



Costs of Occupational Injuries and Illnesses

**Final NIOSH Report
for Cooperative Agreement with E.R.C., Inc.,
U60/CCU902886**

by

**J. Paul Leigh, Ph.D.¹
Steven Markowitz, M.D.²
Marianne Fabs, Ph.D., M.P.H.²
Chonggak Shin, M.B.A., C.P.A.²
Philip Landrigan, M.D.²**

DO NOT QUOTE OR CITE WITHOUT AUTHORS' PERMISSION

¹Department of Economics, San Jose State University, San Jose, CA 95192-0114; and
Division of Immunology and Rheumatology, 1000 Welch Road, Suite 203, Stanford
University Medical Center, Palo Alto, CA 94304-0146

²Division of Environmental and Occupational Medicine, Department of Community
Medicine, Mt. Sinai School of Medicine, Box 1057, One Gustave L. Levy Place, New
York, NY 10029-6574

Acknowledgements: Hal Walden, Carol Alameda, Roxanne Leary and Susan Neuhooff
provided computer programming and word processing.

Table of Contents

Page

Chapter 1: Introduction and Summary

- I. Introduction
- II. Epidemiology of Injuries, 1992
- III. Epidemiology of Illnesses, 1992
- IV. Techniques for Analyzing Costs
- V. Direct and Indirect Costs of Injuries, 1992
- VI. Direct and Indirect Costs of Illnesses, 1992
- VII. Willingness-to-Pay Estimates for Injuries and Illnesses, 1992
- VIII. Workers' Compensation Cost Estimates Across Occupations and Industries
- IX. Who Pays?
- X. Limitations and Assumptions
- XI. Cost Comparisons with Other Health Problems
- XII. Conclusion

Chapter 2: Incidence of Job-Related Injuries

- I. Introduction
- II. Fatalities
 - A. Primary Sources
 - 1. Census of Fatal Occupational Injuries (CFOI), conducted by the Bureau of Labor Statistics (BLS)
 - 2. National Traumatic Occupational Fatalities (NTOF), conducted by the National Institute for Occupational Safety and Health (NIOSH)

PROTECTED UNDER INTERNATIONAL COPYRIGHT
ALL RIGHTS RESERVED
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE

REPRODUCED BY:
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161
NTIS

Page

3. Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics (BLS's Annual Survey)
4. National Council on Compensation Insurance (NCCI), a private company collecting Workers' Compensation (WC) data
5. Supplementary Data System (SDS), conducted by the BLS that in turn drew data from many Workers' Compensation (WC) insurers

B. Secondary Sources

1. National Safety Council (NSC), a not-for-profit company
2. Private researchers
 - a. Miller (1994)
 - b. Mason (1989), study commissioned by NIOSH
 - c. Rossmann, Miller and Douglas (1991), study commissioned by NIOSH
 - d. Marquis (1992), Congressional testimony

- C. Table 2.3 summarizes deaths from 1980 to 1992

III. Non-Fatal Injuries

A. Primary Sources

1. Bureau of Labor Statistics' Annual Survey of Injuries and Illness (BLS's Annual Survey)
 - a. Introduction
 - b. Estimates
 - c. Historical trends
2. NCCI, a private company collecting WC statistics
3. National Health Interview Survey (NHIS), conducted by the National Center for Health Statistics (NCHS)

B. Secondary Sources

1. Hensler, et al. (1991) and Marquis (1992), researchers with Rand
2. Rossman, Miller and Douglas (1991), private researchers, study commissioned by NIOSH
3. Miller (1994), private researcher
4. National Safety Council (NSC), a not-for-profit company
5. Mason (1989), private researcher, study commissioned by NIOSH

C. Classification scheme and Table 2.12 summarizing non-fatal estimates in latest year available and for 1992

IV. Collateral Damage and Summary Table 2.14 Including Deaths and Non-Fatal Injuries

V. Demographic, Occupational, Industrial and Regional Differences in Frequencies and Rates

A. Demographics

1. Age and Experience
2. Race, ethnic origin
3. Gender
4. Self-employed and small firms

B. Occupations and Industries

1. From the BLS's Annual Survey
2. From the National Traumatic Occupational Fatality Study
3. From the Census of Fatal Occupational Injuries (CFOI)

C. Geography, States

Page

VI. Causes of Death and Types of Non-fatal Injuries

A. Causes of Deaths

B. Types of Non-fatal Injuries

1. Data from the National Safety Council (NSC); from Hensler et al. (1991) and Marquis (1992); and from Rossman, Miller and Douglas (1991)
2. Data from the National Health Interview Survey (NHIS); and NHIS from the Occupational Health and Safety Supplement (NHISOSH Supplement), 1988
3. Data from the NHIS, 1985-87
4. Data from the Annual Survey of Occupational Injuries and Illnesses (BLS's Annual Survey)

VII. Conclusion

Chapter 3: Counting Occupational Illnesses

I. Introduction

II. Approach to the Problem

A. Major Obstacles to the Recognition and Counting of Occupational Diseases

B. Proportional Attributable Risk Model

1. Cancer
2. Cardiovascular and cerebrovascular disease
3. Chronic obstructive pulmonary disease
4. Pneumoconioses
5. Neurologic and renal disease

III. Estimates of Morbidity and Mortality from Occupational Disease

A. Occupational Morbidity

1. Survey-based data
 - a. BLS Annual Survey
 - b. Public employee data
 - c. Heavy metal poisoning
 - d. National Health Interview Survey
 - e. National Hospital Discharge Survey
2. Attributable risk-based estimates of morbidity
 - a. Cancer
 - b. Cardiovascular and cerebrovascular disease
 - c. Chronic obstructive pulmonary disease

B. Occupational Mortality

1. Specific occupational diseases
2. Attributable risk-based estimates of mortality

IV. Conclusion

Chapter 4: Two Methods for Measuring Costs

I. Direct and Indirect Cost Approach

II. Willingness-to-Pay (WTP) Approach

A. Introduction

B. Explanation of WTP

C. Review of studies in labor markets and automobile market

III. Conclusion

Chapter 5: Direct and Indirect Costs of Injuries

- I. Introduction
- II. Estimates
 - A. Direct costs
 - B. Indirect costs
 - 1. NCCI, indemnity
 - a. Administrative costs
 - b. Fringe benefits
 - 2. Present Value of lost earnings for fatalities
 - 3. All other indirect costs
 - a. Hiring and training costs
 - b. Property damage
 - c. Time and travel delays
 - d. Police and fire services
 - e. Family home health care
 - f. Innocent third parties
 - C. Summary Table 3.7
- III. Literature Review
 - A. Job Injury Studies
 - 1. National Safety Council (NSC) (1993)
 - 2. Rand Institute, Hensler et al. (1991) and Marquis (1992)
 - 3. Miller and Galbraith (1994)
 - 4. Rossman, Miller, and Douglas (1991)
 - 5. Neumark et al. (1992)
 - 6. Nelson (1992, 1993)
 - 7. Burton (1994)
 - 8. Boden and Fleischman (1989)
 - 9. Webster and Snook (1990)

B. Related Studies

1. Rice et al. (1989), and Max, Rice, MacKensie (1990)
2. Max and Rice (1993)
3. Blincoe and Faigin (1992)

IV. Conclusion

Chapter 6: Costs of Occupational Illnesses

- I. Introduction
- II. Methods and Data
- III. Results
- IV. Discussion
- V. Conclusion

Chapter 7: WTP Cost Estimates for Injuries and Illnesses

- I. WTP Estimates from the Literature
- II. Our WTP Estimates for Injuries
- III. Our WTP Estimates for Illnesses
- IV. Conclusion

Chapter 8: Workers' Compensation Costs Within Occupations and Industries

- I. Introduction
- II. Description of the Supplementary Data System

Page

- III. Method
 - A. Introduction
 - B. Costs calculations
 - C. Denominators
- IV. Discussion of Tables
- V. Conclusion

Chapter 9: Who Pays?

- I. Introduction
- II. Nominal Payment
- III. Actual Payment
 - A. Who Pays for WC?
 - 1. Introduction
 - 2. Theory
 - 3. Evidence
 - 4. Conclusion
 - B. Who Pays for non-WC costs?
- IV. Conclusion

Chapter 10: Limitations and Assumptions

- I. Introduction

II. Limitations

- A. Fraudulent claims
- B. Generous WC benefits increase injuries
- C. More injuries occur at home than at work
- D. WC medical costs exaggerate true medical costs
- E. Total and average costs versus marginal costs
- F. Full employment
- G. Incidence and prevalence costs

III. List of 30 Consequential Assumptions

- A. Introduction
- B. List

Chapter 11: Comparison with Other Health Problems

- I. Costs of AIDS, Alzheimers disease, back pain, circulatory diseases, and cancer
- II. Reallocation between circulatory disease and occupational injuries and illnesses
- III. Conclusion

Chapter 12: Conclusion

References

Costs of Occupational Injuries and Illnesses

Chapter 1: Introduction and Summary

I. Introduction

Every year millions of American workers suffer injuries, diseases and deaths in their workplaces. Yet little effort has been made to estimate either the extent of these deaths and injuries or their cost to the economy. Thus, important questions about workplace safety and the economic resources expended due to workplace health problems remain unanswered. In this report, we address these questions by presenting estimates of the incidence, prevalence and costs of workplace-related injuries, illnesses, and deaths for the entire civilian workforce of the United States in 1992.

Our major findings are:

1. Roughly 6,500 job-related injury deaths, 13.2 million non-fatal injuries, 60,300 disease deaths and 862,200 illnesses occurred in the American workplace in 1992 (see Table 1.1).
2. The total direct and indirect costs associated with these injuries and illnesses were estimated to be \$173.9 billion or 3% of Gross Domestic Product, which was \$5,950.7 billion in 1992. Direct costs included medical expenses on hospitals, physicians, drugs, property damage, and so on, as well as health insurance administrative costs. Direct costs were estimated to be \$66.2 billion (See Table 1.1).
3. The indirect costs included loss of wages, costs of fringe benefits, and home production (e.g., child care provided by parent and home repairs), as well as insurance administration costs, employer retraining and workplace disruption costs, time delays, and indirect costs of deaths and injuries to innocent bystanders. Indirect costs were estimated to be \$107.7 billion (see Table 1.1).
4. Total direct and indirect costs for injuries were \$148.4 billion while total direct and indirect costs for diseases were \$25.5353 billion.

Table 1.1

Number and Costs of Injuries and Illnesses in 1992

Category	Number	Costs (in billions)		
		Total***	Direct	Indirect
Injuries*	13,253,529	\$148.4	\$50.1	\$98.2
Deaths	6,529	3.8	.3	3.5
Non-fatal	13,247,000	144.6	44.8	94.6
Illnesses**		\$ 25.7	\$16.1	\$ 9.5
Deaths	60,290	19.5	10.7	9.0
Morbidity	862,200	5.8	5.4	.5

* Innocent bystanders excluded from counts of injuries but included in dollar estimates.

** The number of deaths and morbidity for illnesses cannot be summed precisely.

***May not sum due to rounding.

Source: Current Study

5. These costs are large when compared to other diseases. The costs combined are larger than those for AIDS, Alzheimer's disease and back pain and are on a par with those for cancer and for all circulatory (heart and stroke) diseases.
6. Our measures ignored the costs of pain and suffering. Had these been included, using estimates from the willingness-to-pay technique, overall costs would have been estimated to be anywhere from \$568 billion to nearly \$900 billion.
7. These costs were borne by injured workers and their families, by all other workers through lower wages, by firms through lower profits, by consumers through higher prices, and by taxpayers through higher taxes.
8. Workers' Compensation covers only slightly more than 30% of all costs.
9. Our study appears to be the first to use national data to produce estimates on costs for occupational injuries and illnesses. Prior studies have underestimated costs by ignoring non-disabling injuries, deaths, workplace violence, by taking inadequate account

of diseases, and, most importantly, by relying only on one or two sources of data.

10. Greater efforts need to be directed toward gathering data on job-related injuries and illnesses. The United States needs better data (a Census of Fatal Occupational Injuries, CFOI) for non-fatal injuries and all illnesses.

Additional findings include these:

11. Many episodes of occupational injuries also involved innocent bystanders. For example, a single pilot death may be associated with scores of deaths to passengers. We estimated 218 deaths and 68,000 non-fatal injuries to innocent bystanders in 1992. The total costs of deaths and injuries to bystanders were \$2.9132 billion.
12. Small firms contributed much higher per capita costs than large firms.
13. The self-employed, persons employed in small firms, and persons over age 65 contributed a high and disproportionate number of injury deaths.
14. Men were approximately 12 to 13 times more likely than women to suffer a fatal injury. But men were only roughly three times as likely as women to experience a non-fatal injury.
15. Occupations with high mortality rates included lumberjacks, construction laborers, taxi drivers, truck drivers and pilots. Occupations contributing high numbers and rates of non-fatal injuries included laborers, truck drivers, nursing orderlies, janitors, and assemblers.
16. Occupations contributing the most to costs included laborers, sanitation workers, warehouse workers, nursing orderlies, and mechanics. On a per capita basis, mechanics, miscellaneous laborers, and drill press workers contributed the most to costs. The most costly industries included trucking, logging, construction, and meat products. On a per capita basis, the costly industries were mining, logging, transport, and sanitary suppliers.

17. Roughly 40% of injury deaths involved transportation accidents and 18% involved murder.
18. Murder was the leading cause of injury deaths among executives, sales, and service workers.
19. Murder and assault at retail stores could be reduced if laws were passed to require stores to post armed guards on duty especially during evening hours.
20. Being at work is not safer than being at home. People who work are more likely to be injured at work than at home. This is especially true for men. Moreover, work-related injuries were more likely to result in hospitalizations than injuries originating outside of work.
21. Non-fatal injuries most frequently involved (in order) the person's back, legs, arms, and fingers. Back injuries alone generated nearly \$50 billion in costs.
22. Any of the major sources of data, such as the Bureau of Labor Statistics, National Institute for Occupational Safety and Health, Workers' Compensation, or National Health Interview Survey, by themselves underestimate the numbers of injuries and illnesses. The National Health Interview Survey especially may not be reliable. Several data sources must be examined and combined to produce overall, national estimates of injuries and illnesses.

These costs are great, but the reason for their size is no mystery. Roughly 120 million Americans worked in 1992. Every job carries some risks (Leigh 1995a). Many people are exposed to job-related safety risks of traffic accidents, falls, murder, electrocution, fire, being struck by objects, explosion, heat, cold, animal attacks, airplane crashes, as well as health risks from radiation, asbestos, silica, benzene, coal dust, tuberculosis, smoke, carbon monoxide, pesticides, benzidine, arsenic, lead, chromium, and stress leading to circulatory disease and cancer.

The estimates presented in this report are the result of an exhaustive compilation of data from a variety of sources. Chapters 2 through 9 present a

detailed account of our methodology and estimates. Each section of this summary has a corresponding chapter that provides a full description of the methods used to calculate that estimate.

In developing the estimates, we deliberately selected conservative rather than generous assumptions. The assumptions with greatest consequences are listed in Chapter 10. Here, we mention four---all of them conservative.

First, with 7.4% of the workforce unemployed, 1992 was a high unemployment year. When fewer people are employed, fewer job-related injuries and diseases occur.

Second, we did not account for health effects of occupational injuries and illnesses on the relatives of victims or, more importantly, for the cost of caregivers' time and energy. After a serious injury or disease, someone in the family frequently provides care.

Third, we restricted job-related circulatory disease deaths to people 65 years old and under. It could be argued that each job has a cumulative effect on circulatory disease that does not become evident while the person is working but that does become evident during retirement.

Finally, and perhaps most importantly, the direct and indirect methods of estimating costs we relied on ignored costs of pain and suffering. These costs would add an additional \$100 to \$700 billion to our overall \$173.9 billion estimate.

The costs of occupational injuries and illnesses are considerable, both in terms of economic resources and human suffering. Potential victims include anyone of the roughly 120 million Americans who work for a living. Costs are borne by workers, firms, consumers, and taxpayers.

II. Epidemiology of Injuries

Table 1.2 presents our estimates of deaths and non-fatal injuries. The methods through which these estimates were derived are presented in Chapter 2. Here, we discuss methods only briefly and present our main findings.

The estimate of the number of deaths from injuries was derived from five primary sources and three secondary sources, with the BLS's Census of Fatal Occupational Injuries (CFOI) given the heaviest weight. Our estimate of non-fatal injuries was an average of adjusted estimates from three primary and four secondary sources. The primary sources from non-fatal injuries included the BLS Annual Survey of Occupational Injuries and Illnesses (Annual Survey), the National Council on Compensation Insurance's (NCCI) Ultimate Reports, and the National Health Interview Survey (NHIS). These data have strengths and weaknesses as described in Chapters 2 and 5, and certain adjustments were necessary (e.g., the BLS Annual Survey suffers from a widely acknowledged undercount). Since some sources only had estimates up to 1985, 1989, 1990, or 1991, simple forecasting models were used to estimate the numbers of injuries and fatalities for 1992.

We estimated that 6,529 workers died from workplace-related injuries in 1992. As with any point estimate, our estimate of 6,529 represents a mid-point between an upper (7,567) and lower bound (6,063). Our point estimate is closer to the lower than upper bound because we have more confidence in the studies that generate low estimates of deaths. These bounds are presented in Table 1.2. These bounds are not confidence intervals. Bound estimates were suggested by at least one study or our own analysis. The lower bound estimates we obtained were presumed to be extreme minimums. For example, our lower bound on deaths (6,063) was drawn directly from the BLS' Census on Fatal Occupational Injuries (CFOI). The CFOI required that at least two documents (e.g., a death certificate and a Workers' Compensation claim) attest to the fact that a given injury fatality was job-related.

A disproportionate share of injuries, especially injury deaths (40%), were caused by transportation accidents including aircraft crashes, boat and rail accidents, but most importantly, vehicle collisions. Other causes of deaths were assaults and violent acts (20%), falls (10%), electrocutions (5%), fires, and explosions (3%).

In 1992, there were 13.247 million non-fatal injuries in the workplace. Disabling injuries accounted for 6.09 million and non-disabling accounted for 7.15

million injuries. Disabling means that the injury resulted in at least one day of work loss, while non-disabling means no full days of work loss.

Within the disabling category, there are several sub-categories. We relied on the Workers' Compensation (WC) categories: Permanent Total (PT), Permanent Partial (PP), and Temporary Total and Partial (TTP). Permanent Total is the most severe disability category. Although there are some legal exceptions it generally means the person will never work again any job. Permanent Partial is the next most severe category. It means the person will probably never work again at the old job, but again, with training, may find another job. Temporary Total and Partial means temporarily out of work or working at diminished capacity but fully anticipating returning to the old job. We estimated the percentages of disabling injuries in each WC category: 0.176% for PT, 12.497% for PP, 30.983% for TTP, and 56.344% for one-to-seven days of disability. This last category was necessary because WC requires at least three days and sometimes seven days of work loss before any of the three categories---PT, PP, and TTP---apply.

Table 1.2

Estimates of Injury Deaths and Non-fatal Injuries^a

			Lower and Upper Bound for Deaths and Total Non-fatal
Injuries			
Deaths	6,529 ^b		6063 ^b to 7567 ^b
Total non-fatal injuries	13.247	million	10.786 to 17.210
Non-disabling (54% of Total)	7.1534	million	
Disabling (46% of Total)	6.0936	million	
Permanent Total (.176% of disabling)	10,725 ^b		
Permanent Partial (12.497% of disabling)	.761517	million	
Temporary Total and Partial (30.983% of disabling)	1.88798	million	
One to seven days lost (56.344% of disabling)	3.43338	million	
Hospitalizations (7.02% of Total non-fatal injuries + 10% of Deaths)	.92994	million	

^aExcludes injuries to innocent third parties

^bDeaths and Permanent Totals not expressed in millions

Source: Current Study

III. Epidemiology of Illnesses

Tables 3.11 and 3.12 in Chapter 3 are summarized below in Table 1.3.

We estimated that 862,200 new cases of occupational illnesses and 60,290 deaths resulted from occupational diseases in the United States in 1992. Six disease categories causing death were identified: cancer, cardiovascular and cerebrovascular disease, chronic respiratory disease, pneumoconioses, nervous system disorders, and renal disorders. We assumed 100% of the pneumoconioses were due to occupational exposures. The occupational proportion for all other diseases was no more than .10. Lead, carbon monoxide, and solvent exposures as well as psychosocial stress have been linked to cardiovascular and cerebrovascular disease. Occupational exposure to coal, silica, grain dust, and cadmium have been

linked to chronic respiratory diseases. Job-related exposures to lead, mercury, glycol ethers, some solvents, and pesticides have been linked to renal disorders and nervous system disorders. The discussion of illness and morbidity appears in Chapter 6.

These estimates of illness were based on data collected by the Bureau of Labor Statistics (Annual Survey), public sector employee health and safety programs, the National Adult Blood Surveillance program, the National Health Interview Survey, the National Hospital Discharge Survey and the National Center for Health Statistics. The death estimates were based on data from the National Center for Health Statistics.

These estimates are considered conservative because the occupational origins of many cases of chronic occupational diseases are not identified by physicians. Since few causes of death are specific for occupational exposures, we principally used a proportionate attributable risk model to develop estimates of the numbers of deaths that occurred each year in the United States as a result of occupational exposures. While the data that support the development of these estimates have improved during the past 15 years, important gaps and serious potential for underestimation of the true number remain. An extended discussion of the strengths and weaknesses of these methodologies appears in Chapter 3.

Table 1.3
Estimated Occupational Disease Mortality (I)
and Morbidity (II) Due to Selected Causes, 1992

<u>I. Mortality</u>			
<u>Selected causes of death</u>	<u>Number of Deaths ages 25 and over</u>	<u>Estimated percentage due to occupation</u>	<u>Number of Deaths Number of deaths due to occupation U.S. 1992</u>
Cancer	517,090	6-10%	31,025-51,709
Cardiovascular and cerebrovascular disease	101,846 ^a	5-10%	5,092-10,185
Chronic respiratory disease	91,541	10%	9,154
Pneumoconioses	1,136	100%	1,136
Nervous system disorders	26,936	1-3%	269-808
Renal disorders	<u>22,957</u>	1-3%	<u>223-689</u>
Total (for mortality only)	713,506		46,899-73,681 (midpoint: 60,290)
 <u>II. Illness and Morbidity</u>			
<u>A. Survey-based Data Source</u>		<u>Number of Occupational Illnesses</u>	
BLS Annual Survey		457,400	
Adult blood lead surveillance program ^b		14,250 ^b	
Public employees ^c		92,010 ^c	
Subtotal		563,660	
 <u>B. Proportional Attributable Risk-based Data</u>			
Cancer; Coronary heart disease; Cerebral disease; Chronic obstructive pulmonary disease			
Subtotal		258,340-348,710	
Total (Morbidity only)		817,015-907,385 (midpoint: 862,200)	

^aOnly includes deaths between ages 25 and 64 years, inclusive.

^bThis figure excludes cases with elevated blood lead that is included in the BLS Annual Survey, estimated to be 3,500.

^cFederal Occupational Workers' Compensation Program, State-based Public Employees Occupational Safety and Health Programs.

^dExcludes overlap of 1485 cases of cancer, heart disease, stroke and COPD included in the BLS survey.

IV. Cost Methods

Economists have developed two methods for estimating the costs of injuries and illnesses: the Direct and Indirect cost method and the Willingness-to-Pay (WTP) method. The Direct/Indirect method is the most widely used method in medical settings. It is practical, intuitive, and easy to implement (i.e., numbers are available). The WTP method is more widely used in the economics literature. Many, but not all, economists believe it is theoretically more compelling than the Direct/Indirect method. All economists agree, however, that it is difficult to implement.

Direct costs represent actual dollars spent or anticipated to be spent on providing medical care to an injured or ill person as well as property damage, police and fire services, administrative costs for delivering benefits and direct costs to innocent third parties. Medical costs include doctors' and nurses' services, hospital charges, drug costs, rehabilitation services, ambulance fees, payments for medical equipment and supplies, as well as administrative and insurance charges associated with delivering the medical care.

Administration of indemnity benefits include the costs associated with providing workers' compensation indemnity and Social Security disability payments to injured and sick workers and their families. Property damage includes costs of damage to vehicles, machines, buildings and so on, directly associated with the injuries and illnesses. Direct costs are frequently referred to as "accounting" or "out-of-pocket" costs.

Indirect costs are not "out-of-pocket" costs. They represent foregone alternatives. The largest category of indirect costs include the injured or sick workers' lost earnings, fringe benefits and home production. Indirect costs also include employer costs associated with retraining and restaffing, co-worker costs of lost productivity, and risk of injury and illness to innocent bystanders.

The WTP method attempts to put prices on injuries and illnesses that are generated in private market transactions. The presumption behind WTP is that individual workers themselves are in the best position to evaluate the true value of medical costs, lost earnings, family hardship, pain and suffering, and so on, than researchers analyzing statistical data. These prices, theoretically, may be

observed through market transactions. (A detailed account of WTP is in Chapters 4 and 7).

But there are critics of WTP. First, WTP estimates represent marginal rather than average or total costs. Marginal costs are the more relevant costs for assessing, for example, how changes in OSHA regulations affect the costs of occupational injuries and illnesses. They may not be appropriate for measuring the overall national cost burden of an illness or injury, however. Second, the WTP method assumes considerable knowledge of health and safety risks especially at the job. But as we point out in Chapter 4, this is a questionable assumption.

In any case, almost all economists would agree that WTP estimates are less reliable at measuring WTP costs than Direct/Indirect estimates are at measuring Direct/Indirect costs. Moreover, we are not aware of any WTP estimates for occupational illnesses. On practical grounds, as in a lawsuit involving a wrongful death, there is considerable controversy among economists surrounding which method is preferred.

In this report, we present estimates derived from both methods. We prefer the estimates based upon the Direct/Indirect method, since these are more conservative estimates (WTP estimates tend to be two to five times the size of the Direct/Indirect method estimates).

V. Estimates of Direct and Indirect Costs of Injuries

In order to estimate the costs of injuries, we needed to estimate the number of different types of workplace-related injuries and multiply these by the average costs of such injuries. The data allowed us to specify three broad categories of injuries: deaths, disabling and non-disabling. The disabling injuries were, in turn, split into the Workers' Compensation (WC) categories so that we could match them with WC cost figures from the National Council on Compensation Insurance (NCCI) Ultimate Reports.

But WC cost figures from the NCCI did not capture all costs. Someone must pay these bills, collect premiums, and service the financial reserves. Insurance companies or their government agency equivalents have costs of administration, maintaining a reserve of funds and, in the case of companies, providing a

reasonable rate of return or profit to owners or shareholders. To incorporate these costs, we used a low average of estimates from the literature on administrative costs.

In 1992, injuries in the workplace generated a total cost to our economy of \$148.39 billion (see Table 1.4 here and Table 5.7 in Chapter 5). This estimate was derived using the Direct/Indirect method.

Direct costs of fatal and non-fatal injuries in the workplace were \$50.1046 billion in 1992. While these costs were clearly substantial, they represented only roughly 34% of total costs, with indirect costs contributing 66%.

Costs can be further described within the broad direct and indirect categories, shown in Table 1.4 and Table 5.7. Of the \$30.8 billion in direct costs, \$25.1 billion went to doctors, hospitals, drug companies, nursing homes, rehabilitation providers, and so on. Roughly \$5.7 and \$8.7 billion went to cover medical and indemnity insurance administration expenses. Roughly \$8.7 billion went for property damage; .8 for policy and fire services; .9 for direct costs to innocent bystanders.

The calculation of the indirect costs is based upon a variety of sources including indemnity data in the NCCI and national government data on employment, earnings, and mortality. Fatal injury cost estimates rely on a present value calculation. Home production, hiring, training and workplace disruption, and so on are priced in accord with estimates in the literature.

The \$98.18 billion of indirect costs can also be disaggregated (Table 1.4 and Table 5.8): \$68 billion in wage losses; \$14 billion in fringe benefits; \$8 billion in home production losses (home production refers to lost or diminished ability to participate in running a household,

Table 1.4

Summary of Costs

I. Direct Costs Total	\$ 50.1046
A. Medical costs for doctors, hospitals, drugs, and so on	25.0739
B. Administration of WC (31%); and Medicaid, Welfare, Medicare, private insurance and others (16% combined)	5.7012
C. Administrative costs on indemnity payments for WC (31%); and Social Security, Welfare, Private Insurance, Private Insurance (10% combined) (These percentages apply only to indemnity)	\$ 8.8645
D. Property damage costs	\$ 8.7497
E. Police and Fire Services	\$.7801
F. Direct costs to innocent third parties	\$.9322
II. Indirect Costs	\$ 98.1837
A. Lost earnings	\$ 68.1559
1. Fatalities	2.5481
2. Non-fatalities	65.6078
B. Fringe benefits	\$ 14.3332
1. Fatalities (16% women, 22% men)	.5556
2. Non-fatalities (21% everybody)	13.7776
C. Home production	\$ 8.2059
1. Fatalities (see Tables 3.5 & 3.6)	.3067
2. Non-fatalities (same as average % for fatalities: 12.93%)	\$ 7.8992
D. Workplace training, restaffing, disruption	\$ 5.1986
1. Fatalities	.0397
2. Non-fatalities	5.1589
E. Time delays	\$.3091
1. Fatalities (3.7% of total)	.0114
2. Non-fatalities (96.3% of total)	.2977
F. Indirect costs to innocent third parties	\$ 1.9810
1. Fatalities (3.7%)	.0733
2. Non-fatalities (96.3%)	1.9077
Grand Total	\$148.3883 billion

including child-care, repairs, cooking); \$5.2 billion for workplace training, restaffing and disruption; \$.3 for time delays; and \$1.98 for injuries to third parties. Much prior estimation has ignored the value of home production, and injuries to third parties.

VI. Estimates of Direct and Indirect Costs of Illnesses

Occupationally related illnesses contributed \$25.5353 billion to national economic costs (Table 1.1 here and Table 6.1, Chapter 6). Roughly 63% of these costs were attributed to direct costs while 37% were attributed to indirect costs. The methods used to derive these estimates are given in Chapter 6. Here, we briefly note that we used an established accounting method (Rice, et al. 1989) which attributes proportionate shares of total national health care expenditures to illness categories. Epidemiology estimates of the share of these costs attributable to occupational illness categories were developed by Markowitz, et al. (1989). For example, 8% of cancer costs were estimated to be occupationally-related while 100% of pneumoconioses costs (primarily lung diseases) were attributed to occupation.

Table 1.5 (and Table 6.3) shows the categories of fatal diseases, the estimated proportion due to occupation, and direct and indirect costs in billions of 1992 dollars. Of the total \$19.693 billion, nearly half, \$9.374 billion, is attributable to workplace-related cancers. Cardiovascular diseases, such as hypertension and stroke, contribute the next greatest share of total costs for fatalities.

Indirect costs are particularly significant (i.e., they are higher than direct costs) for occupationally-related cancer, pneumoconioses, and renal disorders. This is due to higher death rates at younger ages associated with these diseases. Indirect costs are disaggregated further in Table 1.5 and Table 6.3, where we show the costs of morbidity (lost productivity due to illness) and mortality. Mortality costs account for the largest share (78%) of indirect costs.

Table 1.5

**Range of Total Costs of Occupational Injuries by
Direct and Indirect Costs by Disease (Midpoint estimates)
(Costs in 000s)**

	Cancer	Nervous System Disorders	Respiratory Disorders	Cardiovascular Diseases	Renal Disorders	TOTAL
Direct Cost	\$4,521,965	\$241,740	\$8,585	\$2,634,150	\$3,214,237	\$78,993
Indirect Cost	\$4,851,902	\$ 44,380	\$193,069	\$1,270,471	\$2,561,202	\$71,839
Mortality	\$4,160,602	\$ 25,393	\$ 77,470	\$ 511,019	\$2,196,282	\$32,438
Morbidity	\$ 691,300	\$ 18,967	\$115,599	\$ 759,452	\$ 364,921	\$39,402
TOTAL	\$9,373,867	\$286,120	\$201,654	\$3,904,621	\$5,775,439	\$150,833
						\$19,692,534

SOURCE: U.S. Health Care Financing Administration, Health Care Financing Review, Fall 1994; National Hospital Discharge Survey; National Center for Health Statistics, 1992; National Nursing Home Survey; National Center for Health Statistics, 1985; Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor, 1993; Money Income of Households, Families and Persons in the United States, 1992; U.S. Bureau of the Census, 1992.

TABLE 1.5, TYPED IN MICROSOFT WORD FOR IBM AND LABELED TBL15WRD.DOC ON DISKETTE,
BELONGS HERE.

VII. Willingness-to-Pay Estimates of the Costs of Injuries and Illnesses

As noted above, an alternative method for determining the cost of injuries and illnesses is the Willingness-to-Pay method (WTP). The WTP method is designed to be comprehensive (i.e., it does not split costs into direct and indirect groups). It attempts to put prices on injuries and illnesses that are generated in private market transactions unfettered by Medicaid, Workers' Compensation, government subsidies, and so on.

We use the summary of WTP estimates in Viscusi (1993) to price our deaths, injuries and illnesses. We use \$4 million for each death and \$40,000 for each non-fatal injury and disease. These WTP estimates apply to everyone. Reliable WTP estimates that vary by age or gender, for example, are not available.

Assuming 6,529 injury and 60,290 disease deaths at \$4 million per death in 1992 (Viscusi 1993), our WTP cost estimate for deaths only would be \$267.276 billion. The calculation for non-fatal injuries and illnesses is a little more involved, depending on the estimates used for non-disabling injuries. Moreover, only a handful of studies have addressed non-fatal injuries. The WTP value of job-related injuries has ranged between \$13,810 to \$89,408, with the mean value being around \$40,000 (Viscusi 1993). Assuming 13,247,000 non-fatal injuries and 857,500 diseases priced at \$40,000 yields a cost of \$564.180 billion. These two estimates sum to \$831.456 billion. But the \$40,000 may only apply to disabling injuries. Assuming 46% are disabling, we multiply \$564.180 by .46 to yield \$259.5228 or 260. Summing 260 with 267 yields \$527 billion. Our WTP estimates therefore range from \$527 to \$831 billion. Since GDP in 1992 was 5.9507 trillion, these \$527 to \$831 billion represent roughly 9% to 14% of GDP. These high WTP numbers point out a shortcoming of the WTP method. Another high estimate will further illustrate this point. All U.S. injury and disease deaths occurring on and off the job totalled to roughly 2.2 million in 1992. Multiplying 2.2 million deaths by 4 million dollars per death yields \$8.8 trillion. Thus, all deaths would cost more than the GDP of the United States using the WTP method.

VIII. Workers' Compensation Cost Estimates Across Occupations and Industries

In Chapter 8, we analyze the industries and occupations that contribute the most to costs. Contribution is evaluated both in the total volume amount and in a per capita or per worker amount. The level of employment will obviously influence the total volume amount. The per capita amount is probably a better measure of the hazardous nature of the job as viewed by an individual worker.

The data used to generate these rankings were drawn from a large Bureau of Labor Statistics data set: the Supplementary Data System (SDS). Illness cases were included in the SDS, and WC boards would have attested to the veracity of these occupational illnesses.

As we will see in Chapters 2 and 3, WC underestimates injuries and especially illnesses. The SDS, therefore, is not the most reliable data for estimating the overall burden of occupational injuries and illnesses. It appears to have the best data available for estimating relative cost burdens, however, i.e., one occupation compared to another. No other single data set with which we are familiar has occupation and industry data with consistent information on types of injuries or illnesses that can be matched to WC average costs.

The industries that contributed the most to the total volume of costs (Table 8.1, Chapter 8) and to cost-per-worker (Table 8.3, Chapter 8) were trucking, public safety, motor vehicle manufacturing, construction, meat products, and many transportation industries. Occupations (Table 8.2, Chapter 8) that contributed the most to the total volume of costs and to per-worker costs included truck drivers, miscellaneous operators and laborers, construction laborers, nursing aides and orderlies, janitors, garbage collectors, warehouse workers, and operatives n.e.c..

The occupation lists reinforce the view that many of the most hazardous jobs carry the least prestige and pay. Moreover, the high ranking of laborers, operatives n.e.c., garbage collectors, and warehouse workers, is consistent with other research (Leigh 1995a) suggesting that many of the most dangerous jobs are not generally regarded as dangerous by the public. Also high on the list are apprentices of all sorts. Their high ranking could be the result of the fact that inexperienced employees suffer a disproportionate share of injuries.

IX. Who Pays?

Economic research, reviewed in Chapter 9, suggests that as much as 80% of WC costs are borne by workers in the form of lower wages. These lower wages apply to all employees regardless whether they experience any job-related injury or illness. But as we will see, WC covers only about 45% of all costs. We estimate that the majority of costs are borne by injured workers and their families as well as workers in general who receive lower wages than they would otherwise. Nevertheless, a significant proportion of costs are also paid by firms, consumers, and taxpayers.

X. Limitations and Assumptions

Limitations are discussed in Chapter 10. The most serious limitation is that no single source of data provided all of the information we needed. In all, we considered 11 primary data sources and over 300 secondary sources of data from other studies. Each data source had limitations and numerous assumptions had to be made in our analysis. The most important of these assumptions appear on our list of 36 consequential assumptions in Chapter 10. In making these assumptions, we erred on the side of conservatism (i.e., we more often invoked assumptions which yielded the lowest estimate). Out of 36 assumptions, 31 resulted in lower estimates and four in higher estimates than would otherwise be the case (one assumption was ambiguous). Moreover, we believe our reasons for invoking the four higher estimate assumptions were compelling.

XI. Cost Comparisons with other Health Problems

We find that the medical costs of occupational injuries and illnesses are over four times the medical costs of AIDS. The direct and indirect costs combined are roughly as great as either the costs of heart diseases and stroke or the costs of cancer.

A case could be made for reallocating some dollars from, say, heart disease prevention, cure and research, toward occupational injury and illness prevention, cure and research. This case would be based on the economic laws of diminishing returns and increasing opportunity costs. Put simply, the last, say, 5% of heart

disease spending could be re-allocated to occupational injury and illness spending with a substantial net gain in lives saved and overall health.

XII. Conclusion

Our study attempted to estimate the total costs of occupational injuries and illnesses to the United States in 1992. This study appears to be the first to use national data to estimate these costs. We find that the costs of occupational injuries and illnesses are considerable, surpassing those of AIDS and on a par with those of cancer and heart disease. Potential victims include any one of the roughly 120 million Americans who work for a living. Since the injuries and illnesses occur at places of business, some of their costs are spread to consumers in the form of higher prices throughout the economy and all workers in the form of lower wages. But despite the size of these costs and the fact that so many people pay them, occupational injuries and illnesses do not receive the attention they deserve. The National Institute of Occupational Safety and Health (NIOSH) receives one of the lowest levels of funding of the nearly 20 National Institutes of Health and related agencies in the Centers for Disease Control. NIOSH research awards sum to roughly one half of 1% of the National Cancer Institute, less than 1% of the National Institute on Aging, and roughly 7% of the National Institute on Dental Research (U.S. Department of Health and Human Services 1992, 1993). Moreover, the NIOSH budget has been cut more than most other federal research institutes in recent years (McGarity and Shapiro 1993, p. 187).

Out of four years of medical training, the typical American doctor receives six hours of instruction in occupational safety and health. There are more fish and game inspectors in the United States than OSHA inspectors (McGarity and Shapiro 1993, p. 213). Finally, the national debate on medical care rarely addresses occupational safety and health issues. This is unfortunate. The potential for medical cost savings from prevention of occupational injuries and illnesses appears to be significant.

CHAPTER 2

Incidence of Occupational Injuries

Chapter 2: Incidence of Occupational Injuries

Outline

- I. Introduction**
- II. Fatalities**
 - A. Primary Sources**
 - 1. Census of Fatal Occupational Injuries (CFOI), conducted by the Bureau of Labor Statistics (BLS)
 - 2. National Traumatic Occupational Fatalities (NTOF), conducted by the National Institute for Occupational Safety and Health (NIOSH)
 - 3. Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics (BLS's Annual Survey)
 - 4. National Council on Compensation Insurance (NCCI), a private company collecting Workers' Compensation (WC) data
 - 5. Supplementary Data System (SDS), conducted by the BLS that in turn drew data from many Workers' Compensation (WC) insurers
 - B. Secondary Sources**
 - 1. National Safety Council (NSC), a not-for-profit company
 - 2. Private researchers
 - a. Miller (1994)
 - b. Mason (1989), study commissioned by NIOSH
 - c. Rossman, Miller and Douglas (1991), study commissioned by NIOSH
 - d. Marquis (1992), Congressional testimony
 - C. Table 2.3 summarizes deaths from 1980 to 1992**
- III. Non-Fatal Injuries**
 - A. Primary Sources**
 - 1. Bureau of Labor Statistics' Annual Survey of Injuries and Illness (BLS's Annual Survey)
 - a. Introduction
 - b. Estimates
 - c. Historical trends
 - 2. NCCI, a private company collecting WC statistics
 - 3. National Health Interview Survey (NHIS), conducted by the National Center for Health Statistics (NCHS)
 - B. Secondary Sources**
 - 1. Hensler, et al. (1991) and Marquis (1992), researchers with Rand
 - 2. Rossman, Miller and Douglas (1991), private researchers, study commissioned by NIOSH

3. Miller (1994), private researcher
 4. National Safety Council (NSC), a not-for-profit company
 5. Mason (1989), private researcher, study commissioned by NIOSH
- C. Classification scheme and Table 2.12 summarizing non-fatal estimates in latest year available and for 1992
- IV. Collateral Damage and Summary Table 2.14 Including Deaths and Non-Fatal Injuries
- V. Demographic, Occupational, Industrial and Regional Differences in Frequencies and Rates
- A. Demographics
 1. Age and Experience
 2. Race, ethnic origin
 3. Gender
 4. Self-employed and small firms
 - B. Occupations and Industries
 1. From the BLS's Annual Survey
 2. From the National Traumatic Occupational Fatality Study
 3. From the Census of Fatal Occupational Injuries (CFOI)
 - C. Geography, States
- VI. Causes of Death and Types of Non-fatal Injuries
- A. Causes of Deaths
 - B. Types of Non-fatal Injuries
 1. Data from the National Safety Council (NSC); from Hensler et al. (1991) and Marquis (1992); and from Rossman, Miller and Douglas (1991)
 2. Data from the National Health Interview Survey (NHIS); and NHIS from the Occupational Health and Safety Supplement (NHIS-OSH Supplement), 1988
 3. Data from the NHIS, 1985-87
 4. Data from the Annual Survey of Occupational Injuries and Illnesses (BLS's Annual Survey)
- VII. Conclusion

Chapter 2: Incidence of Occupational Injuries

I. Introduction

In 1966, Secretary of Labor Willard Wirtz offered the following testimony to Congress (Lemen et al. 1989):

Mr. Chairman, and members of the Committee, while we sit here talking, from now until noon, seventeen American men and women will be killed on their jobs.

Every minute we talk, 18 to 20 people will be hurt severely enough to have to leave their jobs--some of them never to work again.

In the time these two sentences have taken, another 20 people--one every second--have been injured on the job--less seriously, but in most cases needlessly.

Today's industrial casualty list--like yesterday's--and tomorrow's--and every working day's in each week, after month, after year--will be 55 dead, 8,500 disabled, over 27,200 hurt.

The figures for the year will be 14,000 to 15,000 dead, over 2 million disabled, over 7 million hurt.

More recently, an analysis of the Office of Technology Assessment (OTA) of the Congress concluded that at least 4,650 and as many as 13,200 workers died each year between 1979 and 1983 as a result of job-related injuries (Office of Technology Assessment 1985). In 1985, the U.S. Congress estimated that job-related deaths due to injuries were 13,000 per year (Lemen et al. 1989). As we will see, what is surprising about the Wirtz quote and the OTA and Congressional conclusions are that the numbers from 1966, 1979, 1983, and 1985 are not terribly different from those today. From these early years of recording injuries, the number of fatal injuries has declined somewhat while the number of non-fatal injuries has nearly doubled.

The primary purpose of this chapter is to update these estimates to 1992. Our secondary purpose is to provide some descriptive analyses of the demographic, occupational, industrial, and geographic characteristics of job-related injuries as well as an analysis of the kinds of injuries that occur.

This chapter is split into seven sections, some with several subsections. The first is this Introduction. Sections II and III present national estimates for the number and rates of fatal injuries and non-fatal injuries. Within the fatal injuries section, five primary and five secondary data sources are discussed. The

primary sources include 1) the Bureau of Labor Statistics' (BLS) Census of Fatal Occupational Injuries (CFOI); 2) the National Institute for Occupational Safety and Health's (NIOSH), National Traumatic Occupational Fatalities (NTOF) study; 3) the BLS's Annual Surveys of Occupational Injuries and Illnesses from 250,000 to 280,000 private firms (Annual Survey); 4) the Workers' Compensation (WC) data from 38 to 41 states and the District of Columbia collected by the National Council on Compensation Insurance (NCCI); and 5) the BLS's Supplementary Data System (SDS) of seven to 11 states Workers' Compensation (WC) records. The secondary sources (i.e., someone else's interpretation of primary data) include studies by 1) the National Safety Council (NSC); 2) Miller et al. (1995); 3) Mason (1989); 4) Rossman, Miller, and Douglas (1991); and 5) Marquis (1992). Each of the sources and their corresponding statistics are classified in separate subsections. The CFOI and the NTOF receive our greatest attention since they appear to be the best data available. Table 2.3 summarizes the estimates from all of the sources. A final estimate is then derived based upon these prior studies.

Section III-Non-fatal Injuries-is also split into subsections based upon primary and secondary data sources. The primary sources include: 1) the BLS's Annual Survey; 2) the NCCI data; and 3) the National Health Interview Survey (NHIS). The secondary sources include: 1) Marquis (1992), who drew her data from the Hensler et al. (1991) study at the Rand Institute for Civil Justice; 2) Rossman, Miller, and Douglas (1991); 3) Miller et al. (1995); 4) the National Safety Council (1993); and 5) Mason (1989). The BLS's Annual Survey and the NHIS receive our greatest attention again because they appear to be the best data. Tables 2.11 and 2.12 summarize the estimates from all sources.

Section IV discusses non-occupational injuries to innocent bystanders. These injuries are especially important when evaluating occupational vehicle and aircraft crashes. We also discuss a neglected area of occupational injuries: the injury and illness burden on the families. When a serious occupational injury affects the breadwinner, families react, and some family members, especially caregivers and children, may experience injuries and illnesses themselves.

Section V addresses the demographic, occupational, industrial, and geographical characteristics of victims. The CFOI, NTOF, BLS's Annual Survey and

the 1988 NHIS data are especially rich in their detail on the characteristics of victims. Section VI investigates the nature, source, and type of injuries. The CPOI and the NTOF have extensive information on the characteristics of deaths and the Annual Survey and the NHIS have considerable information on the characteristics of non-fatal injuries.

The conclusion is presented in Section VII.

Carpal Tunnel Syndrome (CTS) and other repetitive trauma disorders have aspects of injury, but we (as well as the Bureau of Labor Statistics) treat them as illnesses, hence, they are not discussed in this chapter. We, as well as the BLS, do regard back pain as resulting from a back injury and thus include these conditions in this chapter.

II: Fatalities

Five primary sources—CPOI, NTOF, Annual Survey, SDS, and NCCI—and five secondary sources—NSC, Miller et al. (1994), Mason (1989), Rossman et al. (1991), and Marquis (1992)—are introduced in this Section. A summary Table 2.3 is also presented that includes our best estimates of fatalities.

II.A.1 Census of Fatal Occupational Injuries (CFOI)

The Census of Fatal Occupational Injuries (CFOI) is one of the most current and arguably the most reliable of all the data sets we will examine. The CFOI was initiated by the BLS in response to an expert panel from the National Academy of Sciences (National Research Council 1987) that "found it rather startling that an agreed upon method has not been devised to estimate a phenomenon as basic as traumatic death in the workplace." The CFOI was designed to be a true census, or complete counting of job-related injury deaths. There were no limitations imposed such as relying on only WC records, only OSHA records, only death certificates, and so on. Stout and Bell (1991) and Jack and Zak (1993) have shown that no single private, state, or national system, such as WC, or OSHA's form 200, or the BLS's *Annual Surveys of Injuries and Illnesses*, or the National Council on Compensation Insurance (NCCI) reports, or police reports, provide a complete count. WC, for example, has never covered 100% of all employees in any state. This is a key

finding of our study. Apart from the CFOI, the NTOF, and a National Center for Health Statistics (NCHS) study on asbestosis, silicosis, pneumoconiosis and mesothelioma, there are no single sources of data that provide credible national estimates on occupational injuries or illnesses. And, as we will see, even the CFOI, the NTOF, and the NCHS studies have limitations.

Table 2.1 indicates the sources used to compile the CFOI for 1992. Table 2.1 is drawn verbatim from Jack and Zak (1993)—a government publication. But before we explore each of these sources, we want to emphasize the most important findings in Table 2.1. Most prior studies of fatal (and non-fatal) injuries have relied on only one of the sources in Table 2.1. But none of the sources are complete. Below, we detail the reasons for the lack of completeness. Here it will suffice for us to underscore that death certificates missed 28%, WC reports missed 60%, and OSHA form 200 reports missed 63% of the deaths.

The CFOI initially counted 6,083 job-related deaths for 1992. We say "initially" since in the Fall of 1994, the CFOI investigators added an additional 134 deaths that were missed in the initial 1992 study. However, the analysis they conducted on the initial 6,083, including the analysis of Table 2.1 below, were never attempted on the 6,217 (6,083 + 134). We, therefore, will rely on the 6,083 as we analyze the CFOI. We will use an adjusted CFOI number in our final count. Our adjustments will add the 134 discovered in the Fall of 1994, but will exclude 154 military deaths. The 6,083 includes 154 deaths among persons in the Armed Forces residing in the United States. The majority (72%) of the deaths in Table 2.1 were initially located or corroborated with death certificates marked "at work." An additional 1,274 deaths had certificates, but were not marked "at work." The fact that death certificates could not be relied on for 100% coverage is an important finding and it has been corroborated in several studies. A study from Indiana (Ruble 1993) indicated that death certificates missed 17% of job-related deaths. Stout and Bell (1991) found that certificates would have excluded 19% of job-related deaths in their study. In California, Kraus et al. (1990) found that 83% of job-related deaths among persons over age 64 were not recorded as an injury at work on the death certificate.

Table 2.1

Source Documents Used to Compile the
Census of Fatal Occupational Injuries, 1992

Source Document	Fatalities	
	Number	Percent
Total	6083 (or 5929)*	100
Death certificates	4359 (or 5633)**	72 (or 93)**
State WC reports	2434	40
Coroner, medical examiner	3768	61
OSHA reports	1926	32
News media	2077	34
Follow-up questionnaires	1504	25
State motor vehicle reports	485	8
Other federal reports (e.g. MSHA)	328	5
Other reports (e.g. local police)	2033	33

* The 6,083 also includes 154 deaths among persons in the Armed Forces residing in the United States. We will exclude these 154 military deaths but include the 134 omitted deaths in our final CFOI estimate.

**The number and percent of death certificates in parentheses include 1,274 certificates initially not marked "at work."

Source: Bureau of Labor Statistics, CFOI

Fatal injuries in agriculture were undercounted by roughly 20% according to Murphy et al. (1990). Other estimates of underreporting of job-related fatalities due to incorrect marking of "injury at work" have ranged from 12% to 33% (Colorado Department of Health 1988; Davis et al. 1987; Karlson and Baker 1978; Baker et al. 1982).

One explanation for the omissions resulting from reliance on death certificates could be due to the fact that motor vehicle crashes are the most frequent cause of job-related deaths. Motor vehicle crashes have frequently not been regarded as job-related by the public or by some OSH researchers (Baker et al. 1982, pp. 114-15; and National Safety Council 1993, p. 39). The original OSHA legislation, for example, did not extend any regulations to operating motor vehicles. Only recently has the OSH Administration propagated rules to govern vehicles and drivers (Rolle 1993). An example will illustrate the point. A

self-employed real estate agent may have been killed in a car accident at 8:00 p.m. while traveling to meet a client. Since the self-employed are frequently excluded from WC coverage, the only official report would be a police accident report or coroner's information on a death certificate. But police reports of crashes may be defective. In Washington state, there is no code or identifier on the police traffic collision reports to indicate the decedent was working at the time of the accident (Rolle 1993). The CFOI investigators, in fact, acknowledge that "traffic accident reports usually cannot be used to verify work relationship because they do not contain information on the purpose of the trip" (Toscano and Windau 1993).

Moreover, a coroner, who has no knowledge of the purpose of the trip, may not check the "at work" box on a death certificate. Runyan, Loomis, and Butts (1994) present evidence that coroners have difficulty determining whether many crashes were job-related.

The point is, it is likely that the real estate agent's death would not be reported on any report or certificate as job-related.

The CFOI relied heavily on death certificates to either identify the deaths or corroborate another source. Given the problems associated with death certificates, this heavy reliance suggests that the CFOI may be undercounting job-related deaths.

Another source for the CFOI could have been a special BLS questionnaire sent to employers or employees' next-of-kin. The questionnaire was sent if only one other source was available for the death. But the questionnaire approach entails some problems. Employers may not be forthcoming about the death, especially if they feel it may trigger an OSHA inspection. Responses from next-of-kin to questionnaires about dead relatives are also likely to be scattershot.

The CFOI researchers also searched through newspaper obituaries. But with over two million Americans dying every year, searching through newspaper obituaries is a daunting task.

The CFOI researchers required that two independent sources confirm a death. The requirement of two substantiating sources was designed to improve the reliability of the CFOI data. No other data set we will investigate here had this

requirement. The minimum of two substantiating sources could be criticized, however, as resulting in an undercount. Some employers may not want to acknowledge that a death was job-related. Some employees and their families might be poorly informed concerning reports or claims that should have been filed after a job-related death. For example, one study showed that 22% of potentially eligible WC death claims were never filed (Taylor, Davis, and Brooks 1993). The same authors could not determine whether the lack of claims were due to employers' or families' failure to report.

Another troubling aspect of the CPOI involved the exclusion of 1,361 incidents that were regarded as illnesses. Most of these incidents were recorded as "heart attack while at work" (personal communication with Guy Toscano, 5 May 1994). Many of the "heart attack" cases, in turn, were referred to the CPOI from state WC boards. WC boards have strict guidelines regarding heart failure. In some cases, physician reports and testimony must persuade the WC board that the heart failure was job-related. This is easiest to prove when the heart attack occurred immediately after traumatic injury. The injury itself can put so much physiological strain on the heart that the heart fails (Lown 1979). In other cases, certain occupations are assumed to involve so much stress that even a heart attack away from work may automatically qualify the worker for WC benefits. State law in California, for example, requires WC to compensate for all heart attacks experienced by fire fighters and police officers even if the attack occurred at home.

The CPOI investigators were aware of the possibility that a heart failure could have resulted from a traumatic event, but unless evidence from one of the sources was presented of such an event precipitating the heart failure, then these cases were excluded. Some of these "heart attack" cases may have been improperly excluded by CPOI investigators, not because of investigators' oversight, but because WC records, OSHA reports, police records, and so on, as we have seen, may not always be complete.

The CPOI is the best data set available on injury deaths. But because of the omission of diseases, it is defective in measuring the overall mortality experience of jobs (Leigh 1995a) and cannot be used in our analysis of illnesses

and diseases. This is not the case in other large data sets we will examine. Heart failures, for example, are regularly included in SDS/WC data and the BLS's Annual Survey data introduced below.

As we will see in Section V of this chapter, a troubling race finding emerged from the CFOI 1992 data. There was virtually no difference in the fatality rates for whites (4.938) and blacks (4.962). This finding stands in contrast to almost all other occupational studies and general studies on death rates for injuries that investigated black/white differences. For example, the NIOSH, NTOF study found a black rate of 6.5 per 100,000 and a white rate of 5.8 per 100,000. Cone et al. (1991), in studying data from California, found blacks had job-related injury deaths roughly 20% higher than whites and Hispanics. Copeland (1985) found that blacks contributed to 28% of job-related traffic fatalities compared to a 72% contribution by whites. Yet, the black percentage in the working population was far less than 28%. In the Baker et al. (1982) study of job-related deaths in Maryland, "non-whites were greatly over-represented, constituting 34% of the deaths and 17% of the employed population." It is likely that the large majority of Baker's non-whites were black, given that Maryland's Hispanic population is small compared to, for example, Texas, New Mexico, Arizona, California, Florida, or New York.

In a study using six national data sets and focusing on job exposures to safety and health hazards, Robinson (1991) found African-Americans with higher exposures level than whites in all six data sets. He also found Hispanics with greater hazard exposures than non-Hispanic whites. For all injuries—not just occupational—Baker, O'Neal, Ginsburg, and Li (1992), found a black rate of 82 per 100,000 and a white a rate of 60 per 100,000.

Finally, the racial composition of occupational groups presents compelling evidence that further questions the reliability of the CFOI estimates. African-Americans are over-represented in blue-collar, manual, and unskilled laboring jobs (Gill 1994). Whites are over-represented in professional and managerial jobs (Gill 1994). But blue-collar, manual and laboring jobs are more hazardous than white-collar professional jobs. Root and Sebastian (1981) found blue-collar job occupants with four to five times the number of injuries as

white-collar jobs. An April 1994 BLS News report based on the Annual Survey confirms this tendency for blue-collar jobs to be much more hazardous than white-collar jobs (U.S. Bureau of Labor Statistics 1994b). Operators, fabricators, and laborers contributed 41% of all injuries, yet their employment contribution to the U.S. labor force was less than 15%. None of the 30 occupations generating the most injuries in the 1994 U.S. Department of Labor News report based on the Annual Survey were professional and only one—sales supervisors—was a managerial occupation (U.S. Bureau of Labor Statistics 1994b).

The fact that the CFOI estimated white and black kill ratios were virtually identical is, therefore, disquieting. There may be an undiscovered flaw in the CFOI methods.

Several factors could be at work. Some CFOI deaths were identified through newspaper obituaries. It could be that some newspapers omit a higher proportion of black than white deaths from their obituaries. Police reports and death certificates may also be less complete about the circumstances of a black than a white death. Longstanding patterns of bias may, therefore, result in fewer black deaths being counted.

Assuming this is true, we could adjust the CFOI estimate in the following way. (We will not rely on these adjustments in our calculations for the overall estimates of deaths. These adjustment calculations are included to provide an impression of the size of possible undercounts in the CFOI). The NIOSH, NTOF estimate suggests that the black rate would exceed the white rate by 12.1%. The Robinson (1991, p. 97) non-fatal injury data would suggest that the black rate would exceed the white rate by 42%. The average of the two estimates is 27%. Applying this 27% to the CFOI white rate yielded an estimated black rate of 6.2713. Assuming roughly 12,252,000 employed blacks in 1992 (Toscano and Windau 1993), then the 6.2713 rate for blacks would result in an estimate of $.000061713 \times 12,252,000$ or 768 black deaths as opposed to the 608 deaths recorded in the CFOI for 1992.

The CFOI counted 508 Hispanic deaths which yielded a rate of 5.589. This exceeds the 4.938 rate for whites. A higher rate for Hispanics than non-Hispanic whites has been found by Robinson (1991) using data on non-fatal injuries. But the

5.589 Hispanic rate may also be an underestimate. Robinson's data suggests Hispanics have a rate 79% higher than whites. Assume Robinson's rate is an overestimate, but that a 50% rate applies. This would result in an Hispanic rate of 7.407. Assuming 9,088,000 employed Hispanics in 1992 (Toscano and Windau 1993), this 7.407 rate would imply 672 deaths. But the Hispanic categories differ across the samples (i.e., sometimes whites were identified as non-Hispanic and other times the non-Hispanic adjective was not mentioned). Assuming 95% of Hispanics were not included in any of the race categories in the BLS employment data identified in Toscano and Windau (1993), we must, therefore, multiply 164 by .95 to yield 156.

We estimate 140 more black deaths and 156 more Hispanic deaths than were counted in the CFOI. Adding the two yields 296 more deaths to the CFOI total of 6,063 (6,083 - 154 military deaths + 134 late deaths). We, therefore, estimate 6,359 (6,063 + 296 = 6,359) "race-adjusted" job-related deaths based on the CFOI data for 1992.

This 6,359 estimate assumes that the only problem in the CFOI is an undercount of blacks and Hispanics. No adjustment was made of the undercounts associated with 1) heavy reliance on death certificates; 2) improperly recorded "heart attacks"; 3) the strict two source corroborating requirement; or 4) the general problems suggested by the questionable lack of rate differences for blacks and whites and the modest rate differences between whites and Hispanics. That is, the race and ethnic problems suggest a larger problem of counting people in low-paying jobs. We do not adjust for any under-reporting of deaths in low-paying jobs.

We are not alone in our belief that the 1992 CFOI underestimated the number of deaths. The CFOI authors themselves, Toscano and Windau (1993), state that as counting methods improve, "fatal work injury counts may increase." They do not suggest that the counts may decrease. In other words, they believe their count is conservative (personal communication with Guy Toscano 5 May 1994). In fact, errors of omission were discovered in the 1992 counts as the 1993 CFOI counts were being prepared (U.S. Department of Labor, Bureau of Labor Statistics, News August 10, 1994). As our study was being written, CFOI researchers discovered 134 new

fatalities from 1992. Mr. Toscano believes the true number of deaths will be revised even higher as CFOI research methods continue to improve (personal communication, January 30, 1995). The original, unadjusted 1992 CFOI estimate is now 6,217 (as of August 1995).

In the calculations that follow, we will not rely on our 6,359 "race-adjusted" number. This reflects our desire to be conservative in estimating the number of injuries and illnesses. We will, however, account for the 134 1992 deaths found by the CFOI in the Fall of 1994 and the 154 military deaths. Subtracting 154 military deaths and adding 134 subsequent deaths leaves us with 6,063. Our "race-adjusted" estimate would be 6,359.

The inclusion of 154 resident Armed Forces deaths by the CFOI is commendable. However, as we will see, no other study attempted to include the military. Ideally, we, too, would like to include them. But as a practical matter, so that we can avoid as much interpolation as possible, we will ignore resident Armed Forces injuries. It is nevertheless worth noting that Toscano and Windau (1993) found that they represented about 3% of the total.

One last comment merits attention. The CFOI count was prevalence-based. It could be argued that the prevalence death estimates are too low. Some injuries that occurred in 1992 may not kill the person for some time. Rice et al. (1989), in their study of all injuries, found that roughly 9% of their deaths were attributed to accidents in prior years. Assuming the same percent would apply to our analysis, roughly 600 more deaths should be added to the CFOI. But, this argument is misleading. The CFOI estimate counts all deaths in 1992 and includes deaths that may have occurred a year or more after the accident. In other words, some 1992 CFOI deaths could have resulted from an accident that occurred in 1991 or perhaps 1990.

We therefore assume that the same number of delayed deaths from 1992 into the future will occur as did occur in prior years up until 1992. Since injury deaths rarely are delayed beyond two years, this appears to be a reasonable assumption.

II.A.2 National Institute for Occupational Safety and Health (NIOSH). National Traumatic Occupational Fatality Study (NTOF)

The NTOF, unlike the BLS's CPOI, began in the 1980s. The 50 states, D.C., and New York City were contacted and asked to supply death certificates beginning with 1980. The certificates must have been marked "injury at work." Additional criteria resulted in excluding persons engaged in recreational activities on employer facilities: working for self or non-profit (e.g., mowing own lawn, repairing roof; student engaged in school activities; operating commercial vehicle for non-work purposes; and commuting to or from work).

The NTOF deaths were recorded in the year of the death, not the injury. The NTOF, like the CPOI, is a prevalence study.

Bell et al. (1990) present an analysis of the NTOF for the years 1980 through 1985. The 1980 to 1989 data are analyzed in a publication available from NIOSH in Cincinnati (National Institute for Occupational Safety and Health 1993).

There are a number of problems associated with relying on death certificates, as have been noted above. The undercounts of job-related deaths due to exclusive reliance on death certificates ranged from 12% to 83% as identified in Section II.A.1 above. But these 12% to 83% figures were only estimates based upon a handful of states and industries. The degree of underreporting nationwide is not known. The CPOI (Table 2.1) indicated that exclusive reliance on certificates marked "at work" would have resulted in capturing only 72% of the deaths, ignoring our race and ethnicity adjustments. Using our "race-adjusted" CPOI estimate would imply a 32% nationwide undercount.

There are other problems with the NTOF as indicated in Bell et al. (1990) and NIOSH (1993). For example, in the early years (1980-85) of the NTOF, some state and New York City coroners and certifiers did not regard any homicide or suicide as job-related. The policy was changed in 1986.

Nevertheless, the NTOF was an exceptional effort, collecting information on 63,589 civilian and military deceased workers collected from 1980 through 1989. Of the total, 98% were civilian and 2% were military deaths.

Figure 2.1, drawn directly from a government publication (National Institute for Occupational Safety and Health 1993) indicates the number of civilian deaths

and the death rates in each year. The average number of civilian deaths was around 6.229 per year. The rate was roughly 7.0 per 100,000.

Figure 2.1 shows a provocative downward trend. This trend was apparently real, that is, not due to a statistical quirk or improperly collected data. State of California records on deaths, recorded by WC boards also show a downward trend from the mid-60's to 1984 (Division of Labor Statistics and Research 1985). The National Safety Council's (1993) estimates of all fatal injuries--on and off the job--also showed a distinct downward trend for death rates in the 1980s. In fact, there has been a downward secular trend for all injury death rates since at least 1960, (National Safety Council 1993).

Figure 2.1 also shows that the number of deaths is influenced by the business cycle. More people are working and, thus, more people are exposed to job hazards when unemployment is low than when unemployment is high, other things equal. In addition, a falling unemployment rate is generally associated with employment of new and inexperienced employees who are the most likely of all groups to experience injuries (Division of Labor Statistics and Research 1985). Increases in unemployment may also result in firms laying-off accident-prone workers (Leigh 1985a). The economy suffered a recession---the deepest since the Great Depression --- from 1980 through mid-1983. Beginning in the summer of 1983, the economy entered a recovery that lasted until the summer of 1990. As evident in the data on numbers of deaths in Figure 2.1, the steepest fall occurred from 1980 to 1983. These years combined the downward secular trend with the effect of the rising unemployment rate. The number of deaths actually increased in 1984 and 1985, as the economy roared back to life. The falling unemployment rate exerted a stronger influence than the secular trend in 1984 and 1985. From 1986 through 1989, the secular downward trend appeared to be evenly matched by the upward pressure on deaths resulting from a falling unemployment rate.

Equation 2.1 shows the results of a linear regression using the 10 years of NIOSH data. The dependent variable was the natural log of the number of deaths and the independent variables were the unemployment rate and years, indicated by integers 1 through 10. The natural log was preferred over simply number of deaths since analyses in the sections ahead require that a percentage effect be

estimated. This NIOSH model will be used with other data sets that differ in their level of deaths, hence percentage changes will be more relevant than changes measured in actual numbers in deaths.

