Men	9.5
			Women	4.8
			Total (1973)	11.0
			Men	12.8
			Women	9.3
			Total (1980)	10.7
			Men	11.9
			Women	9.6
			Total (1984)	9.5
			Men	10.5
			Women	8.6
RAND[c]	1991	At the time of the interview, and as a result of a recent or prior injury, are you disabled (can not work, keep house, attend school, or perform any other major work); or Are you limited in performance of work, housework, schoolwork, or any other major activity?	Limited	6.8
			Disabled	3.8
			Either	10.6

[a]Burkhauser and Daly [1996], Table 1, p 63.
[b]Haveman and Wolfe [1990].
[c]RAND estimates from Hensler et al. [1991], Table 2.6, p 20–21.

willingness of individuals to trade-off consumption for reduction in fatality risk, but only an *ex post* measure of the amount of direct economic loss at the time of death. What is more, the measure is prone to distortions arising from characteristics of individuals that might or might not be related to their preferences to accept risk. For example, it leads to lower estimates of the value of life for groups who experience labor market discrimination (but who might, in fact, be willing to forgo significant income to lower their risk of death). It also yields uniformly low values for older individuals who may have long life spans but limited time remaining in the workforce.

A second approach attempts to more directly estimate the willingness to pay for reduction in the probability of death by drawing on a methodology called contingent valuation. Contingent valuation employs surveys in which people are asked how much they would hypothetically pay for reducing the probability of fatality. Follow-up questions are used to test for respondent consistency as well as to create a map of risk preferences. On the basis of the results, estimates of the implied value of life can be calculated.

Many different types of survey instruments and procedures have been constructed to elicit these estimates with varying results. For example, an early study by Acton [1973] estimates the value of fatality risk reduction by asking individuals about their willingness to pay for improved ambulance service in order to reduce the fatality risk following a heart attack. A study by Jones-Lee [1989] uses a survey to gauge willingness to pay for reducing the risk of motor vehicle accidents. A number of other investigators use contingent valuation methodologies pioneered in the area of environmental damage estimation to value occupational health risks [Gerking et al., 1988; Viscusi et al., 1991].

As Hammitt [2000, 2001] points out, the use of tailored surveys in contingent valuation provides for great flexibility in tailoring the survey question to directly elicit preferences for fatality reduction. But this hypothetical nature is also a major drawback in that respondents may lack either the direct experience or have adequate incentive to answer the survey questions accurately. This leads to inconsistencies across the estimates gleaned from different studies. The implied value of life from these studies hover around $3.7 million (in 1997 dollars), but vary enormously from as low as $125,000 to upwards of $10 million [Viscusi, 1993, Table 6].

The hypothetical nature of contingent valuation leads estimates to be driven by sometimes trivial aspects of the survey design, such as the ordering of questions or the description of risk. At the same time, respondents sometime exhibit insensitivity to factors that should have a major impact on risk trade-offs [Hausman, 1993; Jones-Lee et al., 1995; Schwab et al., 1995; Dubourg et al., 1997]. Particularly troubling in this respect, contingent valuation estimates exhibit inconsistencies even within a given study. Hammitt and Graham [1999] show that many contingent valuation study results imply that respondents' willingness to pay is insensitive to the magnitude of risk and fail to find positive relationships between willingness to pay and increasing levels of risk.

The third method for calculating economic losses arising from workplace fatalities attempts to use labor market based evidence on the observed behavior of workers and firms in terms of compensation for risk in wage levels. This framework begins with the premise that wage setting in labor markets results from the interaction of the supply and demand for labor. In addition to workers being compensated for their human capital (education, experience, ability), wages reflect compensation for risks faced on the job. Firms balance the costs associated with higher wages to compensate for more risky work against the costs of lowering exposure to risk through changes in production practices. Workers, on the other hand balance the marginal increase in the rate of pay against their desire to work in safer conditions. In equilibrium, wages therefore reflect the premium required by the marginal worker for facing the level of fatality risk posed at the firm.

Based on this model, a large number of studies estimate the size of ''compensating wage differentials'' for the risk of fatality. The resulting wage differentials are used, in turn, to generate estimates of the implied value of life reflecting these wage-risk trade-offs observed from labor market behavior. Estimation of wage premiums is complicated by the fact that one must independently control for the other factors that also influence supply and demand for labor and in turn observed wage levels. This gives rise to a number of problems that make it difficult to generate unbiased and efficient estimates of wage/risk relationships (see below).

The implied value of life arising from the estimates from these studies range from $3.7 to $8.6 million for workers in 1997 dollars [Viscusi, 1993]. The range not only reflects divergent methods in the estimation equations, but also different mixes of workers (and hence willingness to trade-off risk and compensation) in the samples used to make these estimates.

Critics of the compensating wage approach cite a host of labor market imperfections that make such estimates problematic [see, for example, Leigh, 1991; Dorman, 1996]. For compensating wage differentials for fatalities to fully reflect risk trade-offs, workers must have mobility in labor markets, adequate information about job risks, competitive labor markets, and an ability to factor in risk estimates into decision making. Many studies have tried to deal with some of these problems empirically [e.g. Viscusi, 1979; Viscusi and O'Connor, 1984; and Gerking et al., [1988] compare objective and subjective measures of risk in setting wage premia; Kahn [1994] regarding the impact of monopsony power on wage premiums and accident rates).