Equation 2.1:

$$\begin{array}{lcl} \ln(\text{Deaths}) = 9.2400 & - & 0.0394 \times \text{unemployment rate} & - & 0.0401 \times \text{years} \\ & (t=114.077) & (t=-4.574) & & (t=-9.516) \\ & (p=.0001) & (p=.0026) & & (p=.0001) \end{array}$$

$$R^2 = .9340 \quad n = 10$$

Figure 2.1

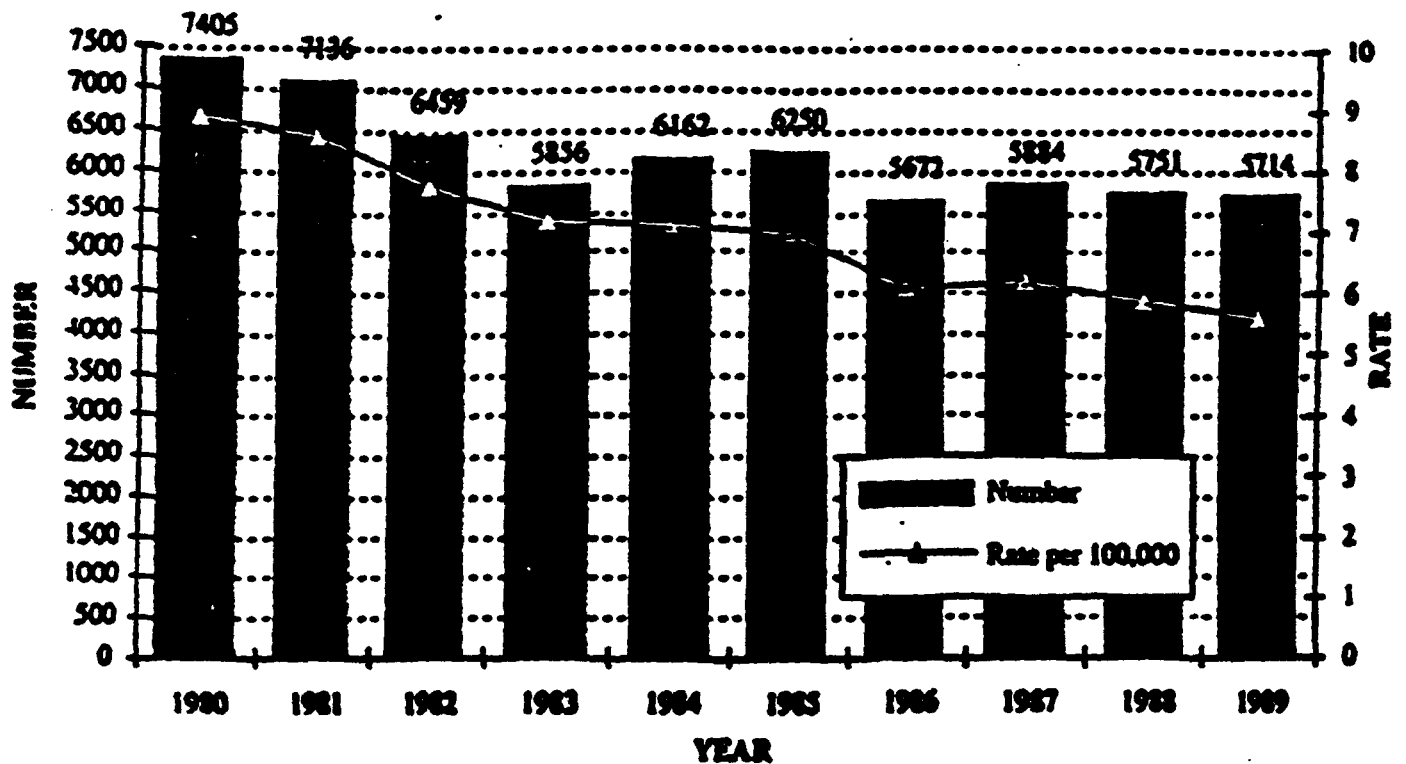


Figure 2-1. Distribution and Rate of Traumatic Occupational Fatalities by Year, US, 1980-1989.

Civilian

THIS PAGE NUMBER AND SPACE RESERVED FOR FIGURE 2.1

As the t and p-values (in parentheses) indicate, the unemployment rate and the advancing years are strongly correlated with the number of deaths in the hypothesized direction. We will use this model to predict what deaths would be in 1992. It would be difficult to make predictions much beyond 1992. As in every forecasting model, as the prediction year moves further into the future, confidence intervals widen considerably.

In 1992, the unemployment rate was 7.4 and the year was 13 (year 10 was 1989). Putting these values into equation 2.1 yields an estimate of 4,569 deaths for 1992:

$$\text{Predicted deaths} = \exp(9.2340 - .0394 \times 7.4 - .0401 \times 13) = 4,569$$

This predicted number—4,569—would correspond to the NIOSH, NTOF data unadjusted for any undercounting. Perhaps the most important cause of the undercount would be due to the NTOF's exclusive reliance on death certificate data. Assume that 28% of deaths were missed by death certificates. (The unadjusted CFOI number implied a 28% undercount while the race and ethnic adjusted CFOI number implied a 32% undercount. We, therefore, use the more conservative number). The predicted number from our model must therefore be divided by .72. The result is 6,346.

This number—6,346—compares favorably with both the CFOI unadjusted number—6,063—and "race and ethnic adjusted" number 6,359. One explanation for the disparities is that the NTOF number relied on a model prediction. It was not derived from a census in 1992. Nevertheless, the disparities (283 and 13) are small. The data were collected in different years by different Federal agencies -- one headquartered in Washington, D.C., and the other in Cincinnati. The proximity of the NTOF estimate to the CFOI count and "race-adjusted" estimate would appear to attest to the credibility of both. We say "appear to" in the last sentence for a reason. It could be argued that by adjusting for the 28% WC undercount found in the CFOI, a NTOF adjusted number close to the CFOI number is virtually guaranteed. But this need not be the case. The NTOF data were gathered by NIOSH, not by BLS, and were collected in years prior to the establishment of the CFOI. In addition, for legal and administrative reasons, the BLS investigators have not analyzed the

NTOF and the NIOSH investigators have not analyzed the CFOI. Moreover, there is considerable independent research suggesting that death certificate counts underestimate the true number of job-related deaths. And these underestimates, in fact, do include 28% as a possible undercount percentage. We, therefore, accept 6,346 as the best 1992 estimate based on adjusted NTOF data.

II.A.3 BLS's Annual Survey

The OSH Act of 1970 requires that almost all private sector employers with 11 or more employees keep a log of occupational injuries and illnesses and submit the data to the BLS once a year. The BLS then assembles the data and publishes the results in its *Annual Survey of Occupational Injuries and Illnesses in the U.S. by Industry*—what we will refer to as the Annual Survey (U.S. Department of Labor 1992, Chapter 14). The Annual Survey contains aggregated data on 250,000 to 280,000 firms, depending on the year, and the variables analyzed. The Annual Survey data suffer a number of weaknesses, as the BLS acknowledges. First, in general, the Annual Survey covers firms regulated by the OSH Act. Railroads and mines are covered under separate federal legislation. But some data on railroads and mines are included in the Annual Survey. A table footnote in the Annual Survey puts it this way:

Data conforming to OSHA definitions for employers in the railroad industry and for mining operators in coal, metal, and non-metal mining were provided to BLS by the Federal Railroad Administration, U.S. Department of Transportation, and the Mine Safety and Health Administration. Independent mining contractors are excluded from the coal, metal, and non-metal industries (U.S. Bureau of Labor Statistics 1991).

The last sentence from this Annual Survey suggests that the mine data are incomplete.

There are other much larger exclusions than independent mining contractors, however. The self-employed are excluded, as are government employees at all levels—federal, state and local. Private household workers and farmers are also excluded. Finally, all firms with fewer than 11 employees are excluded from the fatality data and some firms with fewer than 11 employees are excluded in the non-fatal injury data.

The largest limitations are the exclusions of government employees, employees working in small firms, and the self-employed. Roughly 20% of the civilian workforce has worked for some form of government in recent years, including 1992. Small firms (firms with fewer than 100 employees) account for a high percentage (56%) of new employment in recent years (Brown et al. 1990). Finally, the self-employed comprise roughly 9% of the workforce (Jack and Zak 1993). These limitations have resulted in some questionable conclusions drawn from BLS Annual Survey data. For example, Annual Survey data suggest that an inverted "U" describes the relation between injuries and firm size, with firms employing 100 to 499 persons sustaining the highest injury rates, while the smallest and the largest firms sustain the lowest rates (Leigh 1989a). But the BLS data contradict other studies. Data from death certificates (not the BLS surveys) divided by the appropriate numbers of employees at risk from all firms suggest that the relation is monotonically decreasing (Mendeloff and Kagey 1990). The smallest firms, with one to 10 employees, have the highest injury rates. Using death certificate (not BLS) data from Allegheny County, Pennsylvania, Parkinson et al. (1986) discovered that nearly 80% of fatal job-related accidents occurred in firms with fewer than 100 employees, while roughly 50% of U.S. private sector employees worked in such firms (Brown, Hamilton, and Medoff 1991). Coal mine accidents and injuries are most frequent in firms with the fewest employees (Bennett and Passmore 1984).

Small firms are frequently owned by the self-employed. The Census of Fatal Occupational Injuries (CFOI) data indicated that 20% of injury deaths occurred among the self-employed in 1992 (Jack and Zak 1993). However, the self-employed comprised roughly 9% of the workforce in 1992 (Jack and Zak 1993). If employment is hazardous for the boss in small firms, it is likely to be hazardous for the employees as well. We conclude that the underreporting from small firms more likely explains the inverted "U" than any argument that such firms are safer than medium-sized firms.

A second drawback of the Annual Survey data involves economic incentives that encourage firms to underreport. The enforcement arm of the OSH Administration has indirectly used BLS data. Although BLS has steadfastly refused to let OSHA see

its raw data, OSHA has used its own industry log data (OSHA Form 200) to compare a particular firm to the national or industry average. If the firm's injury rate exceeded the average, that firm was sometimes targeted for inspection (Smith 1992; McGarity and Shapiro 1993). In addition, WC insurance companies require firms to pay high premiums if their injury and illness rates are high (Suruda and Emmett 1988; Burrough and Lubove 1986). For both of these reasons, some firms may deliberately underestimate their injuries. In fact, a number of firms have pleaded guilty of deliberately undercounting accidents (Bell and Denmead 1993; Ruser and Smith 1988; McGarity and Shapiro 1993).

Both drawbacks suggest that the BLS Annual Survey undercounts, perhaps seriously undercounts, injuries and illnesses. We are not alone in this opinion. McGarity and Shapiro (1993) point out that in 1988 a Congressional Office of Technology Assessment (OTA) review of record-keeping accuracy found "possibly significant injury and illness underreporting to the BLS." In the same vein, although pertaining to diseases, a 1987 study by the National Research Council of the National Academy of Sciences concluded that there was "little doubt that serious underreporting exists for occupational diseases" (National Research Council 1987).

Evidence suggests that the BLS's Annual Survey undercounts the number of injury deaths, by perhaps 60%, and the disease deaths by more. During 1979 to 1986, the BLS's Annual Survey estimated roughly 4,000 annual injury and illness deaths. Yet, during 1980 to 1985, NIOSH estimated 7,000 annual injury deaths alone (Bell et al. 1990), while the National Safety Council estimated 12,000 annual injury deaths alone for the same years (National Safety Council 1992). The national estimates derived from a New York study indicated approximately 70,000 disease deaths (Markowitz et al. 1989).

The undercount for non-fatal injuries is likely to be even larger than the one for fatal injuries. This was the conclusion of some of the scientists who participated in the National Academy's conference on undercounting of occupational injuries and illnesses (National Research Council 1987). It is more clear-cut to identify a death as due to an accident at work than a non-fatal injury, especially

one such as back pain. Moreover, it is probably easier for employers and employees to conceal a non-fatal injury than a fatal one.

In one of the few studies on underreporting of non-fatal injuries, Oleinick et al. (1993) suggested that the BLS Annual Survey data may count only roughly 30% of the workdays lost due to non-fatal injuries and illnesses.

The BLS itself now recognizes the serious undercount, especially for deaths, from the exclusions of government employees, small firms, the self-employed and "willful" underreporting (U.S. Bureau of Labor Statistics 1993, p. 7). The CFOI was the BLS's attempt to circumvent these problems for death statistics. As further testimony to the BLS's dissatisfaction with the surveys, researchers are no longer allowed access to unpublished lists of two- and three-digit industry death rates (Knieser and Leeth 1991). Prior to 1988, the BLS readily made these two- and three-digit industry death rates available to researchers (Leigh 1987b).

A final problem concerns the type of fatality in the Annual Survey. Whereas the CFOI and the WTOP were restricted to injuries, the Annual Survey combined deaths from illnesses with injuries. It is likely, nevertheless, that the highest percentage of deaths (90%) resulted from injuries. In 1990 and 1991 (the latest Annual Survey data available on deaths), 9% of deaths were due to heart attacks. Some of these undoubtedly followed a traumatic event, but probably not most. We assume 6% were due to circulatory disease, independent of a traumatic event. The Annual Survey does not identify any other illness category. Nevertheless, the "all other" category captured 9% of deaths. Deaths within "all other" included "contact with carcinogens, and toxins," and "other illnesses" as well as "other injuries." We assume 4% were due to illnesses. Our total would then be 10% due to illnesses and diseases. This 10% conforms well with a separate WC study indicating 11% due to illnesses (Leigh 1995a).

The BLS Annual Survey investigators directly count the numbers of non-fatal illnesses. We therefore did not need to make assumptions regarding the number of non-fatal illnesses. In 1991, for example, approximately 368,000 new cases of fatal and non-fatal illnesses were reported in private industry in the Annual Survey. In the same year, 6.0 million new injuries were reported. Thus, illnesses comprised 5.78% of all new cases of injuries and illnesses.

Curiously, a smaller percentage of illnesses (5.78%) occurred in the non-fatal than fatal (10%) category. But this smaller percentage (5.78% versus 10%) may be the result of not regarding circulatory diseases as occupational until the worker dies. That is, the Annual Survey does not have a heart attack or stroke or circulatory disease category in the non-fatal list.

Despite the BLS Annual Survey data limitations, they provide the most comprehensive and historically consistent data available on fatal and non-fatal injuries and illnesses. We turn now to analyses of these data.

In the 1991 Annual Survey Bulletin No. 2424 (U.S. Bureau of Labor Statistics 1993), the fatalities and rates were as follows: 2,900 and 4.3 for 1990; and 2,800 and 4.3 for 1991. These rates were per 100,000 employees. Assuming 10% of all BLS Annual Survey fatalities were due to diseases, we estimate that the Annual Survey counted 2,610 injury fatalities in 1990 and 2,520 injury fatalities in 1991.

One approach to estimate the deaths in 1992 would be to average the two numbers $(2,610 + 2,520)/2 = 2,565$, forecast to 1992, using the NTOF equation 2.1(2,279), and adjust for the 68% undercount found by CFOI. The CFOI found that deaths on OSHA Form 200 accounted for 32% of all deaths. This procedure yields 7,123 deaths. It could again be argued that this procedure would virtually guarantee an estimate close to the CFOI number. The 32% statistic, after all, was derived by the same BLS office as derived the undercount estimate in the CFOI. (This point does not apply to the NTOF since the NTOF was collected by NIOSH, not BLS, and since the NTOF death certificates were not used by the CFOI). But "guarantee" is a strong word. In fact, this adjusted BLS Annual Survey number—7,123—is further away from the CFOI numbers (6,217; 6,063; and 6,359) than the NTOF number (6,346) is away from the CFOI numbers. Nevertheless, the adjustment by the CFOI 68% underestimate is cause for some concern.

A second approach to using the BLS Annual Survey data is to apply the death rate estimate to all civilian employees.

The 1990 and 1991 death rates for all recorded deaths (illnesses and injuries) were reported by the BLS to be 4.3 per 100,000 workers in both years. Again assuming 10% were illness deaths, this rate would be roughly 3.87 per 100,000 for injury deaths. Assuming that the secular downward trend (Equation 2.1)

in numbers of deaths exerts a similar downward influence on the rate, the 1992 rate would be about 6% less than the 1990-91 rate. The effect of the unemployment rate in Equation 2.1 can also be calculated. We assume that the unemployment effect would result in a $3.94\% \times 1.3 = 5.122\%$ lower death rate in 1992 than 1991. We thus estimate a 11.137% drop in the rate from the average of 1990 and 1991 to 1992. Our 1992 rate estimate would be $3.87 \times (1 - .11137) = 3.44$.

Our second approach to using the Annual Survey to estimate deaths in 1992 would then be to assume that this 3.44 rate applied to all of the omitted firms and industries. Assume 117,598,000 civilian employees in 1992 (U.S. Bureau of the Census 1993). Multiplying 3.44 per 100,000 times 117,598,000 yields an estimate of 4,045 deaths. But we know this is an underestimate. First, small firms and farms have rates much higher than the rates for the firms included in the Annual Survey. Toscano and Windau (1993) estimated a rate of 11.6 per 100,000 for the self-employed. Second, firms included in the Annual Survey that generated the 3.44 rate have an economic incentive to underreport, as the BLS acknowledges. The CFOI rate for all private industry was 5.4 per 100,000. Moreover, the CFOI estimated that the deaths on OSHA log 200 forms underestimated deaths by some 68%.

Our solution is to average the estimates from the two approaches: $(7,123 + 4,045)/2 = 5,584$. This number is our best estimate based on the BLS Annual Survey data.

II.A.4 National Council on Compensation Insurance (NCCI)

The National Council on Compensation Insurance, a private enterprise, collects data from public and private Workers' Compensation insurers from 41 states and the District of Columbia. The NCCI helps establish insurance rates for WC insurers in most states (Berkowitz and Burton 1987). The data are provided to the NCCI by private WC insurers and some competitive state funds. The NCCI does not collect data from (generally large) firms that self-insure, the six states with exclusive state funds (Nevada, North Dakota, Ohio, Washington, West Virginia, and Wyoming), some competitive state funds, and all public and private insurers in three states (California, Minnesota, and New York).

We need to estimate the number of deaths and injuries that would be omitted from the NCCI due to these exclusions. We will estimate these with measures of private sector employment. The six states with exclusive state funds contributed roughly 7.1% of U.S. private sector employment. The three states with all private and public insurers contributed roughly 20.9% of U.S. employment. Information on the number of employees in self-insured firms is not available. However, Nelson (1993) estimates that 18.8% of all WC benefits were paid by self-insured firms in 1991. Burton and Schmidle (1993) estimate that percentage to be 19.5. We will assume that 19.15% (the mid-point between 18.8 and 19.5) applies. We add an additional .85% to account for the competitive funds that do not report to NCCI. Our ultimate percentages of under-coverage of the NCCI would be 28% for the nine excluded states, 19.15% for self-insuring firms, and .85% for the few competing state funds that do not report to the NCCI. These three sum to 40% ($40\% = 28\% + 19.15\% + .85\%$).

The NCCI publishes a number of reports using the data. The NCCI sent us what they refer to as Ultimate Reports: one from May 1992 and another from May 1993 (National Council on Compensation Insurance 1992, 1993). The Ultimate Reports contain information on claims originating in prior years, deaths and non-fatal injuries, costs in the claims-originating years, as well as expected costs in future years.

The NCCI publishes data for an insurance policy year, not a calendar year. Sometimes, the policy years began January 1 and ended December 31, but sometimes they did not. For example, for Delaware in the 1992 report, the policy year began in March 1988 and ended in February 1989. In all policy years, however, the 12 consecutive months were covered, and no policy year exceeded 12 months. Consequently, estimates of annual deaths could be made, especially when the two reports were combined and divided by two. Our first NCCI Ultimate Report was completed in May, 1992, and covered calendar years 1987, 1988, and 1989, depending upon the state. The second Ultimate Report was completed in May, 1993 and covered calendar years 1988, 1989 and 1990.

These Ultimate Reports follow claims originating in one year for at least three years. That is, if an injury/claim occurred in 1989, the Ultimate Report

would collect data on that claim at least until December 1992. It could be, for example, that medical expenses were generated in years after the initial year of the injury. The Ultimate Reports would contain that information.

The NCCI also publishes First Year Reports that follow claims for only 18 months. Since some costs accrue beyond 18 months, we determined that the Ultimate Reports would provide us with better information than the First Year Reports.

To generate national estimates based upon the NCCI data, adjustments have to be made for illnesses, exclusion of some states, exclusion of self-insured firms and some state funds, and the well-known WC underestimate. We will make each of these adjustments in turn, and begin with the deaths reported in the 1992 Ultimate Report.

The 1992 Ultimate Report, (NCCI 1992), covering years 1987, 1988, and 1989, indicated 3,306 deaths. These were WC deaths, hence they included diseases. Leigh (1995a) calculated that roughly 11% of WC deaths were due to illnesses from 1979 to 1986. Above, we assumed that the deaths in the BLS Annual Survey contained 10% that were disease-related in 1991. Since the 11% figure applied to WC while the 10% figure applied to Annual Survey data, we chose the 11% figure. NCCI, after all, is based on WC reports, not BLS reports. Assuming illnesses caused 11% of the deaths, the NCCI data suggest 2,942 injury deaths for the states covered ($3,306 \times .89 = 2,942$).

As indicated above, the NCCI excluded California, Minnesota, Nevada, New York, North Dakota, Ohio, Washington, West Virginia, and Wyoming. These states—California through Wyoming—contributed roughly 28% of total U.S. private employment (U.S. Statistical Abstract 1993) from 1987 through 1990. Assuming that the same WC patterns apply in the nine omitted states as in the 41 included states (plus D.C.), we must add to our injury deaths 1,144 ($= 2,942 / .72 = 2,942$). These two adjustments therefore suggest that the NCCI-based estimate is 4,086 at this point in our analysis.

A third adjustment involves the exclusion of self-insured and some competitive state funds that we estimated above accounted for about 20% of WC benefits, injuries and illnesses. Self-insured firms tend to be large and large firms are safer than small ones (Leigh 1989a). Competitive state funds on the

other hand, tend to insure firms with the highest injury rates (Nelson 1992, 1993). We assume that these large employers and competitive state funds contributions to the death toll would be roughly equal to their benefit contribution: 20%. We therefore divide .8 into 2,942 to arrive at 3,678, for our NCCI death estimate. We must, therefore, add 736 to account for self-insuring firms and some competitive state funds.

This 20% undercount would not apply to the nine omitted states. We accounted for the nine states with employment percentages that did not exclude employees in large self-insuring firms or in competitive state funds.

At this point, our estimate for WC injury deaths adds these numbers: $2,942 + 1,144 + 736 = 4,822$. But this 4,822 only reflects deaths that would have been recorded by WC boards nationwide. A number of studies indicate that WC records, even when they are complete, ignore over half of all injuries, including deaths. We turn now to an examination of these studies and our fourth adjustment to account for the well-recognized underestimates resulting from incomplete WC records. Since this estimate of the WC undercount plays an important role in subsequent analyses, we offer seven studies and sources to support our assumption of a 55% undercount.

Toscano and Windau's (1993) CPOI is perhaps the most credible of all the data we encountered in conducting this study. As indicated in Table 2.1, the traditional state-based WC insurers had records on only roughly 40% of all of the deaths in the CPOI. If the CPOI itself provides an undercount due to missing African-American or Hispanic or poor employees, then this 40% figure would shrink further. This implies at least a 60% undercount.

Cone et al. (1991) identified 682 job-related deaths in California in 1983. WC insurers had records for only 294 or 43.1%. Stout and Bell (1991) estimated that, depending on the state, WC missed from 30% to 60% of job-related deaths.

The 55% or higher undercount extends to non-fatal injuries as well. Parker et al. (1994) studied non-fatal injuries among adolescents in Minnesota. The study consisted of a one-year survey of 534 adolescent work-related injuries reported to the Minnesota Department of Labor and across-sectional survey of 3,312 public high school students. All injuries were serious enough to result in more than three

days away from work or in a permanent impairment. Thus, all injuries would have qualified for WC since Minnesota WC requires a three-day waiting period. The Parker et al. (1994) study showed that 67% of these serious adolescent work injuries were not reported to Minnesota WC insurers or agencies. An even higher percentage would have been excluded had injuries resulting in only a few hours or one or two days of work loss been included.

As we will explain later in this chapter, the National Health Interview Survey conducted an extensive supplement on occupational health and safety in 1988 (NHIS-OSH). The supplement asked questions regarding WC. Roughly 53% of the persons reporting an on-the-job injury to the NHIS interviewers did not file a WC claim (47% did file). The NHIS interviewers did not ask whether the claim was successful. If 90% of these 47% who did file claims would have been successful then WC would be counting 42.3% of all job-related injuries reported by respondents in the NHIS-OSH. In other words, WC would be missing 57.7% of non-fatal injuries that respondents stated were job-related. The missing WC percentage would likely be even higher without the substantial recall bias inherent in the NHIS-OSH (Landen and Hendricks 1992). The NHIS-OSH asked for job injuries in the last 12 months. Minor injuries are easily forgotten. Minor injuries are also less likely to be covered by WC.

The Rand study by Hensler et al. (1991) (discussed in Section III.A.2) also showed a high percentage of injuries missed by WC. On page 77, Hensler et al. (1991) presented data on the sources of payment for accident and injury-related hospitalizations. One column pertained to "WC only" while another was "more than one source." The percent in the WC column was 43.5. The percent in the "more than one" column was 11.9. Assuming all (a conservative assumption) of the "more than one" were also covered by WC, then WC identified roughly 55% of all cases. If the "more than one" source never included WC, then WC would identify 43.5% of non-fatal injuries requiring hospitalizations. On their following page, data on sources of compensation for accident and injury-related outpatient medical care were presented. Several sources were again identified including "self-pay," "health insurance only," "WC only," "other source," and "more than one source." The percent in the "WC only" column was 40.4 while the percent in the "more than

one source" column was 8.2. At the most, WC would pay for 48.6%. At the least, WC would cover 40.4%.

In both of these cases, we favor the lower estimate. Few, if any, WC insurers had deductibles or co-payments at the time of the Hensler et al. (1991) study. Once WC was scheduled to pay for medical care, there was no reason for other sources to become involved.

The Rand data, therefore, suggest that WC was missing 56.5% to 59.6% of non-fatal, job-related injuries. But Hensler et al. (1991) acknowledge that they undercounted minor injuries due to recall bias. Minor injuries, in turn, are much less likely to be covered by WC. Hence, it is likely that the WC undercount suggested by Hensler et al. (1991) would exceed 60%.

Finally, Marquis (1992) adapted the Rand study to analyze costs. Marquis (1992) estimated that WC benefits accounted for only 27.5% of the total cost of occupational injuries, for a WC omission cost estimate of 72.5%.

These seven studies suggest a WC undercount of 55% or more, on average. The estimated undercounts were these: Toscano and Windau (60%); Cone et al. (55.9%); Stout and Bell (45%); Parker et al. (67%); NHIIS-OSH (58%); Hensler et al. (58%); Marquis (72.5%). In addition, the average of these is 60%. We selected 55% for our calculations, however, out of desire to be conservative.

There are a number of reasons for the WC undercount. First, the traditional state-based WC programs do not cover federal employees and sometimes do not cover state and local government employees (the latter are frequently covered under special state-run government employees disability program).

Second, some household workers, some farm workers, self-employed people, and some workers in small firms, are excluded. While little information exists on the hazardous nature of household work, we know that farm work is especially dangerous. Agriculture generates among the highest of all injury rates when compared to other industries (Jenkins et al. 1993; Leigh 1995a).

Toscano and Windau (1993) found a high and disproportionate number of deaths among the self-employed: 20% of the total. Moreover, it could be that the Toscano and Windau (1993) estimate is low (Toscano personal communication with one of the authors May 5, 1994). For example, a real estate agent may have died in a

car crash at 8:00 p.m. It would be difficult for a coroner to determine whether she was driving to a client's house or on a personal trip.

If the self-employed are at high risk, it stands to reason that employees in small firms may also be at high risk for job-related deaths. Mendeloff and Kagey (1990) found evidence for small firms having the highest injury rates among all firms. But WC frequently does not extend coverage to the smallest employers. WC coverage did not extend to employees in firms with fewer than five employees in Missouri, Tennessee, and Mississippi in 1988. In New Mexico, Arkansas, Alabama, Georgia, Florida, South Carolina, North Carolina, Rhode Island, Virginia, Michigan, and Wisconsin, WC coverage did not extend to firms with fewer than three employees (Nelson 1992).

The Seligman et al. (1988) study supports the argument that even though legal WC coverage extends to some small firms, de facto or actual coverage may not. Seligman et al. (1988) found that the OSHA record-keeping was the worst (fewest records) for small firms and the best (most records) for the large firms.

Third, there is the possibility that some injuries may go uncompensated or unreported even when they would easily qualify for WC. This is alarming to contemplate especially when considering deaths. It could be argued that of all injuries, deaths would be the most visible and unimpeachable as truly job-related. But deaths can be expensive to insurers. They involve indemnity payments to spouses and children. Some insurers may be more inclined to fight a death claim than any other kind of claim.

Rejda (1991), Professor of Insurance in the Business School at the University of Nebraska, offers an additional reason in his influential book on social insurance (Rejda 1991). Workers often receive advice only from company supervisors or WC insurance agents. The agents also perform the functions of judges in accepting or denying the claim, controlling the payment, and terminating the benefit.

Finally, some investigators will allege that WC overestimates the number of injuries. This view will be addressed in Chapter 10. We would, nevertheless, like to point out here that a number of injuries commonly thought to be compensable by WC are, in fact, seldom, if ever, compensable. These include commuting to and

from work, and injuries that occurred after the employee had been drinking (Rejda 1991).

Payment for circulatory diseases and heart attacks are rare. Nevertheless, some states will allow workers or their dependents to collect WC after the worker had heart failure following strenuous exertion, i.e., lifting heavy boxes (Rejda 1991). Finally, in some states (California), WC law presumes that heart failure among police officers and fire fighters is compensable.

If we assume a 55% undercount, then we can make our fourth adjustment: $4,822 / .45 = 10,716$. This 10,716 estimate must be combined with the estimate from the 1988 to 1990 policy years and then forecasted to 1992.

In the second NCCI Ultimate Report (NCCI 1993), deaths for 1988, 1989, 1990 were 2,768. Ten states were omitted. These 10 included the nine above-California through Wyoming-together with Texas. These 10 states contributed roughly 35% of private employment from 1988 through 1990. Assuming 1) 11% was again due to diseases, 2) that WC patterns in the omitted 10 states resemble those in the included 40 states, plus D.C., and that these result in a 35% undercount, 3) the omitted self-insured firms and some competitive state funds contributed 20% of deaths, and 4) the same 55% WC undercount applies, then our estimate for injury deaths would be 9,791 ($2,463.5 + 1,326.5 + 615.9 = 4,406$; $4,406 / .45 = 9,791$).

The average for the two NCCI reports would then be 10,254. But these estimates do not apply to 1992. We can use the NTOF model (equation 2.1) to forecast the 1992 estimate. Unemployment grew from an average of 5.625% during 1987 through 1990 to 7.4% in 1992. An increase in unemployment of 1.775 is associated with a $.0394 \times 1.775 = .07$ or 7% reduction in the number of deaths in the NTOF model. This 7% would correspond to 718 fewer deaths using the NCCI data. There was also a secular trend. Assuming the NCCI data were, on average, drawn from the summer of 1989, we have to account for an increase of three years. A three year advance in the time trend in the NTOF model is associated with a 12% drop in the estimated number of deaths. In the NCCI data, this would mean a decline of 1,230 deaths. Adding these two numbers indicates that the 1992 estimate should be 1,948 deaths lower than the 1987-90 average. (We cannot simply place the same 1992 numbers into the NTOF prevention model since this would assume that the

intercept would have been estimated by the NCCI data. This is the reason we estimated "percentage change" rather than absolute effects. We implicitly account for a new intercept by just subtracting from the average NCCI estimate for 1987 to 1990). The NCCI 1987-1990 average was 10,254. Subtracting 1948 yields this NCCI estimate of deaths for 1992: 8,306.

II.A.5 Supplementary Data System (SDS)

The Supplementary Data System (SDS) was organized by the Bureau of Labor Statistics (BLS) in 1976 in an attempt to gain national information on the nature, source and type of occupational injuries and illnesses nationwide (U.S. Department of Labor 1992, Chapter 14). The SDS, in turn, drew data from the reports of injuries and illnesses that employers, employees, and physicians submitted to Workers' Compensation (WC) insurers or agencies. The SDS "closed cases" files we used are described in Leigh (1995a). One advantage of the "closed cases" files is that they are final, not under appeal and less likely to be diluted with bogus claims than the "open cases" files the SDS also contains. The "closed cases" file does not exclude people with on-going benefits. In most cases, WC insurers set aside a given amount of funds to cover on-going cases. "Closed" simply means that the legal issues have been resolved.

Another advantage of the SDS, "closed cases" file is that it includes familiar WC categories for non-fatal injuries (Permanent Total, Permanent Partial, Temporary Total, and Partial and Medical Only) for all cases. Information on WC categories were frequently omitted from the "open cases" file.

A disadvantage of the SDS "closed cases" files is that they were discontinued in 1986. The "open cases" files were discontinued in 1988.

An advantage of both the "open" and "closed" cases files is that the SDS also includes illnesses and heart attacks, unlike the CFOI or the NTOF. A disadvantage of the SDS, whether "open" or "closed" cases files, is that it relies exclusively on WC data.

The SDS data have been used in numerous BLS analyses. Perhaps the best introduction to the data is provided by Root and Sebastian (1981) who developed a job hazard index for roughly 60 occupations and 180 occupation and industry

combinations. The index was created by accounting for the percent of total injuries contributed by a particular occupation or occupation-industry cell and dividing by the expected percent for that occupation or cell. Occupations with the highest indexes were, in order, warehouse laborers, all other laborers, structural metal crafts workers (iron workers), roofers, sheetmetal workers and apprentices, construction laborers, freight handlers, millwrights, and truck drivers.

Root and Sebastian (1981) pointed out that railroad, maritime, farming and private household service occupations were under-represented in the SDS because these occupations were frequently excluded from Workers' Compensation (WC) insurance coverage in a number of states. Root and Sebastian (1981), nevertheless, concluded that "our observations and tests, and the geographic and industrial diversity of the states included in this study, support our thesis that these data are representative of the national experience" (p. 27).

The SDS "closed cases" files data contained 5,498 deaths from 11 states from 1979 to 1981, 1983, 1985, and 1986. These states were Arkansas, Colorado, Delaware, Idaho, Iowa, Montana, New York, North Carolina, Oregon, Virginia, and Wisconsin. This 5,498 number represents approximately 916.3 deaths per year. Given that, on average, these states contributed 16.36% of U.S. civilian employment, the annual estimate would be 5,601 ($916.3 / .1636 = 5,601$). If 89% were injury deaths and 11% were disease deaths (including some heart attacks) (Leigh 1995a), then approximately 4,985 people died from injuries and 616 died from diseases and heart attacks each year.

This annual United States estimate of 4,985 for injury deaths is likely to be low because of exclusive reliance on WC records. If WC records catch only 45% of all injury deaths (see our discussion above on the omissions from WC), then our estimate of national job-related injury deaths would be 11,078 for the years 1979 to 1986: $4,985 / .45 = 11,078$.

To derive a 1992 estimate, we again used the NTOF model. From 1979 to 1986, unemployment averaged 7.69 and the average year was midyear in 1982 (1982-1/2). In 1992, unemployment was 7.4. Subtracting 7.4 from the average of 7.69, unemployment dropped by .29. This change in unemployment increases estimated deaths by 1.14% ($.29 \times 3.94\%$) or 126 deaths in 1992. The 3.84% was taken from the NTOF model 2.1

above. The time trend, on the other hand, grew by 9.5 years. This represents an estimated decrease in deaths of 38% or, in our SDS case, 4,210. Subtracting the 126 from 4,210 yields 4,084 fewer deaths in 1992 compared to the average SDS estimate. Subtracting 4,084 from 11,078 yields 6,994. Our SDS estimate would then be 6,994.

II.B. Secondary Sources on Fatalities

A literature search uncovered five studies that provided estimates of the total number of U.S. job-related injury deaths. The following sections of this chapter will consider each of these studies.

II.B.1 National Safety Council (NSC)

The NSC is a private non-profit public service organization. Their funding derives primarily from corporate donations. Each year, the NSC publishes *Accident Facts*, a paperback book, filled with statistics covering injuries and accidents of all kinds. Some are provocative. For example, bees, wasps, and hornets kill three times as many people as snakes, lizards and spiders (38 versus 11) (National Safety Council 1993, p. 10). Some NSC statistics were drawn directly from government reports. For example, entire tables from the BLS's Annual Survey are reproduced in *Accident Facts*. Other statistics were estimates derived from government reports, academic studies, internal NSC studies, data submitted to the NSC by a number of corporations, and analyses of time trends. The NSC is the largest organization of its kind. There is no single federal government agency or federal health institute dealing only with injuries. The U.S. government's efforts on the collection of data on injuries are split among the National Highway Traffic Safety Administration, Injury Surveillance Departments at NIOSH and OSHA, the Center for Disease Control and Prevention, and the Federal Aviation Administration.

The NSC has been providing estimates for job-related fatal injuries for over 20 years. They estimated 8,500 deaths in 1992. They have also estimated a downward trend in deaths and death rates since 1973 as indicated in Table 2.2.

Table 2.2 also presents data on death rates per 100,000 motor-vehicle work deaths, and deaths among government employees. The last two columns are noteworthy. We are not aware of any other time trend estimates of motor vehicle work deaths or of the number of work deaths among government employees. The latter appears to follow the economy. The economy expanded from 1983 to 1990 but contracted from 1990 through 1992.

From 1980 through 1992, the number of all work deaths (column 2) has fallen roughly 400 per year.

Table 2.2

NSC Estimates of Work Injury Deaths and Death Rates
for all Industries, 1973-1992

<u>Year</u>	<u>All Work Deaths</u>	<u>Death Rate per 100,000*</u>	<u>Motor Vehicle Work Deaths</u>	<u>Government Employee Deaths, and Death Rates per 100,000</u>
1973	14,300	17	4,500	N/A
1975	13,000	15	3,900	N/A
1980	13,200	13	4,500	N/A
1985	11,500	11	4,100	1,300, 8
1986	11,100	10	3,900	1,400, 8
1987	11,300	10	4,200	1,500, 9
1988	11,000	10	3,900	1,600, 9
1989	10,700	9	3,700	1,700, 10
1990	10,100	9	3,600	1,700, 10
1991	9,300	8	3,300	1,500, 8
1992	8,500	7	3,000	1,700, 9

*Denominators for death rates include all persons gainfully employed, including owners, managers, other paid employees, the self-employed, and unpaid family workers, but excluding private household workers.

Source: National Safety Council, 1993

The NSC estimates for job-related deaths rely on death certificate data from the National Center for Health Statistics (NCHS). The NCHS data were readjusted by historical benchmark "allocative factors" as described in Brand and Hoskin (1993).

Problems associated with death certificates have been noted above in the discussions on the CPOI and the NTOF. There are also a number of limitations associated with using percentage allocation factors--some dating back over 30 years--as indicated in Brand and Hoskin (1993).

The allocation factors account for some of the undercounting resulting from reliance on death certificates. The CPOI suggested that certificates marked "at work" underestimate deaths by 28%. We will assume (conservatively) that allocation factors account for the entire 28% (i.e., that we do not need to adjust the NSC estimate for a 28% undercount).

Another drawback to the NSC estimates was the explicit omission of homicides and suicides. The NSC wanted to count accidental injuries, hence violent deaths were excluded. The CPOI indicated that homicides and suicides contributed roughly 20% of all job-related injury deaths in 1992. The NTOF studies indicated that homicide and suicide contributed to 15% of all deaths in the mid-1980s. To estimate a 1992 NSC adjusted number of deaths, we used the more conservative 15%. We divided .85 (=1-.15) into 8,500 to yield:

$$\frac{8500}{.85} = 10,000$$

Our NSC death estimate adjusted for a violent death undercount is 10,000.

II.B.2 Miller (1994)

Dr. Ted Miller (1994) of the National Public Services Research Institute recently provided estimates of the number of job-related injury fatalities. Miller produced five estimates for 1985 and two for 1990. The first estimates in 1985 and 1990 were the same as those provided by the National Safety Council. (Miller was hired by the NSC to revise their estimates). However, he added to the NSC estimate an additional 1,500 to account for homicides. He did not account for suicides. His 1985 NSC adjusted estimate was 13,000. His 1990 estimate unadjusted for homicides was 10,500. His second estimate (1985 only) used the NTOF estimate adjusted for homicides. Again, he added 1,500. NIOSH admitted missing some homicides during the

early 1980s. NIOSH attempted to correct the homicide undercount in the late 1980s (National Institute for Occupational Safety and Health 1993). His NTOF estimate was 9,450 for 1985. His third 1985 estimate was derived from the BLS's Annual Surveys. He adjusted the Annual Survey numbers upward to account for the well-known undercounts mentioned above. He also added his estimate of homicides not reported to the BLS to arrive at a 1985 estimate of 7,400.

Miller's fourth 1985 estimate was derived from the NCCI data for 1985. He took the original NCCI number—3,084—and multiplied by 2.484. The reciprocal of the last number—.4026—indicates that Miller estimated that the NCCI counted only 40.26% of all job-related deaths in 1985. The product $(3,084 \times 2.484)$ yields 7,661. To this 7,661, Miller added another 1,239 for the undercount of homicides, bringing his total 1985 estimate based on the NCCI to 8,900.

Miller's fifth 1985 estimate and second 1990 estimate was the most useful for us since his first four relied on data we have analyzed above. His last estimate was derived from data on auto deaths—the Fatal Accident Report System (FARS)—that has been established at the National Highway Traffic Safety Administration. Miller assumed that 6.85% of all traffic deaths were job-related, and that all job-related injury deaths were 3.355 times the number of job-related motor vehicle crash deaths. He then added 1,500 homicides. These calculations allowed him to estimate 11,900 job-related deaths using the FARS data in 1985 and 11,451 in 1990.

We use only his 1990 FARS estimate. We again forecast to 1992 using the NTOF model in equation 2.1. In 1990, unemployment was 5.5%. By 1992, unemployment had risen to 7.4, registering a 1.9 increase. Our NTOF model equation 2.1 suggests that 1.9% should be multiplied by -3.94% to yield -7.486% (i.e., the NTOF model would predict that fatalities would fall by -7.486% due to an increase in unemployment). The time trend, on the other hand, would predict a fall of two years (1990 to 1992) times 4% for another 8% decline. The two added together yield a 15.486% drop. In our Miller-FARS example, this would imply a 1,773 drop to 9,678. This number—9,678—is our 1992 estimate based on Miller's FARS estimate.

II.B.3 Three Additional Studies

Three additional studies should be mentioned. We will not use death estimates from any of these studies, however.

R.W. Mason (1989) attempted to estimate the national costs of occupational illnesses and injuries in 1987. Mason's report was never published but is available from NIOSH.

Mason did not generate any injury death estimates. Mason discussed two numbers--6,000 and 7,000 per year. The 6,000 figure was suggested by the Office of Technology Assessment (OTA 1985). The OTA, in turn, derived their numbers from inflating the BLS's Annual Survey estimates for 1985. The 7,000 was drawn directly from NTOF. Mason preferred the 7,000 estimate. No further discussion of the 7,000 estimate was provided. Since Mason did not add any further estimate or modifications of the NTOF number, which we have already accounted for, Mason's 7,000 estimate will not be used in our calculations.

Rossmann, Miller, and Douglas (1991) were contracted by NIOSH and the CDC to produce estimates of the costs of occupational traumatic and cumulative injuries. Their report was compiled in March 1991 in manuscript form. It was never published. They assumed 11,000 job-related injury deaths in 1989. This 11,000 "was estimated based upon information from the National Safety Council" (footnote #3 in Rossmann, Miller, and Douglas 1991). No further discussion of the 11,000 estimate was provided. This number is already reflected in the NSC and Miller (1994) estimates we discussed above.

Finally, Susan Marquis' (1992) study should be mentioned. Marquis, a senior economist at the Rand Institute, provided testimony to Congress in May 1992 on the costs of job-related non-fatal injuries. Marquis' study has been widely cited. But, what is frequently missing from the citation is that her study, together with the original Rand injury study on all injuries whether on or off the job, ignored fatalities. Both Marquis' testimony and the original Rand study are discussed in the "Non-fatal Injury" section of this chapter.

II.C. Summary Table of Death Estimates

Table 2.3 summarizes the estimates for all sources considered here. Most prior studies estimated deaths in the 1980s. As indicated above, to make the estimates current, the NTOF model was used (Equation 2.1 above).

The sources are listed down the left-hand side. Years appear across the top. All of the numbers in the 1992 column are estimates except for the 6,063 for the CFOI. Apart from the 8,500 NSC estimate and the CFOI estimate, all other 1992 estimates rely on the NTOF model.

There were several ways to average these numbers. We used two methods. The first used the arithmetic average that sums seven numbers under 1992 and divides by seven. We used the CFOI actual number (6,063) and all others were estimates (6,063 + 6,346 + 5,584 + 8,306 + 6,994 + 10,000 + 9,678). We did not use the CFOI estimate or the NSC actual number to preclude double counting. We have more confidence in the CFOI actual than the CFOI estimate and more confidence in the NSC estimate than the NSC actual. The arithmetic average is 7,567.

The second measure is a weighted average. The CFOI is probably the best data available on injury deaths. The CFOI probably should be weighted more heavily than all of the others given that the CFOI was designed to be a true census. The NTOF is probably the second best data set. All of the others are probably equal in their credibility. We therefore weighted the CFOI by 60%, the NTOF by 20% and the others by 4% as explained in footnote number 4 of Table 2.3. These calculations in footnote 4 resulted in 6,529.

This number—6,529—is our preferred estimate. It heavily weights the CFOI and the NTOF, but allows for other studies that, on balance, suggest the CFOI and NTOF are too low.

We can also place a lower and upper bound on this 6,529 estimate. The lower bound would be the CFOI actual number (6,063) and the upper bound would be our arithmetic average (7,567). This range from 6,063 to 7,567 is not a formal 95% confidence interval. For example, we would find it difficult to believe (less than 1% likely) that the true number of fatalities would be fewer than the CFOI count of 6,063. The CFOI relied on two documents to support every death. Moreover, given that our study has had to use data from so many disparate sources, the assumptions

required to construct a formal confidence interval would undoubtedly be violated several times. The interval from 6,063 to 7,567 simply represents our judgment regarding the range of possible numbers of job-related injury deaths in 1992.

One last detail needs to be addressed. We assume that these 6,529 deaths result from injuries that occurred in 1992. In the language of epidemiology, we assume that 6,529 is an incidence, not a prevalence number. This assumption will be especially important when we develop our cost estimates. This assumption may be viewed as controversial. After all, the CFOI and WIOF numbers were prevalence-based. Some injuries could have occurred prior to 1991 and the person did not die until 1992. Since there is a downward secular trend in injury deaths, one could argue that prevalence exceeds incidence. But there is also an unemployment effect and unemployment was falling from January through December in 1992. There were undoubtedly injuries sustained in November and December of 1992 that lead to deaths in 1993, but none of these would be counted in the CFOI. Since unemployment was less in November and December of 1992 than 1991, we would expect a larger "carryover" from 1992 to 1993 than from 1991 to 1992. But we do not assign numbers to these arguments. Again, we simply assume our 6,529 deaths point estimate and 6,063 to 7,567 interval estimates are incidence-based.

III. Non-Fatal Injuries

The third section of this chapter investigates non-fatal injuries. Again, we will first consider primary data sources and second, secondary sources. Our primary sources include the BLS's Annual Survey, the NCCI data, and the National Health Interview Survey (NHIS) data. Secondary sources include the Rand study by Hensler et al. (1991), Rossman, Miller, and Douglas (1991), Miller et al. (1995), National Safety Council (1993) and Mason (1989). This section closes with a table summarizing our estimates.

As we will see, a problem will arise in this study, as any study on non-fatal injuries, concerning the many ways to classify non-fatal injuries. Our classification scheme allows for some of the most popular categories. We include the NHIS and BLS definitions of disabling and non-disabling; the WC definitions of Permanent, Temporary, Partial and Total disability, and the Rice et al. (1989)

Table 2.3

Estimated Number of Job-Related Injury Deaths and Death Rates

Source	1980	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	Death Rate ¹ per 100,000, 1992
1. CFOI actual													6063	5.20
2. CFOI estimate													6359	5.45
3. NTOF actual	7405	7136	6459	5856	6162	6250	5672	5884	5751	5714				
4. NTOF estimate													6346	5.31
5. Annual Survey actual including diseases											2900	2800		
6. Annual Survey estimate, injury only												5584		3.64
7. NCCI actual including diseases									3306	2768				
8. NCCI estimate injury only												8306		6.95
9. SDS estimate including diseases				5601										
10. SDS estimate injury only												6994		5.85
11. NSC actual	13200													
12. NSC estimate						11500	11100	11300	11000	10700	10100	9300	8500	7.1
13. Miller's estimates					11900								10000	8.36
14. Our 1992 modified Miller estimate													9678	8.09
15. Arithmetic Average of estimates ^{2,3}													7594	6.47
16. Weighted average that gives most weight to CFOI and NTOF estimate ⁴													6623	5.67

Best Point Estimate:

6529

Lower and Upper Bound: 6063 to 7567

Table 2.3 (cont'd.)

Estimated Number of Job-Related Injury Deaths and Death Rates

¹Death rate: $6063/117,598,000 = 5.2$; $6359/117,598,000 = 5.41$; and so on. The 117,598,000 comes from *Tosceno and Winden (1993)*.

²Total of 1992 column for estimates not allowing both CFOI or both NSC numbers: $6063 + 6346 + 5584 + 8306 + 6994 + 10,000 + 9678 = 52971$

³Total divided by 7 = 7567

⁴CFOI is weighted 60%, NTOR, 20%; all others, 4%:

$$6063(.6) + 6346(.20) + 5584(.04) + 8306(.04) + 6994(.04) + 10000(.04) + 9678(.04) = 3638 + 1269 + 223 + 332 + 280 + 400 + 387 = 6529$$

Source: Our study

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 2.3 WHICH WAS TYPED IN MICROSOFT
WORD FOR IBM. SEE FILE TBL23WRD.DOC ON THE DISKETTE.

**AND, THIS PAGE NUMBER AND SPACE RESERVED FOR THE CONTINUATION OF TABLE 2.3 WHICH
WAS TYPED IN MICROSOFT WORD FOR IBM. SEE FILE TEL23WRD.DOC ON THE DISKETTE.**

scheme involving hospitalizations or lack thereof. We will not spend much time on category schemes involving body parts. Our emphasis on disabling injuries, WC categories, and injuries causing hospitalizations more closely matches the medical and indirect costs data available on injuries than the body part schemes would have. The medical and indirect cost data for WC categories is especially rich. Another cost problem plagues body part classifications. Many accidents result in more than one body part being hurt. The same hospitalization cost could cover two body part injuries. If we assigned this hospitalization cost to body parts separately, we would be double counting costs.

We will not count trivial injuries. Injuries that can be accommodated with first aid will be ignored. Our preferred definition of injury is the same as that provided by the BLS:

"[An] occupational injury is any injury such as a cut, fracture, sprain, amputation, etc., which results from a work-related event or from a single instantaneous exposure in the work environment. [An injury would] involve one or more of the following: death, loss of consciousness, restriction of work or motion, transfer to another job or medical treatment, other than first aid."

We and the BLS in its Annual Survey attempt to count injuries, not people injured. BLS information is from business firms that keep logs of injuries. In any given year, a worker could sustain more than one injury. Our primary interest is in counting injuries, although analyses of persons injured is a secondary goal, as we will see in Section 4 of this chapter.

In recent years, the BLS has classified injuries into two categories: disabling and non-disabling. Disabling injuries are those that require one or more days of work loss. We will use the same definitions. BLS estimates disabling injuries to be 46% of the total in recent years. Non-disabling means less than 8 hours (full-time) or 4 hours (part-time) of work loss.

III.A.1.a BLS's Annual Survey of Occupational Injuries and Illnesses Introduction

The BLS's Annual Survey of Occupational Injuries and Illnesses was discussed above (U.S. Department of Labor 1992). The Annual Survey is much more thorough in its investigation of non-fatal than fatal injuries. Moreover, the number of firms reporting non-fatal injuries is greater than that reporting fatalities. All firms

with fewer than 11 employees (not just farms) are exempt from reporting fatalities. However, non-farm firms with fewer than 11 employees who are selected into the sample, report non-fatal injuries (and illnesses). We believe the BLS's Annual Surveys, despite their limitations, present the best current data available and the most historically consistent data on non-fatal injuries.

III.A.1.b Estimates of Non-Fatal Injuries

During 1992, according to the Annual Survey (U.S. Bureau of Labor Statistics 1994), private industry workers experienced roughly 6.342 million new non-fatal job-related injuries. These 6.342 million excluded all deaths. BLS investigators deliberately excluded deaths for the first time in 1992. But historical analyses of Annual Survey data including deaths are still meaningful. This is because the number of deaths (2,500 to 2,700 injury deaths) is so small in comparison to the number of non-fatal injuries (roughly 6,000,000,000). Another magnitude comparison involves rates. The occupational non-fatal injuries in the 1992 Annual Survey occurred at a rate of 8.3 per 100 full-time workers. The fatality rate was 4.3 per 100,000 full-time workers in 1991.

These numbers represent new injuries. We are, therefore, appropriately counting the incidence rather than the prevalence of injuries with these BLS numbers.

To arrive at a 1992 estimate of the total number of job-related injuries among all U.S. workers, we must first account for the well-known undercount of non-fatal injuries mentioned in the fatality section on the Annual Survey above. There are a number of reasons for the undercount. The most important involve the design of the survey. All government employees at the local, state and federal level are excluded. Not all firms with fewer than 11 employees are included. Self-employed persons are excluded. Household workers (e.g., domestics) are excluded. All farms with fewer than 11 employees are excluded.

In addition to these institutional exclusions, there are behavioral exclusions (i.e., there are economic incentives for firms to underreport). But for non-fatal injuries, there may also be economic incentives for employees not to report. Employees may be fearful that their employers will label them "accident

prone" and they will be laid off, if they report too many injuries (O'Loughlin 1993). We are not aware of any studies that attempt to estimate the underreporting of the numbers of injuries carried out by employers and employees. However, there have been some related studies and congressional testimony.

Oleinick et al. (1993) concluded that the BLS Annual Survey may ignore as much as 70% of days of work lost due to all non-fatal injuries (and illnesses) in Michigan. While Oleinick et al. (1995) do not directly address underreporting of the number of injuries, the 70% omission involving days lost suggests that underreporting of the number of injuries is likely to be significant.

Members of the U.S. House of Representatives have been concerned about underreporting for some time. On March 19, 1987, a subcommittee of the Committee of Government Operations held hearings on underreporting (U.S. Congress, House Subcommittee 1987). A number of people provided testimony, including the BLS's Chief of Occupational Safety and Health Statistics, William M. Eisenberg. Mr. Eisenberg acknowledged that underreporting was substantial and that the BLS Annual Survey estimated numbers of job-related injuries were roughly half of other household surveys.

Mr. Lewis Anderson, vice president of the United Food and Commercial Workers International Union, also testified about underreporting by the Iowa Beef Processing Company (IBP) in the Dakota City, Nebraska plant in a three-month period in 1985. IBP was the nation's largest meat packing company in 1987. Its chairman in 1985 was Armand Hammer. IBP reported roughly 1800 incidents to Mr. Anderson's union, but only 160 to the BLS.

The Subcommittee hearings (U.S. Congress Subcommittee 1987) revealed several additional cases of underreporting by employers. Subsequent to these hearings, OSHA began issuing large fines for "willful" underreporting. A number of firms including Caterpillar Tractor, Chrysler, General Dynamics, and Scott Paper have been required to pay substantial fines for "willful" underreporting (Bell and Denmead 1993; Greer 1992).

There are several ways to estimate the number of non-fatal injuries for all U.S. workers. The first would assume that the undercount percent of non-fatal injuries is at least as great as the undercount percent for fatal injuries. We

emphasize "at least as great" since it could be argued that deaths are more difficult to ignore than non-fatal injuries (i.e., records for deaths may be more reliable than records for non-fatal injuries). The 1991 BLS Annual Survey fatality count was 2,800. For reasons cited above, we can assume that 10% of these were deaths due to illnesses. (The 11% figure applies to WC estimates while the 10% figure applies to BLS Annual Survey Statistics). Therefore, our estimate for 1991 would be 2,520 (a 1992 Annual Survey death estimate was never made available by the BLS). Our best fatality estimate from 1992 above was 6,529. We can "backcast" from 1992 to 1991 by again using the NTOF model coefficients. The time trend coefficient would require that 4% of 6,529 (261) added to 6,529. The difference in the unemployment rate between 1992 (7.4) and 1991 (6.7) would require that 2.758% or 180 be added to 6,529. The net result is the addition of 441 to 6,529 to yield 6,970. Thus, the BLS Annual Survey counted only roughly 35.15% of deaths ($2,520/6,970 = .3615$).

Assume that the same percentage undercount from 1991 applies to 1992 for non-fatal injuries. We can, therefore, divide 6.342 million by .3615 to yield an estimate of 17.544 million injuries in 1992.

Alternatively, we could use the undercount statistics from the CFOI in Table 2.1. The "OSHA Reports" in Table 2.1 were the data the BLS Annual Survey relied on for their estimated deaths. The "OSHA Reports" suggest that the BLS Annual Survey would have counted only 32% of deaths identified in the CFOI. If the same undercount of deaths by the Annual Survey applied to non-fatal injuries, then we can divide 6.342 million by .32 to estimate 19.819 million non-fatal injuries.

But these 17.544 and 19.819 million estimates may be too high. The BLS Annual Survey injury and illness fatality estimate (2,800) ignored all firms with fewer than 11 employees, while the BLS Annual Survey non-fatal estimate included non-farm firms with fewer than 11 employees. The fatality estimate used 250,000 firms and the non-fatality injury estimate used 280,000 firms. Perhaps a better estimate would make use of the injury rates for reporting firms. The 1992 Annual Survey estimated an 8.3 per 100 full-time worker non-fatal rate for the firms that reported to the BLS. One estimate using this 8.3 rate would simply multiply 8.3 by the number of civilians employed in 1992 $= .083 \times 117,598,000 = 9.761$ million.

But there is a problem with this approach. The employment number for 1992 we and Toscano and Windau (1993) have been using (117,598,000) includes part-time workers. The 8.3 rate, on the other hand, applies to full-time workers. One argument would hold that the injury rate for part-time workers might be less than the one for full-time workers. Full-time workers work more hours and, therefore, have more hours of exposure than part-time workers. A second argument would hold that per hour of exposure, part-time workers would have a higher rate than full-time workers. Part-time workers are likely to be less experienced and lack of experience is a predictor of high injury rates (Division of Labor Statistics and Research 1985, p. 83).

To make a part-time and full-time adjustment, imagine that the first argument only is relevant. Recently, 18.9% of employed persons were estimated to be working part-time, i.e., less than 35 hours per week (Mishel and Bernstein 1993). Assuming two part-time workers equals one full-time worker, the number of full-time equivalent employees can be calculated as $[(117,598,000 \times (1-.189)) + (117,598,000 \times .189)/2] = 95,371,978 + 11,113,011 = 106,484,980$. This would be the equivalent number of full-time workers in 1992. Multiplying $.083 \times 106,484,980$ yields 8,838,253 or 8.838 million injuries. This 8.838 estimate assumes only that the first argument is relevant.

But if the second argument prevails, it would suggest that 8.838 would be too low. If, for example, part-time workers have double the rate per hour as full-time workers and if part-time total hours are one-half of full-time hours, then no adjustment needs to be made to our employment number (117,598,000) and the first rate multiplied by the employment estimate above applies: 9.761 million.

Both of these "rate" estimates, 8.838 and 9.761 million, assume that the firms and workers are faithfully reporting all injuries. This is a questionable assumption. First, as indicated above in our discussion of Annual Survey death statistics, it is likely that firms underreport due to financial reasons. Moreover, it is also likely workers underreport due to fear of employer reprisal (O'Loughlin 1993; Roy 1992).

Second, small firms, farms, and the self-employed have much higher non-fatal injury and death rates than other firms. Government workers have about the same as

other firms. Hence, this 8.3 rate itself would be too low as an estimate for all workers omitted from the Annual Survey.

None of the four estimates, 17.544, 19.819, 8.838, and 9.761 are without criticisms. We assume that they are equally plausible by simply taking the average: $(17.544 + 19.819 + 8.838 + 9.761)/4 = 13.991$. This estimate suggests that "willful" underreporting together with higher injury rates for small firms, farms and the self-employed would increase actual recorded injuries by roughly 121% $(13.991/6.342 = 2.21)$.

Finally, several clarifications concerning these injuries need to be made. First, these 13.991 million are new injuries in 1992. The 13.991 million is an incidence, not a prevalence number. It does not take into account that, in any given year, there will be workers away from work due to job-related injuries that occurred in prior years. The prevalence of injury would undoubtedly be higher than 13.991 million. However, in our cost chapter, we will account for the fact that some of these 1992 injuries will disable people beyond 1992.

We turn next to a discussion of the historical data in the Annual Survey.

III.A.1.c. Analysis of Historical Annual Survey Data

As noted above, there are many weaknesses associated with the BLS Annual Survey data. Nevertheless, they are better than the other non-fatal injury data sets we will examine. For example, although the National Health Interview Surveys (NHIS) and the National Safety Council (NSC) also have historical data, the Annual Survey is probably the most reliable as we will show. Moreover, the Annual Survey offers far more detail on injuries than either the NHIS or the NSC. The NSC, in fact, reproduces verbatim some of the Annual Survey tables in *Accident Facts*. The NSC relies on both the BLS's and the NHIS to develop its estimates. NSC has time trend data, but the NSC investigators are careful to point out that some of their definitions of injuries and disabilities have changed over time. The NSC explicitly state that their data should not be used for systematic historical analyses. Moreover, the NSC does not collect data from 250,000 or 280,000 firms as does the BLS nor does the NSC interview over 90,000 people annually as does the

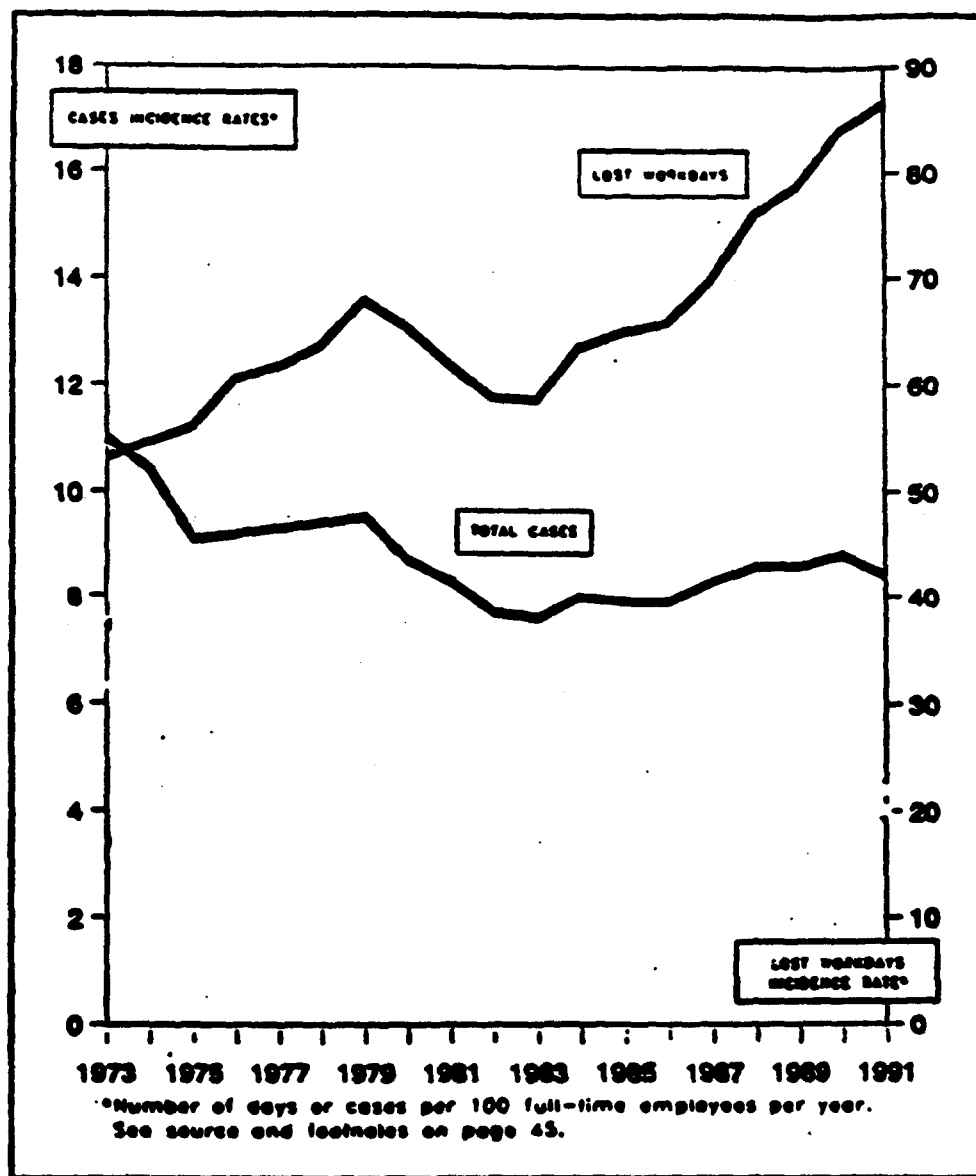
NHIS. The following section will analyze some of these BLS time trend data and construct a forecasting model to be used in subsequent analyses of non-fatal data.

Figure 2.2 and Table 2.5 provide some of the time trend data available. The data in the figure include illnesses. However, illnesses comprised a small percentage of all cases and workdays from 1973 to 1991 (2% to 5%). This is evident in Table 2.5 which contains information on the Annual Surveys data on illnesses. The number of illnesses are small when compared to injuries but their share is rising quickly—from 2.2% of the total in 1983 to 5.8% in 1991. Moreover, the visual patterns apparent in Figure 2.2 are supported with more rigorous regression analyses of the injury-only data in Table 2.5. The vertical axis in Figure 2.2 indicates incidence rates. The left vertical axis indicates the number of cases per 100 full-time employees per year. The right vertical axis indicates the number of lost workdays per 100 full-time employees per year. Years are measured along the horizontal axis. The top line measures the lost workdays rate and the bottom measures the total cases.

Several patterns can be gleaned from Figure 2.2. The lost workdays rate has a secular upward trend. The total cases per 100 full-time employees rate has remained relatively flat, with a slight secular downward trend. Finally, both rates seem to follow the business cycle. We consider each of these in turn.

Consider the trends first. Nelson (1992, 1993) suggests that the rising trend in workdays lost and falling trend in number of injuries can be attributed to an aging workforce. Older workers tend to take longer to recover from any given injury than younger workers. At the same time, older workers have more experience and would probably be more successful than younger, inexperienced workers at avoiding injuries in the first place. Hence, we find fewer injuries per worker, but longer recovery times. These longer recovery times are again apparent in Table 2.5 under the heading "Average Lost Workdays for a Lost Workday Case." The trend is clearly upward from 17 days in 1983 to 21 days in 1991.

Figure 2.2



Source: BLS Annual Survey and
ACCIDENT FACTS 1993 Edition

NATIONAL SAFETY COUNCIL

THIS PAGE NUMBER AND SPACE RESERVED FOR FIGURE 2.2

Table 2.5

Occupational non-fatal injury and illness estimates for private industry, 1983-92,
Incidence rates are per 100 full-time workers,
Data exclude farms with fewer than 11 employees

1	2	3	4	5	6	7	8	9
Year	Number of Non-fatal Injuries	Injury Cases per 100 Full-time Workers	Number of Lost Workdays for Injuries	Average Lost Workdays per Lost Workday Case	Injury only lost workdays per 100 Full-time Workers	Number of Non-fatal Illnesses	Illness to Total Cases, Percent	Unemployment Rate
1983	4,748,000	7.5	2,140,300	17	57.2	106,100	2.2	9.6
1984	5,294,800	7.8	2,449,700	17	61.8	124,800	2.3	7.5
1985	5,381,700	7.7	2,484,700	18	63.3	125,600	2.3	7.2
1986	5,492,000	7.7	2,532,200	18	63.9	136,900	2.4	7.0
1987	5,845,500	8.0	2,721,300	18	67.3	190,400	3.2	6.2
1988	6,197,700	8.3	2,878,400	19	72.5	240,900	3.8	5.5
1989	6,292,500	8.2	2,955,500	19	74.2	283,700	4.3	5.3
1990	6,421,300	8.3	2,987,300	20	78.3	331,700	4.9	5.5
1991	5,977,400	7.9	2,794,000	21	79.8	368,300	5.8	6.7
1992	6,342,000	8.3						7.4

*The BLS changed their format in 1992. Only information for columns 2, 3 and 9 were available in 1992.

Source: BLS Annual Survey, various years.

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 2.5 which was typed in Microsoft Word for IBM and is labeled TBL25WRD.DOC on the diskette.

But there have been other attempts at explaining the secular trends. In Ruser's (1991, 1993) studies using micro data on manufacturing industries, evidence is presented that the increasing generosity of WC benefits compared to wages over time has resulted in workers staying away from work longer once they become injured. He also finds that the increasing generosity of WC benefits increases the number of injuries per 100 workers regardless of the length of time spent in recovery. The macro (economy-wide) time trend data in our Figure 2.2 for lost workdays are consistent with Ruser's micro data. The average length of time away for work for any given injury has been increasing. The macro time trend data for the number of cases per 100 employees in our Figure 2.2, however, are not consistent with Ruser's studies. The rate for numbers of injuries has been decreasing slightly.

But Ruser is not alone in investigating the WC payment and recover time correlation. Cheadle et al. (1994) found that WC benefits did not influence the length of time on WC. They found, instead, that older age, being female, being divorced, being employed in a small firm, and high regional unemployment increased duration.

The second pattern in Figure 2.2 concerns the business cycle. The number of injuries rise during expansions and fall during contractions. One obvious explanation involves the number of exposed workers. During an expansion, more people are working and, hence, the total number of job-related injuries would be expected to increase. But other explanations are less obvious. In fact, even after controlling for the number of people employed, i.e., by treating the rate as the dependent variable (which includes the numbers employed in the denominator) the same pattern emerges. Injury rates rise during economic expansions and fall during economic contractions (Smith 1992). There are explanations for this pattern. First, new hires typically have less experience than employees with tenure and inexperience is notoriously associated with job-related injuries (Division of Labor Statistics and Research 1993; Robinson 1988). Those employees most recently hired are also the ones most frequently laid-off during a recession due to seniority clauses in employment contracts. Second, as business improves, workers are required to put in overtime which probably increases fatigue and ultimately

results in injuries. Finally, it could be that management lays-off more persons who are judged to be accident-prone than non-accident-prone when a business downturn approaches (Leigh 1985a).

Smith (1992) has discovered two other provocative influences on injury rates involving lies. First, the employer might lie. During the first six Reagan years, OSHA's fines for poor business record-keeping on injuries were low. Beginning in 1987, fines became severe. Smith (1992) finds evidence that when fines were low (1981-86), recorded injury rates were low; when fines were high (after 1986), recorded injury rates were high.

Second, the employee might lie. Injuries over the weekend might be attributed to the job on Monday. Opportunistic employees may want to collect WC benefits. Smith (1992) finds that Monday is the most popular day for job-related injuries to occur. He finds an even higher jump in injuries after three-day weekends. Smith (1992) estimates that perhaps as many as 4% of sprains and strains are misrepresented as having occurred at work.

But Smith ignores the medical literature on sprains, strains, injuries, and some diseases and deaths. The body adapts to its surroundings. If muscles are not used for a period of time, rapid use is likely to result in a sprain or strain. This is the point of stretching before exercising (Schneider et al. 1985). The body can also adapt to chemical surroundings. Symptoms of byssinosis (brown lung) are characteristically at their worse on returning to work Monday morning (Levy and Wegman 1983, p. 33). That is, over the weekend, the body begins to recover but with the new re-introduction of cotton dust on Monday the symptoms are the most severe.

Nitroglycerin workers used to drop dead at work most frequently on Mondays. Their blood vessels would be dilated due to work exposure to nitrates. When the nitrates were not in their environment, they would suffer angina away from work. On Monday, with the new introduction of nitrates, their hearts would fail (Levy and Wegman 1983, p. 33).

These arguments about the re-introduction of a hazard on Monday are especially cogent when vacations are involved. Most people return to work on a Monday after a vacation. Two weeks of vacation away from work provides ample time

for the body to lose any resistance that may have been built up while continuously employed. For example, something as simple as regular toenail clipping may have been forgotten on vacation and lead to a painful injury on the first Monday back at work. Long toenails can be ripped backwards in the course of job duties.

It is likely that Mondays are the most popular day for new employees to be introduced to the job. And new employees are much more likely than others to experience an injury. Moreover, new employees that are injured are more likely to experience that injury in the first month on the new job than any other month (Division of Labor Statistics and Research 1985).

An analysis of fatal heart attacks in the CFOI revealed that more attacks occurred on Monday than any other day (U.S. Bureau of Labor Statistics 1995 , p. 121). Finally, an OSHA report indicated that construction injury fatalities most often occur on Mondays and Thursdays (Office of Construction and Engineering 1990). While workers might lie about sprains, they could not lie about fatalities.

Because Smith ignores medical reasons for high levels of injury rates on Mondays, he likely overestimates the number of lies by workers.

The associations between injuries on the one hand and unemployment rates, time trends, and the Reagan under-enforcement years on the other, can be tested in models using 1983-92 data from Table 2.5. Two least squares regressions were run with the natural log of the number of injuries serving as the dependent variable. The number of injuries rather than the rate served as our dependent variable since we wanted one) to compare our non-fatal injury trend with the NTOF fatal injury trend and two) more importantly, to construct a model that could be used to forecast the number of injuries, not rates of injuries. Our first non-fatal injury model ignores the changing fine patterns. The second model explicitly accounts for them with a dummy variable equalling one for 1983-1986 and zero otherwise. The dummy variable approach was suggested by Smith (1992). Here are the results:

Equation 2.2:

$$\begin{aligned} \ln (\text{Injuries}) = & -23.9563 & - & .0378 \times \text{unemployment} & + & .0200 \times \text{time} \\ & (t=-4.570) & & (t=-6.119) & & (t=-7.624) \\ & (p=.0026) & & (p=.0005) & & (p<.0001) \\ & n = 10; R^2 = .9690 \end{aligned}$$

Equation 2.3:

$$\begin{aligned} \ln(\text{Injuries}) = & -21.009 & - & .0362 \times \text{unemployment} \\ & (t=-2.392) & & (t=4.814) \\ & (p=.0539) & & (p=.0030) \\ & + .0185 \times \text{time} & - & .1028 \times \text{dummy} \\ & (t=4.197) & & (t=-.434) \\ & (p=.0057) & & (p=.6792) \\ & & & n = 10; R^2 = .9699 \end{aligned}$$

$t = 1, \dots, 10$

First consider Equation 2.2. The high t-statistics and low p-values on the unemployment rate and on the time trend suggest that these associations are not due to chance. The estimated coefficient on the unemployment rate, $-.0378$, suggests that a one percentage point increase in the unemployment rate is associated with a 3.78 percentage decrease in the number of injuries. The negative sign on the unemployment rate is consistent with the hypothesis that there should be more injuries in expansions and fewer injuries in recessions due to the inexperience of newly hired employees and the increase in the number of persons "at risk" as the economy expands. The results are also consistent with those from Equation 2.1 involving fatality data. Increases in unemployment were associated with fewer deaths.

The coefficient on the time trend (.02) suggests that one more year is associated with 2% more injuries. This is inconsistent with the result from Equation 2.1 involving fatality data. Over time, deaths have decreased. These are important findings: while deaths appear to be falling over time, non-fatal injuries appear to be rising.

Equation 2.3 confirms the importance of the unemployment rate and the time trend. Both generate relatively large t-statistics and low p-values. The dummy variable for the weak OSHA enforcement years entered with a negative sign, contrary to expectations, and did not garner a big t-statistic or small p-value. When the time trend variable was excluded from the regression, in a separate model (Equation 2.4 not shown), the dummy variable did enter with a positive sign and garnered a big "t" and small p-value. Our conclusion is then that Smith's hypothesized weak enforcement years cannot be distinguished from the general secular upward trend in injuries. But this conclusion only applies to these data

that ignore years prior to 1983 (which Smith includes). Moreover, our regression does not exactly follow his specification (i.e., his dependent variable is the rate, not the number of injuries). Given that considerable evidence demonstrates the enforcement year effects in Smith's (1992) study, we accept Smith's conclusion. But in our data, Equation 2.2 appears to be the more appealing forecasting model. We will rely on 2.2 in our attempts to update other estimates to 1992. (Note that the differences in coefficients on unemployment and time between the two models, 2.2 and 2.3, are slight).

We now return to our main discussion of reviewing primary data on non-fatal injuries by considering the popular data derived from the NCCI.

III.A.2 National Council on Compensation Insurance (NCCI)

As explained above, the NCCI is a private firm. Among other activities, the NCCI collects information on 36 to 40 states and D.C. pertaining to the number and costs of WC claims and prepares reports and statistics. We purchased copies of two of their most recent reports: Exhibit 5B, Workers' Compensation Experience Countrywide Ultimate Report Basis, for May 1992 and May 1993.

The May 1992 report corresponded to policy years from 1987 to 1989; the second, May 1993, report corresponded to policy years covering 1988 to 1990. Again, as explained above, data from any one state covered only one 12-month period, and the data pertained to new cases arising in a given policy year. Table 2.6 below summarizes some of the data available in the two May reports. The WC categories are in the first column. These categories include: Permanent Total; Permanent Partial Major; Permanent Partial Minor; Temporary Total and Partial; Medical Only, no indemnity. Permanent Total injuries are the most serious. An injury rendering a construction laborer a paraplegic would likely qualify as Permanent Total. The injured worker cannot work at the old job. WC generally encourages him or her to seek training in a new field. The least serious injuries are Medical Only, no indemnity. A manager sustaining a broken ankle might return to work the following day with the ankle in a cast. All medical expenses would be paid by WC but no lost wages would be covered.

The next two columns (2 and 3) correspond to the May 1992 NCCI Ultimate Report (1987-89) and the last two columns (4 and 5) correspond to the May 1993 NCCI Ultimate Report (1988-90). Within these four columns, we first present the actual, unadjusted NCCI numbers and second, we present our national estimates, assuming the experience of states excluded and the self-insured employers excluded from the NCCI were the same as the states included in the NCCI reports. The .72, .67, .65, and .60 factors were determined based upon which states were excluded from the NCCI data as indicated in the footnotes a through d in Table 2.6. For example, the NCCI did not collect Permanent Total data from California, Minnesota, Nevada, New York, North Dakota, Ohio, Washington, West Virginia, and Wyoming for the policy years in 1987 to 1989. Together, these states contributed roughly 28% of all U.S. civilian employment during 1987 to 1989. Therefore, we concluded NCCI states contributed 72%. To create a national estimate, the NCCI number must first be divided by .72 as explained in footnote e.

But accounting for missing states is not the only adjustment required. The NCCI does not collect data from self-insuring firms and some state funds. Invoking the same assumption we used above in the discussion of NCCI fatalities, we again assumed that self-insuring firms and some state funds would cover 20.0% of injuries. Thus, our NCCI number must be divided by .8, as explained in footnotes 5 through 8. Our national estimates for new annual injuries and illnesses would be 7,371,735 for the 1987 to 1989 period and 8,913,259 for 1988 to 1990. Averaging the two yields 8,142,497. We assume that this 8,142,497 applies to 1989.

Table 2.6

Number of Cases Per Year in Policy Years Covering 1987 Through 1990

1	2	3	4	5
<u>Category of Non-fatal Injury and Illness</u>	<u>1987-1989</u>		<u>1988-1990</u>	
	<u>39 or 41 States plus D.C.</u>	<u>Our National Estimate for Injuries</u>	<u>38 or 40 States plus D.C.</u>	<u>Our National Estimate for Injuries</u>
Permanent Total	5,523 ^a	9,589 ^a	4,795 ^c	9,221 ^d
Permanent Partial Major	120,458 ^a	209,128 ^a	103,280 ^c	198,615 ^d
Permanent Partial Minor	210,414 ^a	365,302 ^a	196,927 ^c	378,706 ^d
Temporary Total & Partial	870,392 ^a	1,511,110 ^a	788,230 ^c	1,513,582 ^d
Medical only, no indemnity	3,510,961 ^b	6,550,300 ^e	3,269,227 ^d	6,810,980 ^b
Total:	4,717,748	7,371,735	4,362,459	8,913,259

^aExcludes California, Minnesota, Nevada, New York, North Dakota, Ohio, Washington, West Virginia, and Wyoming. In 1988, these states contributed 28.38% of U.S. employment. In 1989, they contributed 28.54% of U.S. employment (U.S. Bureau of the Census 1991, 1992).

^bExcludes all states in footnote 1 plus Delaware and Pennsylvania for a total of 11 states excluded. These 11 states contributed 33.03% of U.S. employment in 1988 and 33.19% in 1989.

^cExcludes all states in footnote 1 plus Texas. These 10 states contributed 35.24% of U.S. employment in 1989.

^dExcludes all states in footnote 2 plus Texas. These 12 states contributed 40.12% of U.S. employment in 1989.

^eEquals number in column 2 divided by .72 and .8.

^fEquals number in column 2 divided by .67 and .8.

^gEquals number in column 4 divided by .65 and .8.

^hEquals number in column 4 divided by .60 and .8.

Source: NCCI Ultimate Reports and Current Study.

This 8,142,497 estimate carries three defects. First, it is drawn from WC records only; second, it includes diseases and illnesses; and third, it applies to 1989, not 1992. We can fix all three.

Above, we assumed that national WC numbers of injury deaths underestimate job-related deaths by a factor of 2.222, which corresponds to a 55% undercount. Toscano and Windau (1993), Cone et al. (1991), Stout and Bell (1991), Parker et al. (1994), Hensler et al. (1989), and the NHIS-OSH data, as we have seen, indicated a similar 45% to 70% undercount for fatal and non-fatal injuries. These undercounts arise from the omission of farms, domestic workers, the self-employed, and so on. These omissions are over and above the NCCI's omissions of some states, self-insuring firms, and some state funds and the difficulty of filing for WC.

To correct the first defect, we multiply by 2.222 to yield 18,102,628.

The second defect is that WC data combine diseases with injuries. Leigh (1995a) used the SDS/WC data to estimate that roughly 11% of all deaths were due to diseases. But the NCCI data in Table 2.6 reflect non-fatal cases and there is evidence that non-fatal cases are more likely to be injuries than fatal cases. In a separate analysis of NCCI claims from 17 states, Rossman, Miller, and Douglas (1991) found that 98.37% of WC claims were for an injury. Since the Rossman, Miller, and Douglas estimate applies to disabling claims, not deaths, it is a better estimate than Leigh's (1995) for non-fatal events. Nelson (1992) finds a 2% illness factor in costs for WC, including the costs for fatalities. On the other hand, the BLS's Annual Survey consistently found at least 3% of all events were attributed to illnesses during the time of these policy years—1987 to 1990 (Table 2.5). We, therefore, compromised and used a 3% estimate of disease cases. Our 18,092,628 was then multiplied by .97 to yield 17,549,849.

To estimate the number of injuries in 1992 (the third defect) requires that we use the BLS Annual Survey Equation 2.2. The change in the unemployment rate from 1989 to 1992 was from 5.3 to 7.4 or 2.1. The added years would be three. Multiplying 2.1 and 3 by the corresponding coefficients in the BLS Annual Survey model yields: $-3.78 \times 2.1 + 2 \times 3 = -1.938\%$. This -1.938, multiplied by 17,209,733, yields -340,116. Adding -340,116 to our 1989 estimate yields 17,209,733, our 1992 estimate of new cases nationwide.

An additional issue surrounding NCCI statistics concerns incidence and prevalence. The NCCI statistics that scientists have studied are incidence, not prevalence statistics. That is, they indicate the number of new cases opened in a policy year. They do not include cases from prior years that still receive payments. Most permanent injuries would fall into this category. However, the term "permanent" is a little misleading. Many permanent work impairments, especially partial impairments, do not necessarily last a lifetime. People adapt, become retrained, and find new jobs. WC recognizes this and places caps on the maximum length of time someone may draw on indemnity payments, especially partial impairments. If incidence-only figures are used to estimate the volume of injuries within a year, they will result in an underestimate, since some people injured in prior years will continue to receive benefits in the current year.

It is nevertheless useful to ask how much incidence underestimates prevalence. In data from Washington state, Cheadle et al. (1994) found roughly 55% of all injured persons exit WC within one month; 70% exit within two months; 80% exit within four months. Cheadle et al. (1994) also found that over 90% of all WC cases last no more than 12 months. Given that the majority of permanent cases are dropped only after 10-15 years or when the person dies, virtually all of these 90% must be temporary cases. The data in Table 2.6 provide some support for this over 90% figure pertaining to temporary cases. Roughly 7% of all cases are permanent cases in Table 2.6.

Assume that in the prior year, 7% of the injuries were permanent and that they were still in the WC records in the current year. In this case, incidence would equal prevalence. But there are also likely to be permanent injuries from two, three, four or more years prior to the current year that are still in the WC records. Depending on the length of time it takes for workers to adapt and be retrained, prevalence estimates may exceed incidence estimates by a considerable amount.

But we want our cost study to be comparable to prior cost studies. Most prior cost studies of injuries have estimated incidence, not prevalence. In fact, for injuries, we are aware of only one cost study that used the prevalence method:

the Rand study described in Hensler et al. (1991) and Marquis (1992). This is not the case for diseases for which most prior studies have been prevalence-based.

Marquis estimated that 7 million people suffered new work-related injuries in 1989 and 4 million continued to suffer from injuries sustained in prior years. By this method of calculation, incidence underestimates prevalence by 36.4%.

The use of incidence in the economic part of our injury study will be essential since we will estimate the present value of all future costs associated with new injuries in 1992.

III.A.3 The National Health Interview Survey (NHIS)

We first consider the advantages and disadvantages of the NHIS. The discussion of disadvantages will involve an analysis of 20 years of NHIS time series data. Second, we will construct our estimate of injuries that attempts to account for some of the disadvantages of the NHIS.

The National Health Interview Survey (NHIS) is a

"continuing nationwide survey of the U.S. Civilian non-institutionalized population, conducted on households. Each (survey) is a probability sample of household respondents interviewed by trained personnel of the U.S. Bureau of the Census to obtain information about the health and other characteristics of each living member of the sample household. During a year, the sample is composed of 36,000 to 47,000 households including 92,000 to 125,000 persons, depending upon the year." (U.S. Department of Health and Human Services 1992)

The NHIS has been gathering information on injuries "due to an accident" for over 20 years. The NHIS injury question asks currently employed respondents 18 years old and up, whether the accident resulting in the injury occurred at work or on work time during "the past two weeks." These phrases—"due to an accident" and "during the past two weeks" as well as the sample restriction that persons must be currently employed—need to be emphasized as they apply to job-related injuries.

By using the phrase "due to an accident" the NHIS may unintentionally exclude injuries due to assault, attempted murder, or suicide. The original OSH Act ignored assault and attempted on-the-job murder and suicide. Many OSH researchers continue to ignore them in analyzing job-related injuries (see discussion in Leigh 1995a). Only recently has NIOSH conducted separate studies on assaults and murders. The OSH Administration has yet to promulgate standards to minimize

assault and murder. It would not be surprising if many NHIS respondents would not regard assault at work as an "accident." It is even less likely that attempted suicide would be regarded as an accident. These omissions would represent a serious bias since Toscano and Windau (1993) found that 20% of fatal injuries were due to murders and suicides.

Suicides can be work-related, as WC boards recognize. Freedman (1990) reported a WC case involving a construction worker who was permanently and totally disabled from a job-related injury. Prior to the injury, he was very active. After the injury, he had psychological difficulty adapting to his disability. Two years after the accident, he killed himself. Roy (1992) examines cases of psychological disorders following job-related injuries and found many to be severe. Additional suicide cases are discussed in Conroy (1989a).

Psychological trauma may also occur. Elisburg (1994) reports that most states will allow WC to pay job-stress claims if the stress followed a job-related injury.

Another related disadvantage of the NHIS is that respondents may also undercount vehicle crashes. As we have seen, self-employed people who experienced a car crash may not have regarded it as an on-the-job injury. There appears to be a general tendency by OSH experts, administrators, police, coroners and so on not to regard many vehicle crashes as job-related. This bias might also exist among NHIS respondents themselves.

The second phrase, concerning injuries "in the past two weeks," is helpful. Landen and Hendricks (1992) demonstrate that significant recall bias will affect answers to a question asking respondents about injuries that may have occurred during the past 12 months. Another advantage of the two week interval is that it is more likely that the number of persons injured equals the number of injuries. Over 12 months, persons are more likely to suffer more than one injury than over two weeks.

The phrase "in the past two weeks" also needs to be emphasized as it pertains to incidence and prevalence measurements. The NHIS gathers information only about accidents that occurred during the past two weeks. If the person is still impaired from a job-related accident from, say, 18 months prior to the interview, the NHIS

would not include it as an accident. The NHIS data, therefore, are incidence not prevalence-based.

But the last restriction may be the most serious. By restricting attention to those currently employed and non-hospitalized, a high percentage of disabling injuries may be ignored. Many serious injuries can result in hospitalizations and more importantly, permanent exit from the labor force.

An advantage of the NHIS is that the definition of an injury is clear and similar to our and the BLS's Annual Survey definition. For the NHIS to classify an incident as an injury, it either must have been "medically attended," i.e., received the attention of a doctor, nurse or paramedic, or have resulted in at least one half of one day of work loss (since 1983) and one full day of work loss prior to 1983.

Other advantages include: 1) the NHIS researchers adjusted the responses for two weeks to reflect annual estimates and rates and 2) the data have been collected in a (relatively) consistent manner since 1970. Recent years of the NHIS have estimated the following annual numbers and rates per 100 workers:

8,673,000, 7.4 (1991); 7,277,000, 6.2 (1990); 10,947,000, 9.3 (1989);
10,057,000, 8.7 (1988); 9,131,000, 8.1 (1987); and 10,529,000, 9.7 (1986).

Table 2.7 provides information on the NHIS estimates from 1970 through 1991. The first column presents the year. The second, third, and fourth columns present the number of injuries, workdays lost, and bed disability days. The last column presents the national unemployment rate.

The most recent data we have are from 1991. Given that data are available from 1970 to 1991, we attempted to construct regression models using historical NHIS data to forecast 1992 values. This did not prove to be successful, however, and ultimately led us to question the reliability of the NHIS data. We will first examine the regression models and then explain how we ultimately did forecast into 1992.

Table 2.7

NHIS Estimated Work Injuries, Work Days Lost,
Days in Bed, and the National Unemployment Rate

<u>Year</u>	<u>Number of Injuries (thousands)</u>	<u>Work Days Lost (thousands)</u>	<u>Bed Disability Days (thousands)</u>	<u>Unemployment Rate (percent)</u>
1970	7,750	110,947	26,798	4.9
1971	9,631	120,384	30,122	5.9
1972	7,938	102,247	24,131	5.6
1973	9,027	124,692	32,212	4.9
1974	9,254	144,191	38,143	5.6
1975	9,841	138,838	36,248	8.5
1976	9,292	140,590	35,272	7.7
1977	11,414	160,533	37,381	7.1
1978	10,511	184,031	42,593	6.1
1979	12,014	176,284	40,707	5.8
1980	10,826	184,636	42,657	7.1
1981	11,291	214,873	43,957	7.6
1982	9,543	130,568	43,540	9.7
1983	8,920	133,060	43,197	9.6
1984	10,634	154,154	45,419	7.5
1985	11,363	165,796	46,940	7.2
1986	10,529	148,351	46,021	7.0
1987	9,131	171,029	52,878	6.2
1988	10,057	178,845	47,625	5.5
1989	10,947	191,544	50,851	5.3
1990	7,277	183,024	48,365	5.5
1991	8,673	233,160	54,187	6.7

Source: National Health Interview Survey, various years

The data in Table 2.7 were used to fit regression equations explaining several dependent variables—injuries, workdays, and bed days, as well as the natural logs of each of these—with independent variables—the unemployment rate and the time trend. These are the same independent variables used for the NTOF and Annual Survey models. In the NTOF and BLS Annual Survey models, both the unemployment rate and time trend were statistically significant predictors. We attempted two sets of regressions. In the first, the dependent variables were entered in their natural units (not logged). In the second, the dependent variables were logged. Because both sets yielded similar statistically insignificant results, here we present only the first set. The results for these regressions are presented in Equations 2.4, 2.5, and 2.6.

Equation 2.4:

$$\begin{aligned} \text{Injuries} &= -28002 & + & 159 \times \text{unemployment} & + & 19 \times \text{time} \\ & \quad (t=.3177) & & (t=.8268) & & (t=.4150) \\ & \quad (p=.7541) & & (p=.4192) & & (p=.6826) \end{aligned}$$

$$n = 22; R^2 = .0512$$

Equation 2.5:

$$\begin{aligned} \text{Workdays Lost} &= -7000645 & - & 2866 \times \text{unemployment} & + & 3624 \times \text{time} \\ & \quad (t=.791) & & (t=.7919) & & (t=4.3115) \\ & \quad (p=.4386) & & (p=.4386) & & (p=.0004) \end{aligned}$$

$$n = 22; R^2 = .4945$$

Equation 2.6:

$$\begin{aligned} \text{Bed days} &= -2278205 & + & 87 \times \text{unemployment} & + & 1170 \times \text{time} \\ & \quad (t=-12.205) & & (t=.2120) & & (t=12.1918) \\ & \quad (p=.0001) & & (p=.8347) & & (p=.0001) \end{aligned}$$

$$n = 22; R^2 = .8911$$

The secular upward trend in measures of injuries observed in the NTOF and Annual Survey data is also apparent in these NHIS data: all three coefficients on time are positive. However, the time trend on the important injury model, Equation 2.4, does not generate a low p-value.

The statistically significant unemployment patterns observed in the NTOF and Annual Survey models are not found in the NHIS data. None of the unemployment coefficients were statistically significant in Equations 2.4, 2.5 or 2.6 or in any of the logged models available from the authors. Moreover, positive associations between unemployment on the one hand and injuries and bed days on the other were observed in Equations 2.4 and 2.5. Negative and statistically significant associations were found in the NTOF and Annual Survey models (Equations 2.1, 2.2, and 2.3). These positive associations are not easily explained.

The NHIS slightly changed its definition of injury in 1983, as explained above. We attempted to account for this change with a dummy variable equalling 1 for years prior to 1983 and equalling zero after 1983. The same lack of statistical significance and unexpected positive signs on the unemployment rate were obtained, however.

Finally, as explained above, we tried fitting each equation again with a logged dependent variable. The same disappointing results emerged.

The disparities between the NHIS regression results and the NTOF and Annual Survey results are cause for concern. The unemployment rate has proven itself to be a reliable predictor of job-related injuries using a variety of data sets (Chelius 1977; Smith 1992; Leigh 1985a; Robinson 1991). It is unlikely that all of these prior studies together with our NTOF and Annual Survey models data were flawed. Moreover, the explanation of an unemployment-injury correlation is compelling. First, as more people are added to the payroll, there are greater numbers of workers who are at risk of injury. Second, new, "green", employees are more likely to experience an injury than seasoned workers. It is, therefore, possible that the NHIS is not producing reliable estimates of job-related injuries and injury rates.

A second problem plagues the NHIS data. As we will see in Section V.A.3, NHIS job-injury generally show higher rates for whites than African-Americans. As we will show, these results are in conflict with the great volume of research indicating a disproportionately high percentage of African-Americans in dangerous jobs.

Given the poor statistical showing of the NHIS data in the models above, and the questionable black/white results, we are not confident in using an historical NHIS data model to forecast into 1992. We, instead, use the three most recent NHIS years combined with the Annual Survey model of non-fatal injuries. Table 2.8 shows our calculations. NHIS data from 1989 through 1991 suggest that the 1992 number of injuries would be 8,799,088. This estimate is unadjusted for any underestimates inherent in the NHIS. As argued above, the experts, OSH administrators, and the public very likely did not regard many assaults or motor vehicle crashes as job-related in 1989 to 1992. Moreover, many permanently disabled people would never have been counted by the NHIS if they were not in the labor force. Assuming a 20% undercount by the public (a conservative number given that murder and suicide alone account for over 20% of deaths [Toscano and Windau 1993]), the NHIS estimate would be $8,799,088 / .8 = 10,998,860$.

We turn now to our analyses of secondary data on non-fatal injuries.

III.B.1 Rand, Hensler et al. (1991), and Marquis (1992)

The Rand Institute for Civil Justice conducted a study of the costs of all non-fatal injuries—whether on or off the job—in the late 1980s. The results were published in 1991 (Hensler et al. 1991). An updated version of the study applying only to job-related injuries was prepared for Congressional testimony in 1992 (Marquis 1992). The original and updated versions of the study were based on a large survey conducted by Rand between August 1988 and May 1989. The sample was nationally representative.

This is the first of our "secondary analyses" of non-fatal injuries. We do not directly analyze the data collected by Hensler et al. (1991). We merely discuss the data Hensler et al. present and interpret.

The Rand authors were careful to point out that their unit of analysis was not an injury or an accident or a person but a "person-incident." An accident could have injured more than one person. A person could have sustained more than one medically diagnosed injury during a given accident (e.g., a fractured leg and a concussion would be two separate medically diagnosed injuries). Their "person-incident" term refers to a person who was injured at a specific accident.

This is useful terminology, but it does not negate our approach. We seek to count non-fatal injuries (not people) according to BLS and WC classifications: non-disabling, disabling, Permanent Total (PT), Permanent Partial (PP), Temporary Total or Partial (TTP), other disabling, and whether hospitalized. It is true that two or more medically diagnosed injuries could have been sustained by one person in a given accident. But both injuries would be assessed simultaneously by the BLS in their disabling versus non-disabling categories and by WC boards in their PT, PP, and TTP categories. The confusion that Hensler et al. hoped to avoid by defining injuries as "person-incidents" essentially involved medical diagnoses.

Rand contacted roughly 26,000 people and obtained injury information on 2,770, all of whom had sustained at least one injury over the prior 12 months. The 26,000 were selected as a random sample of the continental United States. However, after all the data were collected, a re-analysis revealed that their sample "somewhat under-represents single-person households, older persons, blacks and Hispanics."

Table 2.8

NHIS Forecasted Injuries Using Coefficients from BLS Annual Survey Data, Equation 2.2

1	2	3	4	5	6	7	8
	Unemployment from Base Year to 1992	Unemployment Coefficient from BLS Model (-3.78%) Times Change in Unemployment	Change in Time from Base Year to 1992	Time Trend Coefficient from BLS Model (+2%) Times Column 4	Sum of Columns 3 plus 5	NHIS Estimate from Base Year	Forecast for 1992: Column 7 adjusted by Column 6
1989	5.3 to 7.4	-7.938%	3	6%	-1.938%	10,947,000	10,734,847
1990	5.5 to 7.4	-7.182%	2	4%	-3.182%	7,277,000	7,045,446
1991	6.7 to 7.4	-2.646	1	2%	-.646%	8,673,000	8,616,972
Average: 8,799,088							

Source: National Health Interview Survey and Current Study

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 2.8, typed in Microsoft Word for IBM and labeled TEL28WRD.DOC on the diskette.

In analyzing their data, the Rand investigators first compared their results with the NHIS from 1981. (It was unclear why 1981 was chosen.) They concluded that their Rand study missed many minor injuries, but compared favorably to the NHIS on serious injuries. They attributed part of this disparity to the 12-month recall bias. The Rand investigators asked respondents to report on injuries sustained during the prior 12 months. The "12 month" aspect of the Rand question insures that many minor injuries will not be reported (Landen and Hendricks 1992).

In addition to the recall bias, the Hensler et al. (1991) study contains other limitations. Deaths were ignored. Institutionalized persons (i.e., persons currently in the hospital, were excluded). The questions they asked respondents did not specifically mention assault or attempted murder or suicide, hence, injuries resulting from violence would likely be underestimated.

Although the Rand study was of all injuries, special attention was directed toward job-related injuries. Apart from their estimate of the injury rates and their costs, a number of other findings emerged: 1) Despite the fact that job-related injuries comprised only 21% of all injuries, job-related injury costs totaled nearly half of all injury costs. 2) Adult injuries were roughly divided between work and non-work. 3) Adult males were much more likely to be injured on-the-job than anywhere else. 4) Low-income men were more likely than women or any other income group to be injured on-the-job. Because job injuries tended to be more serious than others, lower income men were more likely than other groups to require significant and expensive treatment. 5) They found WC was paid in less than 60% of all job-related injury cases and no more than 55% of all job-related injury hospitalizations. Given that the Rand investigators believed they undercounted less serious injuries, one would have hoped for a higher rate of WC coverage. As we have seen, however, most job-related injuries are missed by WC records (Toscano and Windau 1993; Stout and Bell 1991; Cone et al. 1991; Parker et al. 1994; NHIS-OSH 1998).

Hensler et al. (1991) also collected information on hospitalizations. They found that 26% of their work-related injuries resulted in hospitalizations. This 26% rate was much higher than the Rice et al. (1989) 4% estimate for all injuries whether on or off-the-job. Part of the disparity may have been due to job-related

injuries being more serious than other injuries. This interpretation—that work-related injuries were more severe than all injuries—was supported by information gathered on subjective assessments of injuries in the Rand study. Persons in the work-injury category were more likely than persons in any other category to indicate that they felt that their injuries were very serious. Persons in the work-injury category, together with those in the motor vehicle injury category, were more likely than persons in other categories to feel that the effect of the injury on the rest of the household was "very important." This interpretation—that job injuries were more serious than other injuries—was also supported by the Rand finding that the hospitalization rate for all injuries was 17%, while, the one for job-related injuries was 26%. But this is not a complete explanation. Part of the disparity is likely attributed to the omission of many minor injuries from the Rand study that were likely included in the Rice study.

The Hensler et al. (1991) Rand study provided information on the injury rate per 100 workers. They did not attempt to estimate the overall number of injuries. Marquis (1992), however, did attempt to estimate the number of people affected. She estimated that in 1989 "almost seven million individuals or about 4% of American adults suffered a (new) injury on the job that requires medical treatment or results in lost productive time.... In addition, another four million adults suffer problems from a work-related accident that happened in an earlier year."

Marquis (1992) incidence estimate is then seven million while her prevalence estimate is 11 million for 1989.

As we will see, an estimate of the number of individuals affected underestimates the number of injuries. We, therefore, will construct our own estimate of the number of injuries using two methods involving the "person-incident" rates estimated by Hensler et al. and Marquis 1992. We do not use the seven to 11 million estimate from Marquis (1992). Our first estimate involves a comparison to 1989 NHIS estimates and our second estimate involves a direct multiplication by the number of civilians employed.

The first method involves a comparison with the NHIS. This is a legitimate comparison since both the NHIS and Rand estimates apply to persons 18 years of age and older and apply to full and part-time workers. Moreover, the NHIS information

is likely to coincide with the Rand researchers concept of injury-incident. Multiple injuries are less likely in two weeks than 12 months and the NHIS data were constructed as binary (yes-no) variables (i.e., not how many injuries, but whether any injuries at all occurred over the prior two weeks).

In 1989, Hensler et al. (1991) estimated a 9.1% annual injury rate (person-incident rate, i.e., number of incidents, not number of persons) for employed workers, 18 years and older. This 9.1 per 100 annual rate compares favorably to the NHIS 9.3 per 100 rate for the same year. The 9.1 rate is roughly 98% of the 9.3 rate. Our first estimate applies this 98% factor to our NHIS estimated number of injuries in 1989 (10,947,000) to yield 10,706,400 injuries for 1989. (This 10,947,000 NHIS number does not account for any bias resulting from the omission of assaults. It is the actual NHIS 1989 estimate, not our 1992 estimate of 10,998,860 based on the NHIS data).

Our second estimate multiplies the 9.1 rate times the number of employed civilians. In 1989, roughly 117,300,000 civilians were employed. Multiplying 117,300,000 by .093 yields 10,909,000 injuries.

The average of the two estimates, 10,706,400 and 10,909,000, is 10,807,650. This Rand study number (10,807,650) can be used to forecast a 1992 number using the same Annual Survey model and procedure outlined in Table 2.8. Ultimately, 1.938% of 10,807,650 is subtracted from 10,807,650 to yield 10,598,197, our 1992 estimate.

Again, conservatively assuming a 20% undercount due to the public's dismissal of assaults and vehicle crashes as being job-related and Hensler et al.'s acknowledged undercount of minor injuries yields a total of $(10,598,198 + .8)$ or 13,247,746 injuries based upon the Hensler et al. (1991) study.

III.B.2 Rossman, Miller and Douglas (1991)

Rossman, Miller and Douglas (1991) estimated the incidence and costs of workplace injury and illness for 1989. The study was commissioned by NIOSH and is available in manuscript form from NIOSH. A substantial part of their study was based on the Detailed Claims Information (DCI) data maintained by the National Council of Compensation Insurance (NCCI). The DCI data covered 450,000 generated

WC claims (i.e., claims that resulted in some WC payment). The Rossman, et al. study together with the Miller et al. (1995) and Miller (1994) studies mentioned below are the only ones to analyze the rich data available in the DCI. Rossman, Miller and Douglas also analyzed data from the BLS's Annual Survey, the Social Security Administration studies of WC by Nelson (1992, 1993), and the Rice et al. (1989) study on the costs of all injuries.

The Rossman et al. study is the second of our "secondary analysis" of non-fatal injuries. That is, in our discussion of Rossman et al., we do not consider the DCI data directly, only Rossman's presentation and interpretation of the DCI data.

The DCI/NCCI data contain WC information from some 35 to 38 states, depending on the year. Rossman et al. studied data from 1979 to 1988. The DCI sample was restricted by WC coverage. Therefore, many limitations--all recognized by the authors--were encountered. First, Rossman et al. focused on disabling injuries. But, for an injury to be "disabling" for WC requires at least three and sometimes seven days of work loss, depending on the state law. Second, during the time of their study, roughly 12% to 14% of employees were not covered by WC. Third, most of the self-employed were excluded. Fourth, not all injuries were reported to WC, even if they qualified. Workers might have feared employers' recrimination. Fifth, WC mixes illnesses with injuries. Rossman et al., however, estimated that roughly 98% of claims were for injuries and 2% were for illnesses in the DCI. This stands in contrast to the higher percentage of WC death claims (11%) attributed to illnesses (Leigh 1995a) in part because heart failure resulting in death is viewed as a compensable death for firefighters, police officers and other occupations in many states.

Rossman et al. (1991) used the information in the DCI to extrapolate to the nation. Their sources for extrapolation included the BLS's Annual Survey data, the several Social Security Administration studies (Nelson 1992, 1993) and, above all, the Rice et al. (1989) study. They presented a useful summary of their findings, some of which appear here:

... we estimate the incidence of workplace injuries (in 1989) at 11 million. As such, workplace injuries account for roughly 19% of the annual 57 million injuries due to all causes reported by Rice et al. (1989).

Of the 11 million workplace injuries, approximately 11,000 resulted in fatalities (in 1989). The majority were considerably less severe, including 7.4 million that resulted in no work loss and 1.675 million non-hospitalized injuries for which there was less than three days of work loss.

Rossman et al. (1991) also looked at two treatment categories: any medical care, hospital care, and vocational rehabilitation. Approximately 31% received medical care and 3% received vocational rehabilitation. Rossman et al. (1989) considered how long costs were incurred. Roughly 43% of costs for neck or back injuries and 26% of trunk injuries were incurred beyond the first year. These data underscore the point that if we restrict our attention to only new injuries and illnesses within any given year (i.e., if we only look at incidence), we must attempt to forecast the length of time required for recovery and the cost involved. The forecasting problem will be discussed in Chapter 5.

Out of 11 million annual injuries, Rossman et al. (1991) estimated that WC provided indemnity payment to 1.93 million (ignoring the relatively small number of deaths). Roughly 82% of all injuries were, therefore, not compensated with indemnity payments by WC. Most of the 82%—7.4 million injuries or 67% of the 11 million—did not result in any work loss. They also estimated 1.675 million injuries involving some work loss were not covered by WC.

Applying the BLS Annual Survey model (Equation 2.2), we predict that the 1992 Rossman, Miller, and Douglas (1989) estimate would be 1.938% less than their 1989 estimate. We thus forecast 10,786,820 total injuries for 1992. Rossman et al. and Miller (1994) acknowledge the DCI's deficiencies in counting vehicle crashes and assaults and presumably accounted for these factors in producing their 11 million estimate. We, therefore, do not adjust their estimate for these factors. Our 1992 Rossman et al. estimate would then be 10,786,820.

III.B.3 Miller

Miller's (1994) study drew heavily upon the analyses in Rossman, Miller and Douglas (1991), as well as several sources to estimate the number of job-related non-fatal injuries in 1989. The first was the NHIS for 1989. The NHIS estimate was 10,947,000. This represented approximately 18.8% of all injuries for 1989 identified in the NHIS. This 18.8% estimate is similar to the 21% estimate in the

Hensler et al. study (1991) from Rand and the 19% estimate in Rossman et al. (1991) for the same year—1989. These NHIS injuries resulted in contact with a medical provider or restricted activity for at least one-half day.

The second source discussed in Miller (1994) was the BLS's Annual Survey for 1989. Miller (1994) assumed that the BLS rate estimates—8.2 per 100 full-time workers—would apply to the 117.3 million civilian full and part-time employees and self-employed in 1989. He, thus, estimated 9.6 million worker injuries in 1989 with the Annual Survey. He did not make any of the adjustments we made to the Annual Survey data involving full-time/part-time differences, employer or employee "willful" underreporting, and so on.

Miller argued that the NHIS 10,947,000 number was more credible than the BLS's Annual Survey number in part because the NHIS resulted from a national survey. Miller did not address the biases associated with the NHIS that we mentioned above.

Miller encountered the same problem we have in classifying injuries. His solution was to classify according to whether there was work loss or hospitalizations. Using the NHIS 10,947,000 injuries number, Miller estimated that there were 5,094,000 lost workday injuries and 5,853,000 lesser injuries. He assumed, in other words, that 46.53% of all injuries resulted in work loss.

Miller (1994) estimated disabling injuries using four different sources: the NHIS, the DCI data from the NCCI, Social Security disability payments, and Social Security medical payments. The average of these four estimates was 2,291,000 cases for 1989. Subtracting this 2,291,000 from the 5,094,000 lost workday injuries yields 2,803,000 lost workday injuries that were not disabling. Obviously, Miller used a different definition of disabling than we do. Miller's definition is taken from WC records. Miller assumed that only persons who received indemnity payments were disabled. Some states allow indemnity after three days, while others require seven days. Miller's definition is, therefore, subject to the variegated WC systems across the states. Our definition requires only one or more days of work loss. The BLS uses the same definition we do.

Miller (1994) provided two estimates for the number of hospitalized workplace injuries. The first estimate combined the NHIS estimate with the Rice et al.

estimate of hospitalizations for all injuries. His first estimate was 426,000 hospitalized workplace injuries.

The second hospitalized estimate came from Miller's data from the DCI/NCCI data which suggested that 26.8% of disabling injuries resulted in hospitalizations. Multiplying the 26.8% times the Miller's estimated 2,291,000 cases of disabling injuries (above) resulted in an estimate of 614,000 hospitalized workplace injuries.

To resolve these conflicting estimates of hospitalized injuries, Miller: 1) examined the WC hospitalization rate in California, 2) reviewed the hospitalization rate in the Rand study (Hensler et al. 1991), and 3) examined the hospital discharge data analyzed by Lemrow et al. (1990). All three suggested rates (and therefore estimates of total counts) much closer to the DCI/NCCI than to the NHIS rates and totals. Miller, therefore, concluded that the 614,000 hospitalization number was the best estimate for 1989.

Table 2.9 summarizes the Miller findings with his classification scheme.

Table 2.9

Estimates of New Non-fatal and Fatal Injuries, 1989

Total	11.0 million
Lost workdays	5.1 million
Disabling (WC definition)	2.291 million
Hospitalizations	614,000 or (5.58% of all injuries)
Lesser injuries	5.853 million
Deaths	11,000

Source: Miller (1994)

Miller recognized the typical undercount associated with motor vehicle accidents and assaults. He attempted to adjust his estimates accordingly. We, therefore, do not adjust his estimates for these undercounts. It is reassuring that Miller's estimate of the percent of all injuries resulting in work

loss—46.53%—is very close to our own assumption of 46% which, in turn, relied on BLS Annual Survey data (see Section III.C).

We use his 1989 estimate as a basis for a forecast for 1992. As explained above with the NHIS data, we would expect injuries in 1992 to be 1.938% less than those in 1989. Multiplying 11 million times .98062 yields 10.787 million, our 1992 estimate using Miller's data. This is the same number we calculated for Rossman, Miller and Douglas (1991). This is not surprising given that Miller co-authored the Rossman et al. study. To avoid duplication, we will ignore Miller's (1994) estimate in our summary calculations in Section III.C.

III.B.4 National Safety Council (NSC)

The NSC drew on the NHIS and internal NSC records and methods to estimate the number of non-fatal injuries. The NSC estimated number of injuries in 1991 was 8,673,000 which was drawn directly from the NHIS. We will not use the NSC 8,673,000 estimate, since it is merely the NHIS estimate for that year. We will use the NHIS estimates calculated above.

III.B.5 Mason

R.W. Mason (1989) conducted an incidence and cost study of occupational injuries and illnesses for 1987. Mason's study is available from NIOSH.

Mason's (1989) study used secondary data and offered a handful of estimates. Mason's data sources included the *Statistical Abstract of the U.S.* for various years, the *Social Security Bulletin's Annual Statistical Summaries* for 1988 and 1989 and the BLS's Supplementary Data System.

Mason took the BLS Annual Survey injury estimate for 1987 (roughly six million), added an estimate for agriculture and government (295,000), together with the NTOF estimate on fatalities (7,000). Mason also relied on injury data from the Social Security Disability Insurance files.

But there are limitations to Mason's analysis. First, use of Social Security data is not appropriate. Injuries and illnesses that qualify a person for Social Security benefits need not be job-related. WC is designed to cover job-related injuries resulting in disabilities. It is therefore likely that a high proportion

of Social Security disability recipients developed their conditions independent of their job. Second, we already accounted for Annual Survey and NTOF estimates above. For these reasons, we will not use Mason's numbers in our analysis.

III.C. Classification Scheme and Summary Table for Non-fatal Injuries

We now turn to aggregating these studies into one table and producing our estimate of non-fatal injuries. But first we must develop a classification scheme for the non-fatal injuries.

We first considered the WC definition of disabling but rejected it. An injury that results in a lost workday may or may not be viewed as a disabling injury by WC. All state WC programs have waiting periods. Usually, they are three, five, or seven days. If the worker returns to work in that period of time, he or she is not entitled to WC indemnity benefits. (Workers are entitled to medical benefits even if the injury results in no workdays lost). The idea is to discourage minor injury claims. Most BLS Annual Survey disabling injuries would not qualify for WC coverage. This does not mean they were not serious injuries or that they should not be counted. On the contrary, this discrepancy might suggest that the WC programs should reduce their waiting periods to one or two days. The National Commission on State Workers' Compensation Laws, for example, recommends a waiting period of no more than three days (Rejda 1984,p. 320).

Nelson (1992) offers a description of states' waiting periods, and presents data on all states pertaining to the generosity of benefits, accounting for various waiting periods. The most generous states or jurisdictions include Ohio, West Virginia, Iowa, Michigan, New Jersey, Colorado, Connecticut, and D.C. The least generous states include California, Arkansas, Texas, Indiana, Tennessee, Georgia and Mississippi.

The categories of injuries we selected were those that lent themselves to straightforward cost calculations. Cost data were readily available for categories involving disabling/non-disabling and the WC categories. Cost data were not readily available for all of the medically diagnosed injuries.

First, consider the distinction between non-disabling versus disabling. Most researchers consider a disabling injury to be one that caused at least one day of

lost work. This "at least one day" away from work will be our definition. The injuries that cause zero to seven hours of loss will, therefore, not be defined as disabling. In recent years, the BLS Annual Survey has reported that roughly 46% of injury cases have resulted in at least one day away from work. Miller (1994) estimates that 46.56% of all work-injuries result in one or more days of work loss. We will assume a 46% rate.

We turn next to the WC categories of Permanent Total (PT), Permanent Partial (PP), Temporary Total and Partial (TTP), and Medical Only. Data from the NCCI 1988-90 policy years was introduced above. The NCCI's Ultimate Report on 38 states and D.C. indicated that WC boards identified 4,084 PT, 290,056 PP, 719,101 TTP and 3,269,227 Medical Only, for a total of 4,282,468 new cases of injuries. (These numbers do not correspond to those in Table 2.6 because the NCCI data were not complete in the Medical Only category. For example, in the 1988 to 1990 NCCI data, Texas was excluded from the Medical Only category but included in the PT, PP, TTP categories. We needed to develop consistent ratios in this exercise. Hence, we took NCCI PT, PP, and TTP numbers that also excluded Texas). However, the Medical Only category may not involve one day or more of work loss. Some injuries are relatively minor. Some sprains, strains and broken bones will require immediate medical attention beyond first aid, but may not result in more than two days lost from work. But, some of the Medical Only cases will involve seven days. These distinctions are important because states differ in the number of days required to qualify for indemnity benefits. Therefore, it is difficult to categorize Medical Only. Perhaps 30% to 50% require one to seven days out (depending on the state). On the other hand, 100% of the PT, PP, TTP must have required at least three to seven days away from work. We assume a 60% to 40% split on Medical Only, i.e., 60% of the Medical Only would involve no more than seven hours (less than one day) of work loss while 40% would involve one or up to seven days of work loss. Now 40% of 3,269,227 is 1,307,691. With this 60% to 40% assumption, the NCCI data, therefore, suggest $4,084 + 290,056 + 719,017 + 1,307,691 = 2,320,848$ as the total number of disabling injuries. We can now calculate percentages of disabling injuries as follows: $4,084/2,320,848$ or .176% is contributed by PTs; $290,056/2,320,848 = 12.498\%$ is contributed by PPs; $719,017/2,320,848 = 30.981\%$ is contributed by TTPs;

1,307,691/2,320,848 = 56.345% is contributed by injuries in the one to seven days of work loss category. Assuming a 60/40 split on Medical Only, the NCCI would suggest the following percentages: .176% for PT, 12.498% for PP, 30.98% of TTP, and 56.345% for injuries resulting in one to seven days of work loss.

The 60/40 split may seem arbitrary. However, it was decided upon only after an independent test supported it. The independent test involved using non-fatal to fatal injury ratios to estimate our final estimates of PTs, PPs, and TTPs appearing in Table 2.12 below. The NCCI provides data on the number of deaths, PTs, PPs, and TTPs.

We developed our estimate of deaths in a prior section (6,529 in 1992). Our 1992 death estimate combined with the non-fatal injury to death ratio estimates from the NCCI can be used to test the validity of the 60/40 assumption. The NCCI ratios were 1.5873 for PTs to NCCI deaths; 112.7307 for PPs to NCCI deaths; and 279.4796 for TTPs to NCCI deaths. Multiplying these ratios by our 1992 estimate of deaths (6,529) will yield 10,363 for PTs; 736,019 for PPs; and 1,824,722 for TTPs. As we will see, these estimates are remarkably close to the PT, PP, and TTP estimates we obtain in Table 2.12 assuming a 60/40 split (10,725 for PTs; 761,817 for PPs; and 1,887,980 for TTPs in Table 2.12).

Finally, we consider hospitalizations.

We are not aware of any studies that count (as opposed to estimate) the number of hospitalizations due to job injuries. Nevertheless, Hensler et al. (1989) and Miller (1989) provide useful estimates and the Rice et al. (1983) data can be adjusted to produce an estimate.

Rice et al. (1989) were concerned with all injuries, whether or not job-related. In Table 1 of Rice et al. (1989), estimates are presented for the number and rate of injured persons by gender, age, and class of injury, i.e., fatality, and, most importantly, whether the injury resulted in a hospitalization.

We use the Rice et al. (1989) estimates adjusted for age and gender. In the United States, in 1985 through 1992 (the years of the Rice study and ours), roughly 55% of the workforce were men and 45% were women (U.S. Bureau of the Census 1993, p. 93). We, therefore, weight the male Rice et al. numbers by 55% and the female numbers by 45%.

We take persons aged 25 to 64 in Rice's Table 1 as our base numbers. These are the ages of most employed persons in the United States. Roughly 14,408,000 injuries occurred among men and 11,025,000 injuries occurred among women in these ages according to their Table 1. If we weighted men and women equally, we would simply add these two numbers together. But, since we want to weight the men slightly more than the women, we multiply 14,408,000 times .55 and 11,025,000 times .45, and sum: $7,924,400 + 4,961,250 = 12,885,650$. This number carries little meaning for us, since it will ultimately be used only to calculate a percentage. Call this number the M/F age-adjusted number of injuries.

Male/Female age-adjustments can also be made to the number hospitalized and non-hospitalized. Rice et al. (1989) estimate 655,673 hospitalizations among men aged 25 to 64 and 399,482 hospitalizations among women. Multiplying these by .55 and .45 yields: $655,673 \times .55$ plus $399,482 \times .45$ equals $360,820 + 179,767 = 540,587$. This number is the M/F age-adjusted hospitalization figure. Expressing the two M/F age-adjusted figures as ratios yields $540,587/12,885,650$ or 4.2%. This number indicates that roughly 4.2% of all of our Rice-adjusted injuries resulted in hospitalizations in the Rice data adjusted for the likely employment status and male/female composition of employment.

But, the Rice et al. (1989) data are not the only data that can be used to estimate hospitalizations due to job-related injuries. The Hensler et al. (1989) Rand study, examined above, estimated a 27% hospitalization rate for job-related injuries. This 27% figure was their estimate and did not require any adjustment on our part. But the Hensler et al. study, as the authors acknowledge, was much more successful at gathering data on serious than on minor injuries.

The Miller (1994) study estimated a 5.4% (p. 17) hospitalization rate for job-related injuries. Again, the 5.4% did not require any adjustment on our part. Both Hensler et al. (1991) and Miller (1994) suggest that on-the-job injuries tend to be more serious than off-the-job injuries. Moreover, for job injuries, employees must be able to show employers that the injury was serious enough to seek medical care or temporarily leave the job. No additional third party need attest to the severity of an off-the-job injury.

Hensler et al. (1991) provide direct estimates of job-related injury hospitalizations. But, the Rice et al. (1989) study is widely cited. Moreover, Miller (1994) uses much of the Rice et al. data in his calculations. Our average percent would, therefore, be 11.9%. But this estimate weights the three studies equally. We have the most confidence in Rice et al. (1989) and Miller (1994). We, therefore, weight the Rice et al. (1989) and Miller (1994) estimates by 45% apiece and the Hensler et al. (1991) estimate by 10%: $(4.2 \times .45) + (5.4 \times .45) + (27 \times .1) = 1.89 + 2.43 + 2.70 = 7.02\%$.

Table 2.10 summarizes our non-fatal percentage estimates.

We now turn to estimating the total number of injuries within each category of Table 2.10. The five studies used in the calculations are identified along the left-most column. Sections III.A.1,2,3 and III.B.1-5 produced estimates of the numbers of non-fatal job-related injuries in the United States in 1992. Some estimates were merely duplications of others. Estimates from the NSC merely duplicated those of the NHIS. Miller's (1994) estimates largely duplicated those in Rossman, Miller and Douglas (1991). Mason's estimates relied on the Annual Survey and NTOF and also inappropriately used Social Security Disability data. After setting aside duplicating and unreliable estimates, we have the greatest confidence in estimates from Sections III.A.1,2,3 and III.B.1,2. Although we have the greatest confidence in the BLS's Annual Survey, unlike the data on deaths, however, no one study stood head and shoulders above the others. All five were flawed. In fact, we regard this as one of our more important conclusions. More data needs to be collected on non-fatal occupational injuries. We need a CPOI or NTOF for non-fatal injuries.

In this section, we combine the estimates from sections III.A.1,2,3 and III.B.1,2 to produce our best estimates. In the first example (col. 2, Table 2.11), we simply calculated the arithmetic average from the estimates in sections III.A.1,2,3 and III.B.1,2. In the second example (column 4), we weight the Annual Survey estimate by .4 and all of the others by .15. The five studies used in the calculations are identified along the left-most column. The averages of the five study estimates appear in the bottom row. Our best estimate of the numbers of on-the-job injuries in 1992 were 13.247 and 13.433 million.

Table 2.10

Non-fatal Injury Percentage Estimates

	<u>1992 Percent</u>
Total	
Non-disabling	54% out of Total
Disabling	46% out of Total
Permanent Total	.176% out of Disabling
Permanent Partial	12.498% out of Disabling
Temporary Total	30.0981 out of Disabling
Temporary Partial	56.345% out of Disabling
Hospitalizations	7.02% out of Total

Source: Current Study

In keeping with our desire to produce conservative estimates, we will assume 13.247 million as our best point estimate. Our lower and upper bounds would be 10.786 to 17.210.

Table 2.12 presents the estimates with the categories identified above.

We were able to conduct an independent test of the 13.247 million estimate. Recently, Schappert (1994) looked at the National Ambulatory Medical Survey and discovered that all injury-related doctor office visits were estimated to be 65.6 million in 1992. Miller (1994), Hensler et al. (1991), and Rossman et al. (1992) estimated the percentage contribution of job-related injuries to total injuries whether on or off the job. Their percentage estimates were, in order 18.8%, 21%, and 19%. Since the Miller (1994) and Rossman et al. (1991) studies were so similar, we will use only the 19% rate from Rossman et al. (1989). The average of 19 and 21 is 20%. If the same 20% figure applied to Schappert's nationwide data, we would estimate 13.12 million attributed to job-related injuries. Given that many job-related injuries may not have required a doctor visit, this 13.12 million would probably be biased downwards. On the other hand, many injuries would require more than one doctor visit, thus exerting an upward bias on this 13.12 million estimate. Nevertheless, the close proximity between the 13.12 million Schappert (1994) adjusted number and our 13.247 million estimate is striking.

Table 2.11

Estimates of Non-fatal Injuries

<u>Study</u>	<u>Our Estimate Based on Source</u>	<u>Weight</u>	<u>Weighted Average</u>
BLS's Annual Survey	13.991 million	.4	5.5964
NCCI	17.210 million	.15	2.5815
NHIS	10.999 million	.15	1.650
Rand, Hensler, & Marquis	13.248 million	.15	1.987
Rossmann, Miller & Douglas (1991); and Miller (1994)	10.786 million	.15	1.618
Average or Weighted Average (Col. 4)	13.247 million		13.433 million
Range: 10.786 to 17.210 million			

Source: Our Study

IV. Collateral Damage

Most studies on counting injuries end with a table such as Table 2.11 indicating the number and types of injuries. No mention is made, for example, of whether jobs with high injury rates cause diseases in workers or whether the injury was associated with harm to others. In this section, we will argue that there will be collateral damage: first, involving diseases of workers exposed to high risks of injuries on-the-job; second, to the caregivers and families of the injured or deceased worker; and, third, to innocent bystanders.

The injury rate at the jobs that generated deaths and non-fatal injuries may also be associated with disease deaths. The stress associated with working at a job with a high injury rate may be a risk factor for heart disease, cirrhosis and cancer, while the injuries themselves may be risk factors for the development of osteoarthritis later in life and other chronic diseases. Murphy (1991) analyzed 9,855 people from a National Health Interview Survey and discovered that the one job dimension out of 32 that generated the strongest correlation with

Table 2.12

Estimates of Injury Deaths and Non-fatal Injuries

		Lower and Upper Bound for Deaths and Total <u>Non-fatal Injuries</u>
Deaths	6529*	6083 to 7567
Total non-fatal injuries	13.247 million	10.786 to 17.210
Non-disabling (54% of Total)	7.1534 million	
Disabling (46% of Total)	6.0936 million	
Permanent Total (.176% of disabling)	10,725*	
Permanent Partial (12.497% of disabling)	.761517 million	
Temporary Total and Partial (30.983% of disabling)	1.887980 million	
One to seven days lost (56.344% of disabling)	3.43338 million	
Hospitalizations (7.02% of Total)	.929939 million	

*Deaths and Permanent Totals not expressed in millions.

Source: Current Study

cardiovascular disease disability was the measure of the injury hazard of the job. In a separate study using aggregate industry data, Leigh (1986a) found a strong correlation between heart attack deaths on-the-job and injury rates. Shaw and Riskind (1983) found that measures of job hazards were strongly correlated with workers' perceptions of job stress. Finally, sea pilots, who hold extremely hazardous jobs, were found to have high rates of ischemic heart disease (Zorn, Harrington, and Goether 1977).

The stress associated with high injury jobs may also result in workers' increased alcohol use, that, in turn, would result in more liver cirrhosis deaths and coronary heart disease (Leigh and Jiang 1993; Leigh 1995c; Seeman, Seeman, and Bardozi 1988). Stress has also been implicated as an important risk factor for

cancer (Bieliauskas 1982; Justice 1988; Totman 1979). If jobs with high injury rates contribute to undesirable stress, then these jobs are also risk factors for cancer.

Jobs with high injury rates appear to fit Kasl's (1978) conditions to develop job stress and heart disease: chronic stress, external pacing of demands, vigilance, and drastic consequences if the job demands are not met.

On the other hand, many dangerous jobs, such as sawing trees and construction work, provide considerable exercise that, in turn, should lower the risk of heart disease.

WC boards have ruled that some suicides are job-related if a serious injury leads to depression. It seems plausible that injuries resulting in permanent disabilities create stress and depression that, in turn, might lead to heart disease and cancer (Roy 1992). The injuries could also damage the immune system in the same way that psychological stressors and unemployment have been found to damage the immune system (Marriott, Kirkwood, and Stough 1994; Rabkin et al. 1991).

The injuries themselves may cause disease. Job injuries have been linked to the development of osteoarthritis (Anderson and Felson 1988; Cooper et al. 1994; Leigh and Fries 1992; Vingard et al. 1991). Moreover, there is some evidence that osteoarthritis, especially of the knee, can be a risk factor for early death (Hochberg et al. 1989).

The first form of collateral damage, then, applies to the individuals in the high risk jobs and the injuries they sustain. The stress associated with the high injury risk and the complications of the injury may be contributing factors in their heart diseases, cirrhosis, cancer or osteoarthritis.

The second form of collateral damage applies to the caregivers and the families of the deceased and injured workers. The death of a spouse is arguably the most psychologically stressful life event an adult can encounter, especially if that death is sudden and unexpected as it would likely be in the event of a job-related injury death. There is mounting evidence that stress can harm the immune system. In one study, it was found that the repair of DNA was defective in people subjected to psychological stress (Kiecolt-Glaser et al. 1985). Similar

deleterious effects on the immune system have been found following bereavement (Schleifer et al. 1983). Sagan (1987) summarizes the findings on the effect of the death of a spouse this way:

At the time at bereavement, mortality rates (for young widows and widowers) are seven times greater than for married people of the same age. The excess of deaths is found to be predominately due to suicide, accidents, and infectious diseases among males and from cirrhosis of the liver among females. Sudden death, as from cardiac arrest, is particularly common.

But the spouse is not the only one to suffer and experience an increased risk of injury, disease and death. Children may experience greater suffering and ultimately a greater risk of injury, disease, and premature death than the spouse. Loss of a parent when the person was young has been shown to be a risk factor for rheumatoid arthritis, liver cirrhosis, cancer, accidents, tuberculosis, psychosis, and especially suicide (Sagan 1987; Bunch et al. 1971). For those who lost both parents—orphans—the risk of suicide was seven times as great as for those who did not lose either parent (Sagan 1987).

Caregiving for a seriously injured adult can be stressful and can itself lead to injury and illness to the caregiver (Roy 1992). These first two sources of collateral damage are real. However, we are unaware of any studies that attempt to estimate the extent of the damages. That is, we do not know, for example, how many cancers, deaths, or suicides will eventually develop in 1,000 children who experienced the sudden death of a parent compared to another similar group of 1,000 children who did not experience the sudden death of a parent. We do not know how many extra cirrhosis cases developed in women as a result of the sudden job-related death of their husbands. We do not know how much permanent total disability raises the risk of heart disease. We do not know whether 100,000 knee injuries will ultimately result in 10,000 knees with osteoarthritis. These questions should be on the agenda for future research on the health, medical, societal and economic costs of any injury or illness. For our purposes, we will simply mention these first two forms of collateral damage without estimating their size. We will nevertheless address stress and disease issues in Chapter 3 as well as attempt to account for the costs of caregivers' time in Chapters 5 and 6. We will not add any injuries to our 13.247 million estimate from prior sections based

upon the discussion here. This is obviously a conservative approach. The risk for harm to the injured and their families is likely to be substantial.

The volume of the third form of collateral damage—to innocent third parties—may be estimated, however.

A good example of this third form of collateral damage will be a car or truck crash. Vehicle deaths frequently involve more than one vehicle. The second vehicle may or may not be a work vehicle. If a non-work vehicle was involved, it could be that an additional death could occur to an innocent third party (i.e., not an employer or employee, but a person not working). If the third party was in the vehicle while on work-time, he or she would already have been counted as a job death by a different employer. The innocent third party ought to be counted in any study assessing the number of deaths (or certainly the costs) of job-related injury deaths. Even if the third party is not innocent, he or she should perhaps be counted. For example, suppose that the third party caused the accident. One might be tempted to exclude the "guilty" death in our calculations. But the "guilty" driver may never have caused any deaths, including his own, if our hypothetical employee had not been in the wrong place at the wrong time. For example, the "guilty" driver could have hit a guard rail instead, some distance away from where our hypothetical employee was parked. Automobile insurance companies recognize these consequences. Insurance premiums are sometimes raised on individuals surviving a crash even if they were innocent.

The above discussion is somewhat speculative. It nevertheless seems plausible that all innocent third party deaths and some "guilty" third party deaths should be counted as part of the overall volume of injury deaths attributed to the job. This argument has precedent in the literature. Manning et al. (1991) use a similar argument when estimating the societal costs associated with alcohol use. They point out that roughly one half of fatal traffic accidents involved at least one driver who had alcohol in his/her blood. Innocent passengers, non-drinking bystanders, and non-drinking drivers of other vehicles may have been killed by a drunk driver. They calculate that 7,400 of roughly 22,360 road deaths involving alcohol-related accidents were innocent third parties. This is a ratio of roughly one to three or 33%.

It is unlikely that job-related vehicle deaths would generate an additional 33% of third party deaths. People are more inclined to drink on- than off-the-job. We will, conservatively, assume that there will be 10% additional deaths of third parties. The CFOI estimates that roughly 18% of job-related deaths involve vehicle accidents. Multiplying .18 by our preferred estimate of 6529 yields 1175 vehicle deaths. Ten percent of this 1175 is 118. We, therefore, estimate that an additional 118 deaths should be added to our total due to vehicle crashes.