A second set of problems arise from the empirical complexities in deriving unbiased estimates of wage/risk trade-offs. Problems here include disentangling the effects of wages and fatality risk from industry- and occupational- and job-level effects [Leigh, 1995; Dorman and Hagstrom, 1998; Lalive, 2000]; and separating out the impacts of fatal versus nonfatal risk on changes in wages [Moore and Viscusi, 1988; Dillingham et al., 1996]. The finding of higher compensating wage differentials among union than nonunion workers also suggests the existence of information and bargaining power asymmetries that affect the size of differentials [Olson, 1981; Dorman and Hagstrom, 1998]. In addition, extrapolating a value of life based on empirical estimates of the impact of very small changes in fatality risks on wage levels requires strong assumptions about the applicability of local changes to wage/risk profiles to large changes in fatality risk as well as their applicability to other groups of workers [Viscusi, 1993, 2000].

Summary

Table II summarizes the foregoing discussion of the three major methods of measuring the economic cost of fatalities. Given 1997 price levels and fatalities, the value of human life arising from the compensating wage differential approach suggests that economic losses from fatalities at more than $38 billion. This represents a much larger estimate of social cost than found in conventional analyses like that provided by the NSC.[12] Despite the considerable empirical difficulties contained within it, the compensating wage differential approach seems the best available method to estimate the ‘‘true’’ social cost of fatality of the three methods in use, and yields far higher costs than the common sense approaches often cited in public discourse.

ECONOMIC CONSEQUENCES OF WORK DISABILITY

“True” Social Costs of Work Disability

A workplace injury that leads to functional limitations which creates, in turn, a work-related disability will result in economic losses to society if that disability diminishes the worker’s current and future productivity relative to what it would have been in the absence of the injury. Productivity decreases may arise because of reduction in work hours, shift to a new job and/or employer that require less human capital and result in lower pay, or withdrawal from the labor force for a period of time or entirely. The more that the work disability causes the affected worker’s actual income to diverge from the projected earnings trajectory prior to the injury, the larger the economic loss.[13]

Going back to Figure 1, the above implies that workers who experience functional limitations from an injury that have little impact on their long term work activities lead to only modest small social costs, primarily attributable to time away from work at the time of the injury. On the other hand, an injury resulting in functional limitations severe enough to force individuals to change the type of work they do will result in more substantial social losses. This is because the injury not only entails time away from work, but also diminishes productivity. The most extreme case of this—short of fatality—is withdrawal from the labor force.

The social welfare approach to economic valuation seeks a measure of the opportunity costs arising from workplace disabilities. The human capital perspective from labor economics is the predominant methodology for valuation. Opportunity costs here are the lost ‘‘return on investment’’ on human capital.[14] Labor markets in equilibrium result in workers earnings for a given job to be equated to the marginal product of their work to the firm (and society at large). That marginal product is a function of the production process, but also of the human capital endowment of workers—that is, the education, experience, skills, and worker abilities [see Becker, 1964; and Mincer, 1970 for seminal discussions of the human capital approach]. Workers receive a return on this investment over the course of their worklife via the profile of their lifetime earnings. Workplace injuries that lead to disabilities will therefore lead to economic losses associated with the diminishment or loss of accumulated human capital in the labor market.[15]

A social welfare approach complicates estimation considerably in that it requires projecting the counterfactual case of a worker’s earning profile *had they not been injured*. Figure 2 depicts this method of valuing economic losses. The figure compares a worker’s earning profile in the event of an injury from what it would have been in the absence of that injury under three scenarios. It plots the earnings of a worker on the vertical axis over the course of his or her worklife against time on the horizontal axis. The earnings profile increases over time driven by the human capital factors described above. If the worker was not injured, the profile would continue through time along the dotted line. In each case depicted, the worker experiences earnings losses equal to the present value of the difference between the projected earnings profile absent injury (dotted line) and the actual earnings profile given injury (solid line).

12 The NSC uses an estimate of $890,000 (in 1997 dollars) as the cost per occupational death, based on the estimated wage loss, medical expenses, administrative expenses, and other employer costs to arrive at an estimate [see NSC, 1998, pp. 51, 147].

13 One can also frame the social losses from work related disability in the same framework described for fatalities: that is, how much consumption would people willingly forgo in order to reduce the risk of injury at their place of work. This should generate estimated willingness to pay for injury reduction and compensating premiums on the part of firms [e.g. Gerking et al., 1988]. Viscusi [1993] discusses the difficulties of applying the framework to injuries, including the problem of finding accurate measures for injury risks as well as information problems limiting the utility of this information to workers.

14 An alternative method for evaluating the costs of workplace disabilities is the ‘‘friction cost method’’ that looks at firm-level and macro-level effects from changes in productivity levels arising from work absence and disability. This method yields more conservative estimates of the economic costs of workplace disability. See Koopmanschap et. al. [1995] for a discussion and application of this methodology.

15 The compensating wage differential approach described in the section, Economic Consequences of Fatalities, is also directly related to the wage setting perspective described here. It posits that wages will be set by the marginal worker’s willingness to accept on-the-job risks and the employer’s willingness-to-pay to compensate for this risk. The factors that value of life studies control are for the same set of human capital attributes that influence wages as those discussed here.