There may also be third party deaths in fires, explosions, and especially aircraft crashes. Three or four pilot deaths or two or three airline crashes could easily involve over 100 third party deaths. We will assume 30 third party deaths in fires and explosions and 70 third party deaths in airline crashes. Together these sum to 100. Adding these 100 to the 118 third party vehicle deaths yields 218 additional deaths for total of $6,529 + 218 = 6,747$.

Injuries to innocent bystanders could also result from job-related accidents that cause a non-fatal injury to persons not working at the time. Most of these would likely result from vehicle and aircraft crashes, fires, and explosions. Above, we assumed an additional 218 deaths to third parties. That represents a ratio of 3.3 for every 100 job-related deaths. In light of this percentage, we therefore, assume another 3% for Permanent Totals, 2% for Permanent Partial, 1% for Temporary Totals and Partial and one to seven workdays lost and 0% for non-disabling injuries. The rate falls for lesser injuries since vehicle and aircraft crashes account for a lower percentage of lesser than serious injuries. Adding them together results in an additional 68,322 of total non-fatal injuries or .53% more. Despite their small number, these should not be ignored given that they are either disabling or fatal and affect many innocent third parties. These results are summarized in Table 2.13.

Table 2.13

Injury Estimates, Including Collateral Injuries, in Millions*, 1992

	From Table 2.12	Collateral Injuries	Total
Deaths	6529*	218*	6747*
Non-fatal injuries			
Total	13.247	.068	13.315
Non-disabling (54% of Total)	7.1534	0	7.153
Disabling (46% of Total)	6.0936	.068	6.616
Permanent Total (.176% of disabling)	10,725*	322*	11,047*
Permanent Partial (12.497% of disabling)	.761	.015	.776
Temporary Total & Partial (30.983% of disabling)	1.888	.019	1.907
One to seven workdays lost (56.344% of disabling)	3.433	.034	3.467

*Deaths and Permanent Totals are not expressed in millions.

Source: Current Study

V. Demographic, Occupational, Industrial, and Regional Characteristics of Injuries

V.A. Demographics

V.A.1 Age and Experience

Table 2.14 Panels A through E present the age results on fatalities and non-fatal injuries published in the literature, as well as our own analysis of the SDS/WC data.

There are some similar patterns across the three death studies (the CPOI by Toscano and Windau 1993; NTOF by NIOSH 1992; and the SDS/WC by Leigh 1995a). The smallest percentage contributors of total deaths are those in age brackets under 20 and 65 and older. This is understandable given the high percentage of young persons in school (not working) and the high percentage of seniors who are retired (not working). The lowest death rates apply to those persons under 20 years old. The highest rates, apply to those 65 and over. From age 21 to 44 the rates do not

change a great deal. The rates begin to rise for the 45 to 54 group, and again for the 55 to 64 year old group. The SDS data, which were drawn directly from WC records, show a higher percentage of decedents aged 45 to 64 than either the CPOI or the NTOF. It could be that this simply reflects WC coverage, not a real age phenomena. Workers aged 45 to 64 may be in mainstream industries covered by WC while a higher percentage of younger workers are more likely to have jobs in fringe industries not covered by WC.

The death rates by age conform to death rates for persons aged 25 and beyond for all accidents whether on or off-the-job (National Safety Council 1993). As age increases, especially beyond age 64, death rates for all accidents accelerate at an increasing rate (National Safety Council 1993).

Sections D and E of the Table 2.14 present data for non-fatal injuries drawn from the BLS Annual Survey (U.S. Department of Labor April 1994) and from the NHIS's Occupational Health and Safety Supplement Survey (NHIS-OSH). Beginning with the 1992 data, the BLS revised its collection procedures and data presentation. For example, prior to the 1992 data, very little demographic data were available. The new Annual Survey demographic data pertained only to disabling injuries, however. The Annual Survey from 1992 presents only injuries and illnesses resulting in at least one day away from work (what we and the BLS term "disabling" injuries). They are fewer in number than total non-fatal injuries, but are more serious. Unfortunately, these published BLS Annual Survey numbers confuse injuries with illnesses. But the bias is not great since illnesses comprised roughly 7% of all incidents in 1992. The percent contribution of illnesses on the Annual Survey continues to rise. In the early 1980's, illnesses contributed to less than 2% of all incidents. As we will see in the next chapter, much of this increase from 2% to 7% was due to the recognition of carpal tunnel syndrome as a work-related illness.

The NHIS-OSH was a special 1988 supplement to the NHIS pertaining to occupational safety and health data. The NHIS-OSH is described in Section VI.B.2. The NHIS-OSH probably ignored minor injuries due to recall basis (Landen and Hendricks 1992).

The rate data from the NHIS-OSH on non-fatal injuries (Panel E) display a pattern different from the death rate data. (The age breakdown conforms to the presentation in the sources so that arbitrary extrapolation could be avoided). As people grow older, their chances of sustaining a non-fatal injury decreases. The BLS Annual Survey non-fatal data (Panel D) also support this conclusion. The highest percentage of injuries occur in the middle years (25 to 44). As people age, they may take fewer risks. It could also be that the same injury is more likely to kill an older than younger worker. The results on the non-fatal injuries are consistent with the view that work experience reduces non-fatal accident and injury rates, i.e., experienced workers have greater knowledge about how to complete a job safely (Mitchell 1988; Division of Labor Statistics and Research 1985).

A substantial literature has recently emerged concerning child and adolescent work-related injuries. Castillo, Landen, and Layne (1994) used the NTOF data to estimate a death rate of 5.1 per 100,000 full-time equivalent civilian workers aged 16 and 17. These young workers appeared to be at greater risks than adults for dying of electrocution, suffocation, drowning, and poisoning. Layne, Castillo, Stout, and Cutlip (1994) used data from a nationally representative sample of emergency rooms—the National Electronic Injury Surveillance System (NEISS)—to find that adolescents aged 14 through 17 suffered roughly 37,405 injuries nationwide for a 7.0 per 100 full-time worker risk for males and a 4.4 rate for females. The highest percentage of injuries occurred in retail trades, especially restaurants and taverns. Finally, Parker et al. (1994) studied 534 work-related injuries among adolescents in Minnesota. The most serious injuries involved backs and burns.

A characteristic similar to age is length of time on-the-job. There is substantial evidence that new employees experience a high and disproportionate share of injuries. A State of California study (Division of Labor Statistics and Research 1985) of 338,866 work-related disabling injuries in 1983 and 1984 discovered that 42% of all injured workers had been with their employer for less than one year. Moreover, even within the first year of employment, the first month was associated with the greatest number of injuries. It could be argued that job mobility explains this result (i.e., most people at most jobs are relatively new.

But this was not the case). In 1983 (the time of the California study), a national survey showed that only 27% of employees had been on-the-job for less than 12 months (Sehgal 1984).

Finally, the State of California study shows that while nearly 10% of employees had been with their employer for 20 years or more, only 2.6% of injured workers had been with their employers that long. We conclude that inexperience is an important predictor of who is likely to experience an injury.

Table 2.14

Age Characteristics of Deceased and Non-fatally Injured Persons

A. CFOL, 1992, Fatalities

<u>Age</u>	<u>Number</u>	<u>Percent</u>	<u>Rate Per 100,000 Employed</u>
Total	6083	100	5.087
Under 20 years	169	3	2.854
20 to 24 years	528	9	4.169
25 to 34 years	1521	25	4.600
35 to 44 years	1511	25	4.729
45 to 54 years	1143	19	5.370
55 to 64 years	751	12	6.664
65 years and over	460	8	13.423

B. NTOF, 1980-89, Fatalities

<u>Age</u>	<u>Number</u>	<u>Percent</u>	<u>Rate per 100,000 Employed</u>
Total	62218	100	
Under 20	2630	4.2	3.9
20 to 24 years	7588	12.2	5.4
25 to 34 years	16599	26.7	5.2
35 to 44 years	12434	20.0	5.1
45 to 54 years	10028	16.1	5.9
55 to 64 years	8571	13.8	7.4
65 years and over	4368	7.0	14.6

C. SDS/WC, Fatalities

<u>Age</u>	<u>Fatalities</u>		
	<u>Number</u>	<u>Percent</u>	<u>Rate¹</u>
Total ¹	5338	100	
Under 20 years	244	4.6	
20 to 24 years	456	8.5	
25 to 34 years	940	17.6	
35 to 44 years	867	16.2	
45 to 54 years	1172	22.0	
55 to 64 years	1128	21.1	
65 years and over	377	7.1	

D. BLS's Annual Survey for 1992 (U.S. Dept. of Labor, April 26, 1994)
Non-Fatal Disabling Injuries and Illnesses¹

<u>Age</u>	<u>Number</u>	<u>Percent</u>	<u>Rate¹</u>
Total	2262.1	100	
Under 20 years	97.3	4.2	
20 to 24 years	346.3	14.9	
25 to 34 years	762.0	32.7	
35 to 44 years	569.3	24.4	
45 to 54 years	318.5	13.7	
55 to 64 years	147.7	6.3	
65 years and over	21.0	.9	

Table 2.14 (Cont.)

E. NHIS-OSH, 1988, Non-Fatal Injuries

<u>Age</u>	<u>Number</u>	<u>Percent</u>	<u>Rate per 100 Employed</u>
Total	2211	100	8.1
18 to 29 years	858	38.8	11.1
30 to 44 years	918	41.5	8.0
45 to 64 years	405	18.3	5.7
65 years and over	130	1.4	2.8

¹Only decedents with age information were included. 160 decedents missing ages were excluded.

²Denominator data on ages of employed people in the 11 SDS states are not available. We, therefore, do no report rates.

³Disabling: Resulting in one or more days away from work.

⁴No rate data were published. They would be difficult to estimate given the non-random nature of the Annual Survey data.

⁵No separate statistics are available on injuries only. But illnesses comprised roughly 7% of the total in 1992.

Sources are identified in each panel A through E

Table 2.15

Gender Characteristics of Deceased and Injured Persons

A. CFOI, 1992, Fatalities

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100,000 Employed</u>
Total	6083	100	5.087
Female	426	7	.790
Male	5657	93	8.675

B. NTOF, 1980-89, Fatalities

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100,000 Employed</u>
Total	62289	100	7.0
Female	3737	6	.8
Male	58552	94	9.8

C. SDS/WC, 1979-86, Fatalities

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100,000 Employed²</u>
Total ¹	5338	100	
Female	227	4.3	.28
Male	5111	95.7	5.0

D. BLS's Annual Survey, 1992 Non-fatal Disabling³ Injuries and Illnesses⁴

	<u>Number¹</u>	<u>Percent</u>	<u>Rate¹</u>
Total	2,331,100	100	
Female	764,200	32.8	
Male	1,527,400	65.5	

E. NHIS-OSH, 1988, Non-fatal Injuries

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100 Employed</u>
Total	2211	100	8.1
Female	777	35.1	5.6
Male	1434	64.9	10.5

F. NHIS, 1980-81 (Collins, 1985), Non-fatal Injuries

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100 Employed²</u>
Total	11,059,000	100	
Female	2,542,000	30.0	6.0
Male	8,517,000	70.0	14.8

Table 2.15 (Cont.)

Gender Characteristics of Deceased and Injured Persons

¹Only decedents with age information were included. 160 decedents missing ages were excluded.

²Estimated based on national denominator data from *U.S. Statistical Abstract*, 1985.

³Resulting in one or more days away from work.

⁴No separate statistics are available on injuries only. But illnesses comprised roughly 7% of the total.

⁵BLS did not calculate rates. They would be difficult to estimate given the non-random nature of the BLS Annual Survey data.

Sources are identified in each panel

V.A.2 Gender

Table 2.15 presents results on gender differences in death and non-fatal injury rates. Again, just as in the prior table on age differences, Table 2.15 presents the published data we found together with our own analysis of the SDS/WC data.

The death percentages and rates from the CPOI, NTOF, and SDS/WC appear to be consistent. The CPOI 1992 death rates were lower than those from the 1980-89 NTOF, consistent with the long-term downward trend in death rates. The death rates from the SDS/WC data were 60% to 70% the size of the rates from the CPOI and NTOF. This can be easily explained, however. The SDS/WC data were drawn from state WC boards that, in turn, underestimated deaths by 45% to 70% (Toscano and Windau 1993; Stout and Bell 1991; Cone et al. 1991). The ratio of male to female deaths was 11:1 in the CPOI, 12:1 in the NTOF, and 18 to 1 in the SDS/WC data.

The male to female ratio was roughly 2:1 in the Annual Survey. Again, illnesses were so few this ratio is likely to apply to injuries.

The two NHIS data sets on non-fatal injuries—one from the 1988 OSH supplement and the other from 1980-81—are consistent with each other. Females contributed 30% of injuries in 1980-81 and 35% in 1988. The male to female ratio was 1.8 to one in 1988 and 2.3 to one in 1980-81. This increase in female injuries from 1980-81 to 1988 could reflect the increasing numbers of women in dangerous jobs over time.

The provocative finding in Table 2.15, however, pertains to the gender rate differences between fatalities and non-fatal injuries. For death rates, the male to female ratios range between 11:1 and 18:1. For non-fatal injuries, the male to female ratios are roughly 2.3:1 or 1.8:1. Virtually all studies on dangerous jobs have found males at greater risk than females. But our study appears to be the first to show such a sharp distinction between fatal and non-fatal rates.

Sexual assault of women at work is receiving increasing attention. Alexander, Franklin and Wolf (1994) used WC claims data in Washington state and found that sexual assault was especially high for taxicab drivers, job training instructors, radio and TV retail stores salespersons, gasoline service station attendants, truck drivers, and hotel workers.

V.A.3 Race and Ethnic Differences

Table 2.16 presents the race and Hispanic characteristics of the samples. A curious and troubling result appears in the CFOI and NHIS data. There is virtually no difference in the rates for whites (4.938) and blacks (4.962) in the CFOI data. Both NHIS studies show a higher rate for whites than blacks. These findings stand in contrast to all other occupational studies and general studies on death rates for injuries that investigated black/white differences with which we are familiar. For example, the NIOSH study-NTOF-found a black death rate of 6.5 per 100,000 and a white (including Hispanics) rate of 5.8 per 100,000. (If Hispanics had been excluded, the white rate would have been lower). Panel C also provides evidence for blacks experiencing more injuries than whites. Of those reporting to the Annual Survey, black non-Hispanics contributed 13.2% of the black and white total ($8.2/(53.7 + 8.2)$). Yet blacks accounted for less than 11% of total non-Hispanic employment in 1993 (U.S. Bureau of Labor Statistics July 8, 1994).

In our discussion above of the CFOI (II.A.1), we cited a number of studies indicating that the black rate exceeded the white rate (Cone et al. 1991; Copeland 1985; Baker et al. 1982; Robinson 1991). We also cited the social science literature on racial differences in employment in white-collar and blue-collar jobs (Gill, 1994). We concluded that the CFOI likely underestimates black deaths for several reasons including long-standing patterns of discrimination.

Table 2.16

Race and Ethnic Characteristics of Deceased and Injured Persons

A. CFOI, 1992, Fatalities

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100,000 Employed</u>
Total	6083	84	5.087
White	5069	83	4.983
African-American	608	10	4.962
Asian or Pacific Islander	166	3	----- ¹
Other	240	4	----- ¹
Hispanic (of any race)	508	8	5.589

B. NTOP, 1980-89, Fatalities

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100,000 Employed</u>
Total			
White	49,837	80	5.8
African-American	6,739	11	6.5
Asian or Pacific Islander	919	2	----- ²
Other, Native American	307	5	4.9
Hispanic (of any race)	3,830	6	----- ²
Unknown	659	1	----- ²

C. BLS's Annual Survey, 1992 Non-Fatal Disabling³ Injuries and Illnesses⁴

	<u>Number</u>	<u>Percent</u>	<u>Rate per 100 Employed⁵</u>
White, non-Hispanic	1,252,500	53.7	
Black, non-Hispanic	190,600	8.2	
Hispanic	198,000	8.8	
Other	38,900	1.7	
Not reported	651,100	27.9	

D. NHIS-OSH, 1988 Non-Fatal Injuries

	<u>Number</u>	<u>Percent</u>	<u>Rate Per 100 Employed⁶</u>
Total	2,211	100	
White	1,893	85.6	8.5 per 100
Black	255	11.5	7.7
Hispanic, of any race	132	6.0	8.2

E. NHIS, 1980-81 (Collins, 1985) Non-Fatal Injuries

	<u>Number</u>	<u>Percent</u>	<u>Rate Per 100 Employed⁷</u>
Total (includes all races)	11,059,000	100	11.0
White	9,766,000	88.3	11.1
Black	967,000	8.7	10.4

Table 2.16 (Cont.)

Race and Ethnic Characteristics of Deceased and Injured Persons

¹CFOI did not calculate; too few deaths.

²NTOF did not calculate.

³Resulting in one or more days away from work.

⁴No separate statistics are available on injuries only. But illnesses comprised roughly 7% of the total.

⁵BLS did not calculate rates. They would be difficult to estimate given the non-random nature of the BLS Annual Survey data.

⁶Denominators from U.S. Statistical Abstract 1988 and 1981.

Sources are identified in panels A through E

Regarding the NHIS, it could be that African-Americans are reluctant to admit health or injury problems to an interviewer, especially a white interviewer. Bauman and Emmett (1994) found that blacks significantly under-reported their cigarette use when compared to whites. Mensch and Kandel (1988) found a similar result for drug use.

Hispanics as a group are difficult to analyze because researchers and the government have changed definitions of Hispanic. In the 1970s, they were frequently placed in the "other race" category. In the 1980s, a separate category was created, but the separate category continued the "race" confusion. Many Hispanics are Black and Asian. Only in the 1990s have Hispanics been treated as an ethnic rather than a race category in most government documents and private studies.

Few studies have considered Hispanic job injuries. In one of the few, Robinson (1991) found Hispanics with a higher rate than white non-Hispanics. The CFOI counted 508 Hispanic deaths which resulted in a rate of 5.589, a higher rate than for white non-Hispanics.

V.A.4 Self-Employment and Small Firms

The CFOI appears to be the only source that considered whether there were injury differences between the self-employed and all other employees. An astonishing result emerged. The self-employed, including paid and unpaid family

members, comprised 20% of all fatalities. Yet, the self-employed comprised only roughly 9% to 10% of all employed people in the United States in 1992. Many of the self-employed work on family farms, and farming is known to be exceedingly hazardous (Goodman et al. 1985; Gunderson et al. 1990; Purschwitz and Field 1990; Rossignol and Pineault 1993; Shannon et al. 1993).

But small farms comprise only roughly 13% of all the self-employed (Becker 1984). Small businesses, in general, have much higher fatality and non-fatal injury rates than medium and large firms. A 10-year (1977-1986) analysis of OSHA investigations by firm size showed that firms with fewer than 20 employees had the highest kill ratios: 10 per 100,000 compared to less than five per 100,000 for firms with 20-99 workers and three or less per 100,000 for firms with 100 or more employees (Marsh 1994). A Colorado study found much higher fatality rates for small than large firms (Marine et al. 1990). Small mining companies have the highest injury rates of all mining companies (Bennett and Passmore 1984). A study of trucking firms found the highest vehicle crash rate among the smallest firms and the lowest among the largest firms (Moses and Savage 1994). This disparity in rates by firm size might be partially attributed to OSHA enforcement policies. Many small firms are exempt from OSHA regulations. The disparity may also be the result of the greater ability of large firms to purchase safe equipment and pay for safety training.

In any case, the CPOI finding is significant and suggests that greater research and perhaps OSHA regulatory attention be devoted to small firms.

V.B. Occupations and Industries

Some occupations have generated more deaths and injuries and have higher kill ratios and injury rates than others. Variations are also apparent across industries. In this section, we consider occupations and industries with some of the highest and lowest numbers and rates. Unlike the previous section, this section is organized around data since definitions of occupations and industries differ across these data sets and each data set has unique information not available in the other sets.

V.B.1 CFOI

Table 2.17 presents the numbers and percent distribution of fatal occupational injuries in the CFOI by occupation in 1992. There is a sharp split between white-collar and blue-collar, with the blue-collar jobs having rates three to six times larger than those for the white-collar. Moreover, the number of deaths were also much greater among blue- than white-collar workers. The lowest death rates were for managers, professionals, technical, sales, and administrative support. The highest rates were for lumberjacks, taxi drivers, construction laborers, and truck drivers.

These rates and rankings are supported in the literature (Leigh 1995a and 1987; Harrison et al. 1989; Bell et al. 1990; Robinson et al. 1988; Thaler and Rosen 1976; Meng 1991; Cone et al. 1991). Using SDS/WC data, Leigh (1995a) also found lumberjacks, taxi drivers, construction laborers, and truck drivers to have excessively high kill ratios.

Table 2.18 presents the number and percent distribution of fatal occupational injuries by industry, 1992. The table is split in two parts: the top considers private industry and the bottom, government. The denominators for the rates (available in Toscano and Windau 1993) were calculated from Current Population Surveys. The greatest number of fatalities occurred, in order, in construction (903), transportation (884), manufacturing (751), services (725), retail trade (710), government (699), wholesale trade (244), mining (182), and finance, insurance and real estate (118). The high rates were in mining (27), agriculture (24), construction (14), and transportation (13), and the low rates were in the trades (5 and 4), manufacturing (4), government (4), services (2) and finance (2). This sharp contrast between the industries with the high and low rates has been noted before (NIOSH, NTOF 1993; Cotter and Macon 1987; and Leigh 1995b). The NIOSH report on the National Traumatic Occupational Fatalities (NTOF) found that the four industries with the highest rates contributed over 50% of all injury deaths, yet accounted for less than 20% of employment in the economy (Baker et al. 1992 p. 349).

Table 2.17

Number and Percent Distribution of
Fatal Occupational Injuries by Occupations, 1992, CPOI

Occupation ¹	Fatalities			Rank ² for the Rate
	<u>Number</u> 6083	<u>Percent</u> 100	<u>Per 100,000 Employed</u> 5.087	
Total fatalities				
Managerial and professional specialty	694	11	2.228	20
Technical, sales, and administrative support	814	13	2.211	21
Service occupations	526	9	3.268	18
Protective service	273	4	13.025	11
Farming, forestry, and fishing	931	15	26.939	3
Farming occupations	680	11	20.688	7
Forestry and logging occupations	155	3	14.220	10
Precision production, craft and repair	1054	17	8.029	16
Mechanics and repairers	269	4	6.057	17
Construction trades, e.g., carpenters, electricians	578	10	12.067	13
Operators, fabricators, and laborers	1882	31	11.099	14
Machine operators, assemblers, and inspectors	223	4	2.969	19
Transportation and material moving occupations	1100	18	22.550	6
Motor vehicle operators	856	14	23.098	5
Truck drivers	685	11	25.427	4
Taxicab drivers and chauffeurs	105	2	49.533	1
Material moving equipment operators	163	3	16.155	8
Handlers, equipment cleaners, helpers, and laborers	559	9	12.270	12
Construction laborers	226	4	34.557	2
Other laborers	170	3	14.444	9
Military occupations				
Resident Armed Forces	154 ³	3	9.834	15

¹Based on the 1990 Census of Population Occupational Classification System.

²This ranking applies only to the occupations reported in Table 2.17. The Census has categories for over 500 occupations.

³Includes 16 workers not reported as active duty military, but reported as working in a military occupation.

NOTE: Total for major categories may include subcategories not shown separately. Percentages may not add to total because of rounding. There were 28 fatalities for which there was insufficient information to determine an occupational classification.

SOURCE: Bureau of Labor Statistics, in cooperation with federal and state agencies, Census of Fatal Occupational Injuries 1992.

Table 2.18

Number and Percent Distribution of
Fatal Occupational Injuries by Industry, 1992, CFOI

SIC code ¹	Industry	Fatalities			Rank ² for the Rate
		Number	Percent	Per 100,000 Employed	
	Total fatalities	6083	100	5.087	
	Private industry	5384	89	5.411	
01-02,07-09	Agriculture, forestry, and fishing	800	13	24.279	2
10-14	Mining	182	3	27.451	1
15-17	Construction	903	15	13.890	3
20-39	Manufacturing	751	12	3.785	7
40-42,44-49	Transportation and public utilities	884	15	13.220	4
50,51	Wholesale trade	244	4	5.129	5
52-59	Retail trade	710	12	3.643	8
60-67	Finance, insurance, and real estate	118	2	1.562	13
70-89	Services	725	12	2.361	11
91-97	Government ³	699	11	3.553	9
	Federal	241	4	4.916	6
	State	112	2	2.349	12
	Local	338	6	3.381	10

¹From Standard Industrial Classification Manual, 1987 edition.

²This ranking applies only to the industries in Table 2.18. The SIC has over 200 categories of 3-digit industries.

³Also includes workers employed by governmental organizations in other SICs. There were 8 fatalities to workers employed by foreign or regional governmental agencies.

NOTE: Totals for major categories may include subcategories not shown separately. Percentages may not add to total because of rounding. There were 67 fatalities for which there was insufficient information to determine a major industry classification within private industry.

SOURCE: Bureau of Labor Statistics, in cooperation with federal and state agencies, Census of Fatal Occupational Injuries, 1992.

V.B.2 NTOF

Table 2.19 presents the number and rate data by broad occupation division from the NTOF. A familiar pattern emerges: crafts, transport, labor and farming, fishing, and forestry occupations account for 63% of all deaths and produce the highest death rates. Occupations that contribute the remainder include managers, service workers, sales representatives, machine operators, professionals, technicians, and clerks. Except for machine operators, this occupational pattern of deaths follows traditional blue-collar and white-collar lines.

Figures and data in the NIOSH publication describing NTOF (Jenkins et al. 1993) present numbers and rates by industry division. The same pattern seen in the CPOI is again evident in the NTOF. The largest number of fatalities occurred in the construction, transportation, communication, public utilities, manufacturing, agriculture, forestry, and fishing industry divisions. The mining industry had the highest average annual fatality rate per 100,000 workers (31.9), followed by construction (25.76), transportation, communication, and public utilities (23.3), followed by agriculture, forestry, and fishing (18.3).

Tables 2.20 and 2.21 present the leading causes of injury deaths within each occupation and industry division from the NTOF. A few provocative results emerge. Among executives, sales workers and service workers, (Table 2.20), murder was the leading cause of death. The leading cause of death among technical support was aircraft crash (these include helicopter crashes). Craftworkers most frequently died from falls. Among industries, homicides lead the list for retail trade; finance, insurance and real estate; and services.

Castillo and Jenkins (1994) present additional data on occupations at high risk for murder. These include taxicab drivers, sheriffs, police officers, hotel clerks, gas station attendants, guards, stock baggers, barbers, bartenders, and prison guards.

Table 2.19

Number and Rate of Fatal Injuries by Occupation,
1980-1989, by Occupation, NTOF

<u>Occupation</u>	<u>Numbers</u>	<u>Rate per 100,000 Employed</u>	<u>Rank for the Rate</u>
Executive, Administration Manager	4337	3.59	6
Professional	2297	1.70	9
Technical Support	1713	5.44	5
Sales	3509	2.81	8
Clerical	1076	.62	10
Service	4206	2.94	7 (tie)
Farming, Fishing	7585	21.28	2
Crafts	12039	9.30	4
Machine Operators	2387	2.94	7 (tie)
Transport Operators	11578	25.58	1
Laborers	7934	17.22	3

Source: National Traumatic Occupational Fatality Study, NTOF

Table 2.20

Leading Causes of Death Within Occupation Divisions, NTOF

<u>Occupation Division</u>	<u>Causes of Death</u>
1. Executive, administrator, manager	Homicide Motor vehicle crash Machine mishap
2. Professionals, specialists	Motor vehicle crash Homicide Aircraft crash
3. Technical support	Aircraft crash Motor vehicle crash Electrocution
4. Sales workers	Homicide Motor vehicle crash Suicide
5. Clerks	Motor vehicle crash Homicide Fall
6. Service workers	Homicide Motor vehicle crash Fall
7. Farmer, forestry workers or fishers	Machine mishap Struck by falling object Motor vehicle crash
8. Craftworkers	Fall Electrocution Machine mishap
9. Machine operators	Machine mishap Homicide (tie) Motor vehicle crash (tie) Explosion
10. Transport workers	Motor vehicle crash Machine mishap Homicide
11. Laborers	Motor vehicle crash Machine mishap Fall

Source: National Traumatic Occupational Fatality Study, NTOF

Table 2.21

Causes of Injury Deaths Within Industry Divisions, NTOF

<u>Industry</u>	<u>Causes of Death</u>
1. Agriculture, forestry, fishing	Machine mishap Motor vehicle crash Struck by falling object
2. Mining	Machine mishap Motor vehicle crash Struck by falling object
3. Construction	Fall Electrocution Motor vehicle crash
4. Manufacturing	Machine mishap Struck by falling object Motor vehicle crash
5. Transportation, communication, public utility	Motor vehicle crash Aircraft craft Homicide
6. Wholesale trade	Motor vehicle crash Machine mishap Homicide
7. Retail trade	Homicide Motor vehicle crash Suicide
8. Finance, insurance, real estate	Homicide Motor vehicle crash Suicide
9. Service	Homicide Motor vehicle crash Fall
10. Public administration	Motor vehicle crash Homicide Aircraft crash

Source: National Traumatic Occupational Fatality Study, NTOF

V.B.3 BLS's Annual Survey

A recent BLS Annual Survey (U.S. Bureau of Labor Statistics 1993), presents information on the number of deaths within eight broad industry divisions. The same report also indicates the cause of the death, e.g., motor vehicle crash, fall, and so on, within the broad industry division. Since the CFOI and NTOF present much more reliable data for fatal injuries, cause of deaths and industry

division, the BLS's Annual Survey detailed information on these subjects is omitted. But three brief points should be made. First, the same general patterns in the CFOI and NTOF emerged in the Annual Survey death data. For example, three industries—agriculture, construction and transportation—contributed the largest share of deaths and generated the highest rates. Moreover, vehicle crashes caused the most deaths, consistent with both the CFOI and the NTOF. Second, the Annual Survey data did not place homicide nearly as high in the cause of death list as either the CFOI or the NTOF. This underscores the continuing problem associated with convincing industry officials and the public that homicide is a risk in many jobs.

Third, the Annual Survey shows the importance of one occupational illness—heart disease. In recent years, 9% of all Annual Survey deaths have been attributed to heart attacks. These cases were intentionally ignored by the CFOI and NTOF (i.e., the CFOI and the NTOF did not investigate disease deaths).

The BLS's Annual Survey is useful in presenting non-fatal injury data for industries. The information reported here pertains to lost workday cases. This would be equivalent to our definition of disabling injuries. The data at the 1-digit level are similar to those on death rates appearing above in our discussion of the CFOI and the NTOF. The ranking from highest to lowest for lost workday injury incidence rates is as follows: construction; transportation and public utilities; mining; agriculture, forestry, and fishing; manufacturing; wholesale and retail trade; services; finance, insurance and real estate.

The BLS's Annual Survey contains information by four-digit industry and three-digit occupation. Table 2.22 presents information by four-digit industry. Incidence rates for injuries only are presented. The incidence rate is the ratio of number of lost workday cases to the number of full-time equivalent workers. The incidence rates are a measure of the injury risks faced by the typical employee. They do not necessarily measure the overall magnitude of the contribution of a particular industry to the national volume of occupational injuries. For example, an industry such as raw cane sugar employs few people, but has a high incidence rate.

Table 2.22 presents the top 34 industries with the highest lost workday

injury incidence rates for 1991. (At the time of this writing, the 1992 data were not yet available). These industries include ship building and repairing, meat packing plants, special product sawmills, household appliances, pre-fabricated wood buildings, vitreous plumbing fixtures, structural wood members, raw cane sugar, bottled and canned soft drinks, metal barrels and pails.

The 1992 BLS Annual Survey News report (U.S. Bureau of Labor Statistics 1994) provided information for three-digit occupations. Table 2.23 shows the rankings according to the contribution of each occupation to the overall worker injuries and illnesses involving days away from work. Again, illnesses comprised roughly 7% of the total. The numbers are not rates, but rather are the actual number of recorded cases. Obviously, the greater the employment in any occupation, the greater its contribution to total injuries is likely to be. Nevertheless, the ranking is useful as a measure of the overall contribution of an occupation to total injuries, unlike the per worker ranking of industries in Table 2.22.

The top three are non-construction laborers, truck drivers, and nursing aides and orderlies. The kinds of injuries experienced by laborers and drivers are well-known (Leigh 1995a). Injuries can occur among aides and orderlies who must frequently move patients—some quite heavy—from beds to chairs and back again. Additional high-ranking occupations include janitors, construction laborers, assemblers, stock handlers, cashiers, food preparers, cooks, carpenters, registered nurses, maids, welders, sales supervisors, and automobile mechanics.

Finally, Table 2.24 presents data by broad occupation divisions. Operators, fabricators, and laborers contributed by far the largest percent—40.8.

Table 2.22
Four-digit Industries with the highest lost workday case incidence rates¹
for injuries only, private industry, 1991, BLS Annual Survey

Industry²	SIC Code³	Incidence Rate
Ship building and repairing	3731	18.4
Meat packing plants	2011	14.4
Special product sawmills, n.e.c.	2429	13.7
Household appliances, n.e.c.	3639	12.4
Prefabricated wood buildings	2452	12.1
Vitreous plumbing fixtures	3261	11.9
Structural wood members, n.e.c.	2439	11.9
Raw cane sugar	2061	11.4
Bottled and canned soft drinks	2086	11.4
Metal barrels, drums, and pails	3412	11.1
Mattresses and bedsprings	2515	11.1
Aluminum foundries	3365	10.8
Metal sanitary ware	3431	10.6
Cottonseed oil mills	2074	10.5
Leather tanning and finishing	3111	10.2
Steel foundries, n.e.c.	3325	10.2
Gray and ductile iron foundries	3321	10.0
Wood pallets and skids	2448	9.9
Logging	2411	9.9
Secondary nonferrous metals	3341	9.9
Miscellaneous transportation services	478	9.9
Truck trailers	3715	9.8
Animal and marine fats and oils	2077	9.8
Rice milling	2044	9.8
Aluminum die-castings	3363	9.6
Malt	2083	9.6
Nonferrous die-castings, except aluminum	3364	9.5
Steel springs, except wore	3493	9.5
Plastics plumbing fixtures	3088	9.4
Mobile homes	2451	9.4
Fabricated structural metal	3441	9.3
Iron and steel forgings	3462	9.3
Nailed wood boxes and shook	2441	9.3
Copper foundries	3366	9.1

¹The incidence rates represent the number of injuries per 100 full-time workers.

²High-rate industries were those having the 20 highest lost workday case incidence rates for injuries only at the most detailed or lowest SIC level at which rates were calculated and published. Based on this comparison, the highest rates were all reported in manufacturing industries, except SIC 478 (miscellaneous transportation services industry). Generally, manufacturing industries were calculated at the 4-digit code level based on the *Standard Industrial Classification Manual*, 1987 Edition. Agriculture, forestry, and fishing were calculated at the 2-digit level; and the remaining industries at the 3-digit level.

³*Standard Industrial Classification Manual*, 1987 Edition. n.e.c. = not elsewhere classified.

SOURCE: BLS Annual Survey

Table 2.23

Number (not Rate) of Non-fatal Occupational Injuries and Illnesses Involving
Days Away from Work¹ by Selected Occupations, 1992, Private Industry²
BLS Annual Survey

<u>Occupation</u>	<u>Numbers in Thousands</u>
Total	2,331.1
Laborers, nonconstruction	152.1
Truck drivers	145.9
Nursing aides, orderlies	111.1
Janitors and cleaners	59.6
Construction laborers	57.1
Assemblers	47.7
Stock handlers and baggers	44.4
Cashiers	41.7
Miscellaneous food preparers	38.5
Cooks	36.1
Carpenters	34.3
Registered nurses	31.4
Maids and housemen	29.4
Welders and cutters	29.4
Supervisors and proprietors, sales	28.4
Shipping and receiving clerks	26.4
Automobile mechanics	25.7
Groundskeepers and gardeners	21.3
Farm workers	20.8
Kitchen workers	19.5
Waiters and waitresses	19.5
Driver-sales workers	19.2
Electricians	19.2
Sewing machine operators	17.4
Supervisors, production	16.3
Packaging machine operators	15.6
Butchers and meat cutters	15.5
Licensed practical nurses	14.9
Plumbers and pipefitters	13.9
All other occupations	1,164.4

¹Days away from work cases include those which result in days away from work with or without restricted work activity.

²Excludes farms with fewer than 11 employees.p

NOTE: Because of rounding, data may not sum to the totals.

SOURCE: BLS Annual Survey

Table 2.24

Percent Distribution of Non-fatal Occupational Injuries and Illnesses,
Days Away from Work¹ by Broad Occupation, 1992, Private Industry²
BLS Annual Survey

<u>Characteristic</u>	<u>Percent</u>
Total (2,331,100 cases)	100.0
Broad Occupations:	
Managerial and professional	1.5
Technical, sales, and administrative support	15.0
Service	17.4
Farming, forestry, and fishing	2.7
Precision production, craft, and repair	17.0
Operators, fabricators, and laborers	40.8

¹Days away from work cases include those which result in days away from work with or without restricted work activity.

²Excludes farms with fewer than 11 employees.

NOTE: Because of rounding, data may not sum to the totals.

SOURCE: BLS Annual Survey

V.C. Geography, NTOF

Only the NTOF presents a comprehensive analyses of state differences in injury rates. Jenkins et al. (1993) present the NTOF death rates by state. The greatest number of fatalities occurred in Texas (6,664), California (16,623), Florida (3,681), Illinois (2,853), and Pennsylvania (2,564). The states with the highest annual rates were Alaska (34.8), Wyoming (29.0), Montana (20.9), Idaho (16.7), and West Virginia (15.7). States with low rates, less than a 2.9 per 100,000 per year, included New York, Connecticut, and Massachusetts.

VI. Causes of Death and Injury

This section will discuss the causes of fatal and non-fatal injury deaths. This section is organized around data sets since each makes a unique contribution.

VI.A. Deaths

Table 2.25 presents information on the number and percent distribution of fatal injuries by cause of death from the CFOI. At the top of the list, with 40% of all injuries, are transportation accidents, including highway and non-highway accidents, aircraft crashes, pedestrian accidents, boating accidents and railway accidents.

Table 2.25

Number and Percent Distribution of Fatal
Occupational Injuries by Event or Exposure, 1992, CFOI

Event or exposure ¹	Fatalities	
	Number	Percent
Total	6083	100
Transportation accidents	2441	40
Highway accidents	1121	18
Farm, industrial vehicle accidents	436	7
Aircraft crashes	350	6
Pedestrians struck by vehicles	342	6
Boating accidents	110	2
Railway accidents	66	1
Assaults and violent acts	2616	20
Murders	1004	17
Suicides	183	3
Contacts with objects and equipment	1001	16
Falls	590	10
Exposure to harmful substances or environments	593	10
Fires and explosions	167	3
Other	75	1

¹Categories are based on the 1992 BLS Occupational Injury and Illness Classification Structures.

Source: Census of Fatal Occupational Injuries, CFOI

Today, most OSH researchers and a large percent of the public recognize that transportation accidents are the leading cause of job-related injury deaths. It was not always that way, however. Moreover, it could be that, even now, the majority of working people in the United States are not aware that transportation injuries are the leading cause of job-related injury deaths. As indicated above, the OSH Act virtually ignored vehicle collisions. Only in the last few years has the OSH Administration considered regulations governing job-related travel in

vehicles. Moreover, the recent standard governing truck drivers and the number of hours per day they are allowed to drive was promulgated by the National Highway Traffic Safety Agency, not OSHA. The fact that most researchers, and perhaps much of the public, now recognize the importance of vehicle collisions in job-related deaths is testimony to the influence of studies by Baker et al. (1982), Bell et al. (1990), Kraus (1995), Leigh (1987), Toscano and Windau (1993) and others, over to the past 15 years and equally as important, are the popular press' reports on these studies.

Transportation accidents also involve aircraft. These include airline crashes but also, perhaps more importantly, any aircraft. Helicopter pilots, crop dusters, pilots hauling advertising banners above beaches, corporate pilots in small jets, and so on, are at high risk (Leigh 1995a).

The second leading cause of death involves violence, either homicide or suicide. While most other categories of job-related deaths may show fewer deaths in the future, due to the secular decline in the total number of accidents (National Safety Council 1993), this category may become increasingly important (Fox and Levin 1994). Evidence suggests that an increasing number of job-related deaths are due to murder (Davis 1987, Kraus and Davis 1987; Honchar and Suarez 1987; Richardson 1993). The murders in the CFOI (as well as in WC records) must be job-related. They cannot be, for example, the result of a husband and wife quarrel. The victim must have been killed during a robbery or job-related dispute (i.e., a supervisor-subordinate quarrel). The victim could, of course, have been a bystander who was simply performing his or her duties when the robbery or quarrel erupted. Contrary to public opinion, most murders involve attempted robbery, and are not quarrels among employees or bosses (Castillo and Jenkins 1994).

Suicides must also have been judged to be job-related by the CFOI (and the WC). These appear to be especially disturbing, sometimes involving disgruntled workers who shoot their bosses and then turn the gun on themselves (Fox and Levin 1994). Most cases, however, do not also involve attempted murders. A serious injury can leave a worker paralyzed for life. People in this position have been known to take their own lives (Conroy 1989).

The importance of murder and suicide should be emphasized. Together, they are the second leading cause of death and they appear to be increasing. Moreover, they were ignored in the 1970 OSH Act, and were subsequently not of great concern to OSH regulators in the 1970s and 1980s.

Murder on the job is receiving increasing media and legislature attention (Friedman 1994). One proposal to reduce the toll would be to require retail stores that operate at night to post armed guard on duty during evening hours.

The next four categories of causes of death—contact with objects, falls, exposures and fires—are much more likely to be associated with job hazards in the public mind than most transportation accidents or violent acts. Iron workers, for example, most frequently die from falls (Leigh 1995a). Blasters die in fires and explosions. A high percentage (60%) of hospitalized burn injuries among men in Massachusetts were found to be job-related (Rossignol et al. 1986).

VI.B. Types of Non-fatal Injuries

V.B.1 BLS's Annual Survey, Non-fatal Injuries

The BLS's Annual Survey report (U.S. Bureau of Labor Statistics 1994) on characteristics of people and injury episodes contained a table on the percent distribution of non-fatal occupational injuries and illnesses involving days away from work. Some of the data are reproduced here.

The categories with the highest percentages include overexertion (28.3%), contact with object or equipment (27.4%), fall on same level (10.3%), fall to lower level (5.0%), exposure to harmful substance (2.9%), repetitive motion (3.9%), slips, trips (3.5%), transportation accidents (2.9%), assault (1.0%), and fires and explosions (.2%).

These rankings stand in contrast to those from the CPOI. There are a number of reasons for these contrasts. The CPOI was for fatalities only while the Annual Survey was for non-fatal injuries only. Transportation accidents and assaults are more likely to be fatal than other accidents and exposures. But perhaps a more important reason is the nature of the two data sets. The CPOI was designed as a census, a comprehensive count. The Annual Survey used data provided by 250,000 firms. The Annual Survey data has been found to capture only 30% to 40% of all

deaths (Toscano and Windau 1993). The chief of the BLS division responsible for the Annual Survey acknowledges the Survey's inadequacies (U.S. Congress, House Subcommittee 1987). Hence, the discrepancies between the CPOI and the Annual Survey could be viewed as evidence for the problems discussed in the Annual Survey above (II.A.3 and III.A.1).

VI.B.2 NHIS-OSH

In 1988, the annual National Health Interview Survey (NHIS) collected supplemental data on 27,408 employed persons pertaining to job-related injuries and health. The supplement to the NHIS is referred to as the Occupational Health Supplement to the NHIS (or NHIS-OSH). The preliminary analysis of the data became available in 1993 (Park, Wagener, Winn, and Pierce 1993).

The purpose of the NHIS-OSH was to obtain national estimates of the incidence and prevalence of job-related injuries and illnesses. The NHIS-OSH asked close to 100 questions (if all of the branching questions are included). The original objective was to collect data on the leading problems as viewed by NIOSH: lung diseases, musculoskeletal injuries, cancers, traumatic injuries, cardiovascular diseases, disorders of reproduction, neurotoxic disorders, noise-induced loss of hearing, dermatologic conditions, and psychological disorders. But it became evident that information on cancers and neurotoxic conditions could not be obtained through surveys. As a result, attention was focused on back, hand or neck, discomfort; work-related injuries; skin conditions; eyes, nose, and throat irritation; carpal tunnel syndrome, tendinitis; asthma; chronic bronchitis; and deafness. The NHIS-OSH investigators pointed out that there was an "absence of any national data on these leading occupational health problems" (Park et al. 1993, p. 2).

Park et al. (1993) found that 7.7% of the working population in 1988 had reported a job-related injury over the past 12 months. Of course, some could have been injured more than once. From 1987 to 1989, the simple "injury at work" information in the usual NHIS samples (not OSH subsample) was used to calculate rates of 8.1, 8.7 and 9.3 per 100 persons working. These estimates also applied to persons, not injuries. But, the usual NHIS questions applied to the last two weeks

whereas the NHIS-OSH applied to the last 12 months. There are problems created by the 12-month questions when compared to the two-week question. First, persons are less likely to suffer more than one injury in two weeks than 12 months. Second, the usual "injury at work" question in the annual NHIS may suffer less recall bias than the questions used by the NHIS-OSH from 1988. Recall bias was found to be much greater over 12 months than two weeks (Landen and Hendricks 1992). With these caveats in mind, it is nevertheless useful to consider the Park et al. (1993) analysis of the NHIS-OSH.

Park et al. (1993) present data on the percent of injuries by type (as opposed to nature or source) of injury as follows: Strain or sprain (28.4%), other (22.3%), lacerations or punctures (20.5%), contusions or abrasions (12.5%), not stated (7.1%), fractures (6.8%), and burns (4.7%). Park et al. (1993) go on to analyze these data this way:

The distribution is not substantially different from the percent distribution of types of injuries for all injuries to the total U.S. population, reported in an earlier series titled *Types of Injuries by Selected Characteristics: United States, 1985-87* (Collins 1990). There were more burns among the work-related injuries (4.7% as opposed to 2.7% reported in Collins (1990)) and fewer fractures (6.6% as opposed to 12.7% reported in Collins (1990)). However, the more frequent sprains and strains (26.4% versus 21.6%) and lacerations or punctures (20.5% versus 22.1%) were the most frequently injured body parts. About 8% of the injured persons either changed employer, kind of work, or work activity as a result of the injury.

The fact that the injuries sustained while at work were so similar to injuries sustained by adults whether or not working is an important finding for us. This allows us to use the numbers and percentages from the Rice et al. (1989) and other national studies on injuries with confidence.

Park et al. (1993) present another table (their Table D) indicating the nature of injury and body parts injured for workers who missed no days or at least a half-day of work. The greatest numbers of injuries occurred to hands, wrists or fingers (624), backs (463), other (433), and feet, toes and ankles (186). Park et al. (1993) indicate that more than half of workers missed work if they sustained an injury to their shoulder, back, foot, toe, or ankle.

Finally, the NHIS-OSH investigators asked one question that was especially helpful in our analysis. It pertained to whether or not the injured worker filed a WC claim. Roughly 52.7% did not file a claim. The NHIS-OSH investigators did not ask whether the claim was successful (i.e., whether WC paid any benefits). It is likely some people filed a claim but were denied because of a technical reason such as the worker was absent only six days rather than seven days. In this case, we would want to include the injury in our count of the number of injuries not covered by WC. On the other hand, we would not want to include a claim that was fraudulent and was denied WC benefits.

The 12-month recall bias also is important here. Answers to a 12-month question less likely to involve non-disabling injuries than answers to a two-week question. Over 12 months, people are more likely to forget injuries that did not cause work loss as opposed to injuries that did cause work loss. Disabling injuries are more likely to receive WC than non-disabling injuries. Again, the 12-month recall bias would likely influence the 52.7% rate so that the "true" rate would exceed 52.7. A higher rate would decrease the percentage receiving WC benefits. This information on who filed a WC claim was available in the code book accompanying the computer tape for NHIS-OSH, page OH-68.

VI.B.3 NHIS, 1985-87, Non-fatal Injuries

In 1988, the NHIS investigators constructed a table of data from 1985 through 1987 that allows a comparison between the type of injuries sustained by everyone whether on or off-the-job with the types of injuries sustained only by people at-the-job. Table 2.26 was drawn from this NHIS table. National estimates are provided for all injuries and work-related injuries only. Again, most work injuries tend to be similar to all injuries as the percent columns indicate. One exception is for total sprains and strains, especially of the back. A much higher percentage of work injuries than all injuries resulted from back injuries. Other exceptions involve wounds and lacerations. The workplace generates a higher percentage of wounds to upper limbs but a lower percentage to heads, necks and trunks than all classes of injuries. Finally, effects of "foreign body on eye" comprise a higher percentage among work injuries than all classes of injuries.

Rankings by type of injury from previous years, 1980 and 1981, are available (Collins 1986). Rankings by frequency of injury and education level are also available (Collins 1986, 1990). Persons with low levels of education report much higher injury rates than persons with high education levels. This pattern partially reflects the categories of jobs entered into by persons with low and high levels of education.

VI.B.4 National Safety Council, 1993; Rand; and Rossman et al. (1991) and Division of Labor Statistics and Research (1985)

The NSC uses NHIS and WC data, as well as their own data provided by corporations to assemble information on the parts of the body injured in work accidents and the WC costs associated with the injuries. These data are displayed in Table 2.27.

As Table 2.27 indicates, disabling injuries most frequently occur to the back, legs, arms, and fingers. The WC costs follow a similar pattern with an interesting exception: injuries to the trunk are apparently more costly than injuries to the fingers.

Table 2.26

Average Annual Number of Injuries by Class of Accident
and Type of Injury, U.S., 1985-87, NHIS

	<u>Class of Injury</u>		<u>Type of Injury</u>	
	<u>All Classes</u>		<u>Work</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
All injuries	64258	100.0	10512	100.0
Skull fractures and intracranial injuries	1931	3.0	164	1.6
Fractures of neck, trunk and upper limb	4184	6.5	641	6.1
Fracture of upper limb	3169	4.9	369	3.5
Fractures of lower limb	2046	3.2	271	2.6
Dislocations	1079	1.7	178	1.7
Sprains and strains - total	3848	6.0	2925	27.8
Sprains and strains of hip, thigh, knee and leg	2210	3.4	436	4.1
Sprains and strains of ankle and foot	3389	5.3	561	5.3
Sprains and strains of back	4758	7.4	1326	12.6
Open wounds and lacerations - total	14202	22.1	2496	23.7
Open wounds and lacerations of head, neck and trunk	4593	7.1	341	3.2
Open wounds and lacerations of upper limb	5868	9.1	1750	16.6
Open wounds and lacerations of shoulder, arm and hand	2656	4.1	723	6.9
Open wounds and lacerations of fingers	3212	5.0	1027	9.8
Open wounds and lacerations of lower limb	3740	5.8	406	3.9
Open wounds and lacerations of knee, leg and ankle	1878	2.9	264	2.5
Superficial injury	4279	6.7	661	6.3
Contusion with intact skin surface	9828	15.3	1517	14.4
Contusion of face, neck and scalp	1328	2.1	53	0.5
Contusion of trunk	1906	3.0	299	2.8
Effects of foreign body through orifice	1056	1.6	454	4.3
Effects of foreign body on external eye	837	1.3	433	4.1
Burns	1753	2.7	393	3.7
Toxic effects - non-medical	1323	2.1	--	--
All other injuries	8735	13.6	811	7.7

Source: National Health Interview Survey

Table 2.27

Part of Body Injured in Non-fatal Incidents, 1991, NSC

	<u>Number of Disabling Injuries</u>	<u>Percent</u>	<u>Percent of WC Compensation</u>
Back	800,000	24%	31%
Legs	440,000	13%	14%
Arms	370,000	12%	10%
Fingers	360,000	11%	5%
Trunk	360,000	11%	13%
Hands	170,000	5%	3%
Eyes	140,000	4%	1%
Feet	130,000	4%	2%
Head, except eyes	140,000	4%	3%
Total	3,300,000*	100*	100*

*Does not sum to 3,300,000 or 100% due to exclusion of "other", "multiple injuries", and "unknown", "neck", "toes", "body systems."

Source: National Safety Council

The Rand study, by Hensler et al. (1991) and Marquis (1992), found the characteristics of work-related injuries and their contributions to the total of work-related injuries to be these: sprains and pulls (48%), cuts, lacerations, punctures (20%), fractures, broken bones, dislocations (16%) and bruises (13%). Body parts affected and corresponding percentages were: back, spine (34%), hand, fingers, wrist (21%), foot, ankle, knee (15%), head, eyes, ears, face (13%), arm or elbow (12%), leg (8%), neck (6%) and chest, lung, and heart (5%).

In the Rossman et al. (1991) study on the NCCI-DCI data, the following pattern was observed: Sprains and strains accounted for 47%, followed by dislocation and fractures (12%), contusion (12%) and laceration (11%). The most frequent parts of the body to be injured included, in order, lower backs, followed by fingers and thumbs, followed by knees.

Most of the Rossman et al. (1991) DCI cases resulting in days away from work (82%) involved a Temporary Total disability (pp. 18, 19). Roughly 10.5% were Permanent Partial; .5% were Permanent Total; and 7% were Temporary Partial and "mixed patterns of Temporary and Permanent disabilities."

The State of California study (Division of Labor Statistics and Research 1985) of 374,000 disabling injuries reported the following injuries (and

illnesses) by body part: back and spine (21%); lower extremities (leg, foot, ankle, toe, 19%); upper extremities (arm, wrist, hand, not fingers, 13%); finger (11%). The nature of the incidents in California were: strains, sprains, dislocation and hernias (41%); cuts and punctures (14%); fractures (10%); contusions and crushing injuries (8%).

VII. Conclusion

Tables 2.12 and 2.13 summarize the most important findings from this chapter.

We estimate 6,747 deaths of which 6,529 occurred among workers and 218 among innocent bystanders. We estimate 13.315 million injuries of which 13.247 million occurred among workers and 68,000 among innocent bystanders.

Additional findings pertaining to our estimates include these:

- WC underestimate injuries by at least 55%.
- Econometric forecasting models and NHIS data on black/white injury rates suggest that the NHIS data may not be reliable.
- No one source of data is sufficient to estimate deaths or non-fatal injuries. The National Safety Council omitted assaults and violent acts. The Rand study by Hensler et al. (1991) omitted deaths. The National Traumatic Occupational Fatality Study did not include deaths that were not indicated to be "at work" on the death certificate. The CPOI may have resulted in an undercount because of the strict two source requirement. The BLS's Annual Survey underestimates injuries from small firms. All other sources we examined had additional problems.

The most important findings involving socioeconomic and geographic characteristics included these:

- Injury death rates are especially high for workers over 65 years of age.
- Men are more likely than women to sustain a work injury. This is especially true for an injury resulting in death. The non-fatal injury rates for men to women is nearly 2:1 while the fatal injury ratio is about 11:1.

- Blacks and Hispanics experience greater numbers of injuries than whites.
- The CPOI and the NHIS underestimate injuries experienced by blacks.
- The self-employed are at very high risk for sustaining a work-related injury.
- Laborers, truck drivers, and taxi drivers generate among the highest kill ratios of all occupations.
- Mining, farming, and construction are the industries with the highest rates of fatal and non-fatal injuries.
- Murder is the most likely way for executives to die in the line of duty.
- Operators and laborers generate the greatest numbers of deaths and non-fatal injuries among all broad occupation groups.
- Laborers, truck drivers, nursing aids, janitors, assemblers, stock handlers and cashiers generate the most disabling injuries among detailed occupations.

The most important findings pertaining to types of injuries include these:

- The National Health Interview Survey-Occupational Health Supplement suggests that WC misses at least 52.7% of all injuries.
- Injuries to the back generate the highest frequency of disabling injuries and WC costs of all other medically diagnosed injuries.
- Injuries to the back, wounds to upper limbs, and effects of "foreign body on eye" are more frequent among work injuries than all other classes of injuries.
- Recall bias on 12 month questions may result in a serious undercount of non-disabling injuries.
- Transportation accidents involving highway vehicles, industrial vehicles and aircraft boats and railroads contribute to 40% of injury deaths. Transportation accidents have frequently been ignored by OSHA.

- Assaults and violent acts contribute another 20% of injury deaths. These too, have frequently been ignored by OSHA.
- Transportation accidents, assaults and violent acts comprise a smaller share of non-fatal injuries than fatal injuries. Assaults and violent acts are more likely to be fatal than most other injuries at work.

In the subsequent chapters, the estimates in Table 2.12 and 2.13 will be multiplied by medical costs, indirect costs, and willingness-to-pay costs to arrive at an estimate of the total costs of occupational injuries in 1992.

Chapter 3

Counting Occupational Illnesses

Chapter 3: Counting Occupational Illnesses

I. Introduction

II. Approach to the Problem

- A. Major Obstacles to the Recognition and Counting of Occupational Diseases**
- B. Proportional Attributable Risk Model**
 - B.1. Cancer**
 - B.2. Cardiovascular and cerebrovascular disease**
 - B.3. Chronic obstructive pulmonary disease**
 - B.4. Pneumoconioses**
 - B.5. Neurologic and renal disease**

III. Estimates of Morbidity and Mortality from Occupational Disease

- A. Occupational Morbidity**
 - A.1. Survey-based data**
 - A.1.1. BLS Annual Survey**
 - A.1.2. Public employee data**
 - A.1.3. Heavy metal poisoning**
 - A.1.4. National Health Interview Survey**
 - A.1.5. National Hospital Discharge Survey**
 - A.2. Attributable risk-based estimates of morbidity**
 - A.2.1. Cancer**
 - A.2.2. Cardiovascular and cerebrovascular disease**
 - A.2.3. Chronic obstructive pulmonary disease**
- B. Occupational Mortality**
 - B.1. Specific occupational diseases**
 - B.2. Attributable risk-based estimates of mortality**

Chapter 3: Counting Occupational Illnesses

I. Introduction

Millions of America's workers are exposed to occupational toxins, work under hazardous conditions and are injured or made ill by their work. The cost to the victims of these diseases and injuries would appear to be substantial, but to date have not been well documented. Accurate data on the extent of this problem are important to the United States for two reasons: 1) they will provide a rational basis for prevention and for legal enforcement of standards, and 2) they will enhance the competitive ability of the United States in world markets. The goal of this chapter is to obtain a count, or a reasonable estimate, of the number of workers who develop and die from occupational diseases and injuries each year in the United States. However modest this goal may seem, in fact, the task is difficult. Previous attempts to achieve this goal have been less than fully successful, because they rely on unsubstantiated data sources (President's Report on Occupational Safety and Health 1972) or on single data sources (Bureau of Labor Statistics 1994a), or represent extrapolations from the experience of a single state (Landrigan and Markowitz 1989). Several Congressional committees examined the official statistics on occupational disease in the United States in the 1980's and concluded that they seriously underreport occupational injuries and illnesses (Subcommittee on Government Operations, 98th Congress 1984; Subcommittee on Government Operations, 99th Congress 1986). An expert committee convened by the National Research Council reached a similar conclusion (Pollack and Keimig 1987).

There have been, however, recent gains in our ability to identify the extent of occupational disease in a comprehensive manner in the U.S. population. It is therefore worthwhile to evaluate current data sources in order to measure our progress in obtaining such a count. In addition, enumeration of the costs of occupational illnesses requires a counting, however approximate, of the number of cases of such illness.

Significant improvements in the surveillance of occupational diseases have been achieved in the past decade in the United States. Some of the limitations in the data gathered by the Department of Labor have been acknowledged and are being

partly addressed in a re-designed annual survey conducted by the Bureau of Labor Statistics (Bureau of Labor Statistics 1993) and proposed initiatives of OSHA (U.S. Department of Labor 1994). A new national adult lead poisoning surveillance program coordinated by National Institute for Occupational Safety Health (NIOSH) demonstrates that such a national surveillance program is possible (Chowdhury et al. 1994). The NIOSH program, Sentinel Event Notification System for Occupational Risks (SENSOR), initiated in the late 1980s, is leading to high quality case finding and identification of selected occupational disorders in numerous states (Baker 1989; Matte et al. 1989). Both the quality and quantity of surveillance activities undertaken by state health departments, led by those in New Jersey, Michigan, California, New York, and others, have markedly improved (Matte et al. 1990; Rosenman et al. 1990; Windau et al. 1990). While much remains to be done, the progress in the past two decades has been measurable and important.

Despite such gains, calculating how many workers are made ill and die by occupational causes each year remains a perilous task. The peril lies in the inescapable use of assumptions and estimations. While their use is hardly the unique province of occupational health, the degree of extrapolation from known data and the associated lack of consensus is especially problematic in occupational health. The vigorous scientific debate over how much cancer is ascribed to occupational causes in the early 1980s is an example of such disagreement (Peto and Schneiderman 1981).

It is not possible at the present time to obtain an accurate and precise picture of the full extent of occupational disease in the United States. It is possible, however, to obtain an estimate of the number of people who become ill and die from occupational causes, subject to important qualifications. First, to better reflect the inherent uncertainty in the estimates obtained, we use ranges of numbers when possible rather than point estimates. Second, where data are less than optimal, we attempt to specify the limitations of the data. When assumptions are required, we make these assumptions explicit and provide a rationale for their use. Third, and finally, since the underlying goal is to estimate the costs of occupational illness, it is necessary to convert qualitative concerns into quantitative ones. This process involves some error, but hopefully no more error

than would be involved in ignoring these qualitative concerns altogether in an attempt to avoid uncertainty.

II. Approach to the Problem

II.A. Major Obstacles to the Recognition and Counting of Occupational Diseases

Numerous explanations for the difficulty in counting how many cases of illness and death result from occupational exposures have been offered.

One explanation for the under-reporting of occupational illness is the inherent difficulty in diagnosing occupational diseases and in establishing cause and effect relationships. The link between occupation and disease is often elusive, because most occupational diseases are not clinically or pathologically distinct from chronic diseases associated with non-occupational etiologies. For example, the lung cancer caused by asbestos is identical in its clinical and pathological presentation with that caused by cigarette smoking (Selikoff and Lee 1978). Indeed, synergism has been shown to exist between occupational and non-occupational risk factors in the causation of cancer (Hammond et al. 1979). Similarly, solvent-induced encephalopathy may easily be attributed to old age (Landrigan 1983) and lead-induced neuropathy to hypertension or diabetes (Landrigan et al. 1984). Only in rare instances, such as in the association between asbestos and malignant mesothelioma (Selikoff et al. 1964) or in that between vinyl chloride monomer and angiosarcoma of the liver (Creech and Johnson 1974), is the causal association between occupational exposure and disease highly specific.

A second cause of the widespread under-recognition of occupational disease is that the majority of chemicals in commerce have never been fully evaluated with regard to their potential toxicity. A study by the National Research Council in the 1980's found no information available on the toxicity of approximately 80% of the 60,000 chemical substances in commercial use (National Research Council 1984). Even for those groups of substances that are most closely regulated and about

which the most information is available—drugs and food additives—reasonably complete information on potential untoward effects is available for only a minority of agents.

This problem of insufficient toxicological data is compounded by the fact that pre-market testing of the toxicity of newly developing chemical substances is inadequate. Pre-market testing is the most effective means of assessing the toxicity of new chemical compounds. However, until the passage of the Toxic Substances Control Act (TSCA) in 1976, there was no legal mechanism in the United States for prospective evaluation of the toxicity of new industrial compounds. Even since passage of the TSCA, inadequacies in testing requirements remain. Many thousands of potentially toxic compounds whose introduction to commerce antedated passage of TSCA remain untested, and there are no requirements at present for routinely testing such compounds. Also, testing procedures for new industrial compounds have not been standardized, especially for measurement of reproductive, neurological, immunological outcomes. Responsibility for deciding whether or not to test a new chemical and for the development of testing protocols is left almost entirely to the discretion of chemical manufacturers.

The long latency that typically elapses between occupational exposure and onset of illness is a third factor that may obscure the occupational etiology of chronic disease. For example, few occupational cancers appear within 10 or even 20 years of first exposure. Similarly, the chronic neurotoxic effects of solvents may become evident only after many decades of exposure (Landrigan 1983). A worker so affected may well have retired. In such a case, it is unlikely that the workers will be diagnosed as having a disease of occupational origin and even less likely that the employer will learn of this episode of occupational illness.

Lack of awareness among health practitioners about the hazards found at work is a fourth cause of underestimation of occupational disease. This lack of information reflects the fact that most physicians are not adequately trained to suspect work as a cause of disease (Rosenstock 1981). Very little time is devoted in most U.S. medical schools to teaching physicians to take a proper occupational history, to recognize the symptoms of common industrial toxins, or to recall the known associations between occupational exposures and disease. The average

American medical student receives only six hours of training in occupational medicine during the four years of medical school (Burstein and Levy 1994). In consequence of this lack of training, most physicians do not routinely obtain histories of occupational exposure from their patients. Surveys indicate that adequate occupational histories are recorded on fewer than 10% of hospital charts (Institute of Medicine 1988).

Compounding this lack of medical awareness is the limited ability of many workers to provide an accurate report of their toxic exposures. Workers may have had multiple toxic exposures in a variety of jobs over a working lifetime. Until recently, they have not been informed of the nature of the hazard of the materials with which they have worked. Employers' reporting requirements remain limited even under the OSHA Hazard Communication Standard and under State and local right-to-know laws (Pollack and Keimig 1987). In many instances, an ill patient will simply not know about his or her past occupational exposures.

Finally, given the potential financial liability associated with the finding that a disease is of occupational origin, employers may be resistant to recognizing the work-relatedness of a disorder, especially in cases where personal habits (such as cigarette smoking) or non-occupational pursuits are possible contributory factors. Since employers are often in the best position to recognize causal associations between workplace exposures and disease, this unfortunate conflict of interest represents a major obstacle to obtaining accurate estimates of the burden of occupational illness.

II.B. Proportional Attributable Risk Model

Given our inability to delineate for nearly all causes of death which individual deaths were due to occupational causes acting alone or in conjunction with other causes, it is necessary to resort to estimating the proportions of diseases and deaths to which occupational exposures have contributed. Such an approach was applied to occupational cancer 15 years ago when it provoked a lively debate (Peto and Schneiderman 1981). Gains in knowledge in the intervening time period can contribute to a more informed discussion of the issues but cannot produce irrefutable, precise proportions of disease attributable to occupational

factors for the general population. The aim of this section, then, is to establish reasonable ranges of such proportions for major causes of death, while fully acknowledging the limitations of the approach.

Several seminal issues underlie this approach to estimating occupational morbidity and mortality. First, since most disease is multi-factorial in origin, to attribute a death to an occupational exposure does not exclude a causal role for another factor that is not occupational. Both causes may have actively contributed to a person's death. Indeed, most lung cancers in asbestos-exposed workers who smoke cigarettes occur as a result of the combined action of exposure to asbestos and cigarettes (Hammond et al. 1979). It would be proper, therefore, to assign a lung cancer death in such a person simultaneously to an occupational cause and to a lifestyle factor. This will lead to double-counting as long as categories of causes are considered mutually exclusive. In this chapter, we use the term attributable proportion with reference to an exposure to mean the proportion of disease that would have not occurred in the absence of that exposure.