TABLE II. Alternative Methodologies for Valuation of the Economic Consequences of Fatalities

Methodology	Description	Representative studies	Principal data sources	Advantages	Limitations
Present value of future earnings	Calculate present value of foregone earnings stream given assumptions about age, earnings growth, and discount rate.	Leigh et al. [1997]; NSC [1998].	Earnings data (various sources).	Tractability, particularly for specific groups. Intuitive appeal.	Labor market distortions (e.g., value of life less for groups experiencing discrimination. Ability to extrapolate to larger populations. Does not reflect underlying choices regarding risk.
Contingent valuation	Survey-based procedure eliciting willingness to pay for lowered risk of death.	Acton [1973]; Jones-Lee et al. [1995]; Hammitt and Graham [1999]; Hammitt [2000].	Survey evidence on hypothetical risk exposure.	Allows direct elicitation of preferences. Potentially allows for greater degree of extrapolation given the survey population.	Hypothetical nature of survey does not necessarily allow one to find true preferences [Hammit, 2000]. Difficulties in people adequately understanding small risks. Results of many CV studies inconsistent with basic notions regarding risk [Hammitt and Graham, 1999; Hammitt, 2000].
Compensating wage differentials	Calculate differentials in wages attributable to small differences in risk then used in calculating implied value of life.	Viscusi [1993, 2000]; Kneiser and Leeth [1991].	Wage data; data regarding fatality incidence. Primarily industry and occupation level studies.	Value of life estimates based on actual market behavior of individuals. Risk / VHL relations consistent with behavioral models (e.g., positive relation between increase risk and requirement for higher wages).	Labor market imperfections (e.g. lack of labor mobility) undercut theory of fully compensating wage premiums. Empirical problems of discerning differentials [e.g., Leigh, 1995; Dorman and Hagstrom, 1998; Lalive, 2000]. Applicability of VHL estimates from one group to other groups [Viscusi, 2000].

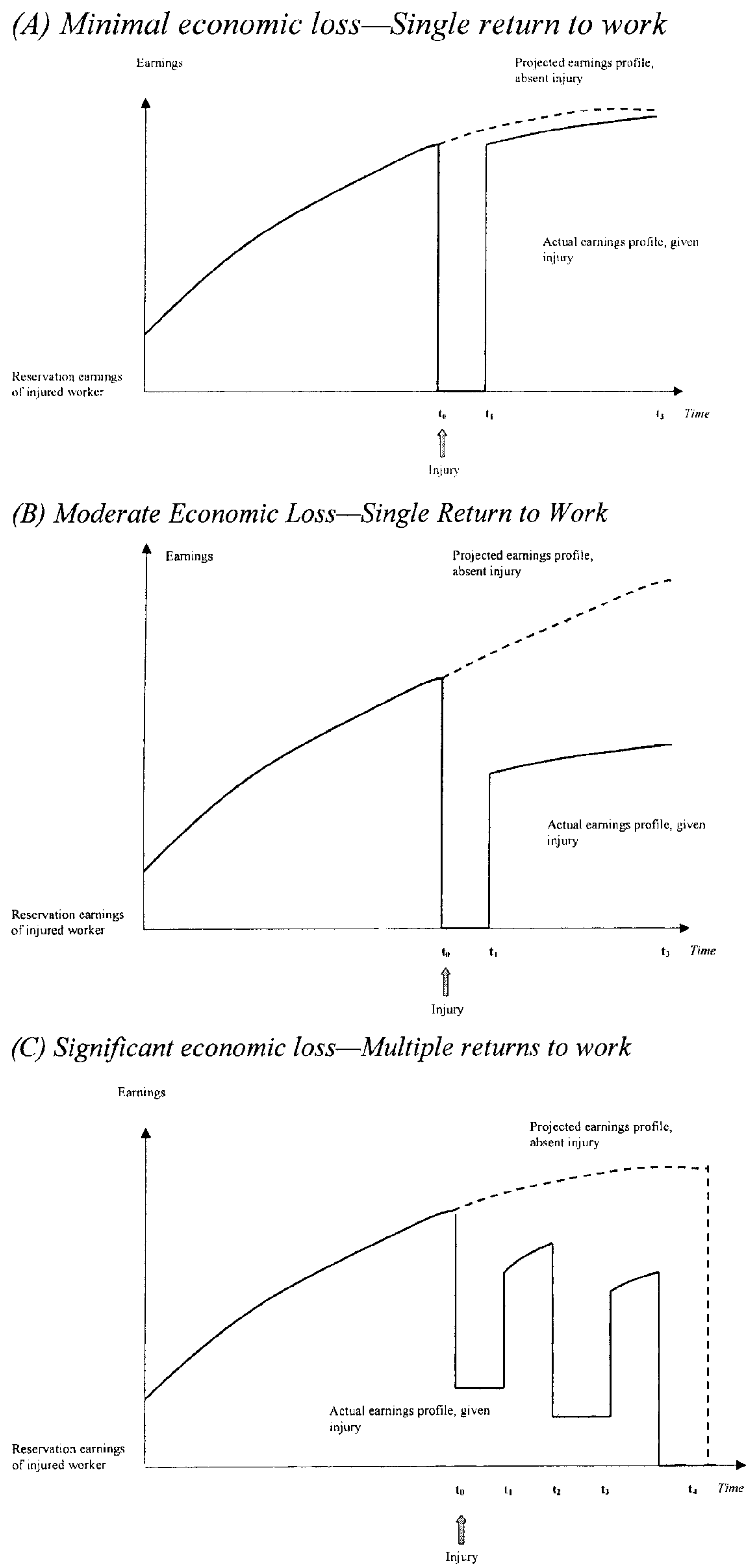

FIGURE 2. Economic Loss Estimates.

Figure 2a depicts a case of minimal economic loss, where a worker injured at time t_0 is forced to withdraw from the labor force until t_1. The figure does not plot earnings replacement from sources like workers' compensation, so the actual earnings for the worker falls to the worker's reservation earnings for this interval.[16] After t_1, the worker re-enters the labor market at a somewhat lower level of earnings than prior to the injury (due, for example, from lower hours worked in initial recovery). The worker's earnings rise quickly, however, to the preinjury trajectory until the end of work at t_3. Figure 2b depicts a case of more severe economic impact, where the post injury earnings trajectory has a lower absolute level upon re-entry to the labor market at t_2 and a reduced rate of earnings increase to t_3. Finally, Figure 2c depicts a case where the postinjury earnings profile is marked by repeated entries and exits from the labor market, with deleterious effects on the absolute level of earnings and the rate of growth in earnings.

Estimating the true social welfare costs of workplace disabilities requires measuring changes in workplace behavior arising from injuries or illnesses giving rise to the profiles depicted in Figure 2. One way of doing so is breaking the determinants of earnings profiles into separate components of labor market behavior. A rich body of research has examined how workplace disabilities affect labor force participation, the duration of absence from work following injury, the factors affecting long-term return to work, and the impact of discrimination towards the disabled on wages and employment. Table III provides an overview of this literature, surveying the major issues, studies, data sources, social welfare issues, and empirical controversies in each area. There are many theoretical and methodological issues raised in estimating each of these components that are beyond the scope of this article. Instead, we focus on the social welfare framework for assessing and alternative methods used for estimating the magnitude of lifetime earnings losses arising from injuries.

Estimating Earnings Losses

Researchers employ a variety of approaches to estimate the earnings losses as depicted in Figure 2. The majority of studies measure lifetime earnings losses of workers experiencing occupational injuries by drawing on state workers compensation records. By using workers compensation records regarding individuals receiving disability benefits, they are able to estimate losses by subtracting a measure of expected earnings from actual postinjury earning profiles.

In their study of the economic well-being of disabled workers, Haveman and Wolfe [1990] report that the ratio of real earnings of disabled to nondisabled male workers increased from 0.61 in 1962 to 0.74 in 1973, and then steadily declined beginning in 1976 from 0.66 to a low of 0.51 in 1982, recovering slightly in 1984 to 0.54. One method of estimating the cost of workplace disability uses similar earnings loss estimates, adjusted for indemnity benefits, and then applies these fixed percentages to the estimated total number of workers for different categories of disability.[17] For example, Leigh et al. [1997] use a ratio of 60% for temporary disability claims; 50% for permanent partial disabilities, and 40% for permanent total disability claims to generate their workplace cost estimate. The NSC [1998] similarly relies on assumptions about earnings losses for groups experiencing different levels of work disability.

Using fixed percentages assumes relatively constant levels of earnings losses from workplace disabilities across wide groupings of workers (e.g., those sustaining permanent workplace disabilities). In fact, there is considerable heterogeneity in social costs given variation in severity as well as underlying characteristics of injured workers. A second group of studies attempts to estimate differences across groups in earnings losses, improving estimation of the "true" social welfare losses portrayed in Figure 2. Cheit [1961], Johnson et al., [1978], and Ginnold 1979 use workers compensation administrative data on permanent disabilities to estimate earnings losses. These studies compare actual, postinjury earnings profiles with projected future earnings, basing those projections on growth in general wage levels, adjusted for changes in earnings related to workers' age [Cheit, 1961; Ginnold, 1979] and by inflation and average productivity increases for the private sector [Johnson et al., 1978]. Berkowitz and Burton [1987] use state-level growth factors to estimate expected earnings absent injury in a study of workers injured during 1968 in Florida, California, and Wisconsin.

A third group of studies employ more refined methods to create comparison groups in order to project postinjury earnings profiles. These studies attempt to combine administrative data from workers compensation systems with those of unemployment systems in order to generate the counterfactual earnings profile for workers had they not been injured. This allows for more precise estimates of the losses associated with workplace injuries of different severity levels (not restricted to permanent disabilities) holding

16 "Reservation earnings" for a worker is the amount of earnings where a worker is indifferent between entering and staying out of the labor market. In Figure 2c, the minimum earnings fall with each re-entry to the labor market, implying that the amount of earnings required to "coax" the injured worker back into the labor market falls over time.

17 The Havemen and Wolfe estimates are based on data drawn from the CPS. A study also drawn from the CPS for 1987 reveals an increase in the ratio for disabled men as a whole to 0.64 [Bennefield and McNeil, 1989, Table D]. The ratio of real earnings for minorities is far wider, beginning at 0.37 in 1962, growing to a high of 0.53 in 1973 and then declining sharply to 0.25 and 1982 and 0.15 in 1984 (Table III).

TABLE III. Specific Labor Market Causes of Economics Losses From Workplace Disabilities