A deeper problem exists, however. While it is likely that occupational causes frequently interact with non-occupational causes to produce illness and death, the nature of this interaction is largely unknown and unquantified. It is, therefore, difficult to determine, for most occupational exposures, the relative importance of each factor, occupational and non-occupational, acting alone and in concert.

Second, the proportion of disease due to occupational causes (or any other causes) can be expected to vary in time and place. This is due principally to 1) differing relative risks due to variation in type, intensity and duration of exposures and 2) variation in the proportion of the populations exposed to various occupational toxins. An empirical demonstration of this variation and its sources is provided by the body of case control studies of lung cancer completed in the past 15 years (Milne et al. 1983; Correa et al. 1983; Pastorino et al. 1984; Kjuus et al. 1986; Lerchen et al. 1987; Schoenberg et al. 1987; Dambar and Larsson 1987; Benhamou et al. 1988; Levin et al. 1988; Ronco et al. 1988; Vineis et al. 1988; Dambar and Larsson 1988; Morabia et al. 1992).

These considerations determine the type of evidence that would be needed to achieve validity and precision in determining the proportion of categories of diseases due to occupational exposures. Large case-control studies including subjects drawn from a nationally representative sample would yield suitable proportionate attributable risk estimates. Such a study for lung cancer was recommended 15 years ago as part of the occupational cancer debate (Doll and Peto 1981). While many smaller lung cancer case control studies in numerous geographic areas have been completed (Milne et al. 1983; Correa et al. 1983; Pastorino et al. 1984; Kjuus et al. 1986; Lerchen et al. 1987; Schoenberg et al. 1987; Damber and Larsson 1987; Benhamou et al. 1988; Levin et al. 1988; Ronco et al. 1988; Vineis et al. 1988; Dambar and Larsson 1988; Morabia et al. 1992), a truly national study in the United States has not been initiated. Alternatively, a comprehensive set of cohort studies covering many occupations would provide the needed estimates of relative risk and levels of exposure in the relevant populations, though interaction with non-occupational risk factors would remain problematic. Despite increased occupational studies in the past two decades, the database that would allow precise estimates of the proportions of major causes of death due to occupational remains far from complete.

The occupational health research community is unlikely to command the resources in the foreseeable future to undertake the number and kinds of detailed studies that would provide the knowledge base allowing qualitatively better estimates of the occupational contribution to disease than we are able to complete at present. Our approach in this document is to use estimates of ranges of proportions of major categories of diseases that are consonant with current knowledge and thinking. Ranges of estimates of similar magnitudes have been used by numerous groups of occupational health researchers in various states, including New York, Connecticut, Texas and New Jersey, Pennsylvania, and Canada (Markowitz et al. 1989; Fahs et al. 1989; Markowitz and Landrigan 1989; Occupational Health Working Group 1990; Rothstein and Cooper 1993; Pennsylvania Department of Health 1990; Kraut 1994). A summary of our estimates is provided in Table 3.1.

II.B.1. Cancer

We estimate that 6% to 10% of all cancers among people aged 25 and older in the United States are caused by occupational exposures.

Previous estimates of the proportion of cancer due to occupational factors range from 4% to 38%. The former number was proposed as the best point estimate by Doll and Peto as part of a major review of the causes of cancer published in 1981 (Doll and Peto 1981). Their report was written in part in response to a 1978 consensus document written by numerous U.S. governmental agencies estimating that 22% to 38% of all cancers in the United States were due to occupational carcinogens (Bridbord et al 1978). The 1978 report was flawed inasmuch as relative risks derived from cohorts heavily exposed to occupational agents were applied to populations with a broad range of exposure to these agents, yielding an overestimate of the number of people likely to develop occupational cancer. On the other hand, a major industry-sponsored review of the 1978 report by Stallones and Downs only mildly criticized the governmental report and estimated that 10% to 33% of cancer in the United States were caused at that time by occupational agents (Stallones and Downs 1978).

The estimate of 6% to 10% is grounded in part on a specific set of studies of selected cancers and in part on general trends in human and animal cancer research. There have been at least a dozen case control studies of lung cancer and occupation completed in the United States and Europe since 1982. After controlling for cigarette smoking, they collectively show that 10% to 33% of all types of lung cancer in males are attributable to occupational exposures (references cited above). Applying a narrower range of point estimates, 15% to 20%, to the 91,405 deaths from lung cancer among males in the United States in 1992 yields a total of 13,711 to 18,281 deaths in males from lung cancer due to occupational agents. These lung cancer deaths represent 2.7% to 3.5% of all cancer deaths in the United States in 1992. A similar analysis of deaths from another well-documented occupational cancer, bladder cancer, provides an estimate that 21% to 27% of male bladder cancer deaths are due to occupation in the United States (Silverman et al. 1989a; Silverman et al. 1989b). Since there were 7,123 deaths from bladder cancer among U.S. males in 1992, 1,496 to 1,923 bladder cancer deaths, or approximately 0.3% of all cancer deaths, were due to occupational agents. Together, bladder

cancer and lung cancer among males alone accounted for approximately 3% to 4% of all cancer deaths in the United States in 1992. There are an insufficient number of studies of other specific cancer sites to apply point estimates or ranges as the percentages of these cancers attributable to occupation.

Three sets of research findings in occupational cancer in the past 10 to 15 years support the proposition that the percentage of cancer due to occupation is significantly higher than the 3% to 4% specifically due to cancer of the lung and bladder. First, recent studies have increased the likelihood that a number of well-known toxins are human carcinogens. Included in this category are cadmium, fiberglass, silica and lung cancer (Stayner et al. 1992; National Toxicology Program 1994); vinyl chloride and brain cancer (Wong et al. 1991); and orthotoluidine and bladder cancer (Ward et al. 1991; Sellers and Markowitz 1992). For other agents, limited evidence has accumulated to support, though has not yet established, an etiologic role in cancer. Among these agents are formaldehyde, 1,3 butadiene, and perchloroethylene (National Toxicology Program 1994). While the carcinogenicity of some of these agents may be refuted as additional human evidence is accumulated, it is unlikely all will be exonerated as human carcinogens. Notably, industrial exposure to many of these agents is common, increasing the significance of even modest elevations in relative risk.

A second set of findings that is not addressed by the agent by agent approach to identifying occupational cancer is the large number of studies that demonstrate increased risks of cancer for specific occupations without clear identification of the suspect agents. Many occupations have multiple exposures, exposures of uncertain intensity, or no obvious exposures at all. Yet, some of these occupations show consistent elevations on cancer risk. Examples include farmers and lymphoma (Pearce and Reif 1990; Blair et al. 1992) and fire fighters and brain cancer (Demers et al. 1992; Demers et al. 1994; Vena and Fiedler 1987). Undoubtedly, some of these associations are not causal, but it is also likely that many are. Additional research will elucidate the nature of these relationships. Until this is achieved, it is not possible to ascribe a numeric estimate of the contributions of these jobs to occupational cancer. However, to ignore these findings entirely would be to discard the findings of many well-performed studies.

Third, toxicological assays in animals completed in the past two decades show that a significant number of chemicals tested to date show evidence of carcinogenicity. More than 600 chemical agents have been shown to be carcinogenic in at least one rodent species (Rall et al. 1987). In a review of the experience from the National Toxicology Program (NTP), 130, or one-third, of 404 experiments conducted by the NTP in 105 chemicals showed evidence of carcinogenicity (Rall et al. 1987). Among the more important agents that tested positive in the NTP experiments but for which epidemiologic research is incomplete are methylene chloride, tetrachloroethylene, and propylene oxide (Rall et al. 1987). While there is considerable disagreement about the significance of the results of animal testing for human cancer (Huff and Rall 1992), it is nonetheless considered prudent, given a paucity of human data, to regard chemicals that cause cancer in animal experiments as being reasonably likely of doing so in humans as well (IARC 1987). While the results of animal studies certainly do not contribute to the precision of the estimates of the fraction of human cancer attributable to occupational exposures, they nonetheless suggest that the problem of occupational cancer may be larger than is recognized when only established human carcinogens are considered.

Taken together, these lines of evidence—an increased number of epidemiologic studies tying individual agents to specific cancers; the body of literature relating specific occupations to selected cancers even in the absence of identified agents; and the finding that a large proportion of chemicals cause malignancies in animals—exert an upward pressure on the numeric estimates of the proportion of cancer attributable to occupational exposures. They support our notion that no fewer than 6% of cancer deaths have an occupational cause, and, indeed, that the 6% to 10% range may be a conservative estimate of the occupational fraction of cancer deaths.

II.B.2 Cardiovascular and Cerebrovascular Disease

Despite the importance of heart and related large vessel disease as a cause of mortality in the United States, there has been little attention given to the overall burden of cardiovascular disease (CVD) caused by occupational risk

factors. Unlike carcinogenesis, relatively few chemical agents have been shown to cause or promote heart disease and hypertension. Carbon disulphide and nitroglycerin have been demonstrated to cause or exacerbate ischemic heart disease. Carbon monoxide displaces oxygen from hemoglobin, reducing oxygen supply to the heart, and worsening symptoms of coronary heart disease. It also appears to promote atherogenesis. Lead raises blood pressure, thereby contributing to the risk of hypertensive and ischemic heart disease and stroke.

Lead and carbon monoxide are widespread hazards. According to the National Occupational Exposure Survey conducted by NIOSH in the early 1980s, there were 1.4 million people with potential occupational exposure to lead (NIOSH 1992). The number of people exposed to carbon monoxide is less well-described, but is large. The level of excess risk of cardiovascular and cerebrovascular disease experienced by the large numbers of workers exposed to these agents is not known. It is, therefore, not possible to calculate the fraction of CVD caused by these agents.

A large body of scientific literature exists linking a number of non-chemical occupational risk factors to heart disease and stroke or to the antecedent risk factors known to cause these diseases, such as high blood pressure, increased serum lipids, and others. Occupational stress, noise, shiftwork, passive smoking, and the physical inactivity inherent in many occupations have been implicated in excessive rates of heart disease, stroke, and hypertension. It is beyond the scope of this chapter to examine in detail the dozens of studies that have addressed these issues, which have been recently reviewed elsewhere (Kristensen 1989; Olsen and Kristensen 1991; Schnall et al. 1994).

Psychosocial stress in the workplace has been shown to be a probable cause of cardiovascular disease. Empirical support for this relationship is best developed when stress is formulated in the "job strain" model introduced by Karasek 15 years ago (Karasek 1979). This model designates jobs involving high demands and low decision-making latitude as "high strain" jobs. A recent review evaluated 36 studies published between 1981 and 1993 addressing this issue, the majority of which showed a positive association between job strain and cardiovascular disease or known cardiovascular disease risk factors (Schnall et al. 1994). The findings

were consistent across populations, study designs, and outcome measures. The authors concluded that available data "strongly suggest" that job strain causes cardiovascular disease.

Olsen and Kristensen use these studies to obtain estimates of the etiologic fraction of cardiovascular disease that is caused by job strain and by other workplace factors in Denmark (Olsen and Kristensen 1991). They restrict their estimates to "premature" cardiovascular disease (i.e., such disease occurring in people under age 70). They estimate that 6% of men and 16% of women have high strain jobs. They use an average relative risk of two for cardiovascular disease associated with job strain to determine that 6% of CVD in men and 14% of CVD among women is due to job strain. The authors note the similarity between their results and those obtained in Sweden, that is, etiologic fractions of 3%-7% for CVD in men and 9%-13% for CVD in women (Olsen and Kristensen 1991).

By a similar method, Olsen and Kristensen obtain etiologic fractions of CVD ascribed to other non-chemical occupational risk factors: 7% of CVD in both sexes due to shiftwork; 2% of CVD in both sexes due to passive smoking; 1% of CVD in both sexes due to noise; and 42% of CVD in both sexes due to sedentary work. Excluding the risk attributable to sedentary work, the aggregate risk of CVD due to these non-chemical occupational risk factors was 16% in men and 22% in women.

For the present analysis, any risk of cardiovascular disease due to physical inactivity of work is excluded for two reasons. First, there is likely to be much disagreement about whether physical inactivity should be considered an occupational risk factor, much less whether it should be viewed in the same manner as other occupational agents. Second, the etiologic fraction assigned to sedentary work is so large, that, if used, it would become the greatest determinant of our estimates of the number of cases of CVD due to occupational causes. Given the lack of consensus about sedentary work, it seems reasonable to exclude it in order to maintain the integrity of the proportion of CVD due to other occupational factors.

The age groups for inclusion in the estimates of occupational disease is of crucial importance for cardiovascular disease. In 1991, 84% of all deaths due to cardiovascular diseases in the United States occurred among people aged 65 and over (National Center for Health Statistics 1993). This skewed age distribution is

less true for cancer. In 1991, 69% of deaths from cancer in the United States occurred among people aged 65 and over (National Center for Health Statistics 1993). For our estimates of the number of cancers caused by occupational factors, we apply a range of proportions to cancers in all age groups, because the well-known phenomenon of latency dictates that occupational exposures experienced during the working years, ages 40 to 60, may not be expressed until well after retirement age. Whether such a latent period applies to the non-chemical occupational risk factors for CVD is not known. We, therefore, restrict our estimates of occupational cardiovascular disease to people aged 64 and below. This is close to the age range used by Olsen and Kristensen (Olsen and Kristensen 1991).

We estimate that 5% to 10% of all ischemic and hypertensive heart disease and cerebrovascular disease among people below age 65 in the United States is due to occupational causes. We employ lower percentages than those cited above in an attempt to be conservative and in recognition of the uncertainty of the underlying data.

II.B.3 Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is the principal occupational cause of respiratory mortality and morbidity other than the pneumoconioses. COPD also constitutes the primary cause of deaths due to chronic respiratory disease in the United States. While cigarette smoking is undoubtedly the major cause of COPD at present, studies have demonstrated a role for occupational exposures in the etiology of COPD. The best quantitative data exist for a limited number of exposures, principally coal, silica, grain dust, cadmium and others (U.S. Department of Health and Human Services 1985). Other studies have related specific occupations to excess COPD mortality (Becklake 1989; Oxman et al. 1993). The literature relating to this topic is extensive and has been reviewed recently elsewhere (Becklake 1989; Oxman et al. 1993).

Recent studies clearly support a role for occupational exposures in COPD mortality (Korn et al. 1987; Lebowitz 1977; Krzyzanowski and Kauffman 1988; Viegli et al. 1991; Xu et al. 1992). These large population-based studies consistently

show that exposure to a wide variety of occupational dusts, and, to a lesser extent, gases and fumes, is associated with a 30% to 50% increase in symptoms and pulmonary function deficits characteristic of COPD. In order to recognize the likelihood that occupational exposures play a limited but definite role in the cause of death from COPD, we assign an estimate of 10% to the proportion of COPD caused by occupational exposures, acknowledging that this estimate should be regarded as provisional until better data exist.

II.B.4 Pneumoconioses

That all deaths and most illness caused by pneumoconioses are due to occupational exposures to pathogenic dusts is obvious and deserves little comment. Exposure to asbestos, coal, silica and other dusts occurs outside of the workplace, especially in the homes of workers and in the neighborhoods of dust-producing facilities. However, the intensity of these non-occupational exposures is unlikely to cause death.

A more important issue is the extent to which pneumoconioses may be under-diagnosed and, therefore, missing from death certificates. The most extensive analysis of the under-diagnosis of mortality from a pneumoconiosis has been performed among insulators in the United States and Canada by Selikoff and colleagues (Selikoff and Seidman 1991). Between 1977 and 1986, there were 123 insulator deaths ascribed to asbestosis on the death certificates in this cohort. After investigators reviewed medical records, chest radiographs, and tissue pathology when available ("best evidence"), they ascribed 259 insulator deaths occurring between 1977 and 1986 to asbestosis (Selikoff and Seidman 1991). Over one-half of pneumoconiosis deaths were, thus, missed in this group well-known to have heavy asbestos exposure. Unfortunately, there are not a sufficient number of other studies of the under-diagnosis of pneumoconioses on death certificates to allow a reliable correction of the mortality statistics available from the National Center for Health Statistics.

II.B.5 Renal and Neurologic Disease

The extent of research documenting the occupational causes of renal and neurologic disease is considerably less extensive than that supporting the relationships between occupational agents and cancer and chronic respiratory disease. Examples of exposure-response relationships for these outcomes abound, even if the accumulated research has not been sufficiently comprehensive or appropriately designed to support precise estimates of the occupational etiologic fraction. Both categories of disease can be caused by exposure to common occupational toxins. Renal toxicity has been associated with occupational exposure to lead and mercury, glycol ethers, and other organic solvents (Landrigan et al. 1984; Daniell 1994). Neurological disorders stemming from the workplace exposures have been caused by pesticides, heavy metals, many organic solvents, and other organic agents (National Research Council 1992; Landrigan et al. 1994; Office of Technology Assessment 1990). Because the exposure-response relationships have not been well characterized for these disease categories, estimates of the etiologic fraction due to occupation can only be crudely estimated. We employ a range of 1% to 3% for the occupational proportion of these diseases in order to ascribe a limited role for the contribution of occupational agents to deaths from diseases of these organ systems. This range may represent an under-estimate, but data do not exist to support a higher attributable percentage with any degree of confidence.

III. Estimates of Morbidity and Mortality from Occupational Disease

III.A Occupational Morbidity

III.A.1 Survey-based Data

III.A.1.1 BLS Annual Survey

Background

The federal Bureau of Labor Statistics has conducted the Annual Survey of Occupational Injuries and Illnesses (BLS Annual Survey) since 1972 under a mandate established by the Occupational Safety and Health Act of 1970. The goal of the survey is to obtain the numbers and the rates of illnesses recorded by the employers as being occupational in origin. The 1992 survey reflects questionnaire data obtained from a stratified random sample of approximately 250,000

establishments in the private sector. The survey completed by the employer is principally a distillation of data that employers are required to maintain by OSHA (OSHA Log 200). The most recent year for which detailed data are available is calendar year 1992 (Bureau of Labor Statistics 1995).

The BLS Annual Survey has several important exclusions. It excludes farms with fewer than 11 employees, the self-employed, and employees of the federal, state, and local governments. In order to include information on miners and railroad workers, the BLS Annual Survey reports data collected by the Mine Safety and Health Administration and the Federal Railroad Administration.

It is noteworthy that BLS requires employers to record all occupational illnesses on the annual survey, regardless of whether the illness led to work restriction or lost work time. This is in contradistinction to occupational injuries, which are only recorded on the survey if there is loss of consciousness, restriction of work or motion, job transfer, or medical treatment other than first aid.

Some well-recognized weaknesses severely limit the ability of the BLS survey to provide a full and accurate count of occupational illnesses in the United States. Data are employer-derived. Any illness that the employee does not report to the employer as being work-related is not likely to be reported by the employer on the annual survey. Among active workers, such a failure to report may be due to fear of consequences by the employee. A second major obstacle to reporting is the failure of the employee's physician to diagnose the illness as being work-related. Occupational disease occurring among retired workers are not subject to the BLS reporting requirement. Indeed, it is unlikely that the employer would be aware of the onset of a work-related illness in a retiree. Since many cases of chronic occupational illnesses with long latency, including cancer and lung disease, are likely to have their onset following retirement, a large proportion of such cases would not be included in the data collected by the BLS.

These limitations are recognized by BLS in its report on its annual survey. In the published report on the 1991 survey, BLS states: "Some conditions, for example, long-term latent illnesses caused by exposure to carcinogens, are difficult to relate to the workplace and are not recognized and reported. These

long-term latent illnesses are believed to be understated in the survey's illness measures " (Bureau of Labor Statistics 1993).

Nonetheless, the BLS annual survey has some important strengths. It has been conducted consistently over the past 20 years, and therefore, time trends can be expected to be reasonably reliable. Furthermore, the illnesses recorded by employers as being work-related would be generally accepted as being work-related. Hence, the numbers provided by the annual survey can be viewed as a lower limit to the number of illnesses that actually occur. Although it is generally accepted that chronic occupational illnesses are under-recorded in the BLS Annual Survey, whether significant under-reporting of the more easily recognized acute occupational illnesses also occurs in the BLS annual survey is less clear.

Results of the BLS Annual Survey, 1982 to 1992

In 1992, there were 457,400 occupational illnesses in the private industry in the United States, according to the BLS Annual Survey (Table 3.2) (Bureau of Labor Statistics 1994). This is an increase of 89,100 cases, or 24%, over the 368,300 illnesses recorded in the 1991 BLS Annual Survey. Expressed as rates, the incidence of new occupational illnesses was 49.0 per 10,000 full-time workers in 1991 and 59.8 per 10,000 such workers in 1992, a 22% increase.

Disorders associated with repeated trauma, such as carpal tunnel syndrome, tendinitis of the wrist and elbow, and hearing loss, dominate the occupational illnesses recorded in the annual survey and have done so since 1987 (Table 3.2) (Bureau of Labor Statistics 1994b). In 1992, they accounted for 62% of all illness cases recorded on the annual survey. Other important categories of disease were skin disorders, pulmonary diseases, and disorders associated with physical trauma (Table 3.2).

The time trend of occupational illnesses recorded in the annual survey since its inception is remarkable. Table 3.3 shows the numbers of occupational illnesses by disease category from 1973 to 1992. Recorded occupational illnesses decrease sharply through the 1970's and reached a nadir in 1982 when 105,600 such illnesses were reported in the private sector. The numbers of occupational illnesses increased thereafter, especially after 1986. The 1992 total, 457,400 cases,

represents an increase of 333%, or 351,000 cases per year, compared to 1982. Indeed, most of this increase has occurred over a shorter time period (i.e., since 1986). Comparing 1986 and 1992, there has been an increase of 234%, or 320,600 occupational illness cases per year (Table 3.4).

Table 3.4 compares the number of new cases of occupational illnesses and percent changes according to the BLS Annual Surveys for selected years, 1982, 1986 and 1992. Table 3.5 shows the comparable data by incidence rates for 1986 and 1992. Because the average annual employment in the private sector rose only 23% between 1982 and 1992 and 9% between 1986 and 1992, the percent changes in the rates are only slightly less than the percent changes in the numbers of new cases.

Disorders associated with repeated trauma clearly account for the largest proportion of the increment in cases of occupational illness. This rise is well-known. Whereas repeated trauma disorders were associated with 45,500 cases of occupational illness in 1986, or 32% of all illnesses recorded by the BLS, they increased to 281,800 by 1992, or 62% of all BLS-recorded occupational illnesses. Of the 320,600 additional cases of all occupational illness that occurred in 1992 compared to 1986, 236,300, or 74%, were disorders associated with repeated trauma (Table 3.4) (Bureau of Labor Statistics 1994b).

This epidemic rise in disorders associated with repeated trauma, however, cannot be allowed to obscure the significant increases that have occurred in other categories of occupational illness. Overall, there was an 80% increase in the recorded incidence in these occupational illnesses in the five years between 1986 and 1992 (Table 3.5). Excluding disorders associated with repeated trauma, there were an additional 84,300 cases of occupational disease recorded in the BLS Survey in 1992 compared to 1986 (Table 3.4). Indeed, the total number of reported occupational illnesses other than those due to repeated trauma in 1992, 175,600 cases, exceeds the total number of recorded occupational illnesses (including those associated with repeated trauma) in 1986, when 136,800 cases of occupational illness were reported by employers. With the exception of dust diseases of the lungs, all other categories of occupational diseases experienced 50% to 180% increases in the numbers of cases and 40% to 160% increases in case rates reported by employers on the BLS survey between 1986 and 1992. Of the specific categories,

the category showing the greatest increase is that of disorders due to physical agents, which increased by 141% in cases between 1986 and 1992. The breadth of the increase is also shown by the 181% increase in the rate of diseases in the category of "all other occupational illnesses" between 1986 and 1992 (Bureau of Labor Statistics 1993, 1994b).

These increases in the numbers and rates of occupational diseases recorded by employers and reported to the BLS in recent years are remarkable. During the same time period, 1986 to 1992, the rate of occupational injuries per 100 full time workers recorded by the BLS increased from 7.7 in 1986 to 8.3 in 1992, a 7.8% increase. The number of recorded fatalities in the workplace has likewise not increased dramatically in the past five years. This suggests that, if the increase in occupational diseases reflects an increase in the prevalence of workplace hazards, these hazards must be quite specific. Yet, the breadth of the categories of diseases showing an increase in rates of illness argues against such specificity.

The change in the recording of occupational illnesses may be due to a change in the underlying occurrence of disease or to a change in the recognition and reporting of these conditions. The latter may reflect increased awareness of occupational diseases among workers, improved diagnosis by physicians, improved reporting by workers to employers, enhanced recording of occupational illnesses by employers, or a combination of all of these factors. In the case of disorders associated with repeated trauma, it is likely that rapid changes in the workplace have altered the nature and prevalence of hazards leading to repeated trauma. Most of the increase in the disorders associated with repeated trauma between 1986 and 1992 would, therefore, represent a frank increase in the underlying incidence of disease. On the other hand, with respect to the other occupational illnesses, while one cannot rule out that workplace conditions in the private sector have changed between 1986 and 1992 such that the likelihood of occupational illness has increased, it is more likely that the recognition of occupational illnesses has significantly changed in this five-year time period. This would imply that workers, employers, and/or health care professionals have significantly improved their ability to recognize, report, and/or record occupational illnesses. While

this explanation is the most plausible one with respect to the occupational illnesses other than those involving repeated trauma, it is nonetheless striking that the recognition of occupational disease would change in such a short time period.

Revised BLS Annual Survey, 1992

In response to recommendations by the National Academy of Sciences (Pollack and Keimig 1987), the BLS re-designed its annual survey in the early 1990s (Bureau of Labor Statistics 1994a). In addition to previous information collected, the new survey includes specific information on workers with occupational illnesses and injuries that are considered serious (i.e., involve 1 or more lost work days). Newly collected information includes occupation, age, gender, race, length of service, nature of illness/injury, part of body affected, event or exposure, and primary and secondary sources of illness and injury. This re-designed survey was first conducted in 1992.

Preliminary data from the re-designed 1992 BLS Annual Survey are now available (Bureau of Labor Statistics 1995). In 1992, one-third (34%), or 2.33 million, of the 6.80 million occupational illnesses and injuries recorded in the 1992 BLS Annual Survey were of a serious nature. Of these 2.3 million serious occupational illnesses and injuries, 2.29 million were classified into either injuries or illnesses.

Occupational illnesses were more likely to be serious than occupational injuries. Occupational illnesses represented 6.7% (457,400) of the total 6.8 million occupational illnesses and injuries in 1992, yet they comprised 8.0% (182,862) of the 2.29 million serious occupational illnesses and injuries in 1992, an excess of 19%. Occupational illnesses also disproportionately accounted for the most serious cases (i.e., involving more than 30 days away from work). Nearly one-third (31%), or 56,883, of the 182,862 occupational illnesses led to greater than 30 lost work days, compared to 19% (392,389) of the 2.1 million occupational injuries.

The re-design of the BLS Annual Survey in 1992 provides an unprecedented opportunity to examine the extent to which employers record specific chronic

diseases as occupational in origin. Categories of disease used in previous BLS Annual survey were too broad and few to identify diseases of interest such as cancer and heart disease. Table 3.6 shows numbers of selected occupational illnesses in the BLS survey in 1992. For coronary heart disease, stroke, cancer and chronic respiratory disease combined, there were 1,485 cases, or 0.8% of all serious occupational illnesses. While the nature of non-serious occupational illnesses recorded in the BLS survey is unknown, they are unlikely to consist of a significant number of cases of coronary heart disease, stroke, cancer and chronic respiratory disease, given the severity of morbidity that usually accompanies these diseases. Thus, even with the well-demonstrated increase in occupational diseases recorded by the BLS, especially from 1986 to 1992, including diseases other than those involving repeated trauma, the four leading causes of death and disease in the United States are still not recorded in large numbers by the occupational disease surveillance system of the Bureau of Labor Statistics.

III.A.1.2 Public Employee Data

The most important exclusion from the BLS Annual Survey for which data exist on occupational illnesses and injuries are workers in the public sector. In 1992, there were a total of 18,644,000 workers employed by public agencies including 2,969,000 Federal employees, 4,408,000 state employees, and 11,267,000 employees of local governments (Green and Becker 1994). There were 90,459,600 private sector workers covered by the BLS annual survey in 1992. Public workers represented approximately 17% of the total work force in the United States in 1992.

Data on occupational illnesses among Federal employees are collected by the Federal Occupational Workers' Compensation Program (OWCP). In 1993, there were 24,500 claims filed for occupational illnesses, and 15,500 of these claims were approved (Office of Workers' Compensation Program, 1994). There were approximately 2.9 million Federal employees in 1993, yielding a rate of 51.7 cases of occupational illnesses per 10,000 full-time workers. Data for 1991 and 1992, the most recent years for which data from the BLS Annual Survey could be obtained, are not available from the OWCP. The OWCP does not categorize approved claims by category of illness. The 24,500 claims filed during 1993 have been so categorized,

but 17,257 (70%) of these claims are categorized as "other occupational diseases," making the disease profile by category uninformative (Office of Workers' Compensation Program 1994).

Data on the rates and numbers of illnesses due to occupation among state and local employees are also available for selected states. States collect these data in relation to occupational safety and health plans that have been adopted for public employees. Such plans usually meet or exceed the regulations promulgated and enforced by federal OSHA. A recent study of state and local employees in New Jersey documented 1,700 occupational illnesses among state and local employees in 1990, yielding an incidence of 50 per 10,000 public sector workers (Roche 1993). Similar rates were obtained for 1988 and 1989. The profile of disease category differed significantly from the profile recorded in the BLS Annual Survey. Two-thirds of the illnesses among New Jersey public employees were skin diseases or respiratory conditions due to toxic agents. Only 3% of illness episodes were due to repeated trauma.

The rates of occupational disease among Federal and non-federal public workers are remarkably congruent with each other and with the rates of such illness among private sector workers as recorded in the BLS Annual Survey. It is reasonable to apply an occupational illness rate of 50 per 10,000 full-time workers to the 18,644,000 Federal, state and local workers employed in 1992. This yields a total of 92,010 illnesses among public workers occurring in 1992. This total should be added to the number of occupational illnesses recorded in the BLS survey to obtain a more complete picture of the number of occupational illness occurring among American workers (Table 3.12). Data for illnesses among state and local employees are not available for 1992. Since the illness rate in the public sector probably increased in 1992, as it did in the private sector, using 92,010 as the number of occupational illnesses in the public sector in 1992 would be a conservative estimate.

III.A.1.3 Heavy Metal Poisoning

Numerous states require that clinical laboratories report the results of selected categories of specimens to the state health department. Among the agents relevant to the occupational setting are lead, arsenic, cadmium, and mercury as well as measures reflecting pesticide exposure. Since 1992, NIOSH has compiled the results of adult blood lead testing in the Adult Blood Lead Epidemiology and Surveillance (ABLES) program (Chowdhury et al. 1994). By the end of 1993, 20 states were reporting elevated blood lead levels to NIOSH and an additional 10 states are developing the capacity to collect and report blood lead data ((Chowdhury et al. 1994). In 1993, there were 11,240 individuals with blood lead levels that equalled or exceeded 25 micrograms per deciliter (ug/dl) of blood in the 20 reporting states (Chowdhury et al. 1994) (Table 7). These 20 states contain 60% of the U.S. population. Since among these states are the most heavily industrial states in the United States (e.g., California, Illinois, New Jersey, New York, Pennsylvania, and Michigan), it may be reasonably estimated that they contain 75% of all individuals in the United States who have elevated blood lead levels. Using this adjustment, it can be estimated that approximately 15,000 individuals had elevated blood lead levels in the entire United States in 1993.

Assuming that 95% of adults with elevated blood lead levels have an occupational source of lead exposure (Chowdhury et al. 1994), then an estimated 14,250 individuals had elevated blood lead values as a result of occupational lead exposure in 1993. This number well exceeds 7,000, the total number of poisonings that were reported by employers to BLS in the annual survey in 1992. (BLS data from the 1992 survey are used, because 1993 data are not yet available). The BLS category of poisonings includes illnesses with systemic effects due to heavy metals, solvents, pesticides, toxic gases, and other chemical agents. It should be noted that we assume that the numbers of adults with excessive occupational lead exposure in 1992 and in 1993 were not appreciably different. If 3,500, or one-half, of the 7,000 cases of poisonings reported by the BLS in 1992, were due to elevated body lead burden secondary to occupational exposure, then 10,750 adults with such workplace lead exposure were not reported to the BLS in the annual survey. This represents three-quarters of the estimated number of adults with excessive blood levels due to occupational exposure. Indeed, even if all of the

7,000 poisonings reported by employers to BLS in 1992 represented individuals with excessive blood lead levels, over one-half (51%) of the such individuals recorded by the NIOSH ABLES program would not have been reported by employers to BLS.

With regard to severity of blood lead elevation, 3,199 (28%) of the individuals with elevated blood lead levels in 1993 had blood leads greater than or equal to 40 ug/dl, which is the level which OSHA requires actions to protect workers from lead exposure in the workplace. 906 (8%) of the cases reported in the ABLES program had blood lead levels $\geq$ 50 ug/dl, which is the level at which OSHA mandates the removal of the individual from lead exposure (Table 7) (Chowdhury et al. 1994).

III.A.1.4 National Health Interview Survey

The National Health Interview Survey (NHIS) is a household survey conducted by the National Center for Health Statistics in order to obtain estimates of the prevalence of health conditions from a representative sample of households reflecting the civilian non-institutionalized population of the United States. In 1988, an Occupational Health Supplement (NHIS-OHS) was included in order to obtain population-based estimates of the prevalence of selected conditions that may be associated with work (Centers for Disease Control and Prevention 1993). Approximately 50,000 households were sampled in 1988, and 27,408 currently employed individuals were interviewed. The results of the NHIS reflect the reporting of health problems by participating individuals. No medical or workplace verification of the reported information is performed. Despite this limitation, the NHIS Occupational Health Supplement is uniquely able to provide valid estimates of the perceptions of potentially work-related illnesses for the United States as a whole (Centers for Disease Control and Prevention 1993).

Among the health conditions addressed by the NHIS-OHS are work-related injuries, dermatologic conditions, cumulative trauma disorders, eye, nose and throat irritation, hearing loss, and low back pain (Centers for Disease Control and Prevention 1993). NHIS-OHS data on injuries and low back pain are addressed in Chapter 2 of this report describing workplace injuries. To date, the only other fully analyzed condition is carpal tunnel syndrome (Tanaka et al. 1995). Carpal

tunnel syndrome, or entrapment of the median nerve in the wrist, is one of the cumulative trauma disorders of the upper extremity.

Tanaka and colleagues from NIOSH recently reported that, based on the 1988 NHIS-OHS data (Tanaka et al. 1995), 1.1 million people in the United States who have worked at least part of the past 12 months reported "prolonged hand discomfort" that they referred to as "carpal tunnel syndrome." "Prolonged hand discomfort" was defined as discomfort for seven consecutive days or 20 or more days in total during the previous 12 months. Of these 1.1 million people, 675,000 people also reported that their health care providers had told them that they had carpal tunnel syndrome. This corresponds to approximately one of every 200 workers who have worked at least part of the previous 12 months. Of the 675,000 people who report that their health care providers had diagnosed carpal tunnel syndrome, Tanaka et al. report that 52.8% also state that their health care providers has said that the carpal tunnel syndrome is work-related (Tanaka et al. 1995). Thus, by this method, Tanaka and colleagues estimate that the national prevalence of work-related carpal tunnel syndrome in 1988 was 356,000 cases (Tanaka et al. 1995). This estimate does not include workers who had not worked in the 12 months prior to the survey and who may have been disabled due to work-related carpal tunnel syndrome.

Comparison between the results of the NHIS-OHS and the BLS Annual Survey are difficult, because the former measures prevalence of disease during a specified interval and the latter includes reports of new episodes of illness. In 1988, 115,000 individuals had disorders associated with repeated trauma, according to the BLS Annual Survey (Bureau of Labor Statistics 1993). The BLS includes in this category noise-induced hearing loss, Raynaud's phenomenon, tenosynovitis, and bursitis in addition to carpal tunnel syndrome. While it is not known what proportion of these 115,000 illnesses were carpal tunnel syndrome, it is unlikely to represent the most common diagnosis. In a recent study of workers' compensation claims in Ohio, Tanaka and NIOSH colleagues reported that less than 50% of cases with disorders associated with repeated trauma involved the wrist. The diagnosis in the majority of these cases was tenosynovitis of the wrist (Tanaka et al. 1988). The NHIS-OHS analysis completed to date suggests, however, that the BLS

annual survey is under-estimating the incidence of work-related carpal tunnel syndrome.

Tanaka and others at NIOSH continue to analyze NHIS-OHS data for conditions other than carpal tunnel syndrome, but the resultant analyses are not yet available.

III.A.1.5 National Hospital Discharge Survey

A unique source of information about medical care utilization for occupationally specific diseases is provided by the National Hospital Discharge Survey maintained by the National Center for Health Statistics. This database provides summary information about inpatient admissions at non-federal hospitals in the United States, including primary and other diagnoses, patient gender and age, hospital charges, payment sources and other variables. A full description of the database and its use are available elsewhere (Graves 1994).

A fundamental problem with the National Hospital Discharge Survey is that the unit of measurement is hospitalizations or discharges, not individuals. To the extent that individual patients have more than one hospitalization per year, the number of discharges will be discrepant from the number of people with a given diagnosis. It is, therefore, not possible to obtain a count of the number of unique individuals who are hospitalized per year for a particular health problem. In addition, since individuals hospitalized in any particular year will have been first diagnosed as having the disorder of interest during any of a number of years, including the year of hospitalization and preceding years, the incidence of disease for any specific year cannot be obtained. While prevalence of occupational disease is of interest, the focus of this chapter so far has been on the number of new cases or episodes of occupational illness per year in the United States.

The hospital discharge survey has another obvious liability. Only individuals with disease sufficiently severe to require hospitalization will be included in the database. For many chronic diseases, the majority of patients will not become so ill as to require hospitalization, especially given the increasing breadth and

depth of outpatient treatments available. These patients may nonetheless suffer significant morbidity, incur costly medical care and lose substantial numbers of days from work. Thus, even if the data of the discharge survey were suitably organized and evaluated to yield disease incidence and prevalence, it would only reflect part of the spectrum of morbidity associated with any specific disease.

Table 3.8 gives numbers of hospitalizations incurred as a result of diseases that are specific to occupational exposures (National Hospital Discharge Survey 1991). For the primary diagnosis associated with the hospital stay, there were 2,360 hospitalizations for pneumoconioses, principally coal workers pneumoconiosis (1,646 hospitalizations) and asbestosis (479 hospitalizations), and 857 hospitalizations for malignant neoplasm of the pleura, most of which are malignant mesothelioma of the pleura.

Table 3.8 also provides the numbers of hospitalizations for which pneumoconioses and malignancy of the pleura were not the primary diagnoses, but were among the multiple diagnoses listed for hospitalizations in the National Hospital Discharge Survey (National Hospital Discharge Survey 1991). These are primary and secondary diagnoses. The National Hospital Discharge Survey allows up to seven diagnoses per hospital discharge, including the primary diagnosis. The numbers of discharges with occupationally-specific diseases among the secondary diagnoses is considerably higher than those with such diseases constituting the primary diagnoses. This is less true for malignancy of the pleura than for the pneumoconioses, since malignant mesothelioma is highly lethal and can be expected to be the dominating diagnosis on most hospitalizations of patients with this cancer. While the secondary diagnoses can be considered as illnesses that are active medical concerns at the time of hospitalization, the degree to which they are contributing factors to the hospitalization is uncertain.

III.A.2. Attributable risk-based estimates of morbidity

III.A.2.1 Cancer

Among the major causes of morbidity and mortality in the United States, cancer represents the group of chronic diseases for which occupational etiology is best documented. Nevertheless, cancers are scarcely recorded in the BLS Annual

Survey or in workers' compensation data. Prior to 1992, it was not possible to identify the numbers of cancers recorded in the BLS Annual Survey, because only broad diagnostic categories of disease were utilized. Revision of the BLS Annual Survey beginning in 1992 allows identification of numbers of specific diseases that were considered serious (i.e., involve 1 or more days of lost work time). According to the 1992 Annual Survey, among these serious cases, employers reported 103 employees with occupational neoplasms, most of which were malignant (Bureau of Labor Statistics 1995). Since it is likely that virtually all cancers that are identified as occupational by employers would involve lost work time, it is unlikely that many additional cancers would be recorded among the non-serious cases identified in the BLS survey.

Workers' compensation is another potential source of data for enumerating occupational cancers. Like the BLS Annual Survey, many states do not use a specific category for occupational cancers (e.g., California and Washington). By contrast, New York and New Jersey do report the number of cancers identified by the workers' compensation systems as being work-related. In New York State, eight people had occupational cancer claims accepted for workers' compensation in 1988 (New York Workers' Compensation Board 1993). In New Jersey, an annual average of 131 individuals were recognized as having occupational cancer by the workers' compensation system between 1988 and 1991, whereas the average annual total number of occupational disease awards was 6,340 (New Jersey Workers' Compensation Board 1990). There were 36,896 individuals newly diagnosed as having cancer (excluding basal cell cancer of the skin) and 17,285 deaths from cancer in New Jersey in 1988 (New Jersey Department of Health 1992). While acknowledging that the cases of cancer awarded workers' compensation in 1988 reflects incident cancer cases from previous years, it is nonetheless clear that a small proportion (i.e., less than 1%, of cancers are recognized as being occupational by selected workers' compensation systems).

In order to obtain a more accurate count of the number of cases of occupational illness per year in the United States, we use the proportional attributable risk model to estimate the number of cancers in the United States that are likely to be occupational in origin (Section I.B). The American Cancer

Society (ACS) publishes estimates of the numbers of cases of cancer that occur annually in the United States based on the data collected under the Surveillance, Epidemiology, and End Results (SEER) program of the National Cancer Institute. According to these ACS estimates, there were 1,113,100 malignancies (excluding basal cell cancer of the skin) newly diagnosed among adults 25 years and over in the U.S. in 1992 (American Cancer Society 1995). Assuming that 6% to 10% of these cancer are occupational in origin, then 66,790 to 111,310 new cases of cancer were caused by workplace factors in 1992 (Table 9).

III.A.2.2 Cardiovascular and Cerebrovascular Disease

As described in Section I.B, we use an estimate of 5% to 10% of cases of cardiovascular and cerebrovascular disease among people aged 25 to 64, inclusive, as caused by occupational factors. The rationale for attribution of this range of proportions to occupational etiology is presented in Section I.B. For accounting of occupational morbidity due to heart disease, the focus is restricted to coronary heart disease, since it is the major cause of heart disease, and current studies support a causal role of occupational factors in the etiology of coronary heart disease.

National incidence data for coronary heart disease are less than optimal, since they are extrapolated from the Framingham heart disease sample of approximately 5,000 people. Nonetheless, these data have been used to determine that there are approximately 1.25 million new or recurrent myocardial infarctions each year in the United States, including 530,000 myocardial infarctions among individuals between the ages of 25 and 64, inclusive (Kannel and Thom 1994; American Heart Association 1994; National Heart, Lung, and Blood Institute 1995). Approximately 78,000 of these one-half million heart attacks are fatal. The Framingham database has also allowed an estimation of approximately 200,000 new cases of uncomplicated angina pectoris each year in the United States among people less than 65 years old (American Heart Association 1994; National Heart, Lung, and Blood Institute 1995).

Applying the proportional range cited above, there are 36,500 to 73,000 new or recurrent cases of coronary heart disease (including new or recurrent

myocardial infarctions and new cases of uncomplicated angina) each year in the United States due to occupational risk factors (Table 9).

Data from the Framingham study also allow estimation that an estimated 101,000 to 144,000 strokes and transient ischemic attacks annually in the United States occur among people less than 65 years of age (Kannel and Thom 1994; American Heart Association 1994). Since most coronary heart disease and cerebrovascular disease result from the same underlying disease process, atherosclerosis, we use the same range of percentages (5% to 10%) as caused by occupational factors. Hence, it is estimated that 5,050 to 14,400 strokes and transient ischemic attacks among people less than 65 years of age are associated with occupational exposures (job stress; shiftwork; noise; and occupational exposures) each year in the United States (Table 3.9).

By contrast, the revised BLS Annual Survey recorded 591 work-related cases of ischemic heart disease and 76 people with cerebrovascular disease in 1992. Even given the provisional nature of the estimates obtained using the proportional attributable risk approach, there is an obvious and large discrepancy between the BLS data and the estimates derived above.

III.A.2.3 Chronic Obstructive Lung Disease

Despite the fact that chronic obstructive lung disease (COPD) is the fourth leading overall cause of mortality in the United States and increased during the 1980s (American Lung Association 1995), national data on the incidence of COPD are virtually non-existent. Given the chronic nature of COPD, the impact of this set of diseases has traditionally been measured by its mortality rate and prevalence. The American Lung Association estimates that 15.4 million Americans suffered from COPD in 1992 (American Lung Association 1995). One estimate of the number of new cases of COPD in the United States was 1.5 million in 1984 (Farer and Schieffelbein 1987). Recognizing the dearth of well-founded data in this area, we use this estimate of 1.5 million new cases. Given the rise in COPD mortality from 27.7 per 100,000 in the United States in 1984 to 34.1 per 100,000 in 1992, the estimate of 1.5 million, if accurate, would be an underestimate of the annual

number of new cases of COPD in the 1990s. Applying the estimated percentage of COPD attributable to occupational exposures, 10% (Section I.B), yields an estimate of 150,000 new cases of COPD each year occurring as a result of exposure to airborne contaminants in the workplace (Table 3.9).

In the 1992 BLS survey, 717 cases of work-related COPD were recorded among the "serious" illness cases (i.e., cases where 1 or more days of work was missed).

III.B. Occupational Mortality

III.B.1 Specific Occupational Diseases

As discussed previously, though the spectrum of diseases associated with occupations is broad, the diseases uniquely caused by occupational exposures are very limited. Included in this group are the pneumoconioses and one type of cancer, malignant mesothelioma of the pleura and peritoneum. Table 3.10 shows the numbers of deaths attributed to these diagnoses as the underlying cause of death and as one of multiple causes of death listed on the death certificate (National Center for Health Statistics 1992). In 1992, there were 1,236 deaths due to the dust diseases of the lung as the underlying cause, including 631 deaths due to coal workers pneumoconiosis and 285 deaths due to asbestosis. For malignancies of the pleura, most of which are malignant mesothelioma, there was a total of 476 deaths (National Center for Health Statistics 1992). Because there is no ICD code specific for malignant mesothelioma of the peritoneum, it is not possible to identify the number of peritoneal mesotheliomas that occurred in 1992.

Table 3.10 also shows the numbers of deaths due to pneumoconioses and malignancies of the pleura when they appear as one of multiple causes of death on the death certificate for the most recent year available, 1990. As expected, the numbers of such deaths are higher than the numbers of death where underlying cause is specified. Citation of a disease among multiple causes can be reasonably interpreted as signifying that it was a contributing factor in death. In 1990, there were 3,659 deaths in which one of the pneumoconioses was a contributing factor and 553 deaths in which malignancy of the pleura was a factor contributing to death (NIOSH, 1994; National Center for Health Statistics 1992).

III.B.2 Attributable Risk-based Estimates of Mortality

Table 3.11 provides the results of applying the proportional attributable risk model as described in Section I.B to the major causes of death in the United States in 1992. With the exception of pneumoconioses, all causes of death are associated with an occupational etiology in no more than an estimated 10% of cases. Nonetheless, this analysis yields an estimate of 46,899 to 73,681 deaths as a result of occupational risk factors in the United States in 1992. Cancer dominates these estimates due to its high overall incidence and to the restriction of occupationally-associated cardiovascular and cerebrovascular deaths to persons under 65 years of age. For each of the three major causes of death, however, the number of deaths, ranging between 5,000 and 52,000, is significant.

To provide a population perspective on this overall estimate of occupational mortality, comparisons to other diseases may be instructive. In 1992, there were 25,488 deaths from homicides, 30,484 deaths from suicides, and 33,566 deaths from AIDS in the United States. The number of deaths that occurred in 1992 as a result of tobacco consumption is far higher. The latter is well-recognized, even if resources to end the epidemic of cigarette-associated diseases have not yet been mobilized. By contrast, the likely toll from occupational mortality, though highly preventable, has not yet been recognized.

IV. Conclusion

Identifying the true burden of occupational disease in the United States has been an elusive goal for at least 25 years. This goal remains unattained, but recent progress in occupational health surveillance and research allows enhanced estimates of this burden. Specifically, improvements in national data systems for occupational diseases and an accumulating body of epidemiologic and toxicological research provide increasing confidence that the overall magnitude of the problem of occupational disease can be approximated. Proper interpretation of national surveys and prudent application of a proportional attributable risk model to major causes of death and disease in the United States provide the foundation that allow the following conclusions:

1. According to the best information available, 817,000 to 907,000 new cases of occupational illness occurred in the United States in 1992. This estimate represents a compilation of cases from the BLS Annual Survey (457,400), national surveillance of heavy metal poisoning (14,250), public employees data (92,010) and proportions of major chronic diseases associated with occupational factors (258,300 - 348,700), accounting for the limited overlap among the sources of data. Much of this disease burden is serious in nature and involves significant lost time from work.
2. Approximately 47,000 to 74,000 deaths resulted from occupational diseases in the United States in 1992. This estimate includes two types of disease categories: a) deaths that are uniquely caused by occupational agents, such as the pneumoconioses and malignant mesothelioma and b) a much larger number of deaths that fall into six major categories of death in the United States: cancer, coronary heart disease, cerebrovascular disease, chronic obstructive pulmonary disease, nervous system disorders, and renal diseases.

These estimates should be considered conservative for a variety of reasons. First, they under-estimate important causes of occupational morbidity, including hearing loss, reproductive toxicity and others. They were under-estimated, because they do not cause death or data on their incidence are not available. Second, limited proportions were used in the attributable risk model employed in our approach. Third, occupational cardiovascular morbidity and mortality was limited to events among people less than 65 years old, because the extension of the

occupational impact on cardiovascular disease after retirement is uncertain. Much work remains to be done.

Table 3.1

Estimated Percentages of Selected Diseases
Caused by Occupational Factors

<u>Condition</u> (ICD-9 Codes)	<u>Percentage</u> <u>Attributed to</u> <u>Occupation</u>
Cancer (140-209)	6%-10%
Coronary heart disease ¹ (410-414, 440)	5%-10%
Cerebrovascular disease ¹ (430-438)	5%-10%
Chronic obstructive pulmonary disease (490-496)	10%
Renal disorders (580-589)	1%-3%
Nervous System disorders (323.7, 331, 332, 349.82, 356, 357.7, 359.4)	1%-3%

¹ Only includes new and recurrent cases of coronary heart disease and cerebrovascular disease among people between ages 25 and 64, inclusive. See text for explanation.

Table 3.2

Numbers of Occupational Illnesses in the United States, 1992
Bureau of Labor Statistics Annual Survey

<u>Category of Illness</u>	<u>Number of Cases (%)</u>	
Skin diseases	62,900	(13.8)
Dust diseases of the lungs	2,800	(0.6)
Respiratory conditions due to toxic agents	23,500	(5.1)
Poisonings	7,000	(1.5)
Disorders due to physical agents	22,200	(4.9)
Disorders associated with repeated trauma	281,800	(61.6)
All other occupational illnesses	<u>57,300</u>	(12.5)
Total	457,400	(100)

Source: Bureau of Labor Statistics, Department of Labor, December, 1994.

Table 3.3

Occupational Injuries and Illnesses in the United States, 1973-1992
Bureau of Labor Statistics Annual Survey

Year	Dust diseases of the lungs	Respiratory conditions due to toxic agents	Poisoning	Skin diseases or disorders	Disorders due to physical agents	Associated with repeated trauma	Other occupational illness	TOTAL
1973	1,500	11,500	6,800	89,200	27,500	23,600	40,400	200,500
1974	1,700	12,700	7,400	89,400	27,100	24,600	37,400	200,400
1975	1,000	11,900	6,200	74,400	21,200	23,700	24,900	163,300
1976	1,200	13,100	6,100	71,600	24,200	23,000	28,800	167,900
1977	2,000	13,100	5,700	73,000	23,600	23,400	21,100	161,900
1978	1,600	13,600	5,600	66,900	16,700	20,200	19,600	143,500
1979	1,700	13,100	5,800	67,900	16,100	21,900	23,200	148,900
1980	2,300	11,400	4,700	66,100	13,200	23,100	19,200	130,200
1981	2,100	10,800	5,600	51,200	11,900	22,900	21,500	126,100
1982	2,000	8,800	3,400	41,900	8,300	22,600	18,600	105,600
1983	1,700	7,900	3,000	39,500	8,800	26,700	18,400	106,100
1984	1,800	10,600	4,500	42,500	9,000	34,700	21,400	124,800
1985	1,700	11,600	4,200	41,800	9,000	37,000	20,100	125,400
1986	3,200	12,300	4,300	41,900	9,200	46,000	20,400	136,800
1987	3,400	14,300	4,800	54,200	13,800	72,900	26,800	190,200
1988	2,900	16,100	5,500	57,900	17,300	115,400	25,600	240,700
1989	2,600	18,900	5,800	62,100	17,700	146,900	29,700	283,700
1990	3,000	20,500	6,100	60,900	18,200	185,400	37,300	331,600
1991	2,500	18,300	6,700	58,200	18,200	223,600	40,800	368,300
1992	2,800	23,500	7,000	62,900	22,200	281,800	57,300	457,400

Source: Occupational Injuries and Illnesses in the United States by Industry, 1991. Bureau of Labor Statistics, United States Department of Labor, May 1993. Unpublished data, Bureau of Labor Statistics, United States Department of Labor, December, 1994.

Table 3.4

Number of New Cases of Occupational Illnesses by Category of Illness
BLS Annual Survey, 1982, 1986 and 1992

<u>Category of Illness</u>	<u>1982</u>	<u>1986</u>	<u>1992</u>	<u>% Change</u> <u>1982-1992</u>	<u>% Change</u> <u>1986-1992</u>
Skin diseases	41,900	41,900	62,900	+50.1%	+50.1%
Dust diseases of the lungs	2,000	3,200	2,800	+40.0%	-12.5%
Respiratory conditions due to toxic agents	8,800	12,300	23,500	+167.0%	+91.1%
Poisoning	3,400	4,300	7,000	+105.9%	+62.8%
Disorder due to physical agents	8,300	9,200	22,200	+167.5%	+141.3%
Disorders associated with repeated trauma	22,600	45,500	281,800	+1,146.9%	+519.3%
All other occupational illnesses	18,600	20,400	57,300	+208.1%	+180.9%
Total	105,600	136,800	457,400	+333.1%	+234.4%
(Total excluding repeated trauma)	83,000	91,300	175,600	+111.6%	+92.3%
Average annual employment, private sector	73,729,000	83,291,200	90,459,600	+22.8%	+8.7%

Source: *Occupational Injuries and Illnesses in the United States by Industry*, 1991. U.S. Department of Labor. Bureau of Labor Statistics, May 1993.

Bureau of Labor Statistics, United States Department of Labor,
December, 1994.

Table 3.5

Incidence of Occupational Illness
BLS Annual Survey, 1986 versus 1992
(Rate per 10,000 full-time workers)

<u>Category of Illness</u>	<u>1986</u>	<u>1992</u>	<u>% Change</u>
Skin diseases	5.9	8.2	+39.0%
Dust diseases of the lung	0.5	0.3	-40.0%
Respiratory conditions due to toxic agents	1.7	3.1	+82.4%
Poisonings	0.6	0.9	+50.0%
Disorders due to physical agents	1.3	2.9	+123.1%
Disorders associated with repeated trauma	6.4	36.8	+475.0%
All other occupational illnesses	2.9	7.5	+158.6%
Total	19.2	59.8	+211.5%
(Total excluding repeated trauma)	12.8	23.0	+79.7%

Source: 1) Occupational Injuries and Illnesses in the United States by Industry, 1991. U.S. Department of Labor. Bureau of Labor Statistics, May 1993.
2) Bureau of Labor Statistics, United States Department of Labor, December, 1994.

Table 3.6

Number of Occupational Illnesses Involving Days Away from Work
BLS Annual Survey, 1992

Systemic diseases and disorders	148,834
Nervous system and sense organs diseases	49,474
Carpal tunnel syndrome	33,042
Circulatory system diseases	1,462
Ischemic heart disease	591
Stroke	75
Respiratory system diseases	3,892
COPD	716
Asthma	272
Pneumoconioses	188
Digestive system disease and disorders	32,987
Musculoskeletal system and connective tissue disease and disorders	46,148
Rheumatism (incl. tendinitis, synovitis, ganglia and others)	40,324
Skin diseases	13,845
Infectious diseases	3,237
Neoplasms	103
Symptoms, signs and ill-defined conditions	21,274
Other conditions	6,992
Mental disorders or syndromes	6,765
Multiple disorders and conditions	2,385

Source: Bureau of Labor Statistics, U.S. Department of Labor, 1995

Table 3.7

Numbers of Adults with Elevated Blood Lead Levels,
20 States, 1993*

<u>High Blood Lead Level</u> <u>(μg/dl)</u>	<u>Numbers of Persons</u> <u>(%)</u>	
25-39	8,041	71.5%
40-49	2,293	20.4%
50-59	627	5.6%
≥ 60	279	2.5%
Total	11,240	100%

*Source: National Adult Blood Lead Epidemiology and Surveillance, NIOSH
Adapted from MMWR Vol. 43:26, July 8, 1994

Table 3.8

Numbers of Hospital Discharges for Primary and Secondary Diagnoses for
Pneumoconioses and Malignancies of the Pleura, United States, 1991

<u>Diagnosis (ICD-9 code)</u>	<u>Number of Discharges with Pneumoconiosis or Malignancies of the Pleura as Primary Diagnosis</u>	<u>Number of Discharges with Pneumoconiosis or Malignancies of the Pleura as Secondary Diagnosis</u>
<u>Pneumoconioses</u>		
Asbestosis (501)	479	6,456
Silicosis (502)	---	3,704
Coal Workers		
Pneumoconioses (500)	1,646	10,825
Pneumoconioses due to	---	46
other inorganic dust (503)		
Pneumopathy due to		475
inhalation of other dust		
(504) (byssinosis)	235	
Pneumoconioses, unspecified		
(505)	---	801
Total	<u>2,360</u>	<u>22,307</u>
 <u>Malignancies of the Pleura</u>		
(163.0, 163.1, 163.9)	857	1,843

Source: National Hospital Discharge Survey 1991

Table 3.9

Estimated Incidence of Occupational Illness for
Major Causes of Death, United States

<u>Condition¹</u>	<u>Estimated annual</u> <u>number of new cases</u> <u>in United States</u>	<u>Percentage</u> <u>attributed to</u> <u>occupation</u>	<u>Estimated</u> <u>number of cases</u> <u>due to occupation</u>
Cancer	1,113,100	6%-10%	66,790-111,130
Coronary heart disease ²	730,000	5%-10%	36,500-73,000
Cerebrovascular disease ²	101,000- 144,000	5%-10%	5,050-14,400
Chronic obstructive pulmonary disease	1,500,000	10%	150,000
Total			258,340-348,710

¹ See Appendix to Table 3.11 for listing of ICD codes included in these conditions.

² Only includes new and recurrent cases of coronary heart disease and cerebrovascular disease among people between ages 25 and 64, inclusive.

Sources: See text

Table 3.10

Deaths due to Pneumoconioses and Malignancy of the Pleura
Underlying Cause and Multiple Causes
United States, 1990 and 1992

<u>Cause of Death (ICD-9 Code)</u>	<u>Number of deaths</u>		
	<u>1992</u>	<u>1991</u>	<u>1990</u>
<u>Underlying Cause</u>		<u>Underlying Cause</u>	<u>Multiple Causes</u>
Coal workers' pneumoconiosis (500)	631	693	1990
Asbestosis (501)	285	269	948
Silicosis (502)	117	153	308
Other pneumoconioses (503-505)	<u>103</u>	<u>122</u>	<u>413</u>
Total	1,136	1,237	3,656
Malignancy of the pleura (163.0, 163.1, 163.9)	477	452	553

Source: National Center for Health Statistics

Table 3.11

Estimated Occupational Disease Mortality due to Selected Causes
United States, 1992

<u>Selected causes of death¹</u>	<u>Number of deaths U.S., ages 25 and over²</u>	<u>Estimated percentage due to occupation</u>	<u>Number of deaths due to occupation U.S., 1992</u>
<u>Cancer</u>	517,090	6%-10%	31,025-51,709
<u>Cardiovascular and cerebrovascular disease¹</u>	101,846 ³	5-10%	5,092-10,185
<u>Chronic respiratory disease</u>	91,541	10%	9,154
<u>Pneumoconioses</u>	1,136	100%	1,136
<u>Nervous system disorders</u>	26,936	1%-3%	269 - 808
<u>Renal disorders</u>	22,957	1%-3%	223 - 689
<u>Total</u>	713,506		46,899-73,681

¹ See Appendix to Table 11 for listing of ICD codes used for selected causes of death

² Source: National Center for Health Statistics

³ Only includes deaths between ages 25 and 64 years, inclusive

Appendix to Table 3.11

Codes of ICD, 9th revision used in Table 9

Cancer: 140-209 (malignant neoplasms)

Cardiovascular and cerebrovascular disease:

401-404 (hypertension, hypertensive heart and renal disease)

410-414 (ischemic heart disease)

430-438 (cerebrovascular disease)

440 (atherosclerosis)

Chronic respiratory disease:

490-496 (chronic obstructive pulmonary disease and allied conditions)

500-505 (pneumoconioses);

Nervous system disorders:

323.7 (toxic encephalitis)

331 (other cerebral degenerations)

332 (Parkinson's disease)

349.82 (toxic encephalopathy)

356 (hereditary and idiopathic peripheral neuropathy)

357.7 (polyneuropathy due to other toxic agents)

359.4 (toxic myopathy)

Renal disorders: 580--589 (nephrotis, nephrotic syndrome, and nephrosis)

Table 3.12

**Numbers of Occupational Illnesses Based on Current Surveys
and Proportional Attributable Risk Estimates
United States, 1992**

<u>Survey-based Data Source</u>	<u>Number of Occupational Illnesses</u>
BLS Annual Survey	457,400
Adult blood lead surveillance program	14,250
Public employees	92,010
Sub-total	563,660
<u>Proportional Attributable Risk-based Data</u>	
Cancer	
Coronary heart disease	
Cerebral disease	
Chronic obstructive lung disease	
Sub-total (from Table 3.9)	258,340-348,710
Total	817,015-907,385*

* Total excludes estimated overlap among data sources. This includes 1,485 cases of cancer, heart disease, stroke and COPD that were recorded in the 1992 BLS Annual Survey and an estimated 3,500 cases of elevated blood lead level that are included in the 1992 BLS Annual Survey.

Chapter 4
Two Methods for Measuring Costs

Outline for Chapter 4: Two Methods for Measuring Costs

I. Introduction

II. Direct and Indirect Cost Method

III. Willingness-to-Pay Method

A. Introduction

B. Explanation of WTP

C. Review of Studies in Labor Markets and Automobile Market

IV. Conclusion

Chapter 4: Two Methods for Measuring Costs

I. Introduction

Economists have developed two methods for estimating the costs of injuries and illnesses: the Direct and Indirect Cost method and the Willingness-to-Pay (WTP) method. The Direct/Indirect method is widely used in the medical literature. It is practical, intuitive, and easy to implement (i.e., estimates are available and reliable). The WTP method, sometimes referred to as the Human Capital method, is more widely used in the economics literature. But, WTP is based on orthodox economic theory that assumes that individuals know best how to plan for their future. But, if this were true, it would be difficult to justify—based upon orthodox theory—a Social Security system that forces individuals to save for retirement, since that theory would assume people on their own would save enough for their retirement. Based on orthodox theory, it is also difficult to justify seatbelt or motorcycle helmet laws. Orthodox theory would not accept the notion that young adults, for example, tend to have an inappropriately low aversion to risk. Finally, WTP also assumes that individuals have considerable knowledge of all the health and safety aspects of their behavior and exposures. Many, but not all (Robinson 1986), economists believe that it is theoretically more compelling than the Direct/Indirect method. Virtually all economists, however, will acknowledge that the WTP method is difficult to implement, especially for any category other than injury death (i.e., only a handful of non-fatal injury estimates are available and their reliability is questionable). Even fewer WTP studies are available for illnesses. The legal literature has relied on both (Staller, Sullivan, and Friedman 1994; Viscusi 1992).

The chapter follows a simple outline. Section II explains the Direct/Indirect method. Section III explains the Willingness-to-Pay method. Section III also contains a review of the most popular WTP studies. Section IV contains the conclusion.

II. Direct and Indirect Cost Method

The Direct/Indirect method was popularized by Dorothy P. Rice (1965). It has been applied to a wide variety of injuries and illnesses and continues to be heavily relied on in the medical and public health literature (American Heart Association 1992; Goodman, Holder, and Nishiura 1991; Hensler et al. 1991; Miller and Blincoe 1994; National Safety Council 1993; Neumark et al. 1991; Rice, Hodgson and Kopstein 1985).

Direct costs represent actual dollars spent or anticipated to be spent on providing medical care to an injured or ill person as well as property damage, police and fire services, administrative costs for delivering indemnity benefits and direct costs to innocent third parties. Medical costs include doctors' and nurses' services, hospital charges, drugs costs, rehabilitation services, ambulance fees, payments for medical equipment and supplies. Administration of indemnity benefits include the costs associated with providing Workers' Compensation indemnity and social security disability payments to injured or sick workers and their families. Property damage includes costs of damage to vehicles, machines, buildings, and so on directly associated with the injuries and illnesses. Direct costs are frequently referred to as "accounting" or "out-of-pocket" costs associated with providing medical care.

Indirect costs are not "accounting" or "out-of-pocket" costs. They represent foregone opportunities represent foregone opportunities for the injured or ill person, his/her family or unpaid caregivers, employer, co-workers and society at large. Included in this category are the injured or sick workers' lost earnings, fringe benefits, home production, as well as costs of lost productivity, time delays of commuters, family caregivers' time, and indirect costs to innocent bystanders.

The largest category of indirect costs is the injured or ill workers' lost earnings. Earnings are a measure of output. If the person is no longer earning, then he or she is no longer adding to national output. This loss is, therefore, not only suffered by the injured worker, but also by the economy as a whole. These lost earnings are, in turn, split into morbidity and mortality costs. Morbidity costs refer to earnings of the worker with a non-fatal injury or illness and mortality costs to the earnings of a deceased worker. Morbidity costs reflect the

value of days lost from work. Mortality costs represent the future output that would have been forthcoming if the person had not died young. Indirect costs also include administrative and insurance costs associated indemnity and benefit payments from each of the following: Workers' Compensation, Social Security disability, private disability and mortgage benefits payments and life insurance, and welfare. Finally, indirect costs also include lost home production, co-worker costs of lost productivity due to psychological trauma particularly after a death (Haines 1993), time delays, family home health care, and indirect costs to innocent third parties.

III. Willingness-to-Pay

III.A. Introduction

The Willingness-to-Pay (WTP) approach is an alternative method for determining the cost of injuries and illnesses. The WTP method is designed to be comprehensive. It does not split costs into direct and indirect components. It attempts to apply prices that are generated in market transactions unfettered by Medicaid, Workers' Compensation, and other government subsidies. On theoretical grounds, the WTP method is preferred over the more traditional direct and indirect cost method by the majority of academic economists. On practical grounds, when decisions need be made, such as in a lawsuit involving a wrongful death, there is considerable controversy surrounding which method is preferred (Dickens 1990).

There are several advantages associated with the WTP approach over the traditional Direct and Indirect cost approach. First, under the Direct/Indirect approach, retirees, children, and homemakers are greatly undervalued. Their foregone earnings may be minimal. Second, pain and suffering do not enter the Direct/Indirect method. Third, the Direct/Indirect method does not account for the sentiments of the community. Do people, in general, greatly dislike injuries or only mildly dislike them? Some people may actually enjoy taking risks.

Finally, WTP estimates represent marginal costs (i.e., how much more would it cost to save, say, one additional life). These marginal costs are more appropriate than average or total costs when attempting to evaluate the benefits and costs of, for example, a new OSHA standard on cotton dust. They are not

appropriate if the goal is to obtain an impression of the overall size of a problem. But this is precisely our goal—to estimate the overall costs of occupational injuries and illnesses. Hence, again, the Direct/Indirect methods appear to be better suited for our purposes.

The discussion in this WTP section is split into two parts. First, we will explain the WTP approach. Second, we review WTP estimates from the labor market and the market for new cars. A conclusion closes the chapter.

III.B. Explanation of WTP

The idea behind the WTP method is simple. Only individuals themselves know the true cost to themselves of any particular injury or illness. Individuals, presumably, are in a better position to evaluate the medical costs, lost earnings, family hardship, pain and suffering, and so on than any researchers analyzing statistical data. Some people might want to hold onto life no matter what pain must be endured or the costs of drugs or drain on the estate. Others might prefer suicide if the pain is too great and there are no prospects for recovery. Some of us with young children might purchase child proof swimming pool covers. Others among us might not. Some will buy smoke detectors, others will not. Some will order air bags for the car and others will not. In each case, individuals make choices involving risk. In some cases, such as for swimming pool covers, smoke detectors and air bags, the choices will influence market prices. A risk-for-dollar price trade-off will be observed in the market. Consumers can lower their risks with pool covers, smoke detectors and air bags if they are willing to pay for these safety items. This is the derivation of the term Willingness-to-Pay. But, there are many influences on market prices for swimming pool covers, smoke detectors and air bags, such as the costs of producing the covers, detectors, and air bags, the income of consumers and so on. Nevertheless, with careful econometric analysis, economists have attempted to measure that portion of some market prices that reflect the risk-for-dollar trade-off. The risk premium portion of these prices presumably provides an aggregate estimate of how a community would value an increase or decrease in risk.

Imagine we have a town of 100,000 residents. Over the next year, suppose 10 will die, but no one knows which 10. The WTP method would, for example, attempt to answer this question: how much would these 100,000 people collectively be willing to pay to reduce the number of deaths to nine, again, not knowing who the nine are? Phrased a different way, the WTP approach would attempt to answer this question: how much would an individual be willing to pay to decrease his or her chances of death in the coming year by $1/100,000$?

The most popular WTP technique uses data from the labor market. For example, suppose that in an Oregon and Washington labor market 200,000 high school graduates were competing for 100,000 jobs for lumberjacks and 100,000 jobs for plumbers. Imagine that all of the risks of injuries and illnesses for lumberjacks were identical to those of plumbers, except that for death. Suppose that the annual death rate for lumberjacks is $11/100,000$ and is $10/100,000$ for plumbers. Further assume that all of the prospective employees prefer safety to risk, and that all employees and employers are fully aware of the risks. In a competitive labor market, the employers of plumbers would not have to pay as high a wage as employers of lumberjacks. Suppose that the wage of the lumberjacks is \$.05 per hour more than the wage for plumbers. "The market," then, would be putting a price on the risk of death. For \$.05 more per hour, the marginal plumber presumably would be willing to take a job as a lumberjack. The implicit value of life would be $\$.05 \text{ hour} \times 2,000 \text{ hrs/year} \times 1 \text{ more death} \times 100,000 \text{ lumberjacks}$ or \$10,000,000. The community then would be implicitly valuing a life at \$10 million.

Assuming workers are well-informed, mobile, and rational, the theory that predicts a market trade-off exists between risks of dying on-the-job and wages cannot be faulted. The theory does not indicate how big the compensating wage or value per statistical life will be, however.

The trade-off will generate a line or curve with a positive slope in a wage and risk diagram. Jobs with high (low) risks should command high (low) wages. In the jargon of economics, the trade-off will generate a collection of equilibrium points that will form the compensating wages curve. The slope of the curve will indicate how much higher wages will have to increase before a marginal worker will

take a job with a little higher risk. Econometric techniques that attempt to estimate the compensating wages curve have been applied to labor market data.

III.C. Review of Studies in Labor Markets and Automobile Markets

The most widely-cited WTP studies were derived from labor market and automobile market studies. In the first part of this section, we first review the labor market studies. In the second part, we consider an influential automobile market study.

The labor market studies reviewed here used occupational fatalities as measures of hazards to find evidence for compensating wages. The studies fall into seven categories: BLS Annual Survey industry, NIOSH industry/state (NTOF), high-risk occupations, police only, industry and occupation data from New York State, occupations from England, and industries from Texas.

A number of studies used unpublished Annual Survey data from the Bureau of Labor Statistics (BLS) on occupational fatalities within two- and three-digit industries. All found some evidence for compensating wages. These studies include: Berger and Gabriel (1991); Dickens (1984); Dillingham (1985); Dorsey (1983); Garen (1988); Leigh (1987b); Moore and Viscusi (1988); Olson (1981); and Viscusi (1979).

The BLS industry fatality data are limited, however, as each of the authors points out. The industry numbers cannot be reasonably applied to white-collar workers. Root and Sebastian (1981) indicate that approximately four-fifths of all job-related injuries occur among blue-collar and service workers. White-collar work is not nearly as hazardous as blue-collar work; consequently, only blue-collar workers are considered by most authors using BLS Annual Survey industry data. But, wholesale exclusion of white-collar workers creates problems. If white-collar workers were exposed to the same amount of risk regardless of industry, their exclusion would not be troublesome. This is unlikely, however. Airplane pilots hold extremely hazardous white-collar jobs. The elevated risk of fatality within the air transportation industry is the result of more pilot (white-collar) fatalities than ground-crew technician and mechanic (blue-collar) fatalities.

Second, the BLS industry fatality numbers from the Annual Survey may be ignoring more than 60% of all job-related deaths, as we indicated in Chapter 2. The BLS Annual Survey death data are derived only from firms with 11 or more employees. The average number of annual fatalities for all firms of this size combined was estimated to be roughly 4090 (U.S. Department of Labor 1984) in the early 1980s (the time most relevant to the samples in the BLS Annual Survey industry WTP studies). Alternative estimates of annual industrial fatalities in all firms during 1984 were roughly 11,000 to 12,000 (Baker et al. 1982; National Safety Council 1983) and 7000 (National Institute for Occupational Safety and Health 1987). The BLS low estimate may, in part, be due to the exclusion of small firms, and because there was undoubtedly considerable underreporting by firms to the BLS, especially prior to the heavy OSHA fines beginning in 1987 (Chapter 2).

In any case, the BLS no longer has confidence in these fatality rates from the Annual Survey. They no longer release them to researchers (Kniesner and Leeth 1991).

Another popular data set has been NIOSH's NTOF discussed in Chapter 2. The NIOSH, NTOF study provided fatality data by state for nine broad industry categories. Moore and Viscusi (1988) and Viscusi and Moore (1988) found evidence for compensating wages in samples combining blue- with white-collar employees, and women with men. Fisher, Chestnut, and Violette (1989) criticized the NTOF study for including information on only nine broad industry categories. Variation in measurements across industries was considerably less in the NIOSH than in the BLS Annual Survey data.

In the third data set, Thaler and Rosen (1975) and Arnould and Nichols (1983) used fatality numbers in high-risk occupations based on insurance companies' statistics. The insurance data suffered a number of well-recognized weaknesses, however. First, the data confused occupational hazards with life-style choices. They represented deaths from all causes, not just job-related deaths. Second, the data applied to only a select group of 37 "extra-risk" occupations. Third, a few of the statistics defied explanation. Cooks, for example, faced three times the risks of firefighters. In an independent test, Leigh (1981) could not replicate Thaler and Rosen's statistically significant results.

Low and McPheters (1983) uncovered a fourth set of data on police fatalities in roughly 70 municipalities. They regressed average police earnings on the number of fatalities and a variety of control variables. They found a positive and significant coefficient on the fatality measure, thus, presumably providing evidence for compensating wages. In a comment on their paper, Leigh (1986e) pointed out that they used the wrong explanatory variable. It should have been the death rate, not the number of deaths. The raw count alone could be acting as a proxy for city size and the size of the city police force is known to be strongly correlated with police wages. When equations were re-estimated with the death rate on the right-hand-side, the estimated coefficient was not significant at conventional levels. In any case, the Low and McPheters data were limited to only one occupation.

Drawing from Workers' Compensation files for the State of New York in 1970, Dillingham produced job-related mortality rates for 83 occupations and 157 industries in a fifth data set. But job-related deaths are rare events, as he indicated. Only roughly 600 job-related deaths were reported in New York in 1970. With so few deaths and so many occupations and industries, his mortality estimates "may not reflect the true long-run frequency of fatal injury" (Dillingham 1985, p. 289). He, nevertheless, found evidence for compensating wages in a sample of wage-earners (not salary earners) who, for the most part, were blue-collar and service workers.

A sixth data set comes from England. Marin and Psacharopoulos (1982) constructed annual mortality rates for 220 English occupational groups. The mortality rate variable that gave them the strongest evidence for compensating differentials was that for accidental deaths on-the-job. They found evidence for compensating wages. They also found evidence that unions reduced the compensating wage premium. American researchers, Dickens (1984), Olson (1981), Smith (1976), and Thaler and Rosen (1976), using U.S. data, found just the opposite. The American data suggested that unions enhanced the compensating wage premium. The American researchers suggested that information on job hazards was probably more widespread among union than non-union members. Marin and Psacharopoulos did not provide a complete list of the 220 occupations. In any case, the list would not be

very useful to American researchers because definitions of occupations differ substantially across the Atlantic.

Leigh and Gill (1991) used a seventh data set on female fatalities in Texas. They pointed out that almost all tests for compensating wages were conducted on men, perhaps with good reason. In Baker's et al. (1982) study of 148 job-related fatalities in Maryland in 1980, all but two were male. A study of occupational mortality in Texas (Centers for Disease Control 1985) revealed that out of 758 total deaths, only 46 were females. In the exhaustive NIOSH, NTOF (Jenkins et al. 1993) study, roughly 6% of job-related fatalities were female. There are a disproportionate number of men in risky jobs. Leigh and Gill further pointed out that attempts to account for gender differences with a dummy variable is not desirable. Any job risk measure will, therefore, reflect a gender wage differential if women are included in the sample. That is, part of the significance of a coefficient for a variable measuring job hazards could be the result of gender differences in employment in hazardous versus safe jobs. Barry (1985) did not find evidence for compensating wages for various measures of hazards (not deaths) in women-only samples. Leigh and Gill (1991), using unique Texas data, found evidence for compensating wages among women in union jobs, but not among women in non-union jobs.

In summary, most existing evidence suggests wages are higher for male, blue-collar and service hourly workers in jobs with high death rates, compared to similar male, blue-collar and service hourly workers in jobs with low death rates. The most convincing U.S. data that provide these results are BLS Annual Survey unpublished two- and three-digit industry and the NIOSH industry/state data.

But, Leigh's (1995b) study challenges the most widely-cited labor market studies. Both the Annual Survey and the NIOSH, NTOF death rates were combined with three national probability samples to investigate compensating wages for hazardous work. Compensating wages were expected in blue-collar, male-only samples, but not in male and female clerk samples. An inter-industry differentials hypothesis was investigated by alternately including and excluding dummy variables for broad industry divisions. When the seven industry dummy variables were excluded in the regressions, a strong partial correlation was observed between death rates and

wages. When the dummies were included, the correlations evaporated. These patterns were also observed in samples of clerks. Evidence thus supported the inter-industry differentials hypothesis, not the compensating wage differentials hypothesis.

The compensating wage hypothesis itself, therefore, cannot be entirely free of scrutiny. Widespread information about job hazards, mobility, and rationality might be questionable assumptions.

Police officers, fire fighters, iron workers, airplane pilots, and others in obviously dangerous jobs no doubt receive compensating wages. But, the U.S. Census lists over 500 occupations and close to 200 two- and three-digit industries. Moreover, as the NIOSH, NTOF data demonstrate, substantial variation is apparent across states. Lists of fatality rates by occupation (alone), industry (alone), and state (by industry) are available (Leigh 1995a). Readers are encouraged to peruse these lists. Aside from the obvious dangerous jobs, the majority of the others are difficult to rank. Workers may only have to rank two jobs, however. But even paired comparisons are difficult, as a perusal of the lists would illustrate. For example, laborers, apprentices in construction trades, garbage collectors, warehouse workers, truck drivers, delivery workers, gas station, and parking lot attendants, have high kill ratios (Leigh 1995a). Moreover, common misconceptions concerning job-related deaths are pervasive. Firefighters are more likely to die from heart attacks than smoke inhalation, falls, or burns combined (Washburn, Harlow, and Fahey 1987). Police officers are as likely to die in a car crash as in a gun battle.

Many economists readily accept that information pertaining to health and preventive medicine varies directly with education (Ippolito and Mathios 1990; Kenkel 1991). It is not surprising, therefore, that a high and disproportionate number of persons with low levels of education occupy dangerous jobs (Leigh 1986b, 1988b).

Poor information on occupational traumatic deaths is widely acknowledged among epidemiologists. A review by Windau and Goodrich (1990) indicates that the annual estimates of traumatic deaths in the 1980s ranged between 3,000 to 12,000. Windau and Goodrich concluded that a new system of gathering data that does not

rely on BLS industry statistics was necessary to provide reliable data. The NIOSH, NTOF and the BLS's CPOI presumably were conducted for exactly that purpose.

To the extent that occupational disease death rates are correlated with traumatic death rates across jobs, the problem of poor information is even greater. The BLS Annual Survey estimates that disease deaths account for about 10% of the total of all occupational deaths (U.S. Bureau of Labor Statistics 1993). By contrast, our Chapter 3 as well as a study in New York suggests that disease deaths are eight to 10 times as many as all traumatic deaths (Markowitz et al. 1989). A study from Pennsylvania suggests that there are 18 disease deaths for a single injury death (Neumark et al. 1991). Since the prospects of disease deaths are generally viewed as more menacing than traumatic deaths by the public due to the involuntary nature of exposure to carcinogens (Slovic 1978), poor information combined with public perceptions of threat further complicates the search for compensating wages.

Viscusi (1992) attempts to rebut some of these criticisms. He suggests that workers learn about risks on-the-job and quit if risks are too great. But, a high and disproportionate number of youths and new employees die of on-the-job accidents (Division of Labor Research and Statistics 1985; Leigh 1995a). Accidents are sudden, but decisions to leave a job or find a new job may require months, or even years.

We are not alone in voicing a concern over the lack of information on hazards available in the labor market. Neumark et al. (1991) are also skeptical. Neumark is an economics professor at the University of Pennsylvania. He and others published the only study that attempted to estimate the total cost of occupational injuries and diseases. Their study applied only to Pennsylvania. They explicitly ignored WTP estimates because of the information problem. According to Neumark et al. (1991):

... the compensating wage differentials approach to estimating costs of occupational hazards (WTP) seem(s) likely to remain seriously flawed until there is an extensive and well-publicized body of literature on the extent and costs of workplace hazards. Only then could workers be assumed to make informed decisions about the amount of risk they are willing to accept on the job. (Neumark et al., p. 976).

The assumption of widespread information is also questioned by business professors. Rejda (1984, 1991) is the author of the influential reference book *Social Insurance and Economic Security*. He is a professor of insurance in the Business School at the University of Nebraska. He shares, with trade unionists, a widely held belief that, in general, workers, especially non-unionized workers, do not have the bargaining power or information necessary to negotiate with employers over how safe or risky their workplaces should be. He states: "few workers are in a position to determine accurately the probability of an occupational injury and the resulting economic loss" (pp. 299-300).

Mobility is another concern. It could be that workers do not receive compensating wages for job risks in secondary (low wage, high turnover) labor markets due to lack of mobility from secondary to primary (high wage, low turnover) labor markets (Robinson 1988b).

It could also be that time is required for persons to make a job change, and during that time, an accident could occur. This would be especially true of persons in their prime earning years who have family obligations and might require substantial training to qualify for a different job.

The rationality assumption has served economics well. But, no economist would argue it provides a complete description of all human behavior. While some economists have attempted to use the assumption to help explain decisions involving, for example, romance, most have shied away from such attempts. Few economists have attempted to apply the assumption to behavior involving death. We recognize, for example, that few "agents" would trade-off any potential gain, no matter how large, for a 95% chance of dying. It is difficult to be rational when contemplating one's own death. Many philosophers argue that the prospect of death has given rise to religious beliefs. Few economists have attempted to apply the rationality assumption to religious beliefs. Additional problems involving rational behavior and job-related death are discussed in Dickens (1985) and Bryant (1990).

In summary, most labor market studies find evidence for compensating wage differentials, and these differentials can be used to calculate a WTP estimate for life. But serious problems plague all of these studies.

But there have been WTP studies outside of the labor market including, for example, purchases of smoke detectors and the decision to use a seat belt (Viscusi 1993). One of the most highly regarded studies outside the labor market was conducted by Atkinson and Halverson (1990).

Atkinson and Halvorsen (1990) attempted to estimate the value of life based upon consumer purchases of automobiles. Using a variation on the compensating wage approach, they regressed the price of 112 car models from 1978 on characteristics of the cars, characteristics of deceased drivers, and the fatality rates for the cars. The characteristics of deceased drivers and fatality rates for the cars were drawn from the Fatality Automobile Reporting System (FARS) data file at the National Highway Traffic Safety Administration (NHTSA). They found a statistically significant and negative estimated coefficient on their fatality rate variable. With appropriate manipulations, they generated estimates of the value of life that compared favorably with the existing labor market estimates they cited (Leigh and Folsom 1984; Olson 1981; Viscusi 1979).

Their study suffered three data problems, however. The first problem pertained to their fatality rates for the 112 cars. Did these rates apply to the cars or the drivers of the cars? One extreme view of accidents is that the car is responsible. It is too light, poorly manufactured, not equipped with automatic seat belts or air bags or anti-lock brakes or otherwise not crashworthy. This doctrine is generally espoused by liberals. Conservatives, on the other hand, would paraphrase the National Rifle Association: it's not cars that kill people, it's drivers that kill people. Teenagers, men, unmarried people, and people with bad driving records are greater accident risks than people with the opposite characteristics. Conservatives and insurance companies would agree that some characteristics of drivers must be taken into account if a proper estimate of the risk-for-price tradeoff is to be estimated.

Atkinson and Halvorsen (1990) followed the approach pioneered by labor economists in which wages were regressed on job fatality rates. Labor economists also invariably include personal characteristics such as years of schooling and work experience as covariates. Garen (1988) went one step further and argued that holding constant observed personal characteristics was not enough. Workers

"self-select" into hazardous and safe jobs and unobserved personal heterogeneity must be removed to properly estimate the wage-risk relationship.

Atkinson and Halvorsen recognized the bias in their fatality rate. They believed it could be removed by including the average characteristics of deceased drivers. They included the following covariates in their regressions: percentage of decedents age 18 to 24, percentage of male decedents, percentage of decedents with alcohol in the blood, percentage of decedents wearing seat belts, and percentage with no previous offenses. These appear to be reasonable covariates, designed to measure some personal characteristics. Yet, when they were entered into the regressions, they did not generate statistically significant coefficients (p. 134, footnote 6). In their results on "Age of Drivers" in their Table 2, they did not find age to be statistically significant in their regressions. None of the personal characteristics, in fact, were statistically significant either separately or jointly. We are left with the conclusion that personal characteristics of drivers did not influence the price of the car or in any way interfere with the correlation between the car's fatality rate and its price. The personal characteristics they had were apparently not important and their estimated coefficient on the fatality rate would presumably not be affected by excluding them. These results are alarming.

It might be that Atkinson and Halvorsen (1990) were not able to include some relevant personal characteristics, such as income, family size, education, whether employed, and marital status.

For example, most studies find that age, especially after 45, income, education, and family size are directly related to car purchase price (Lave and Train 1979; Manski and Sherman 1980; McCarthy 1990). Manski and Sherman summarized their findings this way: "... the influence of price and operating cost varies considerably among socioeconomic and demographic groupings." Manski and Sherman (1980, p. 359), and Lave and Train (1979) produced evidence of a U-shaped relation between education and price with the cheapest and most expensive cars being owned by those with little education.

But cheap cars tend to be light, lack expensive safety features, and be less-crashworthy than large cars (Manski and Sherman 1980; Lave and Train 1979; McCarthy 1990).

In Zlatoper's (1989, p. 145) extensive review of highway fatality studies, age and income were frequently found to be strongly and inversely related to motor vehicle deaths. Additional risk factors for motor vehicle crash deaths included male sex and employment (Zlatoper 1989). Although not widely researched, education, being married, and number of dependents may be inversely correlated with highway deaths since they have been strongly linked to seatbelt use, smoking, and overall health status (Farrell and Fuchs 1982; Leigh 1990; Taubman and Rosen 1982).

Finally, alcohol use is one of the most robust statistically significant covariates of highway fatalities (Zlatoper 1989). In addition, the relation between alcohol abuse and income appears to be "U" shaped with a disproportionate number of heavy drinkers among the poor and rich (Sagan 1987, p. 163 and Manning et al. 1989). The poor also have a high and disproportionate number of people who never drink (Sagan 1987; Rubin 1994).

If drivers were at least partially responsible for a car's fatality rate, and if personal characteristics were correlated with variables influencing the demand for cars, price of cars, and fatality rates, then estimated coefficients and t-statistics on the fatality rate should change as personal characteristics were added or deleted from the regressions. But Atkinson and Halvorsen (1990) did not find that coefficients or t-statistics changed and they did not find that any personal characteristics were statistically significant. The lack of statistical significance is difficult to explain, and raises questions about the reliability of their data.

Second, Atkinson and Halvorsen never explained why 112 cars from only 1978 models were selected for analysis. A personal communication with the person in charge of the FARS file at NHTSA, Ms. Louann Hall, indicated that in 1978, the NHTSA collected data on over 200 car models. Moreover, as Ms. Hall indicated, over 200 car models were also available in many other years.

Third, the assumption of perfect knowledge concerning a car's safety characteristics is not universally accepted. McCarthy (1990) suggests that many new car buyers were not informed about cars' crashworthiness and that market efficiency would be improved by requiring car dealers to post crashworthiness statistics next to the price. Information on crashworthiness is similar to any information on preventive medicine.

Atkinson and Halvorsen's (1990) simple idea that we ought to be able to use car prices and car and driver characteristics to estimate the value of life is innovative and compelling. Proper estimates would require the careful collection of data on personal characteristics of drivers, such as income, education, marital status, and number of dependents. Believable results would include evidence that the personal characteristics of drivers do make a difference when attempting to estimate a price-fatality tradeoff.

IV. Conclusion

The WTP method is preferred over the Direct/Indirect method among most academic economists because they find the theory more compelling. But the data required to estimate WTP estimates and some of the assumptions—especially about information on risks—leave many economists in a quandary when faced with a real world decision. Moreover, outside of academic economic departments, the Direct/Indirect method is more popular.

This chapter presented methods for the Direct/Indirect and the Willingness-to-Pay approach. We, nevertheless, prefer the estimates based upon the Direct/Indirect method on pragmatic and theoretical grounds. On pragmatic grounds, we know that few WTP estimates are available. Most apply to injury deaths, not non-fatal injuries, and not deaths or conditions due to diseases. We are not aware of any WTP estimates on non-fatal injuries that apply to the convenient WC disability categories from Chapter 2. The WTP death estimates, moreover, are hotly debated. As we will see, the WTP estimates tend to be three to eight times the size of the Direct/Indirect estimates. In keeping with our desire to be conservative, to produce estimates that our critics cannot charge are too high, we will spend more time on and will prefer the Direct/Indirect estimates over the WTP

estimates. Also, on pragmatic grounds, we would like to compare our estimates with those for heart disease, cancer, AIDS, and so on. We are aware of credible Direct/Indirect cost estimates for these diseases, but we are not aware of any WTP estimates for these diseases.

On theoretical grounds, we prefer average and total cost concepts to marginal costs concepts. We seek to measure the overall volume of costs associated with occupational injuries and illnesses. We do not seek to determine what the marginal benefits and marginal costs would be for a proposed change in an OSHA regulation. The WTP methodology attempts to estimate marginal rather than average or total costs. This aspect of WTP in part explains why WTP estimates for all annual U.S. deaths for any given year exceed the U.S. GDP (Chapter 7).

The Direct/Indirect estimates will occupy the majority of the following chapters.

Chapter 5
Cost of Injuries

Outline for Chapter 5: Costs of Injuries

- I. Introduction
- II. Direct and Indirect Costs Estimates
 - A. Direct Costs
 - B. Indirect Costs
 - 1. NCCI, Indemnity
 - 2. Present Value of Lost Earnings
 - 3. All Other Indirect Costs
 - C. Summary Table 3.7
- III. Literature Review
 - A. Job Injury Studies
 - 1. National Safety Council (1993)
 - 2. Rand, Hensler et al. (1991) and Marquis (1992)
 - 3. Miller and Galbraith (1994)
 - 4. Rossman, Miller, and Douglas (1991)
 - 5. Neumark et al. (1992)
 - 6. Nelson (1992, 1993)
 - 7. Burton (1994)
 - 8. Boden and Fleischman (1989)
 - 9. Webster and Snook (1990)
 - B. Related Studies
 - 1. Rice et al. (1989)
 - 2. Max and Rice (1993)
 - 3. Blincoe and Faigin (1992)
- IV. Conclusion

Chapter 5: Cost of Injuries

I. Introduction

As indicated in Chapter 4, economists have developed two methods for estimating the costs of injuries and illnesses: the Direct and Indirect method and the Willingness-to-Pay (WTP) method. This chapter presents injury cost estimates of the Direct/Indirect method only. Chapter 7 presents WTP injury and illness cost estimates.

The chapter follows a simple outline. Section II presents our estimates of direct (II.A) and indirect (II.B.) costs that incorporate data from Nelson (1992, 1993), the NCCI, and government reports on survival probabilities and earnings, as well as on statistics in government and other studies on fringe benefits, administrative costs, home production and other indirect costs. Within the indirect cost discussion, we consider NCCI indemnity costs (II.B.1), the present value of lost earnings (II.B.2), and all other indirect costs (II.B.3). A summary table appears in II.C. Section III reviews existing studies. III.A.1. National Safety Council (1993); III.A.2. Rand, Hensler et al. Rand, Hensler et al. (1991) and Marquis (1992); III.A.3. Miller and Galbraith (1994); III.A.4. Rossman, Miller, and Douglas (1991); III.A.5. Neumark et al. (1992); III.A.6 Nelson (1992, 1993); III.A.7. Burton (1994); III.A.8 Boden and Fleischman (1989); III.A.9 Webster and Snook (1990); III.B.1 Rice et al. (1989); III.B.2 Max and Rice (1993); III.B.3 Blincoe and Faigin (1992). Our conclusion is in Section IV.

II. Direct and Indirect Costs Estimates

II.A. Direct Costs

In this section, we estimate direct costs. Direct costs are composed of three components: medical, insurance administration, and other costs. Medical costs cover payments to medical and nursing home care providers such as doctors, hospitals, drug companies, nursing homes, and so on. Insurance administration costs cover the overhead for running an insurance company or an equivalent government agency. Other direct costs include costs for damaged property, police and fire services, and direct costs to innocent third parties.

To calculate medical costs we simply multiply our estimates of numbers of injuries in Tables 2.12 and 2.13 (Chapter 2) by our estimates of average costs developed below. The disabling injuries are split into the Workers' Compensation (WC) categories so that we can match them with average WC cost figures from the National Council on Compensation Insurance (NCCI) Ultimate Reports. The NCCI Ultimate Reports provide information on the average cost for each of the WC categories, including deaths. The amount and detail of WC data NCCI is unsurpassed.

In most states, WC insurers and insurance commissioners use NCCI data to help develop insurance premiums that WC insurers charge their customers. Rates are established for occupations, trades and industries based upon their risks (Rejda 1991). Only the large companies that self-insure see a direct economic incentive to reduce their WC claims, however. Non-self-insured firms face only an indirect incentive. Non-self-insured firms are placed in groups with other non-self-insured firms. They are in a pooled risk category. If the injury rate for the group decreases then each non-self-insured firm might be charged a lower premium. But if the non-self-insured firms are small and the group is large, then the non-self-insured firms individually may not have an incentive to reduce accidents. In fact, the opposite may be true. There is little they can do individually to decrease their premiums, so that they effectively have an incentive to disregard safety. The same phenomenon occurs when eating out with a large group. It is most likely that the bill will be split evenly. Each person then has an incentive to order the most expensive meal at the restaurant.

Some research suggests that self-insured firms are quite responsive to WC premiums (Ruser 1991). As premiums increase, firms make attempts to reduce their injury and illness rates. But these attempts do not always involve expenditures on providing for a safe and healthful workplace. Self-insured firms also appear to be much more disposed to challenging and appealing WC claims than non-self-insured firms (Hyatt and Kralj 1995).

The National Council on Compensation Insurance (NCCI) provides estimates of medical dollars spent and forecasted spending from 38 to 41 states for all WC categories: death, Permanent Total (PT), Permanent Partial (PP), Temporary Total

and Partial combined (TTP), and the Medical Only category. All dollars are for cases originating in a given insurance policy year. The estimates are, therefore, incidence-, not prevalence-based. The most recent data we have were published in May 1993 and covered policy years 1988, 1989, and a few into 1990. As mentioned in Chapter 2, policy years covered exactly 12 months. Our selected year for research purposes is 1992. We inflated the NCCI cost figures to express them in 1992 dollars.

NCCI publishes several reports: First Year, Second Year, Third Year, and so on, up to the Ultimate Report corresponding to the Fourth year report. All reports include forecasts of future expenses. The First Year Report covers expenses from policies for the first year after the policy was written. The First Year Report obviously will be limited by lack of information on injuries that occurred at the end of the year or injuries that generate costs for more than a year. The Second Year NCCI Report follows policies for two years and contains more complete data than the First Year Report. The Ultimate Report arguably contains the best data since injuries and policies have been followed for a minimum of three years.

To test this hypothesis about data completeness in the Ultimate Report, we also obtained a copy of First Year Reports from 1990 and 1991. We discovered some serious omissions on First Year Reports. For example, the First Year Reports contained only roughly one-third of Permanent Total injuries reported in the Ultimate Report.

Nearly 100% of actual medical costs for decedents, Temporary Total and Partial (TTPs) injuries, as well as Medical Only injuries, are captured in the Ultimate Report. It would be unlikely that medical costs for these injuries would go beyond three years. This would not be the case with Permanent Total (PTs) or Permanent Partial (PPs) injuries, however.

The National Council on Compensation Insurance's (NCCI) Ultimate Report published in May 1993 covered policies from 1988, 1989, and a few into 1990. The Ultimate Report sums all of the actual medical costs on all Permanent Total and Partial cases (PT and PPs) originating in a given policy year. These costs would correspond to the first three to five years depending on the state and insurance policy. But medical costs are likely to be incurred into the future for Permanent

Totals and Partial, beyond the three to five years of data available in the Ultimate Report. The NCCI simply uses the dollar amounts per PT and PP provided by the private insurance company. In a few cases, this is part of a lump sum legal settlement made to the injured worker. In these cases, the insurance company bears no further liability. In most cases, however, these dollars represent payments already made or monies anticipated to be spent. The lump sum payments, as well as the monies anticipated to be spent reflect the present value forecasts of expected future medical expenditures. These forecasts make use of the extensive historical data that each insurer maintains.

The forecasted costs were developed by the actuarial experts from all of the WC insurers in the 38 to 41 states and D.C. participating in NCCI.

The forecasting technique involves the "loss development factor" or "chain ladder" approach, whereby historical patterns in costs are used to predict future costs (personal communication with Judy Gilliam at NCCI June 13, 1994). The WC private insurers must use these forecasts to determine how much money to put aside in their "case reserve." These dollars in the NCCI reports, in fact, include what actuaries believe should now be set aside to cover the future costs of the case.

These forecasts can be criticized on a number of grounds. First, it is not known whether future cost increases will match past cost increases. Second, we do not know if the therapy for a given disability will change over time. Third, we do not know if new jobs might be created in the future for which a group of disabled people might qualify.

But there are rebuttals to these criticisms. First, there do not exist any better data on the medical costs within the WC categories. Second, the largest medical expenses on these injuries occur early, hence the forecasted dollars would be a small amount of the total. Boden and Fleischman (1989) found that the correlation coefficient between estimates including and excluding forecasted amounts was .99. They attributed this high correlation to the relatively small amount of forecasted dollars. Surgery, for example, is much more likely to occur in the first few years than over the remainder of years beyond the fifth year after the injury. In fact, Third Year Reports, overall, capture over 90% of Ultimate Report dollars (Nelson 1992). But the most important rebuttal is this:

the NCCI cost estimates reflect the present value calculations of the actuaries most familiar with the case. If actuarials' forecasts were consistently wrong, the companies would eventually become unprofitable and go out of business. It would be presumptuous of us to second guess these private market actuarial calculations.

On average, the actuarial forecasts are probably reasonably accurate. The same reasoning has met with widespread approval among economists when applied to, for example, future interest rates and stock prices (Malkiel 1991). This is the efficient markets hypothesis. According to this hypothesis, it would be arrogant (and inaccurate!) for economists to believe that they know more than "the market" about the "true" value of stock prices or the future course of interest rates.

Another criticism of the NCCI data, unrelated to the forecasted dollars, involves the combination of dollars. The future, discounted dollars, as well as dollars spent a year or two after the injury are added together with dollars spent early in the first year of treatment of the injury. For example, our most recent NCCI Ultimate Report includes policy years from 1988, 1989, and 1990, published in May 1993. Some dollars could have spent in 1988; others in late 1992. The NCCI leaves these dollars in nominal, not real amounts.

If dollars from the early years are to apply to 1992 they should be inflated. But we do not know what dollars were spent when policies were written for 1988 to 1990. Yet some costs will extend to 1992. We assumed that, on average, these NCCI dollars were from 1990. Therefore, we multiplied them by the adjustment factor of 1.168 assuming a 16.8% rate of increase in medical costs from 1990 to 1992 (U.S. Bureau of the Census 1993). We selected 1990 again out of a desire to be conservative. Had we chosen 1989, we would have multiplied by a factor bigger than 1.168.

Table 5.1 presents some medical cost calculations. The first column presents categories of injuries including deaths, PTs, PPs, TTPs, Medical only, one to seven days lost, and non-disabling. These are WC categories and correspond to our categories from Chapter 2. The second column pertains to the dollars per category. The ratios were drawn from the NCCI Ultimate Report (May 1993). The numerator contains dollars of costs and the denominator contains cases. Column 3 adjusts for inflation, multiplying column 2 by 1.168. Column 4 represents our estimates of

injuries from Chapter 2, Table 2.13. These numbers do not include injuries to innocent bystanders. The product of the number of injuries in the categories times the average cost per category appears in column 5.

Average costs for rows 6 and 7 reflect multiples of the NCCI Medical Only category, as explained in footnote 1 in Table 5.1. The number of injuries in row 6—one to seven days of disability—was multiplied by the NCCI Medical Only figure times 1.5. This multiplication by 1.5 was intended to reflect that one to seven days of disability would involve a more serious injury than a non-disabling injury. The number of injuries in row 7—non-disabling—was multiplied by the NCCI Medical Only average cost times .8.

The 1.5 factor is further away from 1.0 than .8 is away from 1.0. We assume that there were fewer disabling injuries than non-disabling injuries but that they were much more costly than the non-disabling injuries. This is consistent with the observation that direct costs are not normally distributed, they are skewed to the right. The majority of medical problems are minor and do not involve a great cost. A few serious medical problems account for a high proportion of costs.

Our total appears at the bottom. This \$25.0915 billion estimate does not need to be multiplied by any WC undercount factor, since the WC undercount was already accounted for in our estimates in Tables 2.12 and 2.13.

But this \$25.0915 billion represents only what is paid to hospitals, doctors, drug companies, and so on. Someone must pay these bills, collect premiums and service the financial reserves. Insurance companies or their government agency equivalents have costs of administration, maintaining a reserve of funds, interest payments and, in the case of companies, providing a reasonable rate of return or profit to owners or shareholders via dividends. Some readers may question including profit as a cost. But a normal profit is a cost associated any private firm, as every introductory economics text explains.

We believe insurance administration costs should be included in direct costs. For injuries qualifying for WC, these costs are directly passed on from the insurance companies to the firms receiving WC insurance. That is, these costs are reflected in the premiums businesses pay and, therefore, constitute a real out-of-pocket cost to business firms. We will also argue that even when injuries

are not covered by WC, there will be some insurance administration, reserve, profit, dividends, and interest expenses, since some other private health insurance company or Medicare or Medicaid would likely cover the injuries not covered by WC. These expenses are obvious when covered by a private health insurer other than a WC carrier. Some of these expenses are also present even for Medicare, Medicaid, other state and local government medical payers, as well as private charities.

Administrative and overhead costs would cover expenses for the insurance company itself, e.g., employee salaries, electricity, building maintenance, some share of building construction costs, computer equipment, interest on debt and so on. Reserve expenses would cover the cost associated with accumulating and holding cash reserves, as well as the reserves themselves. Including cash reserves as a cost is appropriate. After all, if no injuries occurred, there would be no need for the cash reserve and premiums charged to businesses or persons would be zero. The amount of cash reserves is obviously reflected in the premiums that businesses must pay.

All private insurers attempt to make a profit and perhaps pay dividends, refinance debt, and so on. Direct costs calculations have sometimes ignored these expenses. They should not be ignored. Clearly, they will be reflected in premiums (i.e., in the WC costs as viewed by business). In a competitive market, the entire premium would be the best measure of costs (Danson 1992).

We, therefore, will use the difference between the premiums and benefits paid to measure the administrative costs.

To estimate these overhead costs, we begin with WC data in Nelson (1992, 1993). Every three to four years, the Social Security Administration asks William J. Nelson Jr. (or his equivalent in prior years) to generate national estimates on the annual costs of WC including the special WC funds for federal government employees, the Black Lung Trust, and the WC program for longshoremen. Mr. Nelson's numbers are prevalence-based (i.e., they cover actual expenses in a given year). They do not cover forecasted expenses. They do include, however, expenses for injuries that could have occurred in years prior to the years for which costs are calculated.

Table 5.1

Calculations of NCCI Medical Expenses Within Injury Categories

1	2	3	4	5
Injury Category	Dollars per Injury Within Category	Inflation adjustment Col. 2 x 1.168	Numbers in Category from Table 2.12	Product of Col. 3 x Col. 4, Billion Dollars
1 Deaths	\$47,682,147 2768	\$ 20,120	6,529	\$.1314
2 Permanent Total (PT)	\$543,621,590 4795	\$132,419	10,725	\$ 1.4202
3 Permanent Partial (PP)	\$4,605,986,805 300,207	\$ 17,920	.7616	\$13.6479 million
4 Temporary Total and Temporary Partial (TTP)	\$2,193,035,195 788,230	\$ 3,250	1.888	\$ 6.1360 million
5 Medical Only (MO)	\$962,983,190 3,269,227	\$ 344	See rows 6,7	See rows 6,7
6 One to Seven days of disability ¹ (work loss)		\$ 516	3.433	\$ 1.7714 million
7 Non-disabling ¹ (no work loss)		\$ 275	7.153	\$ 1.9671 million
8 Total				\$25.0739 Billion

¹We assume that the average Medical Only costs applied to the One to Seven days of disability and to the Non-disability injuries, after adjusting for the likely greater severity of a Disabling injury versus a Non-disabling injury. One to Seven days - medical only times 1.5; Non-disabling - Medical Only times .8.
Source: Our study

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 5.1 which was typed in Microsoft Word for IBM and is labeled TEL51WRD.DOC on the diskette.

Mr. Nelson culls data from a variety of sources including the A.M. Best Company (a national data-collecting agency for private insurance), the National Council Compensation Insurance (NCCI) discussed in Chapter 2, the Federal Black Lung program, the Federal Employees Compensation program and the Federal Longshoremen and Harbor Workers' Compensation program. The A.M. Best and NCCI data cover the traditional WC programs within the states and D.C. All other programs are federal and are, technically, not part of the traditional state-based network of WC. For example, Toscano and Windau (1993) put federal reports on job-related deaths in a different category than the state WC records as indicated in Table 2.1 from Chapter 2.

Nelson does not have a separate category for all administrative expenses, including profit, interest, and so on. These expenses cannot be estimated directly. They can be deduced from premiums, however. Using 1991 data, Nelson calculated that all WC premiums summed to \$55.2 billion while all WC benefit payments (medical plus indemnity) summed to \$42.1 billion. The difference between these two is 13.1. Now 13.1 divided by 42.1 yields 31%. This 31% of benefits would represent administrative expenses, profit, interest, dividends, and new cash reserves. Henceforth, we will refer to all of these categories as administrative costs. We will use the 31% figure in our calculations below.

But not all injuries are covered by WC. The estimates from Table 2.13, Chapter 2, are more than twice the number of actual WC cases. It could be argued that there is no administrative expense for the people who were not covered by WC. We disagree. Most of those persons not covered by WC were probably covered by either their own medical insurance, their group health insurance from their employer, the medical insurance of their spouse or parent, or indirectly by others' medical insurance.

Other persons among the injured may not receive WC payments, but may receive funds from Medicare, Medicaid, county relief agencies, or private charities. While these insurers do not require a normal profit, they do require other administrative expense.

Finally, out-of-pocket expenses from people without insurance do not require any additional administrative or profit expense. But out-of-pocket expenses are

small compared to the amount that WC, private insurers, Medicare, Medicaid and government agencies pay for medical bills for those injured on-the-job.

Nevertheless, the 31¢ for administrative expense would not always apply to non-WC payments. It is likely that administrative expense would be less for other insurers, especially government insurers. Some WC administrative costs involve litigation costs. It may be that litigation expenses are less for non-WC private insurances (Berkowitz and Burton 1987). This could be especially true for self-insured firms where the WC benefit is viewed as a direct cost and results in reduced profits. The "adversary" is more widely diffused in the ordinary health insurance market. On the other hand, administration expenses for private health insurance may be less than those costs for non-self-insuring firms. After all, a major reason WC came into existence was to minimize litigation.

There is a large literature on administrative costs of insurance. We cannot adequately review all of these studies. We instead briefly mention the important studies and suggest a range of reasonable estimates. There is one point all of these studies acknowledge, however: insurance administration costs are significant and cannot be ignored in a cost study of medical care delivery. In reviewing these studies, all of our percentages will be expressed in terms of administrative cost per claim or per medical expense, not per dollar spent on all costs including administration.

Cutler (1994) estimated that administration expenses average 15¢ of insurance claims (i.e., 15¢ of medical expenses). Woolhandler and Himmelstein (1991) estimated that the typical private health insurer would generate administrative costs of 24¢ to 33¢ of total benefits. The California Medical Association's (1993) survey of insurers in California indicated an 18¢ rate (out of benefits paid) for purely administrative costs and an additional 6¢ rate for profit (out of benefits paid) in 1992 for a total of 24¢.

Danzon (1992) estimated a 12¢ rate for private insurers and a 49¢ for public insurers. Danzon, however, included the time spent waiting for service for patients for public insurance, but not for private insurance. Danzon is unique among analysts for including waiting costs by patients as an administrative cost. Danzon (1992) is also unique in arguing for higher administration costs for public

than private health insurance. Most published studies show a lower rate in the public sector. Thorpe (1992) estimated a rate of nearly 66¢ for private companies providing insurance for small firms to a little over 2¢ for Medicare. In fact, a lower rate in the public section is often mentioned in arguments for greater government control of the health insurance market (Woolhandler and Himmelstein, 1991).

The *U.S. Statistical Abstract* for 1993 in Table 841 shows figures for health insurance companies (U.S. Bureau of the Census 1993). In 1990, the most recent data year, premiums totaled \$118.6 and benefit payments totaled \$97.7 billion. If all dollars over the benefit payments are administrative costs, this would imply a rate of 21.4¢ out of benefits.

It is tempting to use the 21.4¢ figure. However, WC insurance apparently involves a greater administrative cost than the typical insurer. We, therefore, allowed for two rates: 31¢ for WC and 16¢ for all others. The 31¢ is drawn from Nelson (1992, 1993). The 16¢ is drawn from our review of the literature with the strongest weight given to the *U.S. Statistical Abstract* (1993, Table 841). We do not assume 21.4¢ because some portion of non-WC injuries would be lowered by coverage from government agencies and these would likely have administrative costs less than the private carriers. Medicare and Medicaid would tend to reduce this non-WC percent below 21.4 while WC would tend to increase this percent above 21.4¢. But, as we will see in Chapter 9, "Who Pays," WC contributes substantially more than Medicare and Medicaid.

We assume that 45¢ of medical expenses are covered by WC. This is the same percent we assumed for WC coverage of all job-related injuries. Forty-five percent times \$25.0739 billion yields \$11.2833 billion. Assuming a 31¢ administrative cost on this \$11.2833 billion yields \$3.4978 billion. The non-WC medical expenses would be 55¢ of \$25.0739 or \$13.7715. This \$13.7715 multiplied by 16¢ yields \$2.2034 billion. Summing the two administrative costs yields \$5.7012 billion. Adding this \$5.7084 to \$25.0915 yields \$30.7751.

We can also use Burton's (1993) data as an independent test of our estimate of WC administrative costs. The Burton (1993) study is described at length in Section III.A.7. Here, we simply note that Burton is an economist who provides

estimates of WC costs, independent of Nelson (1992, 1993). Burton draws heavily from Nelson (1992, 1993), however, in developing his cost estimates. Burton (1993) estimates that total WC premiums were \$60.0 billion in 1992. Burton does not indicate how the \$60.0 billion is split between benefits for medical versus indemnity costs, however. If we assume the Nelson (1992, 1993) percentages apply, then medical benefits would be $16.8/55.2 = 30.43\%$ and indemnity expenses would be $25.3/55.2$ or 45.83% . Multiply these percentages by \$60.0 billion yields \$18.26 billion for medical costs and \$27.5 billion for indemnity costs. The Burton-based WC administrative costs would be $(\frac{\$18.26}{1.31} \times .31) = \$4.3211$ billion for medical expenses and $(\frac{\$27.5}{1.31} \times .31) = \$6.5076$ billion for indemnity expenses.

The Burton-based \$4.3210 exceeds our preliminary estimate above of \$3.4978. Our preferred estimate is the Nelson-based \$3.4978. We select the lower estimate in the interest of being conservative and because we have more confidence in the Nelson estimate.

There are many advantages and disadvantages to this approach of multiplying NCCI average cost estimates times the number of injuries. We first consider the advantages.

First, the NCCI data are the only data that are available on costs for the categories of WC. The SDS data which we have relied on for estimates of injuries, for example, has only intermittent data on costs since the BLS did not require cost data from the states that participated in the SDS.

Second, the medical costs include all customary costs for ambulances, emergency rooms, physicians, therapists, nurses, hospitals, rehabilitation, and so on. By relying on the NCCI data, we avoid problems associated with creating our own estimates of costs for ambulances, therapists, and so on. We do not become entangled with ferreting out differences between, for example, hospitals and insurers in what was supposed to be paid versus what was actually paid.

Third, in the years we rely on (1988 to 1990), WC almost always paid for 100% of medical expenses. Few, if any, co-payments or deductibles occurred. Recently, however, a handful of states have been experimenting with modest deductibles as a cost-containment mechanism (Hensler et al. 1991 and Tinsley

1992), but these slight adjustments are unlikely to affect our estimates. We therefore avoid questionable assumptions about deductibles and co-payments that would have to be made using private health insurance data.

Fourth, the NCCI data are incidence-based and follow each case for at least three years. We do not have to make our own forecast for how the expense of the case would vary over the first three years.

Fifth, these are simple calculations. They do not require that we match cost data to hospitalizations to injuries based on the part of the body affected. There is a serious difficulty associated with cost measurements based on body parts. Perhaps as many as 40% of all injuries affect more than one body part (Hensler et al. 1991; Hall and Owings 1994).

Sixth, the NCCI cost data are widely cited (Nelson 1992, 1993; Boden and Fleischman 1989; Rice et al. 1989; National Safety Council 1993; Burton 1994).

There are many disadvantages. First, we must assume that the non-participating states—California, Minnesota, Nevada, New York, North Dakota, Ohio, Washington, West Virginia, Wyoming (and Delaware and Pennsylvania on Medical Only costs)—have the same average costs as the 39 to 41 included states and D.C. This is not likely to be true. This assumption, in fact, is conservative (i.e., it tends to underestimate costs). California and New York account for over 70% of the population of these omitted states (U.S. Bureau of Census 1993). California and New York have medical costs nearly 20% higher per patient than the rest of the nation (U.S. Bureau of Census 1993).

Second, we must assume that the large self-insured firms (excluded from NCCI) have similar average costs as the firms included in the NCCI numbers. This second assumption, on its face, does not appear to create any obvious bias, however.

Third, the administrative charges for WC were based on total benefits to premium differences. Total WC benefits include indemnity. It could be that indemnity administration is more expensive than medical administration due to litigation. Medical expenses are less often subject to litigation than indemnity expenses. Hence, we may be overestimating insurance administration for medical expenses. But we will retain this assumption for our analysis of indemnity, hence,

we may likely underestimate administrative costs for indemnity. Moreover, total indemnity expenses are greater than total medical expenses. Hence, by applying the same percentage to both medical and indemnity expenses, we will likely underestimate combined total administrative costs for medical and indemnity benefits.

As a corollary to this third limitation, some might argue that a disadvantage is that some portion of WC payments accrue to lawyers who acted on behalf of injured workers. While this point may have some credibility with indemnity payments, it would not with Medical payments, since the latter are paid to Medical care providers, not to individual injured workers (Berkowitz and Burton 1987).

The fourth limitation is that we must assume the average costs for the illnesses are the same as that for the injuries. This fourth assumption is not terribly problematic given that illnesses probably comprise less than 3% of total WC costs. Boden and Fleischman (1989) together with Rossman, Douglas and Miller (1991) have estimated that illnesses contribute to 2% or less of total WC costs.

Fifth, we must assume that the estimated injuries in the Permanent Total, Permanent Partial, Temporary Total and Partial and Medical Only categories are reasonable (i.e., that the same percentages apply to injuries not captured by WC statistics as those that are captured by WC statistics).

Administrative Costs. Calculation of administrative costs for lost earnings is more complicated than for medical expense. Administrative costs would not accrue for earnings or wages, but for indemnity benefits. The final number in Table 3.3 (\$65.6078) is for lost earnings and output. We first must convert \$65.6078 to indemnity benefits. WC undoubtedly contributes the most for total indemnity, but Social Security disability payments, private disability insurance, and Welfare payments for the disabled would also contribute some indemnity payments. Nelson (1993) estimated total WC indemnity benefits to be \$25.3 billion in 1991. Burton (1993) estimated that total WC premiums were \$60.0 billion in 1992. Burton does not indicate how the \$60.0 billion is split between benefits for medical versus indemnity costs. If we assume the Nelson (1992, 1993) percentages apply, then medical benefits would be $16.8/55.2 = 30.43\%$ for medical and $25.3/55.2$

or 45.83% for indemnity. Multiplying these percentages by \$60 billion yields \$18.26 billion for medical costs and \$27.5 billion for indemnity costs in 1992. We begin with this Burton/Nelson \$27.5 billion estimate for 1992 indemnity.

This \$27.5 billion includes indemnity for deaths. But we will discuss deaths in the "Fatality" section below. We must, therefore, exclude any indemnity for deaths from this analysis. The NCCI data indicate that roughly 2.7% of all indemnity went for deaths. Multiplying 27.5 by $(1 - .027)$ yields 26.75.

We will assume that another \$5.75 billion was paid as indemnity by either Social Security, private disability insurance, or Welfare aid to the disabled. This \$5.75 billion assumption is conservative given that our WC estimate is \$26.75 billion and WC covers approximately 45% of all injuries. The two amounts, \$26.75 and \$5.75 billion sum to \$32.5 billion. This \$32.5 billion represents roughly 50% of the \$65.6078. We, thus, estimate that the sum of all indemnity payments replace roughly 50% of the before-tax earnings. Ehrenberg and Smith (1991) also suggest a 50% for most indemnity plans. Our WC replacement rate was roughly 51%. This 50% for the total including Social Security, Welfare, and so on, is less because we were conservative in assigning only 5.75 billion for indemnity to Social Security, Welfare, and so on.

To calculate administrative expenses, we assume a 31% rate for WC and a 10% rate for all other insurers. Above, we assumed a 16% rate for all others. But, private medical insurance is more pervasive than private disability insurance. Most non-WC indemnity was probably paid by government and government has low administrative costs. Assuming these two percentages, we, thus, calculate administrative costs as:

$$\begin{aligned} &(\$26.75 \times .31) + (5.75 \times .1) \\ &= 8.2925 + .575 = \$8.8675 \text{ billion} \end{aligned}$$

We therefore estimate that administrative costs would equal $\$8.8675 / \$65.6078 = .135$ or 13.5% of lost earnings.

Property Damage. Property damage is estimated with figures from Blincoe and Faigin (1992) on the cost of all motor vehicle crashes (whether or not job related). Tables are available in Blincoe and Faigin (1992) that estimated costs of crashes resulting in injuries and excluding crashes not resulting in injuries.

For crashes resulting in injuries, property damage was estimated to be \$16.483 billion in 1990, and medical costs were estimated to \$13.887 billion. The ratio of property damage cost to medical costs was 1.18694. We use this 1.8694 factor in our calculations below. First, we estimate the medical costs associated with job-related motor vehicle crashes. We then multiply these medical costs by 1.8694.

Toscano and Windau (1993) found 18% of injury deaths due to motor vehicle crashes and an additional 7% due to farm and industrial vehicle accidents for a total of 25%. The NIOSH researchers found a 23% rate for all vehicle crash deaths in the NTOF (National Institute Occupational Safety and Health 1993). Leigh (1995a) estimated over 25% of injury deaths were due to motor vehicle crashes in the SDS and in a related study, found over 22% of Permanent Partial disabilities (PPs) to involve motor vehicle crashes (Leigh 1995d). PPs, as we have seen, involve the greatest share of costs of all WC categories of costs.

Motor vehicle crashes tend to generate more fatalities and serious injuries per accident than any other job-related accident. We, therefore, assume 18% (rather than 25%, or 23%, or 22%) of all injuries and all costs can be attributed to motor vehicle crashes. As a corollary, we assume that 18% of medical costs arise from vehicle crashes.

The Blincoe and Faigin (1992) factor 1.18694 can then be multiplied by 18% of medical costs as follows: $1.18694 \times .18 \times \$25.0739 \text{ billion} = \$5.3570 \text{ billion}$.

But property damage can also occur to other equipment, not just motor vehicles. On a per injury basis, however, this is less likely to be as severe. Motor vehicle crashes generate more serious and expensive injuries than other accidents (Rice et al. 1989; National Safety Council 1993). Falls, for example, are responsible for a high percentage of industrial accidents. It is unlikely that falls would damage as much equipment as motor vehicle crashes. Nevertheless, property damage will result for some non-motor vehicle crashes. Fires, explosions, aircraft, boating and railway accidents are likely to result in considerable property damage. The CPOI investigators found that fires through railway accidents were responsible for 12% of all deaths. But fires, explosions, aircraft crashes, boating and railway accidents tend to generate more serious injuries than other accidents. We therefore assume that the 10% of injuries resulting from fires

through railway accidents would cause an equivalent amount of damage as motor vehicle crashes. We further assume that all other injuries cause no property damage. Finally, we assume that costs comprise the same percentage as injuries: 10%. To estimate property damage for injuries not involving vehicle crashes, we make the following calculations:

$$1.18694 \times .10 \times \$25.0739 = \$2.9761$$

where 1.18694 is the Blincoe and Faigin factor, \$25.0739 is our estimate of medical costs, .10 represents the 10% of costs direct costs that would be attributed to fires, explosions, aircraft crashes, boating accidents, and railway accidents.

In these calculations, we have used the Blincoe and Faigin ratio of property damage costs to medical costs. We chose to anchor this ratio with medical costs in the denominator since our estimate of medical cost involved the fewest and most defensible assumptions of all of our cost calculations.

The total property damage estimate would then be \$8.3331. Our property damage cost ratio to medical cost is, therefore, .33, considerably less than the Blincoe and Faigin 1.18694 ratio. The reason is that injuries not related to motor vehicle crashes or fires, explosions, aircraft crashes, boating and railway accidents are not as likely to generate as much property damage as injuries resulting from motor vehicle crashes.

Blincoe and Faigin have another category for legal and court costs. In our case, the majority of these costs would already be included in our health insurance administration costs. Blincoe and Faigin found the legal and court costs for injuries and property damage were 64% as large as the medical costs. Blincoe and Faigin's legal and court costs are undoubtedly higher than our costs on a per injury basis because a primary purpose of WC was to remove legal and court costs. We will assume that an additional 5% of property damage would cover legal and court fees surrounding these accidents. Our estimate for damage would be $8.3490 \times 1.05 = \$8.7497$ billion.

Police and Fire Services. Blincoe and Faigin also estimated costs for emergency services. Some of these emergency services involved ambulance costs which would already have been included in our medical costs. But other emergency

services involved police and fire services. Police, for example, would be required to investigate an assault or murder. Firefighters would be required to put out a warehouse fire. Assuming half of Blincoe and Faigin's emergency services are police and fire services, and applying the same ratio technique as above to all injuries, we estimate \$.7801 billion for police and fire services.

Finally, we add direct costs to innocent third parties, e.g. vacation travelers on a crashed airline. A thorough discussion of these costs appears below under the Collateral Damage section.

Table 5.2 summarizes our data from this section.

Table 5.2

Estimate of Total Direct Costs

	Billions of Dollars
Total Direct Costs	\$50.1046
1. Medical Only	25.0739
2. Medical Administration Costs on WC (31%); and Private Insurance, Medicaid, Welfare and Medicare (16%, combined)	5.7012
3. Indemnity Administration Costs on WC (31%); and Social Security, Welfare, and Private Insurance Combined (10%)	8.8675
4. Property Damage	8.7497
5. Police and Fire Services	.7801
6. Injuries to Innocent Third Parties (32% of Total For Third Parties Since Many Fatals With Large Indirects)	.9322

Source: Current Study

We turn now to indirect costs.

II. Indirect Costs: NCCI Indemnity, Present Value, and Other Calculations

This section will present a calculation of the indirect costs based upon indemnity data in the NCCI, national government data on employment, earnings, and mortality probabilities and cost estimates from related studies on indirect costs. As we will see, there are a number of categories for indirect costs and several sources of data will have to be analyzed to provide a reliable estimate.

The largest category of indirect costs is lost wages or lost total employment compensation which includes lost wages and the value of fringe benefits. There are two components of lost compensation: morbidity costs (non-fatal injuries) and mortality costs (fatal injuries). The NCCI data will prove useful in estimating morbidity, but not mortality costs. We will first analyze morbidity and second, mortality costs.

II.B.1. NCCI Indemnity

The NCCI reports contain data on the total amount of indemnity dollars paid by WC in the various WC categories: Deceased, Permanent Total, Permanent Partial, Temporary Total and Partial, and Medical Only. Within the deceased category, WC payments are not for lost wages. They are paid to spouses, sometimes as a lump sum death benefit and sometimes as indemnity until the spouse re-marries. They are also paid as indemnity to children up to age 18 and sometimes 22 if the children stay in school.

The indemnity payments under the deceased category would not be reliable measures of the present value of lost compensation for the deceased. We, therefore, will rely on our own present value calculations for the deceased as described below.

It would be tempting to include the persons in the Permanent Total category as equivalent to the deceased category for the cost calculations. However, the category title--Permanent Total (PT)--is deceptive. Many WC private carriers will settle a PT case with a lump sum payment within a year or two after the injury or illness occurs or is contracted. In the case of monthly indemnity payments, some states do not guarantee that WC indemnity benefits to be paid to all PT victims until retirement age. In some states, persons with PT injuries are encouraged to acquire training for new jobs while receiving indemnity (Berkowitz and Burton 1987). If new work is found, PT indemnity benefits may cease. Hence, the lost earnings for persons with PT injuries would not be the same as for deceased persons.

The NCCI indemnity payments for PTs and PPs involve some forecasted dollars. The forecasts for PPs and PTs are not necessarily for the lifetime of the injured workers. Many WC boards reason that over time, most workers become accommodated to the permanent injury (especially partial) and find new jobs. The idea of the PP indemnity and, to a much lesser extent, PT indemnity, is to allow them time to adapt. Many states and D.C. will pay PP indemnity for only three to fifteen years (Berkowitz and Burton 1987; U.S. Chamber of Commerce 1992). On the other hand, all states will allow PT benefits to proceed well into retirement age if no alternative work can be found.

The indemnity data for PT, PP, and TTP can be used to construct lost earnings. The NCCI indemnity numbers per case cannot simply be used "as is." They underestimate wage loss. The indemnity payments for persons with Permanent Total conditions have been criticized by a number of researchers as being especially inadequate (see references in Rejda 1991; DeVol 1986; and Berkowitz and Burton 1987). Permanent Total payments are frequently made in a lump sum that releases the insurer from further liability. PT payments are also made as percentages of lost wages. In both cases, it is claimed that WC rarely provides adequate benefits until the person can find alternative employment or until retirement age (Rejda 1991; DeVol 1986; Berkowitz and Burton 1987). This criticism of inadequate wage loss benefits is not as great for Permanent Partial (PP) or Temporary Total and Partial (TTP) injuries (Rejda 1991).

The percent of the wage covered by WC indemnity is referred to as the replacement rate. Most frequently, replacement rates are expressed for after-tax wages. We, on the other hand, need before-tax replacement rates since it is the before-tax wage that measures output. Indirect costs are not meant to measure the loss of a workers' take-home pay, but to measure lost output for the nation. Berkowitz and Burton (1987) found after-tax replacement rates to differ by age, by gender, across time and, most importantly, across states. The WC statutes themselves within each state are an imperfect guide to estimating replacement rates since the type of injury within any of the categories (i.e., scheduled and unscheduled benefits, can also greatly affect the replacement rate).

We will assume that before-tax replacement rates were .4 for PTs, .5 for PPs, and .6 for TTPs. We do not use a wage-replacement calculation in the one to seven days lost category. Berkowitz and Burton (1987) found after-tax replacement rates ranged from 75% for some TTPs to 25% for some PPs. But these 75% to 25% rates in Berkowitz and Burton were extreme (not average) rates and were also calculated for after-tax earnings. Since before-tax earnings are greater than after-tax, the before-tax rate will be less than the after-tax rate. In addition, no states awarded an indemnity greater than 66% of the before-tax wage at the time our NCCI data were collected (1988-92). Finally, it is generally accepted that replacement rates for most government indemnity plans including WC are roughly 50%

on before-tax wages (Ehrenberg and Smith 1991). Our .4, .5, and .6 assumptions average to .5. But more importantly, as we will see, the amount of costs for PTs under the .4 assumption (\$6.9994) roughly equals the amount of costs for TTPs (\$7.4581). Thus, our weighted average replacement rate was calculated to be .51. This is a conservative number. Had we assumed a .5 rate, our lost earnings projection would have been higher than they were with a .51 rate.

The indemnity payments in the NCCI Ultimate Reports might be criticized for the forecasting problem noted above. But, again, over 90% of claims are settled within three years. Moreover, the actuaries handling the claims are in a better position than we are to know what the future payments will be. Finally, the dollars paid for indemnity would be easier to forecast than medical expenses since indemnity benefits are based on the percent on the person's wage at the time of injury, plus an inflation adjustment.

The NCCI Ultimate Report for May 1993 contains indemnity payments on all WC categories—Death through Medical Only. For example, the total indemnity payment for Permanent Total injury cases numbered 4759 and amounted to \$1,166,082,099. These cases were from policies originating in either 1988 or 1989 or 1990, depending on the state. Dollars were paid from 1988 to December 1992, depending on the state and the claim.

Table 5.3 presents the calculations necessary to estimate the wage losses for Permanent Total (PT), Permanent Partial (PP), Temporary Total and Partial (TTP) and other injuries. Persons who do not report work loss (non-disabling) would have zero wage losses. The WC categories appear in column 1. Column 2 presents the indemnity cost per case. These data are drawn from the May 1993, NCCI Ultimate Report. Column 3 presents the per case cost divided by our assumed replacement rate. Our replacement rates must necessarily reflect before-tax earnings since these rather than after-tax earnings indicate the human capital contribution to GDP. We assumed a .4 rate for PTs, a .5 rate for PPs, and a .6 rate for TTPs.

The \$288 in row 5 was calculated assuming that, on average, three days of work loss occurred in the category and the average wage was \$12 per hour and the average workday was eight hours. Twelve dollars per hour represents \$24,000 per

year as an average wage or salary for all employees in 1992. (See earnings figures from Tables 5.5 and 5.6).

Column 2 reproduces the estimates from Chapter 2, Table 2.12. We do not include collateral damage in our calculation of morbidity or morality costs for the workers themselves. In column 5, the estimated cases in column 4 were multiplied by the per case cost in column 3. Estimates in column 6 adjust for inflation using the CPI-U-X1. In the May 1993 Ultimate Report, most of the cases originated in 1988 or 1989. But these costs could have been incurred anytime from 1988 through 1992. We chose 1990 as our average year. The total for 1992--\$65.6078 billion--appears at the bottom right corner of Table 5.3. This \$65.6078 billion does not include administrative costs, fringe benefits, present value of wages for fatalities, and additional indirect costs such as employer training costs. Below, we address each of these omitted indirect costs.

Table 5.3

**Estimated Before-Tax Wage Loss
Based on NCCI Average Indemnity Costs**

1	2	3	4	5	6
Category	Per Case	Per Case divided by either .4 (PT) or .5 (PP) or .6 (TTP); One to Seven not affected	1992 Estimated Cases (Chapter 2)	Product (\$ Billions)	1990 to 1992 Wage Inflation Col. 5 x 1.07345*** (\$ Billions)
1. Deaths*			6,529		
2. Permanent Total	\$243,187	\$607,968	10,725	\$ 6.5205	\$ 6.9994
3. Permanent Partial	\$ 30,239	\$ 60,478	771,547	\$46.6617	\$50.0889
4. Temporary Total and Temporary Partial	\$ 2,208	\$ 3,680	1,877,980	\$ 6.9478	\$ 7.4581
5. One to Seven days lost	does not apply	\$ 288**	3,433,378	\$.9888	\$ 1.0614
Non-disabling	0		7,153,400	0	0
Total					\$65.6078 billion

* Does not apply since death benefits paid to spouse until re-married and children until 18 or 21 (depending on the state).

** Assuming 3 days of loss, 8 hours per day, and \$12 per hour.

*** Wage inflation was estimated with the CPI-U-X1.

Source: Our study

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 5.3 which was typed in Microsoft Word for IBM and is labeled TBL53WRD.DOC on the diskette.

Fringe Benefits. For our purposes, employer-financed fringe benefit losses include employer provided health, dental, life, unemployment and WC insurance, child care, Social Security contributions, and pensions. Our calculations of fringe benefits will not include paid vacations or holiday pay. These last two benefits are already reflected in our estimate of before-tax earnings.