Labor market impact of disability	Description	Representative studies	Principal data sources	Social welfare implications	Comments
Labor force participation	Decision to enter/exit labor market.	Entrance in labor force: Burkhauser and Daly [1996]; Diamond and Hausman [1984]; Stern [1989]; Early retirement: Bazzoli [1985]; Sickles and Taubman [1986]	Individual-based data sources (e.g. PSID, CPS, SIPP).	Impact of disability on the tradeoff between staying in and out of labor force arising from disability, other factors held constant.	Estimates must model determinants of general labor market participation to find independent impacts of health or disability. Similar issues raised in decision to leave the labor market because of health effects (early retirement).
Work absence duration	Duration of absence from work arising from workplace disability.	Doherty [1979]; Fenn [1981]; Butler and Worrall [1985]; Haveman et al. [1984]; Krueger [1990]; Bound [1989, 1991]; Johnson and Ondrich [1990] Meyer et al. [1995]; Hyatt [1996]; Mashaw and Reno [1998].	Workers compensation administrative data; Individual-based survey data.	Social losses arising from lost productivity due to disability related absence from work. Studies emphasize work disincentive effects arising from payment of disability benefits (e.g. workers compensation).	Empirical literature particularly focused on estimating the sensitivity of duration of absence with respect to benefit payments.
Return to work	Determinants of the probability of returning to work following disability or repeated spells of absence from labor market.	Johnson et al. [1995, 1998]; Burkhauser and Daly [1996]; Hyatt [1996]; Galizzi and Boden [1996]; Reville [1999]. Impact of accommodations: Butler et al. [1995]; Burkhauser et al. [1995]; Gunderson and Hyatt [1996]; Hunt et al. [1996].	PSID and CPS; Workers compensation administrative data (Table IV); Ontario Workers Compensation Board Survey of Workers.	Social loss arising from inability to reattach to labor market following disability arising from lack of work accommodation, disability benefits, employer perception of productivity, and other impediments.	Empirical literature identifies the fact that first return to work is not always predictive to reattachment to labor market. Also looks closely at the impact of workplace accommodations on long term reattachment.
Wage/employment discrimination	Discrimination in terms of earnings/employment arising specificially from discrimination because of disability.	Baldwin and Johnson [1994,1995, 2000].	SIPP panel data	Discriminatory behavior by employers creates obstacles to use of productive resources.	Empirical evidence of significant part of disabled/non-disabled wage differential unexplained by human capital or functional limitations; Large unexplained component of differences in employment levels for disabled workers.

constant other factors unrelated but correlated with injuries that might also affect earnings.

Boden and Galizzi [1999] use data drawn from Wisconsin to estimate earnings losses for workplace injuries. In contrast to other studies that measure earnings losses for injuries only for workers compensation cases involving permanent disabilities, Boden and Galizzi include workers who experience 4 days or more of lost work, but who do not necessarily sustain permanent earnings losses. This data includes a wide variety of injured workers, from those who suffer only very brief losses and then return to the labor market with no lasting disabilities, to those suffering from long term disabilities.

The authors compare actual postinjury earnings for workers with varying disability severity with a comparison group of workers with very short duration injuries (8–10 days of work loss), complete return to work, and no receipt of permanent disability benefits. The authors also use preinjury data for both groups from unemployment insurance data to test whether the two groups had similar preinjury earnings profile, controlling for other observed characteristics associated with human capital endowments.

Based on this estimation technique, Boden and Galizzi [1999] estimate that the present value of pre-tax losses projected for 10 years past the observation period equals about $8000 (1994 dollars). This is a large number given that their data includes virtually all injuries reported to the state, including minor ones with small earnings effects. The estimated losses vary by the severity of the injury. For example, the estimated present value of a loss for those drawing on workers' compensation for 4–7 days of lost work only is $366 for men. On the other hand, the present value of average pre-tax losses for male workers with permanent partial disabilities are estimated to be over $20,000.

Another method used to estimate the true losses arising from injuries matches data on injured workers with a ''synthetic'' cohort group, matched on the basis of preinjury characteristics. Peterson et al., [1997] and Reville [1999] estimate relative earnings losses to workers in California receiving permanent partial disability from the state by creating a control group of noninjured workers from the same establishments as the injured workers drawn from the state's unemployment insurance system. Because this control group is drawn from the same firms and matched with injured workers on the basis of preinjury earnings, it provides a better estimate of the earnings profile of the workers receiving disability benefits had they not been injured. On the basis of this procedure, Reville estimates that over the 5 years following an injury, workers receive about 40% lower earnings than the control group. Like the Boden and Galizzi study, significant losses are documented even for workers sustaining minor injuries.

Summary

Table IV summarizes the major components of the three methods used to quantify workplace disabilities discussed above. The pre/post injury cohort designs offer the closest methods for estimating the ''true'' social costs of workplace disabilities in that they explicitly attempt to model the earnings streams of works absent the injury. The earnings losses generated by these studies tend to be larger than those generated by the other two estimation procedures. For example, Boden and Galizzi [1999] estimate that income replacement rates for workers with temporary disabilities are only about 29% in contrast to the 60% replacement rate assumed in Leigh et al. [1997]. Similarly, the careful cohort design of Reville [1999] shows large and persistent uncompensated earnings losses for injured workers across disability groups—even those with minor disabilities. Like fatalities, estimation methods that more closely adhere to the model of ''true'' social costs yield significantly higher cost estimates than those often used in public health literatures.

ECONOMIC CONSEQUENCES OF OCCUPATIONAL INJURIES ON NON-WORK DISABILITY

"True" Costs of Non-Work Disability

The final set of pathways described in Figure 1 regard the impact of workplace injuries and illnesses on nonwork disability. This pertains to changes engendered by the injury that have consequences on individuals and their households outside of the workplace. A major consequence of the functional limitations arising from a workplace injury or illness concerns the allocation of time within the household. Functional limitations may limit the activities within the home, from child care to cooking, to self-maintenance.