Some readers may object to including any fringe benefits in our calculations. However, the purpose of measuring indirect costs is to measure a person's lost contribution to society as measured by his or her production on-the-job (and at home). Economic theory suggests that the worker's contribution to production to the firm should equal what the firm must pay to attract him or her. Part of the attraction to any job would be the value of fringe benefits.

The U.S. Chamber of Commerce estimated the percentage to be 35% of total compensation or over 54% of earnings ($35/65 = .54$) in recent years (U.S. Chamber of Commerce 1993b). But some researchers have questioned the methodology of the Chamber of Commerce study. The Chamber of Commerce, for example, looked only at large firms and included paid vacations and holiday pay as part of fringe benefits. This 35% or 54% figure is probably too high.

A more recent BLS study (Brinkley 1994) estimated a 29.6% rate for full-time workers and 20.9% rate for part-time workers out of total compensation and ($30/70=$) 42% and ($21/79=$) 26% out of wages. But these 29.6% and 20.9% also included vacations. Subtracting vacations and supplemental pay attempting to cover all firms, large and small, the BLS estimated fringe benefits at 24.7% of wages and salaries in 1988 (Piacentini 1990).

In a study described below, Miller and Galbraith (1994) assumed a 20% rate out of wages based on data in the *Economic Report of President*.

We will (conservatively) assume a 21% rate out of wages. (As explained below, we assumed a 22% rate for men and 16% for women in the present value calculations. Men more frequently work full-time than women and full-time jobs provide more fringe benefits per dollar of wages). Multiplying .21 by \$65.6078 yields \$13.7776 billion, our estimate for fringe benefits for non-fatal earnings losses.

Fatalities. Fatalities require a present value calculation. We will take a similar approach to calculating the present value as taken by Rice et al. (1989). We assume that persons who died would have earned what others of the same age and gender earned. This is the same assumption used by Rice et al. (1989), Max et al. (1993), Miller and Galbraith (1994) and all other mortality cost estimates using the Direct/Indirect method with which we are familiar.

First, we consider the age and gender composition of our deceased workers. Table 5.4 indicates our estimates of the number of job-related injury deaths in 1992 by sex and age. The percentages were drawn from Toscano and Windau (1993). The estimated numbers of deaths within each category were derived simply by multiplying the percent with our estimated deaths: 6,529. For example, the estimated number of male deaths equals $6,529 \times .93$ or 6,072.

The age and sex data on the deaths were combined with information on wages (U.S. Department of Commerce 1993); probabilities that persons will survive to age 75 (U.S. Bureau of the Census 1993); as well as the employment within those categories (U.S. Bureau of Census 1993). The 65 year was chosen as the average year for retirement.

Table 5.4

Estimated Number and Percent Distribution of
Fatal Injuries by Gender and Age

	<u>Fatalities</u>		<u>Toscano and Windau Employment*</u>
	<u>Number</u>	<u>Percent</u>	
Total	6529	100	119,583,000
<u>Sex</u>			
Men	6072	93	65,209,000
Women	457	7	53,955,000
<u>Both Sexes</u>			
Under 20 years	196	3	5,921,000
20 to 24 years	588	9	12,664,000
25 to 34 years	1632	25	33,068,000
35 to 44 years	1632	25	31,953,000
45 to 54 years	1241	19	21,283,000
55 to 64 years	783	12	11,269,000
65 years and older	522	8	3,427,000

*Includes 1,566,000 for the U.S. Military residing in the United States.

Source: Our study and the Census of Fatal Occupational Injuries.

The present value formula we use is similar to the one in Rice et al. (1989).

$$PV_{\text{death}} = \sum_{n=y}^{75} P_{y,s,n} \times [M_{s,n} + H_{s,n} + F_{s,n}] \times LFPR \times \frac{(1+g)^{75-n}}{(1+r)^{75-n}}$$

where PV_{death} = present discounted value of loss due to injury death per person;

$P_{y,s,n}$ = probability that a person of sex s and age y will survive to age n ;

y = age at which person was injured;

s = sex of person;

n = age of person;

$M_{s,n}$ = mean annual earnings of employed persons of sex s and age n ;

$H_{s,n}$ = annual value of household production for person of sex s and age n ;

$LFPR_{s,n}$ = proportion of the population of sex s and age n that are employed in the labor market, i.e., the labor force participation rate. The $LFPR = 1$ for persons over age 64 at time of death.

$F_{s,n}$ = fringe benefits for sex s and age n ;

g = rate of increase of labor productivity, assumed to be 1%;

r = real discount rate, assumed to be 4%.

The LFPR above deserves comment. Most people retire at or before age 65. We assumed that persons who died prior to 65 would have a LFPR of typical persons now over age 65 (e.g., .161 for men and .083 for women). However, some of our decedents, prior to deaths, were over 65 and still working. For these people, we assumed a LFPR of 1.0 (i.e., we assumed that they would have continued working until age 75). We assumed no one would work beyond age 75.

Table 5.5 presents the present value calculations for a woman and Table 5.6 presents them for a man. We were able to find data only within age categories, not within each age. Table footnotes explain the heading in each column. Briefly, the $P1$'s through $P10$'s represent the probabilities of survival from one age to the next (U.S. Bureau of the Census 1993). The $R1$'s through $R10$'s represent the ratio of the productivity to the discount rate factor. M represents average annual earnings for full-time and part-time employees (U.S. Department of Commerce 1993).

H represents the annual value of household production. The contribution of the individual to economic and social output should include home production. Home production included changing diapers, reading to children, home repairs, building cabinets, plumbing repairs, and so on (and on!). Home production can take place anytime of the day. Estimates on home production were drawn from Douglas, Kenney, and Miller (1990) and updated to 1992 using the CPI-U-X1. These Douglas et al. (1990) estimates assume: 1) higher productivity in the labor market implies higher productivity at home; 2) women, because of socialization and job market discrimination, have more home production than men; 3) women of child-rearing age provide the greatest amount of home production; and 4) women are more likely than men to work part-time and work more hours than men at home.

TABLE 5.5

PRESENT VALUE OF A FEMALE DEATH
Probability of Living ($P_1 - P_{10}$)²Discount Factor ($R_1 - R_{10}$)³

Present Age ¹ Age ¹	Age Group ²																				
PA	A	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
PV(<20) Dies at 19 yrs 364 days	20-24	0.9995	0.999	0.999	0.998	0.998	0.997	0.996	0.993	0.992	0.992	0.971	0.943	0.916	0.890	0.864	0.725	0.704	0.684	0.664	0.645
	25-34	0.997	0.997	0.996	0.996	0.995	0.994	0.994	0.993	0.992	0.992	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	35-44	0.991	0.990	0.989	0.988	0.987	0.986	0.984	0.983	0.981	0.980	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	45-54	0.978	0.976	0.973	0.971	0.968	0.964	0.961	0.957	0.953	0.948	0.467	0.454	0.441	0.428	0.416	0.404	0.392	0.381	0.370	0.359
PV(20-24) Dies at 24 yrs 364 days	25-34	0.9995	0.999	0.998	0.998	0.997	0.997	0.996	0.995	0.995	0.994	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	35-44	0.993	0.992	0.991	0.990	0.989	0.988	0.987	0.985	0.984	0.982	0.725	0.704	0.684	0.664	0.645	0.626	0.608	0.590	0.573	0.557
	45-54	0.980	0.978	0.976	0.973	0.970	0.967	0.963	0.959	0.955	0.950	0.541	0.525	0.510	0.495	0.481	0.467	0.454	0.441	0.428	0.416
	55-64	0.945	0.940	0.933	0.927	0.919	0.911	0.915	0.891	0.881	0.869	0.404	0.392	0.381	0.370	0.359	0.349	0.339	0.329	0.319	0.310
PV(25-34) Dies at 29 yrs 364 days	30-34	0.999	0.999	0.998	0.997	0.997	0.997	0.996	0.995	0.995	0.994	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	35-44	0.996	0.995	0.994	0.993	0.992	0.991	0.989	0.988	0.986	0.985	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	45-54	0.983	0.981	0.978	0.976	0.973	0.970	0.966	0.962	0.958	0.953	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	55-64	0.948	0.942	0.936	0.929	0.922	0.913	0.904	0.894	0.883	0.871	0.467	0.454	0.441	0.428	0.416	0.404	0.392	0.381	0.370	0.359
PV(35-44) Dies at 39 yrs 364 days	40-44	0.999	0.998	0.996	0.995	0.993	0.993	0.993	0.993	0.992	0.991	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	45-54	0.991	0.989	0.986	0.984	0.981	0.978	0.974	0.970	0.966	0.961	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	55-64	0.956	0.951	0.944	0.938	0.930	0.922	0.912	0.902	0.891	0.880	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	65-74	0.867	0.853	0.839	0.823	0.805	0.785	0.764	0.740	0.713	0.683	0.467	0.454	0.441	0.428	0.416	0.404	0.392	0.381	0.370	0.359
PV(45-54) Dies at 49 yrs 364 days	50-54	0.997	0.993	0.989	0.985	0.980	0.980	0.971	0.963	0.953	0.941	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	55-64	0.975	0.970	0.963	0.957	0.949	0.941	0.931	0.921	0.911	0.899	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	65-74	0.886	0.872	0.858	0.842	0.824	0.804	0.783	0.759	0.732	0.692	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	364 days	0.992	0.982	0.972	0.962	0.950	0.941	0.939	0.939	0.939	0.939	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
PV(55-64) Dies at 59 yrs 364 days	60-64	0.992	0.982	0.972	0.962	0.950	0.941	0.939	0.939	0.939	0.939	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	65-74	0.935	0.921	0.907	0.891	0.873	0.853	0.839	0.808	0.781	0.741	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	364 days	0.987	0.971	0.955	0.938	0.922	0.902	0.877	0.852	0.826	0.801	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	65+	0.987	0.971	0.955	0.938	0.922	0.902	0.877	0.852	0.826	0.801	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746

TAB. 4.5 Continued

Average Annual earnings ^a	Home Prod. ^b	Fringe Benefits M • 16 ^c	Combined earnings ^d (M + H + F)	Probability of Living • Discount Factor (P•R) ^e										Σ P1 x RJ ^h 1 = 1 to 10	Labor Force Part. Rate ¹¹		Product	Present Value of Combined Earnings Adjusted for Mortality ¹²
				P1•R1	P2•R2	P3•R3	P4•R4	P5•R5	P6•R6	P7•R7	P8•R8	P9•R9	P10•R10		S	LFPR		
8,280	6,618	1,325	16,223	0.971	0.942	0.915	0.888	0.862						4.578	0.712	52881	\$494,926	
17,675	9,484	2,828	29,987	0.836	0.813	0.788	0.765	0.742	0.721	0.700	0.679	0.659	0.640	7.342	0.741	163147		
19,975	10,462	3,196	33,633	0.620	0.602	0.584	0.566	0.550	0.533	0.517	0.501	0.486	0.471	5.430	0.768	140258		
20,870	9,540	3,339	33,749	0.457	0.443	0.429	0.416	0.403	0.389	0.377	0.365	0.353	0.340	3.971	0.727	97429		
17,176	9,530	2,748	29,454	0.329	0.318	0.306	0.295	0.284	0.273	0.263	0.252	0.242	0.232	2.795	0.466	38360		
9,773	7,955	1,564	19,292	0.222	0.212	0.202	0.193	0.183	0.173	0.164	0.154	0.144	0.134	1.781	0.083	2851		
17,675	9,484	2,828	29,987	0.971	0.942	0.914	0.888	0.861	0.836	0.812	0.787	0.764	0.742	8.517	0.741	189258	\$508,769	
19,975	10,462	3,196	33,633	0.720	0.698	0.678	0.657	0.638	0.618	0.600	0.581	0.564	0.547	6.302	0.768	162780		
20,870	9,540	3,339	33,749	0.530	0.513	0.498	0.482	0.467	0.452	0.437	0.423	0.409	0.395	4.605	0.727	112993		
17,176	9,530	2,748	29,454	0.382	0.368	0.355	0.343	0.330	0.318	0.005	0.293	0.281	0.269	2.945	0.466	40425		
9,773	7,955	1,564	19,292	0.258	0.246	0.235	0.224	0.213	0.201	0.190	0.179	0.167	0.156	2.069	0.083	3313		
18,860	10,220	3,018	32,098	0.970	0.942	0.914	0.887	0.861						4.575	0.741	108813	\$484,492	
19,975	10,462	3,196	33,633	0.836	0.811	0.786	0.763	0.740	0.718	0.696	0.676	0.655	0.635	7.316	0.768	188974		
20,870	9,540	3,339	33,749	0.615	0.596	0.577	0.559	0.542	0.525	0.507	0.491	0.474	0.458	5.345	0.727	131148		
17,176	9,530	2,748	29,454	0.443	0.428	0.413	0.398	0.384	0.369	0.354	0.341	0.327	0.313	3.768	0.466	51712		
9,773	7,955	1,564	19,292	0.299	0.286	0.273	0.260	0.247	0.234	0.220	0.208	0.194	0.181	2.402	0.083	3846		
20,304	10,279	3,249	33,832	0.970	0.941	0.912	0.886	0.858						4.567	0.768	118662	\$371,012	
20,870	9,540	3,339	33,749	0.831	0.806	0.780	0.756	0.732	0.709	0.686	0.663	0.641	0.620	7.224	0.727	177257		
17,176	9,530	2,748	29,454	0.598	0.578	0.557	0.537	0.518	0.499	0.479	0.460	0.441	0.423	5.091	0.466	69878		
9,773	7,955	1,564	19,292	0.405	0.387	0.370	0.352	0.335	0.317	0.299	0.282	0.264	0.245	3.257	0.083	5215		
20,279	9,540	3,245	33,064	0.968	0.936	0.906	0.877	0.847						4.534	0.727	108980	\$211,730	
17,176	9,530	2,748	29,454	0.818	0.791	0.762	0.735	0.708	0.682	0.655	0.630	0.605	0.580	6.966	0.466	95607		
9,773	7,955	1,564	19,292	0.555	0.530	0.506	0.482	0.459	0.435	0.411	0.387	0.362	0.333	4.461	0.083	7143		
15,698	9,530	2,512	27,740	0.963	0.926	0.890	0.856	0.821						4.457	0.466	57609	\$67,771	
9,773	7,955	1,564	19,292	0.784	0.751	0.717	0.684	0.651	0.618	0.591	0.553	0.519	0.478	6.346	0.083	10162		
9,773	7,955	1,564	19,292	0.959	0.916	0.874	0.835	0.797	0.757	0.714	0.674	0.635	0.597	7.758	1.000	149665	\$149,665	
															(or 0.083) ¹³	(or 12422) ¹⁵	(or \$12,422)	

TABLE S.5 Continued

Present Value of Earnings Adjusted for Mortality ¹³ (excluding H and F)	PV2	Present Value of Earnings Adjusted for Mortality ¹⁴ (including F and excluding H)	PV3
	\$290,516		\$336,998
	\$303,355		\$351,891
	\$289,374		\$335,674
	\$224,219		\$260,094
	\$126,212		\$146,406
	\$37,749		\$43,789
	\$73,819		\$87,950
¹⁵ (or \$6,293)	¹⁵	(or \$7,300)	¹⁵

FOOTNOTES

¹ PA (Present Age) indicates the age at death.

² A (Age Group) is the range for which the Present Value (PV) is to be calculated.

³ P1 - P10 (Probability of Living) indicates the probability of living from the present age to all future ages. For example, 0.997 in the second row, under column P1 indicates that a typical 19 year old dying the day before the 20th birthday would have had a 0.997 chance of surviving to age 25 without the job related death at the age of 19.

Source: P1 - P10 (Probability of living) values were obtained from Statistical Abstract of the United States 1993, U.S. Department Of Commerce, Bureau of the Census (Table No. 117, Pg 86).

⁴ R (Discount Factor) is given by $R = (1.01/1.04)$ and N = the number of years a person would have survived from the present age to all future ages. For example, 0.943 under column R2, row 1 is the square of $(1.01/1.04)$.

Productivity is assumed to be 1 % and the real discount rate, 4 %.

⁵ M (Average Annual Earnings) indicates the mean annual earnings of females with earnings within each age group.

Source: M (Mean Annual Earnings) were obtained from Money Income of Households, Families and Persons in the United States 1992, U.S. Dept. of Commerce, Bureau of the Census (Table 30, Pg 146).

⁶ H = Value of average annual production at home. Home production figures are drawn from Douglas, Kenney and Miller (1990), p. 39, updated to 1992 with the CPI - U - X1.

⁷ F = Fringe benefits, assumed to be 16% of earnings for women and 22% of earnings for men.

⁸ C = Average annual earnings + Home production + fringe benefits.

⁹ P1 x R1 = Probability of living times Discount Factor for 1st year; P2 x R2 = Probability of living times Discount Factor for 2nd year; ...

¹⁰ Sum of $P1 \times R1 + P2 \times R2 + \dots$

¹¹ LFPR is the labor force participation rate.

Source: Statistical Abstract of the United States 1993, U.S. Department of Commerce, Bureau of the Census (Table No. 622, p. 393).

¹² PV1 (Present Value) indicates the present discounted value of loss due to injury death per person.

Using symbols from the text:

$$PV_{\text{monthly}} = \sum_{t=1}^{\infty} P_{t,PA} [(M_{t,A} \times H_{t,A} + F_{t,A}) \times LFPR_{t,A}] \times \frac{(1+r)^{-t}}{(1+r)^{-t}}$$

Using symbols from the table:

$$PV_{\text{monthly}} = \sum C \times S \times LFPR$$

¹³ PV2 identical to PV1 above, only excludes home production (H) and fringe benefits (F).

¹⁴ PV3 identical to PV1 above, only excludes home production (H) and includes fringe benefits (F).

¹⁵ LFPR = 1 for those who died after age 64 and LFPR = 0.903 for those who died before age 64.

TABLE 5.6

PRESENT VALUE OF A MALE DEATH
Probability of Living ($P_1 - P_{10}$)²Present Age¹
Age Group³Discount Factor ($R_1 - R_{10}$)⁴

PA	A	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
PA(<20) Dies at 19 yrs 364 days	20-24	0.999	0.997	0.996	0.994	0.993						0.971	0.943	0.916	0.890	0.864					
	25-34	0.991	0.990	0.988	0.986	0.985	0.983	0.981	0.979	0.977	0.975	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	35-44	0.973	0.971	0.968	0.966	0.963	0.960	0.958	0.955	0.952	0.948	0.626	0.606	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	45-54	0.944	0.940	0.936	0.932	0.926	0.921	0.915	0.908	0.901	0.892	0.467	0.454	0.441	0.428	0.416	0.404	0.392	0.381	0.370	0.359
PA(20-24) Dies at 24 yrs 364 days	55-64	0.883	0.873	0.862	0.850	0.836	0.821	0.805	0.787	0.767	0.746	0.349	0.339	0.329	0.319	0.310	0.301	0.292	0.284	0.276	0.268
	65-74	0.723	0.694	0.665	0.636	0.607	0.572	0.527	0.483	0.438	0.394	0.260	0.233	0.245	0.238	0.231	0.225	0.218	0.212	0.206	0.200
	25-34	0.998	0.997	0.995	0.994	0.992	0.990	0.988	0.987	0.985	0.982	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746
	35-44	0.980	0.878	0.975	0.973	0.970	0.968	0.965	0.962	0.959	0.955	0.775	0.704	0.684	0.664	0.645	0.626	0.608	0.590	0.573	0.557
PA(25-34) Dies at 29 yrs 364 days	45-54	0.952	0.948	0.943	0.939	0.934	0.928	0.922	0.915	0.908	0.899	0.541	0.525	0.510	0.495	0.481	0.467	0.454	0.441	0.428	0.416
	55-64	0.890	0.800	0.869	0.857	0.843	0.829	0.812	0.794	0.774	0.753	0.404	0.392	0.381	0.370	0.359	0.349	0.339	0.329	0.319	0.310
	65-74	0.730	0.701	0.672	0.643	0.614	0.579	0.534	0.490	0.445	0.401	0.301	0.292	0.284	0.276	0.268	0.260	0.253	0.245	0.238	0.231
	30-34	0.998	0.996	0.995	0.993	0.990						0.971	0.943	0.916	0.890	0.864					
PA(35-44) Dies at 39 yrs 364 days	45-54	0.988	0.986	0.983	0.981	0.978	0.976	0.973	0.970	0.967	0.963	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	55-64	0.960	0.956	0.951	0.947	0.942	0.936	0.930	0.923	0.916	0.907	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	65-74	0.898	0.888	0.877	0.865	0.851	0.837	0.820	0.802	0.782	0.761	0.467	0.454	0.441	0.428	0.416	0.404	0.392	0.381	0.370	0.359
	40-44	0.997	0.995	0.992	0.988	0.985						0.971	0.943	0.916	0.890	0.864					
PA(45-54) Dies at 49 yrs 364 days	55-64	0.981	0.977	0.973	0.968	0.963	0.958	0.952	0.945	0.937	0.929	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	65-74	0.920	0.910	0.899	0.887	0.873	0.858	0.842	0.824	0.804	0.783	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	30-34	0.760	0.731	0.702	0.673	0.644	0.609	0.564	0.520	0.475	0.431	0.467	0.454	0.441	0.428	0.416	0.404	0.392	0.381	0.370	0.359
	50-54	0.994	0.988	0.982	0.974	0.966						0.971	0.943	0.916	0.890	0.864					
PA(55-64) Dies at 59 yrs 364 days	65-74	0.957	0.955	0.956	0.951	0.951	0.895	0.878	0.860	0.841	0.820	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
	35-44	0.797	0.768	0.739	0.710	0.681	0.646	0.601	0.557	0.512	0.468	0.626	0.608	0.590	0.573	0.557	0.541	0.525	0.510	0.495	0.481
	60-64	0.985	0.969	0.951	0.931	0.910						0.971	0.943	0.916	0.890	0.864					
	65-74	0.887	0.858	0.829	0.800	0.771	0.735	0.691	0.647	0.602	0.558	0.839	0.815	0.791	0.768	0.746	0.725	0.704	0.684	0.664	0.645
PA(65+) Dies at 64 yrs 364 days	65+	0.977	0.948	0.919	0.890	0.861	0.826	0.781	0.737	0.692	0.648	0.971	0.943	0.916	0.890	0.864	0.839	0.815	0.791	0.768	0.746

TABLE Continued

Average Annual earnings ^a	Home Prod. ^b	Fringe Benefits ^c M • .22 ^d (M + H + F)	Combined earnings ^e C	Probability of Living • Discount Factor (P•R) ^f										Σ P1 x R1 ¹⁰ i = 1 to 10	Labor Force Part. ¹¹ Rate ¹²	Product	Present Value of Combined Earnings Adjusted for Mortality ¹³ PVI	
				P1•R1	P2•R2	P3•R3	P4•R4	P5•R5	P6•R6	P7•R7	P8•R8	P9•R9	P10•R10					S
9,964	3,573	2,192	15,729	0.970	0.940	0.912	0.885	0.858							4.565	0.833	59814	\$795,108
24,761	4,374	5,447	34,582	0.831	0.807	0.782	0.757	0.735	0.713	0.691	0.670	0.649	0.629	7.262	0.938	235580		
34,878	4,983	7,673	47,534	0.609	0.590	0.571	0.554	0.536	0.519	0.503	0.487	0.471	0.456	5.297	0.938	236181		
38,864	5,077	8,550	52,491	0.441	0.427	0.413	0.399	0.385	0.372	0.359	0.346	0.333	0.320	3.795	0.908	180868		
32,603	5,207	7,173	44,983	0.308	0.296	0.284	0.271	0.259	0.247	0.235	0.224	0.212	0.200	2.535	0.670	76411		
20,222	4,457	4,449	29,128	0.188	0.175	0.163	0.152	0.140	0.129	0.115	0.102	0.090	0.079	1.334	0.161	6254		
24,761	4,374	5,447	34,582	0.969	0.940	0.911	0.885	0.857	0.831	0.805	0.781	0.756	0.733	8.468	0.938	274687	\$853,610	
34,878	4,983	7,673	47,534	0.711	0.618	0.667	0.646	0.626	0.606	0.587	0.568	0.550	0.532	6.109	0.938	272380		
38,864	5,077	8,550	52,491	0.515	0.498	0.481	0.465	0.449	0.433	0.419	0.404	0.389	0.374	4.406	0.908	210942		
32,603	5,207	7,173	44,983	0.360	0.314	0.331	0.317	0.303	0.289	0.275	0.261	0.247	0.233	2.929	0.670	88275		
20,222	4,457	4,449	29,128	0.220	0.205	0.191	0.177	0.165	0.151	0.135	0.120	0.106	0.093	1.562	0.161	7325		
27,871	4,615	6,132	38,618	0.969	0.939	0.911	0.884	0.855						4.559	0.938	165136	\$845,831	
34,878	4,983	7,673	47,534	0.829	0.804	0.778	0.753	0.730	0.708	0.685	0.663	0.642	0.621	7.212	0.938	321578		
38,864	5,077	8,550	52,491	0.601	0.581	0.561	0.543	0.525	0.506	0.488	0.471	0.453	0.436	5.166	0.908	246205		
32,603	5,207	7,173	44,983	0.419	0.403	0.387	0.370	0.354	0.338	0.321	0.306	0.289	0.273	3.461	0.670	104315		
20,222	4,457	4,449	29,128	0.258	0.240	0.224	0.208	0.193	0.177	0.158	0.141	0.125	0.110	1.833	0.161	8597		
36,607	5,056	8,054	49,717	0.968	0.938	0.909	0.879	0.851						4.545	0.938	211971	\$704,837	
38,864	5,077	8,550	52,491	0.823	0.796	0.770	0.743	0.718	0.695	0.670	0.646	0.622	0.599	7.083	0.908	337603		
32,603	5,207	7,173	44,983	0.576	0.553	0.530	0.508	0.486	0.464	0.442	0.420	0.398	0.377	4.755	0.670	143314		
20,222	4,457	4,449	29,128	0.355	0.332	0.310	0.288	0.268	0.246	0.221	0.198	0.176	0.155	2.548	0.161	11949		
37,750	5,077	8,305	51,132	0.965	0.932	0.900	0.867	0.835						4.498	0.908	208826	\$426,259	
32,603	5,207	7,173	44,983	0.803	0.778	0.740	0.709	0.679	0.649	0.618	0.588	0.558	0.529	6.652	0.670	200477		
20,222	4,457	4,449	29,128	0.499	0.467	0.436	0.407	0.379	0.349	0.316	0.284	0.253	0.225	3.616	0.161	16956		
29,449	5,207	6,479	41,135	0.956	0.914	0.871	0.829	0.786						4.356	0.670	120057	\$145,898	
20,222	4,457	4,449	29,128	0.744	0.699	0.656	0.614	0.575	0.533	0.486	0.443	0.400	0.360	5.510	0.161	25841		
20,222	4,457	4,449	29,128	0.949	0.894	0.842	0.792	0.744	0.693	0.636	0.583	0.532	0.483	7.147	1.000	208177	\$208,177	
															(or 0.161) ¹³	(or 33516) ¹³	(or \$33,516) ¹³	

TABLE 5.6 Continued

	Present Value of Earnings Adjusted for Mortality ¹³ (excluding H and F) PV2	Present Value of Earnings Adjusted for Mortality ¹⁴ (including F and excluding H) PV3
	\$573,500	\$699,669
	\$621,780	\$758,572
	\$619,002	\$755,182
	\$518,204	\$632,209
	\$311,249	\$379,723
	\$103,891	\$126,746
	\$144,527 (or \$23,269) ¹⁵	\$176,322 (or \$28,388) ¹⁵

FOOTNOTES

¹ PA (Present Age) indicates the age at death.

² A (Age Group) is the range for which the Present Value (PV) is to be calculated.

³ P1 - P10 (Probability of Living) indicates the probability of living from the present ages to all future ages. For example, 0.991 in the second row, under column P1 indicates that a typical 19 year old dying the day before the 20th birthday would have had a 0.991 chance of surviving to age 25 without the job related death at the age of 19.

Source: P1 - P10 (Probability of living) values were obtained from Statistical Abstract of the United States 1993. U.S. Department of Commerce, Bureau of the Census (Table No. 117, Pg 86).

⁴ R (Discount Factor) is given by $R = e^{-N}$ where $R = (1.01/1.04)$ and $N =$ the number of years a person would have survived from the present age to all future ages. For example, 0.943 under column R2, row 1 is the square of $(1.01/1.04)$.

Productivity is assumed to be 1 % and the real discount rate, 4 %.

⁵ M (Average Annual Earnings) indicates the mean annual earnings of males with earnings within each age group.

Source: M (Mean Annual Earnings) were obtained from Money Income of Households, Families and Persons in the United States 1992. U.S. Dept. of Commerce, Bureau of the Census (Table 30, Pg 144).

⁶ H = Value of average annual production at home. Home production figures are drawn from Douglas, Kenney and Miller (1990), p. 39, updated to 1992 with the CPI - U - XI.

⁷ F = Fringe benefit, assumed to be 16% of earnings for women and 22% of earnings for men.

⁸ C = Average annual earnings + Home production + fringe benefits.

⁹ P1 x R1 = Probability of living times Discount Factor for 1st year; P2 x R2 = Probability of living times Discount Factor for 2nd year; ...

¹⁰ Sum of P1 x R1 + P2 x R2 + ...

¹¹ LFPR is the labor force participation rate.

Source: Statistical Abstract of the United States, 1993. U.S. Department of Commerce, Bureau of the Census (Table No. 622, p. 393).

¹² PV1 (Present Value) indicates the present discounted value of loss due to injury death per person.

Using symbols from the text:

$$PV_{\text{family}} = \sum_{t=1}^{\infty} \frac{P_{t+1} (M_{t+1} \times H_{t+1} + F_{t+1}) \times LFPR_{t+1}}{(1+r)^{t+1}}$$

Using symbols from the table:

$$PV_{\text{family}} = \sum C \times R \times S \times LFPR$$

¹³ PV2 Identical to PV1 above, only excludes home production (H) and fringe benefits (F).

¹⁴ PV3 Identical to PV1 above, only excludes home production (H) and includes fringe benefits (F).

¹⁵ LFPR = 1 for those who died after age 64 and LFPR = 0.161 for those who died before age 64.

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 5.5. This table was typed in Microsoft Excel and has is stored under twice, with suffixes .XLS and .TXT.

THIS PAGE NUMBER AND SPACE RESERVED FOR THE CONTINUATION OF TABLE 5.3

THIS PAGE NUMBER AND SPACE RESERVED FOR THE CONTINUATION (P.3) OF TABLE 5.5

THIS PAGE NUMBER AND SPACE RESERVED FOR PAGE 4 OF TABLE 5.5

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 5.6

(also typed in Microsoft Excel)

THIS PAGE NUMBER AND SPACE RESERVED FOR PAGE 2 OF TABLE 5.6

THIS PAGE NUMBER AND SPACE RESERVED FOR PAGE 3 OF TABLE 5.6

THIS PAGE NUMBER AND SPACE RESERVED FOR PAGE 4 OF TABLE 5.6

Fringe benefits are indicated with an F. A 22% rate is assumed for men and a 16% rate for women. The disparity reflects the greater likelihood that men will be employed full-time. Finally, LFPR indicates the Labor Force Participation Rate.

To calculate the present value of lost earnings adjusted for mortality, we must combine the data from Table 5.4 with Tables 5.5 and 5.6. An example will illustrate. Suppose we consider men. The number of male deaths within each category would be 182 (under 20 years), 547 (20 to 24 years), 1,518 (25 to 34 years), 1,518 (35 to 44 years), 1,154 (45 to 54 years), 728 (55 to 64 years), 485 (65 years and older)—a total of 5,647 deaths under age 65 and 485 over age 65. As indicated above, we assume 16.1% of the men and 8.3% of the women would have worked beyond age 65 to age 75 (U.S. Bureau of the Census 1993) among those who died before age 65. We assume 100% of those actually working after age 65 would have continued working until age 75. These numbers must be multiplied by their corresponding figures from Table 5.6. The product is \$3.4101 billion.

This \$3.4101 figure applies to men only. The Table 5.6 data were taken from column FV1. Hence, they reflect earnings, home production, and fringe benefits. As we will see, it will be useful for us to calculate the separate present values for earnings, home production, and fringe benefits for men and women. These are the following: present value of earnings (\$2.5481 billion), present value of home production (\$.3067 billion); and present value of fringe benefits (\$.556 billion). The total is \$3.4104 billion. On a per fatality basis, each death results in roughly a \$390,200 loss of earnings, alone, and a \$522,300 loss for earnings, home production and fringe benefits combined.

This \$390,200 is smaller than the amount we found on a per case basis for permanent partial injuries. This can be explained by the age differences for fatalities and non-fatalities. Non-fatal injury rates are more frequent among the young than the old while the opposite is true for fatal injury rates (Table 2.11). This is also less than the \$744,000 for CFOI deaths in New Jersey (Roche 1995). But Roche's study did not adjust for the probability survival from one age to the next. Moreover, New Jersey wages are higher than the national average.

Home Production for Non-fatal Injuries. We assume that home production losses for non-fatal injuries would be proportional to those for fatal injuries. The ratio of home production losses to lost earnings for the fatalities is .1204.

In other words, home production losses were calculated to be the equivalent of 12.04% of lost earnings. Assuming the same percent applies to non-fatal injuries, our estimate of home production losses would be $.1204 \times \$65.6079 = \$7.8992$ billion.

All Other Indirect Costs. We now turn our attention to additional categories of indirect costs including hiring and training costs, time delays, and family home health care.

Any injury resulting in work loss will create some disruption at the work place. For fatalities, Permanent Total and Permanent Partial injuries, these will be serious disruptions. In the short-run, other workers will have to fill-in for the deceased or injured worker. In the long-run, new persons will have to be hired and trained (most persons suffering permanent partial injuries do not return to their old jobs).

The costs for hiring and training are difficult to estimate. Few studies have addressed the issue. Here we will review those by Barron, Black, and Lowenstein (1989), Mincer (1962), and Smart (1987).

Barron, Black and Lowenstein (1989) estimated that 161 hours of managers' and co-workers' time are required to hire and train new workers during the first three months of the new-hires tenure.

Assuming \$15 (1992) for total compensation (wages and fringes) per hour for managers' and co-workers' time, hiring and training costs would be \$2,415 (161×15). (Above, we assumed \$12 per hour for wages and a 21% fringe benefit rate. This is equivalent to \$14.52 per hour. We rounded off to \$15 per hour).

But the Barron et al. study was drawn from a sample with a high percentage of firms paying low wages and from employees with few skills. It is likely that Barron et al. underestimated the hours required for average to above average wage and skilled workers, i.e., for persons with greater skills who have worked at the same firm for a number of years and acquired considerable amounts of "specific" human capital (Mincer 1962). Moreover, Barron et al. only considered the costs for the first three months. Finally, any costs associated with grief or shock of co-workers was also ignored (Haines 1993).

A highly regarded economic study suggested that on-the-job training amounts to 3% of GDP per year. In 1992, GDP was 5951 billion dollars. Three percent of this is 178.53 billion dollars. Dividing 178.53 by 117,598,000 (the number of civilians employed in 1992) yields \$1,518 of on-the-job training invested in every person working for one year.

For a person with 10 years of job tenure, the "stock" of acquired on-the-job knowledge would be worth \$15,180, i.e., a person would have to be hired and provided with the equivalent of ten years of on-the-job training to produce at the same level as the person with 10 years of tenure with a firm. In 1991 median years of job tenure was 4.5 (Marquiere 1993). (Average tenure would be more appropriate for our use and would exceed 4.5. But the average is not available. Use of the median rather than the average is another conservative assumption discussed in Chapter 10). Multiplying 4.5 times \$1,518 yields \$6,831. Again, any grief or shock resulting in lost production to co-workers is not included in this \$6,831.

Additional studies suggest this \$6,831 estimate is too low. Smart (1987) estimates that the cost to the firm of replacing a \$30,000 per year employee is about \$75,000.

We assumed that these hiring, training and disruption costs will add \$6,000 to costs for the company for every death and Permanent Total injury. We assumed a \$5,000 cost for every Permanent Partial injury since most people with PP do not return to old jobs, but some eventually do. We assumed that Temporary injuries will add \$500 apiece and all other disabling injuries will cost \$100 apiece. Our estimate of workplace hiring, training, and disruption costs is then $(6,529 \times \$6,000) + (10,725 \times \$6,000) + (761,547 \times \$5,000) + (1,887,880 \times \$500) + (3,433,378 \times \$100) = \$39,174,000 + 64,350,000 + \$3,807,735,000 + \$943,990,000 = \$0.0392 + \$0.0644 + \$3.8077 + \$0.9440 + \$0.3433 = \$5.1986 \text{ billion}.$

Travel Delays. Work-related motor vehicle crashes are also likely to create travel delays for innocent third parties. Blincoc and Faigin (1992) find these travel delays cost \$.951 billion in 1990. Again, using medical cost as our anchor, the Blincoc and Faigin travel delay factor would be $.951/13.887 = .06848$. Retaining our assumptions above and ignoring any travel delays from accidents not involving motor vehicles, we estimate $.06848 \times \$25.0739 \times .18 = \$0.3091 \text{ billion}.$

Home Care and Family Life. Care received at home (likely to be a large amount for serious injuries) and disruption of family life would create a significant cost. It is difficult to quantify that cost, however. Hensler et al. (1991, p. 98) found that almost one-quarter of injured persons reported that a family member or a friend either provided direct care to the injured person or helped the injured person with chores around the house or shopping. The amount of care would obviously be substantial for major injuries, but probably not be great for minor injuries. This care and home production is valuable and should be added as a cost. Hensler et al. (1991) estimated that \$.162 billion would be lost by family members (of injured workers) taking time off from work. An additional 91 million days of care would be provided by family members (of injured workers) who did not have jobs. If we assume that each day comprises 8 hours of caregiving and that the caregivers time is valued at \$5 dollars per hour (1992 dollars), then the value of the caregivers time would be $8 \times \$5 \times 91$ million days or \$3.64 billion. This \$3.64 together with \$.162 billion sums to \$3.802 billion.

This \$3.8 billion estimate has a number of limitations. First, Hensler et al. (1991) is a prevalence study and ours is an incidence study. However, their prevalence estimates of injuries were less than ours (11 million versus a little over 13 million) (Marquis 1992). Second, the \$5 per hour (1992 dollars) is somewhat arbitrary, but is small (i.e., only 75 cents above the minimum wage). The cost of a nurse to provide the same services would be at least double that. Third, \$.162 was expressed in 1989 not 1992 dollars, but again, this results in a more conservative estimate, though, the \$3.8 billion applies to the total of all injuries, not just job-related injuries. But Marquis found that nearly half of costs for all injuries were due to job-related injuries.

Finally, this \$3.8 billion does not account for any of the long-term psychological effects on family members. Roy (1992) documents a number of cases of workplace injuries that lead to diseases among caregivers, children leaving home at a young age, and other destructive consequences for families. It is likely that the future earning capacity of children is diminished when a parent is killed or seriously injured. A decrease in income, especially a serious decrease when WC is

not available, is associated with divorce and abandonment, again with deleterious effects on children (McFloyd and Flanagan 1993).

Because of these limitations, and more importantly, because we are not familiar with any other attempts to estimate the value of home care for injured persons, we will not include the \$3.8 million in our estimates.

Collateral damage. In Chapter 2, we estimated that harm to innocent third parties would result in 218 deaths, 322 PTs, 15,000 PPs, 19,000 TTPs, and 34,000 injuries with one to seven days of work loss. We estimated these costs using the same techniques outlined above. Our estimates are: \$.3668 billion for medical only; \$.0833 billion for administration for medical only; \$1.4116 for morbidity costs; \$.0713 for mortality costs; \$.3065 for fringe benefits for non-fatal injuries; \$.1694 for home production; \$.1625 for administration in indemnity; \$.0953 for workplace disruption; \$.1576 for property damage; \$.0045 for traveling delays; \$.0114 for police and fire services; and \$.0730 for home health care. These sum to \$2.9132 billion.

Table 5.7

Summary of Costs

I. Direct Costs Total	\$ 50.1046
A. Medical costs for doctors, hospitals, drugs, and so on	25.0739
B. Administration of WC (31%); and Medicaid, Welfare, Medicare, private insurance and others (16% combined)	5.7012
C. Administrative costs on indemnity payments for WC (31%); and Social Security, Welfare, Private Insurance, Private Insurance (10% combined) (These percentages apply only to indemnity)	\$ 8.8645
D. Property damage costs	\$ 8.7497
E. Police and Fire Services	\$.7801
F. Direct costs to innocent third parties	\$.9322
II. Indirect Costs	\$ 98.1837
A. Lost earnings	\$ 68.1559
1. Fatalities	2.5481
2. Non-fatalities	65.6078
B. Fringe benefits	\$ 14.3332
1. Fatalities (16% women, 22% men)	.5556
2. Non-fatalities (21% everybody)	13.7776
C. Home production	\$ 8.2059
1. Fatalities (see Tables 5.5 & 5.6)	.3067
2. Non-fatalities (same as average % for fatalities: 12.93%)	\$ 7.8992
D. Workplace training, restaffing, disruption	\$ 5.1986
1. Fatalities	.0397
2. Non-fatalities	5.1589
E. Time delays	\$.3091
1. Fatalities 3.7% of total	.0114
2. Non-fatalities 96.3% of total	.2977
F. Indirect costs to innocent third parties	\$ 1.9810
1. Fatalities (3.7%)	.0733
2. Non-fatalities (96.3%)	1.9077
Grand Total	\$148.3883 billion

II.C. Summary Table

Table 5.7 summarizes the direct and indirect costs using the NCCI data combined with present value calculations and other sources. These are our preferred estimates. Direct costs are estimated to be \$50.1046; indirect costs, \$98.1837; and total costs \$148.3883.

III. Literature Review

This section will address how our estimates compare with those in the literature. What is most distressing about the literature is how few studies have been conducted. A literature search uncovered nine occupational injury studies and a handful of related studies. Only two of the occupational injury studies (Miller and Galbraith 1994; Rossman, Miller, and Douglas 1991) attempt to be comprehensive (i.e., do not exclude, for example, non-WC costs, deaths, non-disabling injuries, or non-back injuries).

We will begin with the two most widely cited studies (National Safety Council 1993; and Marquis 1993). Authors of both studies readily acknowledge that they were not comprehensive. We then consider the two most comprehensive, Miller and Galbraith (1994) and Rossman, Miller and Douglas (1991). The remaining six studies are considered next: Neumark et al. (1992); Nelson (1992, 1993); Burton (1994); Boden and Fleischman (1989); and Webster and Snook (1990). We then move on to related literatures on the costs of all injuries, (Rice et al. 1989), costs of firearms (Max and Rice 1993), costs of motor vehicle crashes (Blincoe and Faigin 1992), and costs of high profile diseases.

III.A. Job Injury Studies

III.A.1. National Safety Council (NSC)

The NSC injury and cost estimates are widely cited by researchers and the news media. We cited estimates from the NSC book *Accident Facts* in Chapter 2. The NSC collects and presents more data on accidents, injuries and their costs than any other private firm or federal agency. The NSC also explicitly estimates the annual direct and indirect costs associated with job-related injuries. However, despite their expertise in the area, the authors of *Accidental Facts* are cautious

in presenting their data. For example, this footnote appears on page 1 of *Accident Facts 1993*:

Injuries are not reported on a national basis, (by researchers other than those at the NSC), so the totals (the NSC publishes) are approximations based on ratios of disability injuries to deaths developed from a 1990 NSC study. The totals are the best estimates for the current year, however, they should not be compared with totals shown in previous editions of *Accident Facts* to indicate year-to-year changes or trends.

On page 35 of *Accident Facts (1993)*, we encounter these sentences pertaining to the costs of work accidents:

Cost estimating procedures were revised for the 1993 edition of *Accident Facts*. In general, cost estimates are not comparable from year-to-year. As additional or more precise data become available, they are used from that year forward. Previously estimated figures are not revised.

In other words, counting the numbers of accidents and injuries nationwide and calculating their costs are difficult tasks. These counting and costing attempts are constantly being revised and improved. Assumptions, such as those regarding the expected ratios of disabling injuries to deaths, have to be made. NSC statisticians who have been collecting and publishing injury statistics for over 30 years recognize that there is no single estimate or set of estimates that are regarded as definitive. Given the vagaries of, and the conflicting approaches to, evaluating costs, it is likely that any cost estimate (including ours) would be open to even more criticism than an estimate of the number of injuries.

Finally, from our perspective, the NSC contains a serious omission—violent injuries involving assaults, murders and suicides.

With these caveats in mind, we turn to the NSC estimates presented in Table 5.8.

The first column of numbers in Table 5.8 pertain to costs associated with non-intentional job-related injuries and the second, with all non-intentional injuries whether on or off-the-job. The total cost for job-related injuries was \$115.9 billion in 1992. This \$115.9 billion estimate, like our \$152 billion estimate, is an incidence, not a prevalence estimate. The largest portion of job-related costs came from wage and productivity losses (\$62.5 billion) and medical expenses (\$22.0 billion). The other categories of expenses are itemized as administrative expenses (\$14.5 billion), employer costs (\$10.2 billion), motor

vehicle damage (\$3.4 billion), and fire losses (\$3.3 billion). Our approach is similar to the NSC. We include all of the cost categories in their Table 5.8, as a comparison of Table 5.7 with Table 5.8 will indicate. Moreover, although not evident in Table 5.8, the NSC also includes fringe benefits, household production, and travel delays, within their "Wage and productivity losses" category, and expected future medical costs within their "Medical expenses" category. For

Table 5.8

Costs of Accidents and Injuries, 1992

	<u>Work-Related Only</u>	<u>All Injuries</u>
Total	\$115.9 billion	\$399.0 billion
Wage and productivity losses	62.5 billion	211.2 billion
Medical expenses	22.0 billion	75.2 billion
Administrative expenses	14.5 billion	46.9 billion
Employer costs	10.2 billion	17.5 billion
Motor vehicle damage	3.4 billion	38.1 billion
Fire losses	3.3 billion	10.1 billion
Total Cost per death	\$ 780,000	
Total Cost per disabling injury (work loss more than one day)	27,000	

Source: National Safety Council, 1993

administrative expenses, we both include legal costs. The NSC, like us, use the difference between premiums paid to insurance companies and claims paid out by those companies to estimate administrative costs. We also concur with the NSC inclusion of costs to uninjured workers' and firms' production slowdowns, training of replacement workers and extra cost of overtime for non-injured workers. We differ in that our fire losses are combined with motor vehicle damage in the general property damage category. Unlike the NSC, we attempt to estimate the costs for family members providing care and harm to innocent third parties.

The NSC also presented cost estimates for the cost per death (\$780,000) and per disabling injury (\$27,000) defined as any injury resulting in more than one day of lost work.

The explanations for the NSC cost estimates appear on two pages in a technical appendix. The NSC cost estimates were "extensively revised" for the 1992 edition of *Accident Facts*. The two pages in the appendix provide only the briefest discussion of the nature of those revisions. We learned, from Alan Hoskin, Director of Statistics, that most of the revision was conducted by Dr. Ted R. Miller who relied on some estimates from Rossman, Miller, and Douglas (1991) and who subsequently prepared his own cost estimates for 1990, but not 1992 (Miller

and Galbraith 1994). We review both the Rossman et al. and Miller and Galbraith studies below.

Our \$152 billion estimate is considerably larger than the NSC's \$115.9 billion estimate. The disparity is largely the result of two factors: 1) the NSC explicitly ignored violent incidents (assault, murder, suicide) and more importantly and 2) the NSC relied on the NHIS estimate of non-fatal work injuries. As we argued in Chapter 2, the NHIS only captures roughly 50% to 60% of all non-fatal injuries.

It is nevertheless reassuring that our percentage estimates of direct and indirect costs are similar. The NSC direct costs would be roughly \$43 billion or 37% of total costs and the indirect costs would be roughly \$73 billion or 63% of total costs. Our percentages are roughly 34% and 66%.

Additional findings pertained to back injuries. A section in *Accidents Facts* indicates that an NCCI report on 600,000 WC claims found nearly one-third (31%) of lost-time WC claims were due to back injuries. Because the average costs of back injury claims were roughly one-third more than the average costs of all other lost-time claims, the total WC lost-time costs associated with back injuries was more than 40% of all lost-time (disability) claim costs. Most back injuries were the result of lifting.

The same NCCI study found that only 7.4% of all claims lost more than two years of work while 13% of back injury claims lost more than two years at work. These findings on length of time a claim takes to close are especially important for us. Our NCCI data follow claims for at least three years. These NSC findings reinforce our view that the lion's share of claims and expenses are accounted for within our NCCI data and do not require extensive forecasts of future costs.

Table 5.9

NSC Estimates of WC Spending by Body Part		
Rank	Body Part	Percent of WC Spending
1	Back	31%
2	Multiple Parts	15%
3	Legs	14%
4	Trunk	13%
5	Arms	10%
6	Fingers	4%
7	Head (except eyes)	3%
8, 9, 10 (tie)	Neck	2%
8, 9, 10 (tie)	Feet	2%
8, 9, 10 (tie)	Body Systems	2%
11, 12 (tie)	Eyes	1%
11, 12 (tie)	Toes	1%

Source: National Safety Council

The NSC findings are also useful in estimating how our overall costs might be split into body part categories. Table 5.9 reproduces their estimates of WC spending by body part. If the same percentages they find for WC apply to all injuries, then we can estimate the contribution of each body part to our overall cost of \$.163.3 billion: back (\$50.6 billion), multiple parts (\$24.5 billion), legs (\$22.3 billion), trunk (\$21.2 billion), arms (\$16.3 billion), and fingers (\$6.5 billion).

III.A.2. Rand, Hensler et al. (1991), Marquis (1992)

The Rand corporation study of all injuries by Hensler et al. (1991) together with the companion study on only job-related injuries by Marquis (1992) were introduced in Chapter 2. In this section, we will first present an overview of their cost findings, and second, discuss their methodology.

Unlike most of the other studies we review, the Hensler et al. (1991) and Marquis (1992) studies are prevalence-based. Hensler et al. (1991) argue that incidence costs are appropriate for indicating the burden on different families (i.e., families with an older versus a younger primary breadwinner). The prevalence estimates, they argue, are appropriate for looking at the aggregate effect on the economy.

We prefer incidence-based estimates both to indicate differences between groups and to analyze the overall effect on the economy. An extensive discussion of incidence and prevalence appears in Chapter 9.

For all non-fatal injuries, whether on or off the job, Hensler et al. (1991) estimated total costs to be \$175.9 billion for 1989 or roughly 4% of GNP. Of this \$175.9 billion, direct costs accounted for 51% and workloss for 44%. Other categories of indirect costs accounted for the remaining 5%. Hospital spending amounted to about \$53 billion in 1989—almost one-fourth of the USA's total spending on hospitals. Outpatient spending totaled \$34 billion and spending on special equipment and home help totaled \$11.5 billion. Their work loss category was split into four groups: disabled (\$45.9 billion), sick leave (\$23.2 billion), restricted activity (\$7.4 billion), and family members work loss (\$1.4 billion).

Marquis (1992) presented testimony to Congress on the costs of workplace injuries using the Hensler et al. study (1991) as her database. The Marquis study has been widely cited.

Marquis' estimates applied to non-fatal traumatic injuries. Fatalities and all occupational diseases including carpal tunnel syndrome were excluded. She estimated that seven million Americans suffered on-the-job injuries in 1989. Another four million suffered in 1989 as a result of an injury that occurred prior to 1989. Roughly 11 million persons were suffering from an on-the-job injury in 1989 that either occurred in that year or a previous year. Clearly, Marquis' estimate is a prevalence, not an incidence, estimate.

She estimated a total cost of \$83 billion in 1989—almost 2% of GNP. Roughly 40% of that amount was spent on direct (medical) cost, and 60% resulted from work loss costs. Marquis pointed out that workplace injuries were more costly than non-workplace injuries. Only roughly 20% of all injuries in the Hensler et al. study were job-related, but workplace injury costs claimed nearly 50% of all costs. Workplace injuries generate more indirect costs than non-workplace injuries since many people involved in the latter did not hold jobs.

Marquis (1992) did not place a dollar value on the loss in home production (i.e., making home repairs or caring for children). She did, however, estimate that for every day missed from work, roughly two-thirds of one day was missed from home production.

Finally, Marquis (1992) looked at who paid the costs. She estimated that 45% of medical and wage losses were born by the individuals and their families. The remaining 55% was split among a variety of payers. WC (27.5%), private insurance (11%), employer provided benefits (5.5%), Medicare, Supplemental Security Income and Social Security Disability Insurance (5.5%), and, finally, tort liability (5.5%).

The Hensler et al. (1991) and especially the Marquis (1992) studies are limited. First, fatalities were excluded. Second, given the nature of the questions on their questionnaires about accidents and injuries, a considerable number of assaults, attempted murders and suicides were excluded. Third, a great number of minor injuries, involving one to four days of work loss, were excluded.

Evidence for their undercount of minor injuries lies in the hospitalization rate. Their hospitalization rate for all injuries were 17% whereas Rice et al. (1989) in an even more widely cited injury study estimated a 4% rate for all injuries. Their hospitalization rate for workplace injuries was an astonishing 27%. Miller and Rossman et al. (below) estimated workplace injury hospitalization rates of under 8%.

A fourth limitation is that they underrepresented minorities and the poor-groups that are more likely than other groups to experience injuries on- and off-the-job (Graham, Chung, and Evans 1992; Wildarsky 1980). Despite these limitations, which Hensler et al. and Marquis readily acknowledge, their studies are exceptional. No other cost study we reviewed conducted such an independent extensive household survey of injuries.

Several additional findings in the Hensler et al. (1991) study are relevant for us. One finding pertained to the number of medically diagnosed injuries or body parts affected in a single accident. On average, injured persons reported 1.4 injuries per incident (p. 37). The word "injury" here

refers to the type and body part affected. "Types" include strains, sprains, cuts, fractures, broken bones, bruises, pain, and burns. Body parts include head, foot, ankle, back, hand, arm, and so on.

Any costing procedure constructed around type of injury and body part affected will be confounded by this simple fact: some percent, Hensler et al. suggest 40%, of incidents result in more than one body part affected. This is one reason we believe injuries are better classified by the WC categories than body part categories. Another reason is that medical cost and especially wage loss data are difficult to find for body parts.

Finally, the Hensler et al. study reinforces our view that WC misses a large percentage of all injuries. The Rand interviewers specifically asked respondents whether they attempted to collect WC benefits. They summarized their findings this way:

Forty-four percent of those who miss more than seven days of work (and so exceed the waiting period in all states) report receiving workers' compensation... (p. 91)

The true percentage of WC undercount is undoubtedly larger 56% (100 - 44) since: 1) the great majority of injuries do not result in three or seven days of work loss and thus are less likely to qualify for WC and 2) their survey under-represents minorities and the poor who are more likely than other groups to hold jobs that do not qualify for WC (farm labor, domestics).

III.A.3. Miller and Galbraith (1994)

Miller and Galbraith's study (1994) used injury statistics from 1989 and produced cost estimates for December 1990. Table 5.10 presents their findings.

They estimated 10,958,000 injuries (disabling and non-disabling) in 1990. The total amount of their estimated expenses was \$96.6 billion. They also estimated an additional \$61.8 billion based on WTP estimates. These \$96.6 billion applied to 1990. Assuming a 7.345 inflation rate between 1990 and 1992, Miller and Galbraith's (1994) estimate would be \$103.7 billion in 1992. This estimate is only roughly 11% less than the NSC estimate for 1992.

Table 5.10

Costs and Numbers of Workplace Injuries
in December 1990 Dollars, Excluding WTP Estimates

<u>Cost Category</u>	<u>Billions of Dollars</u>
Medical and emergency services	\$17.5
Wage work-loss	41.6
Household work-loss	7.5
Legal and Administrative Costs	5.4
Work disruption	10.0
Motor vehicle liability insurance	11.2
Workers' Compensation and motor vehicle insurance overhead	3.4
Total	\$96.6
Number of injured persons: 10,958,000	
Cost per injury: \$8,815	

Source: Miller and Galbraith (1994)

The largest expense was again associated with work loss (\$41.6 billion) followed by medical and emergency services (\$17.5 billion). Somewhat surprising categories entered third and fourth: motor vehicle liability insurance (\$11.2) and workplace disruption (\$10.0 billion). The liability insurance dollars were for claims paid to non-employees resulting from crashes caused by employees. Workplace disruption included overtime pay, lost production for co-workers, recruitment and training costs.

Household production has been ignored by some researchers, but Miller and Galbraith devoted considerable effort to estimating its value. They assumed that household production days equalled the number of workdays lost plus weekend and holiday time. Specifically, household production days lost equalled workdays times the ratio of 365 days per year divided by 273 workdays per year.

Miller and Galbraith's (1994) technique of multiplying by the ratio of 365 to 273 may seem odd. This would seem to imply that a person who missed a full day of work also misses a full-day of household production. But most people (especially men) do not work eight hours at a job and come home and work eight hours in home production. Miller and Galbraith recognized this. Their estimate of long-term household production—drawn from Rice et al. (1989)—already accounted for

the nature of the time spent at home and at work. They accounted for the lower production at home by multiplying by a percentage of the wage that was considerably less than the wage: 21.4% for long-term wage loss and 90% of hours lost by \$6.79 per hour for short-term loss. Thus, their estimates of short-term household production took similar account of the disparity in values between home versus work production and men versus women. It was the wage multiplication factor, not the 365 to 253 ratio assumption, that provided their major adjustment for hours in the household production estimate.

It is useful to compare ratios of home production to wage loss. Miller and Galbraith's ratio is 7.5/41.6 = 18%. Ours is 12% (8.2059/68.1589). It is reassuring that our percent is close to theirs.

Miller and Galbraith's medical costs were drawn from an NCCI Ultimate Report Basis covering policies in years 1985 and 1986. (Our NCCI data came from policies in years 1988 through 1990). Miller and Galbraith point out that the NCCI data excludes workers in large firms that self-insure and workers in roughly nine to 11 excluded states. They nevertheless argue that the per case estimates should be representative. We rely on the same assumptions about per case estimates pertaining to our 1988 to 1990 data.

Miller and Galbraith also used Nelson's medical cost (not indemnity cost) estimates from the *Social Security Bulletin* (Nelson 1993). Nelson's estimates were prevalence-based. They counted money that was actually spent by WC insurers in a given year, regardless when the injury occurred. Nelson's estimates do not account for any future expenses that would require setting money aside today. Miller and Galbraith assert that if the frequencies and types of injuries as well as cost and procedures of medical care do not greatly vary over the years, incidence and prevalence-based estimates should be roughly equal. This assumption about non-varying injuries and medical care is referred to as the "steady state" assumption.

The Rand researchers (Hensler et al. 1991) argue that discounting would make a difference, so that incidence-based cost measures would be less than prevalence-based measures provided the same number and type of injuries occur each year. The Miller and Galbraith (1994) and Hensler et al. (1991) arguments are at

odds. Either argument could be correct. As we will show in the chapter on limitations (Chapter 9), it depends on the type of discounting that occurs. But even theoretical demonstrations of the differences between the prevalence and incidence methods requires the additional (unrealistic) assumption of a "steady state" whereby the number and types of injury and medical care do not change over time.

This incidence/prevalence problem is unlikely to explain our actual disparities among the Hensler et al. (1991), Miller and Galbraith (1994), Nelson (1992, 1993), and NCCI direct cost comparisons. In the real world, it is unlikely we are in a "steady state" (i.e., injuries and medical care for injuries do change from year to year). Moreover, the methods in prevalence-based studies such as those by Hensler et al. (1991) and Nelson (1992, 1993) to count costs and the populations considered are not the same as the methods and populations for the NCCI incidence-based studies such as those in the NCCI, Miller and Galbraith (1994) and our study. The real world institutional differences between, for example, the Nelson versus the Miller and Galbraith approaches are more likely to explain the disparities in estimates than any theoretical analysis of incidence/prevalence studies.

For example, Nelson had a different definition of WC than the NCCI. Nelson included all civilian federal government employees who were covered by the special federal WC plan. The NCCI data do not include federal employees. But Miller and Galbraith accounted for this when they divided their NCCI estimates by .81. The .81 represents 81% of U.S. workers who were covered by non-federal WC in the year of their study.

Miller and Galbraith assert that estimates of medical costs were only 2.5% less than their own incidence-based estimates (i.e., those that relied on the NCCI data).

Miller and Galbraith (1994) used the same Rice et al. (1989) method we used to estimate wage losses for fatalities. Men and women who died were assumed to have lost the earnings of men and women of the same age who lived and earned wages until age 65. Wage losses for fatalities were discounted at a 4% rate. Unlike other studies, Miller and Galbraith added an average life insurance payment of

\$35,000. Miller and Galbraith also estimated wage losses for non-fatal injuries using techniques similar to ours. They relied on NCCI indemnity data and assumed that WC compensated 60.3% of the before-tax wage-loss and none of the fringe benefit loss.

Miller and Galbraith also added an estimate for other disability insurance programs available to workers: sick leave valued at the average sick leave benefit for non-supervisory workers in the private sector; and fringe benefits which were valued at 20% of wages. This 20% figure was the value of supplements to wages reported in the National Income Accounts by the Council of Economic Advisors (1992).

Most on-the-job injuries are minor and do not qualify for the three to seven day work loss required to qualify for WC. Miller and Galbraith assumed that the injuries requiring some work loss, but not enough to qualify for the three- to seven-day WC criteria, would be for two days of loss.

Administrative costs were calculated by multiplying the estimated medical and indemnity payments by varying percentages: health insurance (8.4%), life and disability insurance (9%), WC (13%), auto liability insurance (12.5%), auto property insurance (11%), sick leave (1%). These percentages applied to insurance claims or payments, not to premiums. Miller and Galbraith cite three sources for these percentages: two different years of the *U.S. Statistical Abstract* and an article from Cornish (1991) in *Best Review*, an insurance industry magazine. Miller and Galbraith did not explain how numbers from these three sources were combined to arrive at the percentages they used. A review of the three sources did not indicate in any obvious procedure whereby the percentages were derived. However, the *U.S. Statistical Abstract* from 1993, Table 841, reveals that in 1990 total health insurance premiums equaled \$118.6 billion while benefit payments equaled \$97.7 billion, implying an administrative cost of 21.4% out of benefits paid. We believe the Miller and Galbraith estimates were too low. We assumed a 31% rate for WC, a 16% rate for all other insurance administration covering medical costs and a 10% rate for all other insurance administration covering indemnity payment.

Workplace disruptions--totalling \$10 billion--were calculated differently for each category injury. A fatal injury was assumed to result in the equivalent of

four months of the deceased worker's wages. These four months of wages were assumed to pay for recruitment, retraining, and loss of special skills. A one-month loss was assumed to cover the expense of all bosses and co-workers in the event of a disabling injury that qualified for WC. Disabling injuries not qualifying for WC were assumed to result in two days of lost-time for the supervisor and four days for all co-workers combined. Injuries that resulted in any work loss for the victim but that Miller and Galbraith did not define as disabling were assumed to generate one day lost for the supervisor and one for all co-workers combined. Miller and Galbraith admit that these assumptions were arbitrary. They did not cite any studies to support their assumptions. On the other hand, the literature on costs of workplace disruption is thin. They should be commended for including these costs (that many other researchers have ignored) and making assumptions that appear plausible. Nevertheless, they may have overestimated these costs. Our estimate of \$5.1986 billion relied on studies by Barron et al. (1990), Mincer (1962) and Smart (1991).

Miller and Galbraith also attempt to account for pain, suffering, and the quality of life. But pain, suffering, and the quality of life are difficult to measure. Miller and Galbraith use Willingness-to-Pay estimates (WTP). Since WTP estimates are designed to capture all of the costs of injuries, and since WTP estimates for fatalities appear to exceed human capital costs by factors of 3 to 6 times or more, Miller and Galbraith subtracted the total of their wage loss estimates from the WTP estimates to arrive at the quality of life estimate.

This technique results in an unusual blend of the Direct/Indirect method estimates and WTP estimates. WTP advocates would, in general, not want to add any additional cost to WTP estimate. But Miller and Galbraith add medical cost. WTP estimates, presumably, already capture medical costs. Perhaps Miller and Galbraith reasoned that the person in the WTP experiment would have assumed medical costs would automatically be covered. But we should be cautious in our criticisms. Miller and Galbraith are clearly sailing in uncharted waters. They at least recognize the costs of pain and suffering and attempt to put a dollar amount on them.

Pain and suffering should ideally be included in cost studies. It is nevertheless difficult to determine which blend of the Direct/Indirect and WTP methods properly accounts for pain and suffering. This quantity of their estimate is \$62 billion.

An additional finding merits attention. In comparing their data with Rice et al. (1989), they find that although workplace injuries accounted for only 20% of all injuries, workplace injuries were more serious than all other injuries. Miller and Galbraith estimated that workplace injuries accounted for 32% of the total injury medical costs in Rice et al. (1989). This reinforces the similar evidence found in Hensler et al. (1991) of the greater severity of workplace injuries when compared to all others.

III.A.4. Rossman, Miller, and Douglas

Rossman, Miller, and Douglas (1991) worked under a contract from NIOSH to estimate the costs of occupational and cumulative trauma injuries. Rossman et al. (1991) drew extensively from data in the Detailed Claims Information (DCI) database maintained by the National Council of Compensation Insurance (NCCI). A significant amount of the methods and additional data were taken from Rice et al. (1989).

As indicated in Chapter 2, their estimated workplace injuries in 1989 were as follows: 11 million injuries, including 11,000 deaths; 590,000 hospitalizations; 1,340,000 non-hospitalized injuries with three or more days lost; 1,675,000 non-hospitalized injuries with some work loss less than three days lost; and 7.4 million injuries with no work loss.

The DCI database was drawn from WC records and classifies job-related injuries and diseases into three types: traumatic injuries, occupational diseases, and cumulative injuries. The DCI data from 1979 to 1988 were used. The DCI data covered more than 450,000 cases. Traumatic injuries accounted for 98% of these 450,000 and diseases and cumulative injuries accounted for only 2%.

As indicated above, Leigh (1995a) also analyzed WC cases, but for only fatalities and found 11% to result from diseases. There appear to be substantial

differences in coverage of diseases by WC with illnesses accounting for a higher percentage of deaths than for non-fatal incidents.

Virtually all DCI cases received some medical care. Roughly 31% of the DCI cases received hospital care. Roughly 82% of all lost workday cases involved a Temporary Total or Temporary Partial disability. Approximately 11% of DCI cases resulted in either a Permanent Total or Permanent Partial disability. Out of this 11%, only roughly 5% were for Permanent Total and 95% were Permanent Partial injuries. They found that traumatic injuries accounted for 98% of all permanent disability cases. Thus, the 98% figure appears to apply to most non-fatal categories within WC.

For injuries qualifying for WC lost workday categories, Rossman et al. (1991) estimated that direct and indirect costs summed to \$21.54 billion in 1989. But they cautioned that "this represents only a small portion of all workplace injury costs." This \$21.54 billion estimate did not include total costs of fatal injuries or injuries that resulted in fewer than three lost workdays. In other words, this \$21.54 billion estimate ignores over nine million injuries by our calculation and over seven million by their calculation. Rossman et al. go on to state that this estimate did not include 1) administrative expenses for injuries outside of WC coverage, 2) employer losses associated with recruitment, retraining, and work disruption, 3) property damage, or 4) legal costs. We would like to add one additional flaw which is more serious than these four: 5) Rossman et al. did not properly account for the WC undercount. We estimate that undercount to be about 55% to 60% while they estimate it at a little over 15%.