The social welfare cost of these changes in household activity requires first thinking about the initial allocation of household time as reflective of the preferences of its members. Nonwork disabilities arising from functional limitation requires the household to reallocate consumption (in terms of income contributions by household members; time allocation towards household work; and finally leisure activities). Since these alternative allocations were presumably available to the household prior to the injury/illness event, the change in allocation is reflective of some loss in household welfare.[18] The major methodologic problem is therefore estimating the changes in household behavior and then

[18] For a complete discussion of this framework of the allocation of time to work and nonwork activities, see Becker [1965]; Gronau [1977]; and Stafford and Duncan [1980]. Kooreman and Kaplan [1987] provide empirical estimates of changes in household time allocation to changes in wage rates and other factors (but not related to injury or illness outcomes or events).

TABLE IV. Alternative Methodologies for Valuation of the Earnings Impact of Work Disability

Methodology	Description	Representative studies	Principal data sources	Advantages	Limitations
Fixed earnings differential used for disabled workers.	Use fixed ratio of lost earnings (or replacement rate of post-injury earnings) as basis of aggregate calculations.	Miller and Galbraith [1995]; Miller et al. [1998]; Leigh et al. [1997]; NSC [1998].	CPS as source of earnings loss multipliers [e.g., Haveman and Wolfe 1990].	Allows extrapolation of earnings losses for national level estimates of disabled workers. Tractability: Does not require cohort comparison groups.	Limited controls for other, non-disability differences between disabled and non-disabled workers. Understates problem of heterogeneity across different groups of disabled workers.
Projected earnings based on growth factors.	Estimate losses by subtracting observed post-injury earnings from projected earnings based on growth factors.	Cheit [1961]; Ginnold [1979]; Berkowitz and Burton [1987].	Workers compensation files for workers receiving permanent disability benefits; Industry- or occupation-level data for growth trends.	Provides some estimate of foregone earnings based on disabled workers occupation and /or industry group. Tractability, does not require detailed cohort comparison group.	Growth factors do not fully capture individual differences within industry/occupation. Understates the heterogeneity of earnings losses, particularly for workers experiencing temporary disabilities.
Workers compensation cohort for disabled and less severely affected workers/synthetic cohort of non-injured workers from the same firms.	Workers compensation cohort for disabled and less severely affected workers/synthetic cohort of non-injured workers from the same firms.	Boden and Galizzi [1999]; Peterson et al. [1997]; Reville [1999].	Workers compensation administrative files for injured workers matched to their pre-injury earnings records [Boden and Galizzi] or a matched cohort of workers [Peterson et al.; Reville]. Both cohort files from state unemployment administrative data.	Cohort group allows closer matching of disabled and non-disabled workers and better estimates of foregone earnings. Provides estimates of earnings losses given worker characteristics. Use of "synthetic" cohort allows closer matching based on pre-injury worker characteristics. Allows estimation of earnings losses for a wider range of severity levels.	Difficult to extrapolate results to national sample. State-based effects from use of workers compensation data may limit generalizability of earnings estimates. Tractability: Creating synthetic cohort data is resource intensive and not possible in many states or at national level.

finding ways of valuing them in order to measure social welfare losses.

Estimating the Cost of Non-Work Disabilities

The body of literature quantifying the economic consequences of non-work disabilities approaches is less extensive than that related to work disabilities.[19] One reason we know less in this realm arises from the difficulty of finding good market proxies to measure the consequences of nonwork disability. In general, estimates of nonwork disabilities can be broken into studies that deal with the impact of injuries on household income, household time allocation, and those that attempt to measure quality of life impacts.

Household income

One economic consequence of workplace injuries at the household level is reduction in the overall earnings of households where one of its members have been injured. In addition to the factors that reduce earnings of the disabled worker described above, other household members may also need to adjust their labor force participation in response to these changes. The direction of the effect is unclear, however: in some cases, other household members may need to withdraw from the labor force in order to provide care for a severely disabled family member. This may require the household to draw on family wealth and depend more heavily on government income. On the other hand, earnings losses by one member of the family may compel other family members to enter or increase their participation in the labor market, offsetting some but usually not all of the income losses and leading to large changes in the allocation of household time as will be discussed below.

The majority of studies reviewed above focus on the impacts of work disabilities at the individual-rather than family-or household-level. Two studies provide some indication of household effects. Haveman and Wolfe [1990] examine changes in the ratio of real equivalent family income for disabled and nondisabled males for their CPS sample. They find somewhat lower ratios for households as opposed to individuals over the period 1962–1984. For example, in 1984 the ratio of disabled to nondisabled real earnings for individuals was 0.54 vs 0.72 for real family income. Nonetheless, the gap between disabled and nondisabled family income persists through the period, indicating that families do not fully make-up the difference in lost earnings.[20] Burkhauser and Daly, [1996] found that the impact of worker earnings losses is more muted at the household level, based on their analysis of PSID data. The authors noted that ‘‘median real household-size adjusted income does not fall by the same amount as labor earnings for either men or women immediately following the onset of a disability. This is true for both before and after government income.’’ (p. 72).

Changes in household income, however, do not fully capture changes in the family welfare arising from workplace injuries. Increased household earning activity by family members to make up an injured worker's earnings contribution may yield significant net losses—even if net household earnings pre/post injury remain stable—because of internal changes to household activities and participation in nonworkplace activities.[21] In order to capture this social loss, one must directly measure time allocation by household members.

Household activity

Rather than focusing on changes in overall income, a second approach directly measures household activity (time allotted to various functions like child care, home cleaning, repairs) and other nonwork activity (e.g., time spent with friends, entertainment, and participation in religious and social organizations). This requires retrospective survey methods or the use of time diary data by the affected worker and sometimes other household members.

Hensler et al. [1991] estimate changes in household activities and time allocation arising from workplace injuries, drawing on their detailed survey work of individuals affected by work and nonwork injuries. They estimate that 40% of the individuals in their sample who were injured at work reduce the amount of time spent on household chores by one or more days, with 11% reporting that they were unable to perform any household work. This group spent an average of 20 fewer days engaged in household chores. About 16% of injured workers in their sample report the need to depend on other family members to care for them. In addition, 38% require other family members to take over some or all of their home activities.

Functional limitations arising from an occupational injury or illness also have other repercussions beyond the home and workplace. Functional limitations may limit a person's ability to engage in social activities (civic, religious, leisure) both directly and because of the changes in time allocation described above. Hensler et al. [1991] report that about 47% of work-injured people in their sample

[19] The topic has received greatest attention from specialty fields within economics, particularly in the area of forensic economics.

[20] As in the studies of individual earnings, Haveman and Wolfe find larger gaps in household earnings among minorities and in families where the disabled worker has less education (see Tables 6 and 7, pp. 47–49).

[21] There also remains the estimation problem of specifically discerning the change in household-level labor market participation elicited by the workplace injury. This raises the same econometric problems of discerning changes in labor market behavior associated with the injury from other factors that also contribute to changes in labor market behavior of household members (see Table III).

report cutting back on other nonwork and nonhousehold activities.

Once changes in time allocation have been established, one must find a means of attaching economic values to that information. The most direct cost of changes in time allocation are from days of work missed by other family members to care for injured workers. For example, based on their survey data, Hensler et al. estimate annual losses of $162 million, arising from the 6.2 million days of work that household members of injured workers miss in order to provide care or help with household activities.[22]

Figures like this represent only a subset of the costs associated with the reallocation of time. For example, Hensler et al. [1991] do not place a value on the estimated 91 million days that other family members cut back on their own home activities to care for the injured person, nor do they value the change in household utility arising from the shift in time allocation. One method to include such costs is to use imputed wage rates, which provide a measure of the opportunity cost of time, and multiplying the reduction in hours spent on household activities by the wage [see Kooreman and Kaplan, 1987 for application of this idea to the overall valuation of household activity]. Although this method requires making strong assumptions that the utility of various activities are roughly equivalent to one another and to the wage rate at the margin, the approach is consistent with the underlying social welfare notions outlined above [e.g., Gronau, 1977].

Alternatively one can determine classes of activities no longer undertaken in the home as a result of the injury and using market based estimates of the price of those activities (e.g. house cleaning activities) to estimate social losses that stem from the injury [Douglas et al., 1990]. This approach is made difficult by finding valid price measures of many activities undertaken in the home but not often provided by competitive markets, or fully capturing the value of reduced activities using market measures (e.g., child care).

Quality of life approaches

An alternative approach to estimating nonwork social losses looks to the overall reduction in quality of life rather than focusing on micro-level changes in behavior as in the household time allocation approach. Although difficult to precisely define, quality of life here refers to diminishment of health, psychological well-being, and family and social interactions arising from the injury. Quality of life losses overlap with changes in household and other nonwork time allocation described above. But they also go beyond this realm to include the burden imposed on the disabled by feelings of depression, anger, and pain arising from limitations in all realms of activity.

One approach used to capture quality of life issues—originally developed as an alternative to setting a value to human life by health policy analysts—is the concept of ‘‘quality-adjusted life years’’ (QALY). QALY attempts to measure the good health lost when someone experiences a health problem or dies, where QALY takes a value between 1 for a year without health impacts and 0 in the case of devastating health effects. Quality of life states between these two extremes are rated by affected individuals along a variety of dimensions such as health perception, and social-, psychological-, and physical- function [Gold et al., 1996]. Various survey instruments have been created to elicit ratings along these dimensions and then to combine them into an overall QALY measure. Consistency of these ratings have been evaluated in a variety of studies [see Miller *et al.*, 1995 for a discussion of methods].

There are a variety of methodological problems raised by QALY. These include the stability of estimates for a given person over time, as well as the consistency of QALY estimates across different people with similar underlying disabilities [Mendeloff, 1997]. Even if consistent QALY estimates can be generated, one must still find a means to monetize them in order to arrive at a social cost estimate. Valuing the quality of life can be conceptually compared to the framework for valuing a statistical life described above: how much consumption would a person be willing to give up in order to reduce the likelihood of some specified diminishment of the quality of life. Contingent valuation methods have not surprisingly been used as one means to make this type of judgment. Yet the use of contingent valuation here suffers from the same methodological problems discussed in regard to fatalities [Miller, 1995; Hammitt, 1999].

Summary

Table V summarizes the three approaches to valuing the cost of nonwork disabilities. It is difficult to rank these approaches regarding estimated magnitudes of social losses. However, methods that explicitly measure changes in household behavior of the injured or other family members come closer to the underlying social welfare notion of costs in this area of activity than approaches simply relying on changes in household income. However, translating changes in time allocation and participation in nonwork activities or QALY into plausible economic costs remains a difficult problem to surmount.

CONCLUSIONS

The number of workers reportedly entering the disability pathway described in Figure 1 is about 2.3 per

[22] See Hensler et al., Table 4.16, 4.18, 4.19 and Figure 4.4, pp. 96–99.

TABLE V. Alternative Methodologies for Valuation of the Economic Consequences of NonWork Disability

Injury/Illness consequence	Methodology	Representative studies	Principal data source	Advantages	Limitations
Household income	Change in injured worker's household income.	Haveman and Wolfe [1990]; Burkhauser and Daly [1996].	Household surveys (CPS; PSID)	Overall welfare as measured by income level. Household income measured in available survey instruments.	Does not indicate how non-income aspects of household activity have been affected. Empirical difficulties in estimating income changes arising specifically from injury for household members
Household time allocation	Change in allocation of time devoted to household activities by injured worker and members of household.	Kooreman and Kaplan [1987] (methodology) Douglas et al., [1990]; Miller [1995]; Hensler et al. [1991].	Survey; Time diaries	Provides direct measures of household activities and changes in worker and other household members. Conceptually linked to underlying social cost idea of household welfare loss. Some market proxies available for certain activities (e.g., cleaning).	Requires post-injury reporting on pre-injury household activity (bias). Surveys often require injured worker to report on time allocation of other household members (accuracy/bias). Difficulties in monetizing losses from changes in household time allocation or participation in activities (e.g., day care; participation in civil society).
Quality of life	Quality Adjusted Life Years (QALY).	Gold et al. [1996]; Miller et al. [1995]; Mendeloff [1997].	Survey	Provides more comprehensive estimate of change in overall welfare in nonwork activities.	Difficult to find consistent measures of QALY across individuals. Difficult to monetize QALY estimates; contingent valuation design problems (Table II). Problem in calibrating results against other instruments.

100 people in the population, while the number of people within the pathway at any given time is roughly 1 in 10 of the population. This suggests that the economic consequences of workplace-induced disabilities are significant.

This paper suggests that in general estimation procedures that more closely adhere to a social welfare perspective on cost yield larger estimates of economic costs than other methods employed in public health literatures. Valuing the economic cost of workplace fatalities is indicative. Though estimation methods remain controversial, an approach focusing on the direct cost of lost earnings for an average worker results in an estimated cost per death of \$890,000 (in 1997 dollars). In contrast, using a willingness to pay approach based on compensating wage differentials yields estimates on the order of \$6 million. Similarly estimation approaches that apply a fixed proportion of earnings losses to injured workers based on observed differences of injured versus noninjured workers understate the social costs of work disability relative to approaches that estimate losses in human capital based on careful estimation of changes in earnings profiles induced by injuries.

Cost estimates like that of the NSC and Leigh et al. rely on simplifying assumptions and less comprehensive estimation methods in order to make projections at a national level. An important implication of this review is that reliance on more tractable methods for making cost estimates yields far lower estimates than procedures more closely rooted in the microeconomic concept of social welfare loss.[23] One hopes that future attempts to arrive at global cost estimates of occupational illness and injuries will increasingly incorporate empirical estimates from many of the recent studies reviewed above. Use of more complete social cost estimates will only underscore the point made by Leigh et al. [1997] concerning the significant role occupational injuries and illnesses contribute to the total burden of health care costs in the United States.

Need for Research Collaboration

A second implication of this article concerns the need for greater collaboration between researchers working in the area of the social costs of occupational injuries. Despite the large body of evidence surveyed above, there remain important gaps in our knowledge of economic consequences. Many of these gaps will only be spanned by better integration of the research methods employed by economists with those used by public health researchers.

The models of behavior underlying public health and occupational medicine differ from those of economics—in part reflecting the foci of interest of the different disciplines. Yet future research requires greater understanding and blending of these perspectives in order to improve the ability of both set of researchers to understand injury and illness outcomes (and the processes that generate them).

This is not to imply that an unbreachable chasm exists between these disciplines, nor that the views are antithetical to one another. In fact, they are in many respects complementary. The ‘‘ecological’’ perspective taken by some public health researchers focuses upon the interrelation of a variety of factors that influence such things as how functional limitations result in work disabilities [Berkowitz, 1985; Israel et al., 1996; Schurman et al., 1998]. The economic approach stresses the importance of incentives (for workers, employers, and other institutional players) in guiding the choices of this same set of players. Cross-pollination through integrated research efforts can lead to improvement in the simplifying assumptions that both disciplines make in respect to examining this issue.[24]

The pathways depicted in Figure 1 also suggest that a productive approach to fostering such collaboration could be based on specific injury/illness related research. Evaluation at the ‘‘illness-level’’ is of course the dominant framework in medical and public health research. It has not been in the area of economic consequences.[25] Economic researchers in this literature are more often grounded in economic and statistical modeling than in the specific etiology of occupational injury or illness. By building collaborative efforts around specific occupational health problems, economists can better appreciate the complexities of factors affecting worker, employer, medical, and other institutional choices. Public health researchers, in turn, can better integrate the role of incentive behavior and market forces when examining the decisions made by these parties.

ACKNOWLEDGMENTS

This research was supported by the National Institute for Occupational Safety and Health. I am grateful to Les Boden, Robert Reville, J. Paul Leigh, Elyce Biddle, Ted Miller, Joan K. Meyer, two anonymous referees, and conference participants for comments on earlier versions of this paper.

23 This is somewhat surprising in that microeconomic approaches to evaluation are often deemed ‘‘conservative’’ and overly reductionist in their approach to social cost.

24 This literature review provides many examples that illustrate the potential benefits of cross-disciplinary collaboration. For example, selection of the appropriate measure of disability as valid predictors of labor force participation and return to work remains an area for productive collaboration across fields. Bazzoli [1985] and Stern [1989] both demonstrate the importance of selecting valid measures of health impacts on estimates of labor force participation.

25 There are of course exceptions, such as the economic evaluation of back-pain injuries by Johnson et al. [1998].

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