They also provided a cost estimate for cumulative trauma injuries (\$153.3 million) and occupational diseases identified by WC boards (\$150.4 million). These, again, were likely to be underestimated for the five reasons above.

Rossman et al. presented a number of findings apart from their overall estimates of the volume and costs of traumatic injuries and repetitive motion disorders. Body parts associated with the highest annual costs were, in order, lower back, knee, multiple body parts, fingers/thumbs, and upper arms. As they state, "head and spinal cord injuries accounted for the highest per case costs

whereas back injuries and injuries to upper and lower extremities, due to their high frequency of occurrence, yielded the highest annual total costs of injuries."

They also estimated that WC covered roughly 84% of the civilian workplace in 1989. They argued, however, that employers who were not covered by WC could still have paid for a significant amount of workplace injuries through employer based health insurance costs. Employer health insurance covered roughly 77% of all employees in 1989. Finally, Rossman et al. (1991) pointed out that workplace injuries also represent an expense to the employer in the form of employers' sponsored disability programs other than WC, motor vehicle insurance premiums, employer contributions to life insurance, employer contributions to Social Security's disability insurance, and Medicaid. None of these were included in their estimates.

We regard the Rossman et al. (1991) epidemiological study as more useful than the economic study. The second author, Miller, later estimated the costs of injuries to be roughly five times greater than their \$21.54 billion estimate (Miller and Galbraith 1994). Finally, estimates for WC expenses alone in 1989 far exceeded \$21.54 billion (Nelson 1992, 1993; Burton 1994).

III.A.5. Neumark et al. 1991

Neumark et al. (1991) attempted to estimate the incidence cost of occupational injuries and diseases in Pennsylvania in 1987, 1988 and 1989. The epidemiological part of the study was conducted by researchers at the Pennsylvania Department of Health. The document they produced—*Occupational Disease and Injury in Pennsylvania*—was apparently not intended for public use. Repeated phone calls to the Pennsylvania Department of Health were unsuccessful in obtaining a copy of the document or even of an abstract. Moreover, the document apparently has never been published in the scientific literature.

Neumark et al. nevertheless presented some of the Pennsylvania Department of Health epidemiological estimates. We will review these epidemiological estimates before examining their cost estimates.

Pennsylvania's contribution to non-fatal injuries and illnesses were drawn from the BLS's Annual Survey for 1987. The non-fatal injuries were estimated to be

140,908 while the non-fatal illnesses were estimated to be 19,982. The total was 160,890. The injury deaths were counted using Pennsylvania's WC records. Some poisoning and disease deaths were also drawn from WC records but most were drawn from sources that were not clearly indicated in the Neumark et al. study. Among fatalities, 267 were identified as due to injuries, 139 as due to poisonings and 4,715 as due to diseases. The total number of disease and poisoning deaths was 4,854. Dividing this number by 267 yields 18.2. In other words, 18.2 disease and poisoning deaths were found for every injury death in the Pennsylvania Department of Health study.

We turn now to the cost estimates. Neumark et al. (1991) provided separate direct cost estimates for injuries and illnesses. Although separate indirect costs estimates were not provided in the text, their tables are well-organized, so that we can estimate separately the cost of injuries and illnesses.

Neumark et al. (1991) made most of the same assumptions for injuries as for illnesses and we review these here since they are required in our calculations of separate costs for injuries versus illnesses.

The mean lost workdays per non-fatal case was assumed to be 18.1. The median age of occurrence was assumed to be 32.8 for non-fatalities and 44.1 for fatalities. One small differing assumption between injuries and illnesses applied to the percent of cases resulting in lost workdays and, hence, indirect costs. Neumark et al. assumed that 46.6% of non-fatal injury cases as opposed to 42.2% of non-fatal disease cases resulted in lost workdays.

The indirect (lost earnings) costs due to fatal injuries can be calculated as follows:

$$\$1,448,408,000 \times (267/5121) = \$76 \text{ million}$$

The first number, 1,448,408,000, is their middle estimate in the confidence interval. The indirect costs due to non-fatal injuries would be 140,908/160,890 times their middle estimate of \$111,243,000 or \$97 million. Adding these two yields \$173 million.

Neumark et al. (1991) used NCCI data (the same data we use) to calculate medical costs, as well as state of Pennsylvania data. Neumark et al. (1991) calculated the medical costs of injuries to be \$568.3 million. Their indirect cost

estimate for injuries and their direct cost estimate for injuries summed to \$741.3 million.

The costs for all injuries and illnesses was estimated to be (at their middle estimate) \$1.6 billion (direct) plus \$.797 billion (indirect) or \$2.4 billion. The percent attributed to injuries would then be 31% ($.7413/2.4 = 31\%$).

They then extrapolated to the U.S. and found a mean estimate of \$54.5 billion for illnesses and injuries. Multiplying this \$54.5 billion by 31% yielded \$17 billion in 1989. This \$17 billion would then be the Neumark et al. estimate of direct and indirect costs for all occupational injuries in the United States in 1989.

We can further split this \$17 billion into direct and indirect components. Assuming the same percentages of direct and indirect costs apply to Pennsylvania as the nation, direct costs would be $\$17 \times .77$ or \$13 billion. Indirect costs would then be \$4 billion.

The Neumark et al. (1991) study is useful for several reasons. 1) Their approach to the NCCI data was essentially the same as ours. To estimate medical costs, they simply multiplied the number of injuries and diseases by the corresponding NCCI medical costs. However, they included all injury deaths with disease deaths. They did not separate injuries in WC categories. Nevertheless, the fact that they took a similar approach provides some precedent for our approach. 2) They point out that there were only two other comparable studies: Markowitz et al. (1989) (New Jersey) and Fahs et al. (1989) (New York). Neumark et al. (1991) believed they were the first to attempt to estimate costs of injuries and diseases combined. We agree. We have not located another study attempting to estimate costs of both. 3) Finally, they ignored Willingness-To-Pay estimates. Few Willingness-To-Pay studies have been conducted on non-fatal injuries and illnesses with consistent definitions of injuries and illnesses. Neumark et al. (1991) were apparently skeptical of the existing WTP estimates that are available in the literature. The most popular WTP estimate requires widespread information on job hazards. Neumark et al. do not believe information is widespread (see Chapter 4).

Oleinick and Gluck (1992) criticized the Neumark et al. (1991) study on several grounds. The most important was this: 1) It is unlikely that disease

deaths would occur at the same age as injury deaths (disease deaths, on average, occur much later).

To this criticism, we add our own. 2) The deficiencies of the BLS's Annual Survey were never mentioned or accounted for. 3) The deficiencies of WC were mentioned, but never corrected. 4) The results for indirect and direct costs are difficult to accept. Generally, indirect costs exceed direct costs by factors of 2, 3, 4, or more. In the Neumark et al (1991) estimates, direct costs exceed indirect costs by three-fold. 5) It is difficult to extrapolate the experience of one state to the entire United States. 6) They ignore recruitment and retraining expenses, disruption of work schedules, property damage, legal fees, and public social services costs for affected workers. 7) The foregone earnings estimate ignores fringe benefits. 8) The final estimate, \$17 billion, is less than WC expenses for the same year (Nelson 1992). 9) But the most serious criticism is the most obvious: the initial epidemiological study by the Pennsylvania Department of Health is not available for public scrutiny nor has it ever been publicized.

The Neumark et al. study nevertheless was the first to publish estimates for direct and indirect costs of occupational injuries and illnesses. It was a pioneering study that proves useful for investigators attempting to construct their own estimates.

III.A.6. WC Data in Nelson (1992, 1993)

Every three to four years, the Social Security Administration asks William J. Nelson Jr. (or his equivalent in prior years) to generate national estimates on the annual costs of WC (Nelson 1992, 1993). Mr. Nelson's numbers are prevalence-based (i.e., they cover actual expenses in a given year). They do not cover expected future expenses that would be required, for example, for a person with a Permanent Total disability that began in the same year. Mr. Nelson culls data from a variety of sources including A.M. Best Company (a national data-collecting agency for private insurance), the National Council on Compensation Insurance (NCCI), the Federal Black Lung program, the Federal Employees Compensation program and the Federal Longshoremen and HarborWorkers' Compensation program. The A.M. Best and NCCI data cover the traditional WC

programs within the states. All other programs are federal and, technically, are not part of the traditional state-based network of WC.

In 1991, Nelson estimated total WC premium costs of \$55.2 billion. Roughly \$42.1 billion of this was spent on benefits and \$13.1 billion was retained for administration expense. Of the \$42.1 billion, roughly \$16.8 went for medical costs and \$25.3 went for indemnity costs.

A simple approach to estimating costs for all injuries (WC and non-WC) takes the national WC estimates in Nelson (1992, 1993), adjusts for federal and state differences in WC, adjusts for illnesses, multiplies by 2.22, and adjusts for the inflation. The 2.22 multiplier results from assuming that WC only covers 45% of all injuries or costs.

For our purposes, to apply the 2.22 multiplier, the data must be in the traditional state-only WC form. Therefore, the contribution of the federal programs must be subtracted before our multiplier is applied. Nelson's (1992, 1993) figures indicate that federal programs have been contributing roughly 5 to 7% of the total benefits. Assume that the federal programs contribute 6%. This would suggest that the traditional state WC programs contribute 94%. In 1991, Nelson (1993) estimated a total of \$55.2 billion. Ninety-four percent of \$55.2 billion is \$51.888 billion.

A second problem pertains to the fact that WC includes illnesses. Rossman, Miller, and Douglas (1991, p. 32) and Nelson (1993) estimate that illnesses comprised 2% of WC expenses. Ninety-eight percent of \$51.888 billion is \$50.85 billion.

We next consider the WC undercount and the 2.22 multiplication factor. The 2.22 factor corresponds to a WC undercount of roughly 55% (i.e., $100/(100-55) = 2.22$). Six studies suggest a WC undercount of 55% or more, on average. The study and the estimated undercounts are these: Toscano and Windau (60%); Cone et al. (55.9%); Stout and Bell (45%); Parker et al. (67%); NHIS-OSH (62%); Hensler et al. (58%). In addition, Marquis (1992) estimates that WC benefits accounted for only 27.5% of the total cost of occupational injuries, for a cost estimate of the undercount of 72.5%. The average of these is a 58% undercount. We selected 55%

again, because of our desire to remain conservative. These studies and the 2.22 factor were discussed in Chapter 2.

Recall that our adjusted estimate of WC total costs was \$50.850 billion. Multiplying by 2.22 yields \$112.99 or \$113 billion.

Finally, we must adjust for inflation from 1991 to 1992. The BLS estimates medical care costs rose 8.7% (U.S. Bureau of Census 1993) from 1991 to 1992, while all other prices rose by 4.2. Assuming a 6% rate to be applicable for us, our 1992 estimate would be \$118 billion.

This \$118 does not include lost fringe benefits, lost home production, lost earnings for the deceased, workplace disruption, or property damage, time delays, police and fire services, family home health care, or expenses associated with persons experiencing collateral damage as explained in Chapter 2. But most importantly, because wage replacement rates are so low, this \$118 billion does not include 100% of lost earnings, only 25% to 66% of lost earnings. If we made adjustments for these factors (i.e., if we added the amount for these factors from Tables 2.13 and 3.7) increase the indemnity by roughly two-fold, our Nelson-based overall estimate would be roughly \$194.9 billion.

$$\begin{aligned} 118 + 25.3 \times 2.222 + 15.9429 + 9.8349 + 5.1986 + 8.7665 \\ 2 + .3093 + .7801 + 3.8 + 2.9132 = \$193.6538 \end{aligned}$$

This \$193.6538 billion is probably an overestimate. The WC data includes death benefits and the relatively high WC administrative costs (31%). Nevertheless, it is useful to note that our \$148 billion estimate is not the highest estimate available in the literature.

III.A.7. Burton (1993)

John F. Burton, Jr. is perhaps the most widely-cited economist writing about WC. He produces national estimates of overall costs annually as well as provides extensive analyses of many WC economic issues every two months in his *Workers' Compensation Monitors* and his *WC Year Books* (Burton 1993; Burton and Schmidle 1994).

Professor Burton makes extensive use of the data in Nelson (1992, 1993), but also considers data from A.M. Best. He and Timothy Schmidle rely on econometric models to update Nelson's and Best's estimates.

His most recent study (as of this writing) applied to 1992. His estimate for 1992 for all premiums was \$60 billion. Burton's estimate for 1990 was \$53.1 billion and for 1991 was \$57.0 billion.

Burton shows that WC costs have been soaring, especially since 1975. In 1992, WC costs reached their highest percentage of total payroll: 2.57%. In recent years, from 1979 to 1990, total benefits have shown an annual rate of increase of around 12.2%. These increases are due largely to the rising cost of medical care and the growing number of people filing successful claims. Unlike Ruser (1991), Burton does not attribute the rising costs to ever more generous indemnity payment structures.

Burton does not estimate medical only costs or indemnity only costs in 1992. He simply reproduces Nelson's estimates from 1990. In 1990, medical and hospitalization payments comprised 41% of all benefits paid while indemnity payments comprised 59% of all benefits paid.

III.A.8. Boden and Fleischman (1989)

Boden and Fleischman (1989) were commissioned by the Workers' Compensation Research Institute to study time trends and state by state variations in WC costs. The analysis was based on information from 42 states and D.C. and included data from 20 years—1965 to 1985.

The data were drawn from the NCCI and independent insurance rating bureaus in California, Massachusetts, Minnesota, New Jersey, New York, and Texas as well as data from exclusive state funds. They did not analyze data from self-insured employers.

The Boden and Fleischman (1989) study is useful for us to review since it offered insights into our methods of estimating costs and since Boden and Fleischman presented some provocative findings. We turn our attention, first, to the insights, and second, to the findings.

We assumed in our cost analysis that illnesses comprised 2% of all WC costs. Boden and Fleischman estimated the percentage was less than 2%. Our 2% assumption, therefore, appears conservative when calculating injury expenses. We do not rely heavily on WC costs of illnesses in our estimates of the overall costs of illnesses to the nation in Chapter 6.

Boden and Fleischman (1989) like us, also encountered the policy year format problem in the NCCI. They point out that "data on individual insurance policies are collected every 12 months, starting eighteen months from the date a policy goes into effect."

Boden and Fleischman's primary focus was on tracking WC costs over time. They, therefore, needed to express costs in calendar, not policy years. But to do so required several contentious assumptions. One assumption was that the same number of policies were written in each month. But this policy year/calendar year issue is not a great controversy for us. We do not seek to track costs over time. The NCCI data are not available for costs in 1992. We take the average costs from 1988 to 1990, conservatively assume these are expressed in 1990 dollars, and adjust them upwards for inflation to 1992.

Boden and Fleischman (1989) used the First and Second Year Report data from the NCCI. We used Ultimate Report data which were more accurate, as Boden and Fleischman pointed out. Ultimate Report data were not available for every year and Boden and Fleischman wanted to analyze 20 years.

Boden and Fleischman (1989) removed the actuarial forecasts of future expected expenses on claims from the NCCI reports from most of their analyses. We included these forecasts, reasoning that such forecasts were made by experts in private markets and that these experts' forecasts were the best available.

The same reasoning has met with widespread approval among economists when applied to, for example, future interest rates (Malkiel 1991). This is the efficient markets hypothesis.

As it turned out, whether the forecasted (or future dollars) were included or excluded did not make much difference. Boden and Fleischman (1989) indicated that when they used the actuarially adjusted data, their results were not substantially different than when they excluded the forecasts. (See their Appendix

B, pps. 60-64). The correlation coefficient across states was .99 between data including and excluding the forecasted amounts. This could be due to the fact that the forecasted amount was so small compared to the amount paid. The great majority of cases were resolved and fully paid for before two years.

Boden and Fleischman's (1989) more important findings included these. 1) The rate of growth in WC medical costs was less than that of other non-WC medical costs from 1965 through 1977. The growth rate in WC medical costs began exceeding the rate for non-WC medical spending in the late 1970s and accelerated its pace in the 1980s. 2) The growth rate was high in some states and low in others. Low states or jurisdictions (for 1980 to 1988) included D.C. (2.2%), Arkansas (5.8%), Michigan (3.3%), North Carolina (4.6%), Ohio, (4.2%), Massachusetts (4.1%). High growth states included Texas (12.7%), Louisiana (13.5%), California (10.1%), Oregon (11.5%), and Oklahoma (11.3%). There were many reasons for the variation across states including: the high costs for the medical services in some states and low costs in others; the industrial and occupational mix; and the financial parameters of WC payments. For example, states with long waiting periods (seven days) tended to have higher average costs than states with short waiting periods (three days). The longer the injured worker is away from the job, the more serious the injury is likely to be.

Finally, Boden and Fleischman (1989) documented a direct relationship between unemployment and average medical costs. After accounting for the secular upward trend in costs, as unemployment increased (decreased), average medical costs for workers' compensation increased (decreased). They explained these results this way:

During recessions, less experienced workers—those with more, but generally less severe, injuries—are laid off first. With the declining incidence of less severe injuries, average severity increases. During periods of high unemployment, the duration of indemnity benefit payments increases because injured workers have more difficulty finding jobs... average medical costs per claim go up. Another product of increased duration is more litigation about the timing of return to work, which itself increases medical costs.

Unemployment rates generally were higher in the 1980s than in the 1960s. Because higher unemployment is associated with greater average severity of injuries, claim duration, and medico-legal costs, worsening labor market conditions may account for part of the acceleration in the growth of per-claim medical costs.

III.A.9. Webster and Snook (1990)

The largest category of job-related injuries occur to the back. The NSC suggests that back injuries generate more WC costs than any other injuries. Webster and Snook (1990) studied nearly 100,000 job-related low back pain claims from the computerized records of the Liberty Mutual Insurance Company. The mean cost per case was \$6807 while the median was \$391 (1986 dollars). Medical costs accounted for 31.5% while indemnity costs accounted for 67.5% of total costs. This 67.5% is truly remarkable: one category of injury accounts for more than two-thirds of all indemnity costs. They estimated that total WC compensable costs in the United States would be \$11.1 billion in 1986. If we assume 1) WC only captures 45% of all cases, 2) indemnity benefits cover 50% of before-tax wage loss (Khrenberg and Smith, 1991), 3) administrative costs add an additional 21% for medical (our average of WC and non-WC) and 16% for indemnity (our average of WC and non-WC), 4) related direct and indirect costs (home production and workplace disruption, fringe benefits and so on) were 27%, (estimated by applying ratios from Table 3.7), and, 5) an average medical and wage inflation of 35% from 1986 to 1992 (U.S. Bureau of Census 1993), then our 1992 estimate of back pain costs due to job-related factors would be:

$$((\$11.1 \times .315 \times 1.21) + (\$11.1 \times .675 \times 1.16)) \times 2.222 \times 1.27 \times 1.35 = \$49.2$$

This \$49.2 represents 33% of our total \$148 billion. This compares favorably to the NSC estimate of back pain contributing 31%. The close proximity of these two estimates provides some support for the consistency of our estimates, since we applied our assumptions and results to obtain the \$49.2 billion estimate from Webster and Snook (1990).

A number of additional points are made in the Webster and Snook (1990) study. 1) After two years of following the claims, only 7.5% were still open. This is reassuring. The greater the number of claims that are resolved early, the more the NCCI, Ultimate Report data we rely on will capture them accurately. 2) In 1986, the private insurance market accounted for 55% of all Workers' Compensation;

26% was covered through state and federal funds, and the remaining 19% was covered by employers' self-insurance.

The bulk of the government expenditure (20%) were captured by state funds either operating in competition with private carriers in some states or monopoly funds in other states.

III.B. Studies Not Dealing Exclusively with Job-Related Injuries

III.B.1. Rice et al. (1989) and Max, Rice, and MacKenzie (1990)

Rice et al., (1989) and Max, Rice and MacKenzie (1990) analyzed the incidence cost of injury for 1985. Rice et al. is the most widely cited study on the costs of injuries. Among their findings were these: 1) In 1985, 56.9 million persons were injured including 143,000 fatalities, 2.3 million injured persons requiring hospitalizations, and 54.4 million non-hospitalized injuries, requiring medical attention or resulting in one or more days of restricted activity. 2) In 1987, Americans lost 118 million days from work due to all injuries. 3) 13,000 of the 143,000 deaths were for people who died after 1985 due to injuries sustained in 1985. Their death estimate was, therefore, incidence-based. 4) In 1985, costs were \$157.6 billion or \$2,772 per injured person. Direct costs amounted to 29% of total costs. Morbidity costs were 41% and mortality costs were 30%. 5) The costs per injured person were: fatalities \$317,181; hospitalized \$34,116; non-hospitalized \$518.

These data are useful for us in providing an impression of the differences in costs among these three groups. However, we will not apply them to our study because the Rice et al. (1989) and Max et al. study (1990) covered injuries for all persons of all ages, so that infants, as well as the elderly, were included.

They had several categories for cause of the injury. Motor vehicle crashes and falls were the two leading causes. No separate analyses were conducted for causes of work-related injuries.

Men generated a little over two dollars of costs for every one dollar generated by women.

For direct costs, the bulk (87%) was generated in the first year of the injury. Roughly 13% was generated in all remaining years. For morbidity (not

mortality) costs, 46% were generated in the first year and roughly 54% were generated in all remaining years.

Rice et al. (1989) used three categories of injuries to calculate costs: fatality, hospitalized, and non-hospitalized. They did not include property damage as part of their costs. Per unit cost data were developed from 1) the National Medical Care Utilization and Expenditure Survey of emergency room and doctor visits, drugs, physical therapy, and ambulance services for medical costs; 2) the NCCI's Detailed Claim Information data base, also for medical costs; and 3) the National Nursing Home Survey (NNHS), for nursing home costs and foregone productivity for those institutionalized.

Several assumptions were made regarding costs for fatalities. They assumed that 50% of the deaths occurred at the scene of the injury, 29% in the emergency room and 21% in the hospital. Each of the categories generated different costs. Insurance overhead costs for fatalities were assumed to be 4% of all injury medical costs.

Their approach to valuing the loss of future earnings was the same as ours. The key assumption is that "people will be working and productive during their expected lifetime in accordance with the current pattern of work experience for their gender and age group." They assumed a 1% rate of productivity growth. Time discount rates were assumed to be 4% and 6%. We assumed 1% for productivity and 4% for the real discount rate.

Their hospitalization costs for non-fatal injuries relied heavily on per day hospital charges in Maryland for 1984 through 1986. The corresponding Maryland hospital charges were inflated by 25% to account for professional fees.

They accounted for home production and assigned different amounts depending upon age and gender. For example, while men aged 45 to 49 in the labor force were assumed to generate \$38,856 in annual earnings and fringe benefits in 1985 at the job, they were assumed to produce \$2989 in home production in the same year. Women aged 40 to 44 in the labor force were assumed to generate \$21,642 in earnings and fringe benefits at the job in 1985 and \$8282 in home production. Women were assumed to produce more in the home than men, even if both husband and wife were working full-time. Our estimates of home production, drawn from Douglas, Miller

and Kenney (1990) relied on similar assumptions. In our Tables 5.5 and 5.6, men were assumed to contribute the equivalent of roughly 7.7% of their wages in home production and women were assumed to contribute the equivalent of 38% of their wages in home production.

The Rice et al. (1989) estimates do not rely on a single source for their costs. They could not, given that there is no national data set on injuries and costs. Many studies were cited and myriad assumptions were made in their explanations for their calculations on their pages 72 to 81.

Their section on limitations of their data is useful since so many of their limitations also apply to our study, but some do not. Unlike us, they do not attempt to value the services of caregivers in the family or friends. They do not attempt to measure the administrative costs of non-hospitalized injuries beyond the first year. We do. Our NCCI data cover at least three years and they contain actuarial projections for all remaining years on a given claim. They ignore legal costs. We include them as part of the administration of insurance.

We, like them, ignore heroic and pro bono effects on the part of doctors and nurses in exceptional cases.

They acknowledge that many assumptions are necessary to produce age, gender, and cause of injury distributions. For example, the national number of emergency helicopter transports is known, but details on age, gender and cause are not. They simply assumed the distribution for ages, gender and causes.

They point out that "the data sets employed differ significantly as to how the cost data can be broken down, necessitating many assumptions. For this reason, a breakdown of costs by AIS, nature, or intent of injury would be unjustified by the available data."

Finally, they believed the estimates to be a lower bound. They most frequently made conservative assumptions regarding the volume and costs of injuries.

We emphasize these caveats and assumptions made by Rice et al. (1989) for an obvious reason: we, too, have many caveats and assumptions. Attempts to merely estimate the numbers of injuries nationwide are fraught with difficulties.

Attempts to then find or create average costs multipliers for these injury estimates could occupy the time of several researchers for years.

We have several advantages over Rice et al (1989). First, we were able to rely on the CFOI, NTOF, SDS and Annual Survey which are large government efforts specifically designed to count job-related injuries. Apart from the NHIS, no government efforts exist to count all injuries. And, as we have seen, the NHIS has some severe limitations especially when injuries involve violent acts.

Second, we rely on WC data from over 40 states collected and distributed by the NCCI. The cost data in the NCCI reports pertain directly to job-related injuries. Again, there are no firms or agencies collecting such a large amount of primary data for all injuries combined. Most of the NSC data in Accident Facts, for example, are secondary (i.e., not collected by the NSC). Moreover, the NCCI cost data have some clear advantages. The WC coverage almost always paid 100% of the medical bill. We, therefore, did not have to estimate what the doctor or hospital or drug charges would have been. They also provided data on indemnity or wage loss benefits on non-fatal injuries, which allowed us to generate estimates of indirect morbidity costs. We did not have to estimate how many days of work loss would have resulted from a given (WC qualifying) injury and then multiply that by an assumed wage.

Because of these data sources, the task of estimating the costs of job-related injuries was easier than the task of estimating the cost of all injuries.

Rice et al. (1989) did not provide separate cost estimates for job-related injuries. Marquis (1992) and the NSC (1993) do provide these estimates. Marquis estimates 47.3% and the NSC estimates 29%, i.e., 47.3% or 29% of total costs for all injuries are accounted for with job-related injuries (Miller and Galbraith estimated that workplace injuries accounted for 32% of [only] medical costs for all injuries). These 47.3% and 29% would suggest job-related injury costs of \$74.5 (Marquis) and \$45.7 (NSC) in 1985. Assuming an average 41% medical and wage inflation from 1985 to 1992 (U.S. Bureau of the Census 1993), our Rice-based job-related injury costs would be \$64.4 billion (NSC) to \$105 billion (Marquis 1992) in 1992.

We believe both estimates are low. Again, Burton (1993) estimated WC costs alone to be \$60 billion in 1992. The NSC estimated accident costs to be \$115.9 in 1992 (excluding violent acts) and the NSC relied exclusively on the low estimates of injuries in the Annual Survey and the NHIS.

III.B.2. Max and Rice, 1993

As indicated in Chapter 2, there appears to be a downward secular trend for job-related injury fatalities. However, one cause of death—murder—is on the rise. Many experts believe that on-the-job murder and assault will increase in the future. Murders are a leading cause of death for lawyers, taxi drivers, restaurant and bar managers, gas station attendants, sales managers, bank tellers, cashiers, secretaries, parking attendants, guards, bartenders, entertainers, waiters and waitresses, receptionists, janitors, and general managers. These murders more often than not involved robberies, not worker, co-worker, or supervisor quarrels. These murders could be reduced by requiring armed quarrels at all late-night convenience gas and liquor stores, restaurants, taverns and so on (Friedman 1994). In light of this evidence, we view Max and Rice's (1993) study on the costs of firearm fatal and non-fatal injuries.

In 1988, "firearm injuries resulted in nearly 34,000 deaths including, 1801 unintentional deaths, 18,169 suicides, 13,645 homicides, and 442 deaths of unknown intent" (Max and Rice 1993). Many of these deaths occurred among young people so that the years of potential life lost were staggering: 1,350,467 in 1985."

The Max and Rice (1993) estimates were incidence-based (i.e., they considered only new injuries in a given year). Incidence-based estimates also include estimates of future costs, properly discounted.

Max and Rice (1993) looked at injuries in only three categories: deaths, hospitalizations, and non-hospitalizations. The problem of multiple injuries occurring at the same accident was, therefore, not encountered.

Chief among the Max and Rice (1994) findings were these: 1) The ratio of fatal to non-fatal injuries was much higher for firearm injuries than all other injuries. For every fatal firearm injury, there were 7.4 non-fatal injuries. But the ratio is closer to 1 to 1,000 for every non-firearm related occupational

injury. Firearm injuries are more likely to result in death than any other category of injury. 2) The total costs of firearm injuries in 1985 was \$14.4 billion. Hospitalized injuries accounted for \$2 billion of which about 66% was for lost productivity and 33% was for direct, medical costs. Roughly \$78 million (\$.078 billion) was for non-hospitalized injuries. The \$78 million was almost equally divided between direct and indirect costs. 3) The direct costs were much greater for the hospitalized group (\$.784 billion) compared to either the fatal group (\$.092 billion) or the non-hospitalized group (\$.036 billion).

III.B.3. Blincoe and Faigin (1992)

Editors of the *Morbidity and Mortality Weekly Report* (a government publication), summarized the Blincoe and Faigin (1992) estimates of costs on motor vehicle crashes this way:

Motor-vehicle crashes during 1990 accounted for 44,531 fatalities, 5.4 million non-fatal injuries, and 28 million damaged vehicles, and an estimated total cost of \$137.5 billion. Major sources for cost were property damage (\$45.7 billion; 33%), productivity losses in the workplace (\$39.8 billion; 29%), medical care expenses (13.9 billion; 10%), and losses related to household productivity (\$10.8 billion; 8%).

The greatest unit cost was associated with fatalities—approximately \$702,000 per fatality. The economic impact of motor vehicle crashes during 1990 was approximately 2.5% of the Gross Domestic Product in the United States. Although most motor-vehicle crashes involved no injury, crashes resulting in injuries and fatalities accounted for three-fourths of all crash costs. Nearly 30% of the first-year medical costs of hospitalized persons injured in a motor vehicle crash in the United States is paid by federal, state, and local government sources such as Medicaid and Medicare.

The Blincoe and Faigin (1992) study appears to be the most comprehensive of all studies on the costs of vehicle crashes. Unlike prior studies on the costs of vehicle crashes, Blincoe and Faigin included property damage, costs of uninjured occupants, legal and court costs, workplace disruption, and delay costs. We, too, include all of these categories, except costs to uninjured occupants.

Blincoe and Faigin found that approximately 22% of people in crashes involving injuries did not file a police report. Theirs was an incidence cost study and they used a 4% discount rate on future dollars. Ours is also an incidence study and we too use a 4% discount rate.

IV. Conclusion

Table 5.7 summarizes our cost findings. Our direct costs summed to \$30.8 billion. Our indirect costs summed to \$121.3. We believe our cost analysis is more comprehensive than any prior study. We include home production losses, administrative costs on indemnity, workplace training, property damage, time delays, police and fire services, family home health care and costs to innocent third parties.

The major point of our review of the existing literature is to affirm that our methods and assumptions are reasonable. In as many cases as possible, we relied on the literature to support our methods and assumptions. We did not seek to create new methods.

We compare our estimates with three other studies on occupational injuries and illnesses. The National Safety Council (NSC) (1993) estimated \$116 billion of costs for injuries only in 1992. But the NSC ignored assault, murder, suicide and other acts of violence. Marquis (1992) estimated the direct and indirect costs of injuries only (not illness) to be roughly \$83.2 billion in 1989. But the Marquis study greatly underestimated non-disabling injuries, ignored deaths, ignored assaults and acts of violence, and the dollars applied to 1989, not 1992. Finally, our adjustments to Nelson's (1990, 1993) WC data would suggest roughly a \$194 billion estimate.

Chapter 6

Costs of Occupational Disease

by
Marianne C. Fahs, Ph.D., M.P.H.,
Chonggak Shin, M.B.A., C.P.A.,
Steven B. Markowitz, M.D., and
Philip J. Landrigan, M.D.

Chapter 6: Costs of Occupational Disease

I. Introduction

With the prominence of economic concerns in health policy discussions, increasing attention has been paid to the economic costs of illness. Expert assessments of policies to confront major health problems now routinely include consideration of illness costs. In occupational health policy, however, this is not the case. Illness costs have been routinely excluded from consideration in the debates over controversial proposals for workplace safety regulations.

The National Institute of Occupational Safety and Health (NIOSH) is mandated by Congress to study the economic impact of proposed industry regulations. However, NIOSH has limited the economic impact analysis to econometric forecasts of labor market dynamics. Consideration of the dynamics of the health care market, including the economic benefits of healthier workers, has been omitted from the economic impact assessments. Consequently, the econometric models currently developed for NIOSH tend to underestimate the net social benefits of occupational risk reduction in the labor force, by omitting the benefits to the economy of healthier, more productive workers. Conversely, the models tend to overestimate the social costs of industry regulation, since potential savings in averted health care costs are ignored for workers whose occupational disease is prevented. These incomplete models of the labor market generate economic impact assessments that produce biased information for policy makers. The bias systematically devalues occupational disease prevention strategies, tending to support the status quo of industry standards.

To guide government policy formation that is in the best interests of the public, predicted economic outcomes of disease prevention strategies, such as industry regulations, should include estimates of the direct and indirect costs of occupationally-related disease averted. However, the literature on the economic costs of occupationally-related disease remains under-developed. Despite frequent calls from national advisory groups and health policy analysts for national-level studies (Institute of Medicine 1981; MMWR 1993; Vital & Health Statistics 1993), studies are either limited to specific diseases, such as work-related hypertension care (Ruchlin et al. 1984), upper extremity cumulative trauma disorders (Webster

and Snook 1994; Tanaka et al. 1988), or to specific geographic regions, such as the states of Pennsylvania, New York, or Michigan (Neumark et al. 1991; Fahs et al. 1989; Oleinick et al. 1993). A national investigation into the economic consequences of occupational disease is called for. It is of some urgency that resources be applied to the development of the health economic and epidemiologic research necessary to improve science-based policy in occupational health.

To begin to address this concern, this chapter investigates data sources and develops cost of illness accounting methods to present a preliminary and partial estimate of the economic costs of occupationally-related illness in the United States. In preparing this estimate, we rely on the epidemiologic estimates of occupational illnesses in Chapter 3. We focus our attention on the six leading causes of death from occupationally-related disease, that is, cancer, nervous system disorders, pneumoconioses, chronic respiratory disease, cardiovascular and cerebrovascular disease, and renal disorders. We supplement the economic estimates of these six occupational illnesses with partial estimates of the cost of illness for chronic, nonfatal occupational illness. Thus, we begin to contribute to a composite framework for understanding the magnitude of the economic costs of occupationally-related disease.

II. Methods and Data

Two approaches can be used in estimating the costs of illness by the human capital method. Prevalence-based costs provide an estimate of the direct and indirect economic burden in a period of time (the base period) as a result of the prevalence of disease, a period most often a year. Included are the costs of the base year manifestations of sequelae of disease which may have had its onset in the base year or any time prior to the base year. Prevalence costs measure the value of resources used or lost during a specified period of time, regardless of the time of disease onset.

Incidence-based costs represent the lifetime costs resulting from the disease or illness. In the aggregate, incidence costs in a given base year refer to the likely course of a disease and its duration, including survival rates since

onset, medical care that will be used and its cost during the duration of the disease, and the impact of the disease on employment, housekeeping, and earnings.

Relatively few incidence-based studies exist, but the state of the art is illustrated by three studies. Hartunian, Smart, and Thompson (1981) estimated the lifetime costs of cancer, coronary heart disease, stroke, and motor vehicle injuries. Policy Analysis, Inc. conducted a study for the National Center for Health Statistics entitled "Evaluation of Cost of Illness Ascertainment Methodology." Final Report, DHHS Pub. No. 233-79-2048, December 1981. This report examines the incidence-based costs of breast cancer, diabetes mellitus, rheumatoid arthritis, stroke, and acute lymphocytic leukemia. Oster, Colditz, and Kelly (1984) estimated the costs of smoking and the benefits of quitting in their book, *The Economic Costs of Smoking and Benefits to Quitting*. Lexington Books, D.C. Heath and Company 1984.

These studies investigate direct and indirect costs by modeling the disease process from onset until cure or death, including the trends of important parameters such as incidence, survival, use and cost of medical care, and time lost from work and housekeeping. In each of these studies, a great deal of effort was expended in locating and making the most of available data, which often were originally gathered for other purposes, were incomplete, and had to be modified to meet the needs of incidence costs analysis. These studies are impressive in their demonstration that incidence-based costs are methodologically feasible, and in their use of extensive sensitivity analysis to reveal the impact of alternative assumptions and parameter values on estimated costs.

For the incidence-based lifetime costs of occupational disease, data are needed on the number of new cases of cancer, heart disease, respiratory disease, renal disorders and so on, that are caused by or associated with various unhealthy occupations. To obtain estimates of lifetime costs of these new cases, one must have information on the severity of disease from onset, the direct medical costs incurred from onset to death, the productive time lost during this period and the lag time between diagnosis and death. Owing to idiosyncrasies in the manner by which most occupational diseases are managed and recorded, accurate data both on incidence and cost are difficult to secure. Without substantial primary data

collection and analysis, which is outside the resource constraints of this project, the current data limitations for age-specific and sex-specific incidence rates and severity of occupational disease preclude the development of an incidence-based cost of illness estimate. The purpose of this chapter is to develop a reasonable appreciation for the potential magnitude of the economic cost of occupational disease in the US in the face of less than optimal data.

The prevalence-based methodology estimates the direct and indirect costs of occupational disease using a step-down accounting strategy and available national data. The prevalence method is the more commonly used accounting strategy due to the less extensive data requirements. This method is primarily concerned with costs during a fixed period of time, normally a calendar year. The economic costs associated with occupational disease are estimated in this analysis using a prevalence-based methodology, following the work of Rice and colleagues (Rice 1966; Rice, Hogson, and Kopstein 1985; Hodgson and Rice 1976; Hodgson 1982). The cost of disease is measured by the cost of resources consumed as the result of the disease during one year, and by the value of the lost productivity resulting from morbidity and premature mortality caused by the disease during that year. In estimating the economic burden resulting from the prevalence of disease, the conventional prevalence methodology attributes the future costs of premature mortality to the year in question, using discounting techniques to estimate the present value of future losses.

Following the prevalence-based method, we apply cost of illness accounting techniques to calculate the present value of the direct and indirect costs associated with occupational disease. Using the national hospital discharge survey (Vital and Health Statistics 1991), we calculated the total number of days spent in the hospital by patients with a primary diagnosis for each of the attributable occupational illness groups defined by specific ICD9 codes for the occupational diseases most responsible for worker mortality presented earlier (Markowitz and Landrigan 1995). Total days of hospitalization by disease group were transformed to obtain standardized proportions of national hospital utilization attributable to occupational disease. We applied these proportions to the national health expenditure accounts (minus nursing home costs), estimated by the Health Care

Financing Agency (HCFA 1994), to obtain an estimate of medical direct costs. The direct costs of nursing home care for occupationally-related disease were estimated using the National Nursing Home Survey (1985). These cost estimates, using diagnosis-specific nursing home length-of-stay data, were added to medical expenditure estimates to obtain an estimate of total direct costs.

Indirect costs were estimated using present value Tables 5.5 and 5.6 in the chapter on the costs of injuries. Unlike the injury application, however, no one was assumed to have a labor force participation rate of 1.0 beyond age 65. Information in these tables applied to age-specific, sex-specific, and disease-specific mortality data from the National Center for Health Statistics, Vital Statistics Division (U.S. National Center for Health Statistics 1993; U.S. Department of Health and Human Services 1993 and 1994), as well as life table estimates, and expected earnings and labor force participation data from the Bureau of Labor Statistics. By applying the attributable risk proportions, presented earlier in the epidemiology chapter, to the total estimates of individual costs by disease, the present value of the indirect costs of premature mortality due to occupational disease is estimated for the base year 1992. Finally, we calculated national disease-specific trends over time in the ratios of morbidity costs to direct costs, and morbidity costs to mortality costs (Rice 1985; Rice 1989) to obtain an estimate of the morbidity costs for the occupational diseases that comprise the major causes of death from occupational disease.

In addition to estimating the economic costs associated with the occupational diseases responsible for major causes of death in the United States we investigated the costs of specific nonfatal occupational diseases, including skin diseases, and carpal tunnel syndrome, as reported to the Bureau of Labor Statistics. Industry-specific wage rates were applied to lost work time to obtain a conservative estimate of indirect costs. Direct costs were based on estimates obtained from published data from the National Council on Compensation Insurance (Neumark et al, 1991).

III. Results

The economic cost of occupational disease in the United States is greater than \$25.5 billion in 1992 dollars. Fatalities due to occupational diseases comprise 77% of the total. Of the \$19.7 billion losses due to deaths from occupational disease in 1992, 54% are direct costs, 36% are mortality costs, and 10% are morbidity costs. Direct costs comprise 92% of total losses for reported nonfatal occupational illness. These results are summarized in Table 6.1.

The distribution by diagnosis of total economic costs for fatal occupational disease shows the greatest losses are caused by diseases of the circulatory system, and chronic respiratory disease, accounting for \$9.4 billion, \$5.8 billion, and \$3.9 billion. Together these three diseases accounted for 97% of the economic costs of fatal occupational illness.

Table 6.2 presents the range of total costs of occupational illness by disease, for fatal occupational illness, estimated at \$19.7 billion dollars, with a high estimate of \$24.2 billion and a low estimate of \$15.2 billion. Total estimated costs for cancer amount to \$9.4 billion, with a high estimate of \$11.7 billion to a low estimate of \$7.0 billion. Total estimated costs for nervous system disorders amount to \$286 million, with a high estimate of \$429 million to a low estimate of \$143 million.

Total estimated costs for pneumoconioses amount to \$202 million. Total estimated costs for chronic respiratory disease amount to \$3.9 billion. Total estimated costs for cardiovascular and cerebrovascular diseases amount to \$5.8 billion, with a high estimate of \$7.7 billion to a low estimate of \$3.9 billion. Total estimated costs for renal disorders amount to \$151 million, with a high estimate of \$226 million to a low estimate of \$15 million.

Table 6.3 presents the breakdown of direct and indirect costs for fatal occupational illness disease. Total direct costs amount to \$10.7 billion, and indirect costs are \$9.0 billion. The total mortality costs amount to \$7.0 billion, and total morbidity costs amount to \$2.0 billion.

The range of estimates for the total direct and indirect costs for fatal occupational illness is \$25.6 billion, with a high estimate of \$32.3 billion and a low estimate of \$18.8 billion. The midpoint estimate for total direct costs is \$10.7 billion, and for total indirect costs is \$9.0 billion. The midpoint estimate

for mortality is \$7.0 billion, and for morbidity is \$2.0 billion. These results are presented in Table 6.4.

Table 6.5 presents the number of new cases of occupational illnesses and morbidity costs by industry and category of illness in 1992. The total costs for morbidity are \$472 million. Table 6 presents the number and estimated total medical costs of new cases of occupational illnesses by industry and category of illness. These costs amount to over \$5 billion.

IV. Discussion

In many ways, the methodological challenges researchers must face in estimating the economic costs of occupationally-related disease mirror the challenges of industrial regulation policy where fragmented information systems diffuse and obscure the predictable health effects of occupational hazards. Occupational health policy analysis, that is, the ability to analyze the effect of disease prevention technologies and clinical detection and treatment systems on health outcomes, cost of resources, and ultimately on productivity, is severely hampered by the fragmented information systems that are associated with the over 1500 employer-based health insurance plans for working populations. In addition, the loss of continuous medical history and follow-up data due to the separation of Medicare, the insurer for the population 65 years and older, from private employer-based insurance information systems further limits the data accessibility that is necessary to understand the full spectrum of the costs of occupationally-related disease, over the life-span.

Sensitivity Analyses

In order to assess the reliability of our estimates, we performed a sensitivity analysis. We analyzed the effect of our results on the assumptions used to estimate morbidity costs. To perform the sensitivity analysis, we calculated morbidity costs two ways. In Tables 6.2-6.4, we presented estimates based on the calculation of morbidity costs as a ratio of mortality costs. Tables 6.7-6.9 present estimates based on the calculation of morbidity costs as a ratio of direct costs. We estimated the ratio as a linear function of 1980 and 1985

ratios, calculated by Rice and colleagues (Rice et al. 1985; Rice et al. 1989). We find the method used does not substantially affect the final estimate of the total costs of occupational disease. The total economic cost estimates vary by less than 10% at midpoint.

Estimates by disease will vary according to the relationship between direct costs and mortality costs within disease categories. For some diseases such as cancer, using a ratio for morbidity costs that is based on mortality costs, the total estimate of the costs of cancer is slightly lower. This is due to the high relative proportion of direct costs to mortality costs for cancer patients. This relationship is not true for pneumoconioses, which have much higher ratios of mortality costs to direct costs. Therefore, the estimate of total costs for pneumoconioses, using morbidity cost based on mortality cost, is substantially higher than the estimate for pneumoconioses using morbidity costs based on direct costs. Overall, in the estimates presented, there appears to be a balancing out of these effects, so that the total estimate appears stable.

There are other assumptions that should be tested in future research. Specifically, the assumptions regarding homogeneity of occupational disease death rates with national average age-specific death rates of the diseases under study should be examined. If, for instance, workers with occupationally-acquired cancer die at an earlier age than patients whose cancers are caused by non-occupational factors, our economic cost estimates are likely to be biased downwards.

National surveys and data sets for describing medical care utilization patterns for the general population should be explored further for measures and data regarding costs and outcomes of occupationally-related disease. These rich sources of clinical and socio-economic data have not been examined, for the most part, for model building and testing of hypotheses regarding health status, medical expenditure, and occupational status. Research diverted toward the sources of knowledge in data sets (such as the National Medical Expenditure Survey, U.S. Department of Health and Human Services 1994) would be a productive use of health policy research dollars.

In summary, the estimates presented in this report are conservative. The economic cost estimates associated with deaths due to occupational disease include

morbidity costs, but do not include costs for persons diagnosed with these potentially fatal occupationally-related diseases who did not die during 1992. In addition, no economic costs were attributed to deaths due to occupationally-related heart disease after age 65. Our supplement to the costs of fatal illness, the BLS report of occupationally-related chronic disease (U.S. Bureau of Labor Statistics 1991), is widely criticized to be under-reported. Estimates from the literature indicate the under-reporting may be as much as three-fold (Oleinick 1993).

V. Conclusion

A full accounting of the social and economic costs of occupational disease should include an analysis of distributional equity. Economic theory predicts that society will underinvest in areas where the benefits of the investment reach beyond the immediate investors. Currently, financial responsibility for disease due to occupational hazards is shifted away from Workers' Compensation, where it properly belongs, toward future Medicare expenses. This shift results in a "hidden tax," in which costs of occupational disease are externalized and thus are funded by general and payroll taxes. Correction of this situation would create private market incentives for prevention of occupational disease and thus would lead to an increase in efficiency of the Medicare health insurance system. Analyses demonstrating the comparative efficiencies of proposed solutions to this distributional inequity would have significant health policy implications. However, cost of illness accounting methodologies, such as that presented in this chapter, do not allow hypothesis-driven analysis of policies to address this hidden cost transfer from the private sector to the public sector.

The development of state-of-the-art health policy models is useful for economic forecasting and would contribute to our knowledge of the magnitude and scope of inefficiencies or inequities under the status quo. Cost effectiveness analysis can simulate and compare the effects of alternate policy choices on workers' health outcomes and medical costs. Such health policy analyses often use mathematical computer-based stochastic models of disease to simulate the dynamics of treatment protocols, patient outcomes, and costs. These policy models rely on

clinical information of some detail including characteristics of the episode of disease and treatment, as well as the effect of the disease on the patient and the patient's family.

Occupational health policy models should be developed to include the hypotheses of the health services research literature, concerning the effectiveness and costs of alternative primary and secondary prevention policies. Moreover, hypotheses of the biological sciences, concerning occupational exposures, interactions of toxins with disease mechanisms, and duration of risk due exposure, also should be considered as parameters in health policy models. Data gathered to document both the social severity and the clinical severity of occupationally-related disease would be extremely useful and would enhance the validity of economic projections. In particular, occupationally-related cancer and heart disease require further specificity. The variables, which define transition times and progression probabilities between stages of disease severity, can substantially affect the economic estimates. For heart disease, a stochastic model which incorporated mathematical decay functions for the declining rate of mortality from heart disease after age 65, due to occupational hypertension acquired before age 65, would substantially improve the economic cost estimates.

In summary, the current economic burden of occupational disease appears to be significant. Further economic research should undertake the task of probabilistic computer-based modeling to advance the scientific basis of the estimates. Monte Carlo sampling methods can estimate the health and economic burdens with statistical precision. Research models developed with epidemiologic detail in a dynamic computer-based optimization environment will enrich the economic contribution to debates concerning occupational health policy.

Table 6.1

Summary of Costs of Selected Occupationally-Related Diseases - 1992
(Costs in 000s)

Economic Cost	Cost of Fatal Occupational Diseases	Cost of Non-Fatal Occupational Diseases	Total Cost of Occupational Diseases
Direct	\$10,699,670	\$5,370,452	\$16,070,122
Indirect	\$8,992,864	\$472,336	\$9,465,200
Mortality	\$7,003,204	--	
Morbidity	\$1,989,661	\$472,336	
TOTAL	\$19,692,534	\$5,842,788	\$25,535,322

SOURCES: U.S. Health Care Financing Administration, Health Care Financing Review (Fall 1994); National Hospital Discharge Survey, National Center for Health Statistics (1992); National Nursing Home Survey, National Center for Health Statistics (1985); Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor (1995); Money Income of Households, Families and Persons in the United States (1992); U.S. Bureau of the Census (1993); and, Tables 2-6, Chapter 6: National costs of occupationally-related disease. In Costs of Occupational Injuries and Illnesses. NIOSH Final Report. Contract #U60CCU902886-07. Internal Document (1995).

Table 6.2

Range of Total Costs of Occupational Fatalities, by Disease
(Costs in 000s)

<u>Disease²</u>	<u>Estimated Proportion Due to Occupation¹</u>	<u>Total Cost Range¹</u>		
		<u>Low Estimate</u>	<u>High Estimate</u>	<u>Midpoint Estimate</u>
Cancer	6 - 10%	\$7,030,400	\$11,717,334	\$9,373,867
Nervous System Disorders	1 - 3%	143,060	429,180	286,120
Pneumoconioses	100%	201,654	201,654	201,654
Chronic Respiratory Disease	10%	3,904,621	3,904,621	3,904,621
Cardiovascular & Cerebrovascular Disease	5 - 10%	3,850,293	7,700,586	5,775,439
Renal Disorders	1 - 3%	75,416	226,249	150,833
TOTAL		\$15,205,444	\$24,179,623	\$19,692,533

¹All cost estimates are in 1992 dollars.

²Specific ICD9 codes used to define diseases are listed in Appendix A.

³Estimated proportions are from Markowitz and Landrigan, 1995.

SOURCE: U.S. Health Care Financing Administration, Health Care Financing Review (Fall 1994); National Hospital Discharge Survey, National Center for Health Statistics (1992); National Nursing Home Survey, National Center for Health Statistics (1985); Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor (1995); Money Income of Households, Families and Persons in the United States (1992); U.S. Bureau of the Census (1993).

Table 6.3

Range of Total Costs of Occupational Fatalities by
Direct and Indirect Costs by Disease (Midpoint estimates)
(Costs in 000s)

	<u>Cancer</u>	<u>Nervous System Disorders</u>	<u>Pneumoconioses</u>	<u>Chronic Respiratory Disease</u>	<u>Cerebrovascular & Cardiovascular Renal Disease Disorders</u>
TOTAL					
Direct Cost \$10,699,670	\$4,521,965	\$241,740	\$8,585	\$2,634,150	\$3,214,237\$78,993
Indirect Cost \$8,992,863	\$4,851,902	\$44,380	\$193,069	\$1,270,471	\$2,561,202\$71,839
Mortality \$7,003,204	\$4,160,602	\$25,393	\$77,470	\$511,019	\$2,196,282\$32,438
Morbidity 989,661	\$691,300	\$18,987	\$115,599	\$759,452	\$364,921\$39,402
TOTAL \$19,692,534	\$9,373,867	\$286,120	\$201,654	\$3,904,621	\$5,775,439\$150,833

SOURCE: U.S. Health Care Financing Administration, *Health Care Financing Review*, Fall 1994; National Hospital Discharge Survey, National Center for Health Statistics, 1992; National Nursing Home Survey, National Center for Health Statistics, 1985; Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor, 1995; Money Income of Households, Families and Persons in the United States, 1992; U.S. Bureau of the Census, 1993.

Table 6.3 GOES HERE

Table 6.4

Range of Direct and Indirect Costs of Occupational Disease Fatalities
(Costs in 000s)

	<u>Low Estimate</u>	<u>High Estimate</u>	<u>Midpoint Estimate</u>
Direct Cost	\$ 8,337,400	\$13,061,940	\$10,699,670
Indirect Cost	6,868,044	11,117,682	8,992,864
Mortality	5,202,044	8,804,364	7,003,204
Morbidity	1,666,000	2,313,319	1,989,660
TOTAL	\$15,205,444	\$24,179,623	\$19,692,533

SOURCE: U.S. Health Care Financing Administration, Health Care Financing Review (Fall 1994); National Hospital Discharge Survey, National Center for Health Statistics (1992); National Nursing Home Survey, National Center for Health Statistics (1985); Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor (1995); Money Income of Households, Families and Persons in the United States (1992); U.S. Bureau of the Census (1993).

Table 6.5
Number of New Cases of Occupational Illnesses and Morbidity Costs by Industry and Category of Illness, 1992 (000s)

	Private retail insurance, all	Agriculture, forestry, and fishing	Industry, Mining	Construction	Manufacturing	Transportation and public utilities	Wholesale trade	Finance, a real estate	Services n	d
Illnesses	6.2	1.9	10.5	292.3	16.7	43.9	16.1	69.8	Total	
457.4										
Skin diseases or disorders										
63.0	2.7	0.2	2.4	31.2	2.9	5.6	1.1	16.9		
Dust diseases of the lungs										
2.4	0.0	0.6	0.1	1.0	0.0	0.2	0.5	0.5		
Respiratory conditions due to toxic agents										
23.6	0.4	0.1	1.0	10.0	1.1	3.3	0.9	6.8		
Poisoning										
7.0	0.1	0.0	0.5	3.5	0.4	1.0	0.9	1.4		
Disorders due to physical agents										
18.2	0.4	0.1	1.2	11.1	0.9	0.0	0.8	3.7		
Disorders associated with repeated trauma										
281.9	1.5	0.7	2.2	219.9	8.7	20.2	11.4	17.3		

<i>All other occupational diseases</i>	<i>1.1</i>	<i>0.2</i>	<i>3.2</i>	<i>15.7</i>	<i>2.5</i>	<i>9.6</i>	<i>1.9</i>	<i>23.3</i>
<i>57.5</i>								

<i>Lost workday cases⁽¹⁾</i>								
<i>Total (including restricted work)</i>	<i>1.8</i>	<i>0.5</i>	<i>3.6</i>	<i>119.9</i>	<i>6.6</i>	<i>16.2</i>	<i>6.7</i>	<i>22.1</i>
<i>177.4</i>								

<i>Average lost workdays per lost workday case</i>	<i>19</i>	<i>27</i>	<i>28</i>	<i>34</i>	<i>30</i>	<i>39</i>	<i>39</i>	<i>27</i>
<i>33</i>								

<i>Average hourly earnings^a</i>	<i>10.6</i>	<i>11.5</i>	<i>14.5</i>	<i>14.1</i>	<i>13.5</i>	<i>9.3</i>	<i>10.8</i>	<i>10.5</i>
<i>10.6</i>								

<i>Total workday costs^a</i>	<i>\$2,767,321</i>	<i>\$1,215,390</i>	<i>\$12,473,121</i>	<i>\$314,954,299</i>	<i>\$21,061,235</i>	<i>\$46,698,107</i>	<i>\$20,459,615</i>	<i>\$52,687,368</i>
<i>\$472,336,400</i>								

Assumption: Average lost workdays come from BLS 1991 data. ^a We assume that restricted work days are 20 percent of a workday. ^a Includes 17% administrative cost. ^a Agricultural industries' wages come from average hourly earnings. Source: US Bureau of Labor Statistics, Bulletin 2370, supplement to Employment and Earnings, July 1991; and Employment and Earnings, monthly.

Table 6.6

Number and Estimated Total Medical Costs of New Cases
of Occupational Illnesses by Industry and Category of Illness
(Costs in 000s)

Occupational Industry Division	Total	Skin Diseases	Dust Diseases	Respiratory Conditions due to	Toxic Agents	Poisoning	Acute Disorders due to Physical	Disorders Associated with Repeated
Private Industry, All Cases	457.40	63.00	2.40	23.60	7.00	18.20	281,9057.50	
Mean Medical Cost using Ohio Worker's Compensation	--	\$0.40	\$5.70	\$5.70	\$5.70	\$5.70	\$5.1555.70	
Mean Medical Cost using NCCI	--	\$8.75	\$8.75	\$8.75	\$8.75	\$8.75	\$8.7558.75	
Total Medical Cost using Worker's Compensation	\$2,838,576	\$34,187	\$18,516	\$182,072	\$54,004	\$140,411	\$1,965,7798443,607	
Total Medical Cost using NCCI	\$5,370,452	\$745,896	\$28,415	\$279,415	\$82,877	\$215,481	\$3,337,5898680,778	

Sources: U.S. Bureau of Labor Statistics, *Occupational Injuries and Illnesses in the U.S. by Industry*, Washington D.C.: Govt. Printing Office, 1993, Bulletin 2424.

Newmark D, et al. Cost of occupational injury and illness in Pennsylvania. *Journal of Occupational Medicine* Sept 1991; 33(9): Webster BS and Snook SH. The cost of compensable upper extremity cumulative trauma disorder. *Journal of Occupational Medicine*, forthcoming.

The Industrial Commission of Ohio and Division of Safety and Hygiene, *Average Costs of Occupational Injuries and Illnesses 1980-1983*, State of Ohio. March 1986.

Notes: Medical costs are updated from the base years using medical portion of the consumer price index.

TABLES 6.5 AND 6.6 ARE INCLUDED SEPARATELY ON THE DISKETTE, LABELED TBL65WP.DOC AND TBL66WP.DOC. THEY ARE NOW IN WORD PERFECT 5.1.

TABLES 6.5 AND 6.6 ARE INCLUDED SEPARATELY ON THE DISKETTE, LABELED TBL65WP.DOC AND TBL66WP.DOC. THEY ARE NOW IN WORD PERFECT 5.1.

Table 6.7

Range of Total Costs of Occupational Fatalities, by Disease
Sensitivity Analysis: Assumptions for Morbidity Costs Based on
Estimated Direct Costs
(Costs in 000s)

<u>Disease²</u>	<u>Estimated Proportion Due to Occupation³</u>	<u>Total Cost Range¹</u>		
		<u>Low Estimate</u>	<u>High Estimate</u>	<u>Midpoint Estimate</u>
Cancer	6 - 10%	\$7,464,566	\$12,440,943	\$9,952,754
Nervous System Disorders	1 - 3%	145,141	435,423	290,282
Pneumoconioses	100%	89,794	89,794	89,794
Chronic Respiratory Disease	10%	4,170,959	4,170,959	4,170,959
Cardiovascular & Cerebrovascular Disease	5 - 10%	4,085,800	8,171,60	6,128,700
Renal Disorders	1 - 3%	59,246	177,737	118,491
TOTAL		\$16,015,505	\$25,486,455	\$20,750,980

¹All cost estimates are in 1992 dollars.

²Specific ICD9 codes used to define diseases are listed in Appendix A.

³Estimated proportions are from Markowitz and Landrigan, 1995.

SOURCE: U.S. Health Care Financing Administration, Health Care Financing Review, (Fall 1994); National Hospital Discharge Survey, National Center for Health Statistics (1992); National Nursing Home Survey, National Center for Health Statistics (1985); Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor (1995); Money Income of Households, Families and Persons in the United States (1992); U.S. Bureau of the Census (1993).

Table 6.8

**Total Costs of Occupational Fatalities by
Direct and Indirect Costs by Disease (Midpoint estimates)
Sensitivity Analysis: Assumptions for Morbidity Costs Based on Estimated Direct Costs
(Costs in 000s)**

	Cancer	Nervous System Disorders	Pneumonia	Chronic Respiratory Disease	Cardiovascular & Cardiovascular Disease	Renal Disorders	TOTAL
Direct Cost	\$4,521,965	\$241,740	\$8,585	\$2,634,150	\$3,214,237	\$78,993	\$10,699,670
Indirect Cost	\$5,430,790	\$48,542	\$81,209	\$1,536,809	\$2,914,463	\$39,498	\$10,051,311
Mortality	\$4,160,602	\$25,393	\$77,470	\$511,019	\$2,196,282	\$32,438	\$7,003,204
Morbidity	\$1,270,188	\$23,149	\$3,739	\$1,025,790	\$718,181	\$7,060	\$3,048,107
TOTAL	\$9,952,754	\$290,282	\$89,794	\$4,170,939	\$6,128,700	\$118,491	\$20,720,981

SOURCE:

U.S. Health Care Financing Administration, Health Care Financing Review, Fall 1994; National Hospital Discharge Survey, National Center for Health Statistics, 1992; National Nursing Home Survey, National Center for Health Statistics, 1985; Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor, 1995; Money Income of Households, Families and Persons in the United States, 1992; U.S. Bureau of the Census, 1993.

TABLE 6.8 IS INCLUDED SEPARATELY ON THE DISKETTE, LABELED TBL68WP.DOC. IT IS IN WORD PERFECT 5.1.

Table 6.9

Range of Total Direct and Indirect Costs of Occupational Disease Fatalities
Sensitivity Analysis: Assumptions for Morbidity Costs
Based on Estimated Direct Costs
(Costs in 000s)

	<u>Low Estimate</u>	<u>High Estimate</u>	<u>Midpoint Estimate</u>
Direct Cost	\$8,337,400	\$13,061,940	\$10,699,670
Indirect Cost			\$10,051,310
Mortality	5,202,044	8,804,364	7,003,204
Morbidity	2,476,061	3,620,151	3,048,106
TOTAL	\$16,015,505	\$25,486,455	\$20,750,980

SOURCE: U.S. Health Care Financing Administration, Health Care Financing Review, (Fall 1994); National Hospital Discharge Survey, National Center for Health Statistics (1992); National Nursing Home Survey, National Center for Health Statistics (1985); Medical Care Component, Consumer Price Index, Bureau of Labor Statistics, Department of Labor (1995); Money Income of Households, Families and Persons in the United States (1992); U.S. Bureau of the Census (1993).

Chapter 7

Willingness-to-Pay Cost Estimates for Injuries and Illnesses

Chapter 7: Willingness-to-Pay Cost Estimates for Injuries and Illnesses

I. WTP Estimates from the Literature

This chapter is split into four sections. In Section I, we revisit the estimates first mentioned in Chapter 4. In Section II, we estimate the WTP for injuries. In Section III, we estimate the WTP for illnesses. Our conclusion appears in Section IV.

As we saw in Chapter 4, economists have attempted to estimate the value of a statistical life in a variety of markets. Several reviews of that literature are available. Nearly 50 WTP studies have been reviewed (Fischer et al. 1989; Miller 1990; Viscusi 1993).

Using data from vehicle crashes, smoke detectors, air pollution, cigarette smoking, and automobile prices, value of life estimates range between \$70,000 to \$4 million.

Viscusi's (1993) summary of WTP value of life estimates derived from all survey data are \$100,000 to \$15,600,000 in 1990 dollars. Value of life estimates range from \$3 million to \$16 million (in 1990 dollars) using labor market data. Viscusi (1993), the leading researcher in the field, prefers the estimates from the labor market.

What is noticeable about almost all of these is that they are much larger than would be obtained from the Direct/Indirect cost approach. For example, our average direct cost injury per death was around \$20,000. Our average of foregone earnings, fringe benefits, and home production was nearly \$600,000 per injury death. These sum to roughly \$620,000, some 2.4 million dollars below the lowest WTP estimate from the labor market. Clearly, if WTP death estimates were used in lieu of Direct/Indirect death estimates, our estimated costs would increase by factors of three to five for injury deaths alone.

But death is not the only job injury risk. A number of labor market studies have addressed non-fatal injuries. The implicit value of the injury has ranged between \$13,810 to \$89,408, with the mean value being around \$40,000, again, in 1990 (Viscusi 1993).

Below, we will use a \$4 million estimate for injury deaths and \$40,000 for non-fatal injuries.

These estimates are low. They are drawn from the low ends of the ranges (\$3 to \$16 million for deaths and \$13,810 to \$89,408 for the non-fatal injuries). Nevertheless, as we will see, even these low WTP estimates per injury generate large estimates for the total for all injuries and illnesses.

II. Injury Estimate

Assuming 6,747 deaths (including innocent third parties) at \$4 million per death (in 1990), our cost estimate would be \$26.988 billion for injury deaths. The calculation for non-fatal injuries is a little more involved, depending on the estimates used for non-disabling injuries. Assuming 13.315 million injuries (including innocent third parties) at \$40,000 apiece yields \$532.6 billion. But most labor market studies used disabling injuries only when analyzing the WTP for non-fatal injuries. Assuming there were 6.1646 million disabling injuries at \$40,000 apiece, and 7.1534 million non-disabling injuries at \$0 apiece, then our non-fatal injury estimate would be \$246.6 billion.

In the first case, including non-disabling injuries, our sum is \$559.6 (26.988 + \$532.6). In the second case, excluding non-disabling injuries, our sum is \$273.6 billion. There was some 6.8% inflation between 1990 and 1992. Our 1992 WTP estimates for injuries would, therefore, be \$292.2 billion to \$597.7 billion.

III. WTP for Illnesses

Assuming 60,500 disease deaths at \$4 million each generates a total cost of \$242 billion for all disease deaths. Assuming 857,500 non-fatal diseases at \$40,000 per case yields an estimate of \$34.3 billion for all non-fatal diseases. But, again, not all of these diseases need be disabling. Assuming 46% are disabling (the same percent we used for injuries), and assuming the cost for disabling disease is \$40,000 each and \$0 for a non-disabling disease, our estimate for all non-fatal diseases would be \$15.7 billion.

We again generate two estimates for the combined cost of fatalities and non-fatalities: \$258 and \$276 billions. After applying the 6.8% inflation factor yields \$276 and \$295 billion.

These estimates are especially rough. We are not aware of WTP estimates for occupational disease. We, instead, substituted WTP estimates for occupational injuries. The extent of the bias resulting from this substitution is not known. One argument would hold that the diseases occur later in life than injuries and that people would be more willing to pay to save their lives if young than if old. But risk aversion seems to grow with age (Leigh 1986c), suggesting just the opposite. Older people might be willing to pay more than younger people. Moreover, we selected a relatively low WTP death estimate at \$4 million. The range in the literature goes to \$16 million. In any case, the age argument would not apply to non-fatal diseases and injuries since many non-fatal diseases—skin problems, Carpal Tunnel Syndrome, and so on—can occur early in life.

IV. Conclusion

Our theoretical discussion of WTP appears in Chapter 4. In that chapter, we concluded that the WTP method is preferred over the Direct/Indirect because the theory is more compelling to most academic economists, especially if information on marginal costs is sought. But the data required to estimate WTP estimates and some of the assumptions—especially about information on risks—leave many economists in a quandary when faced with a real world decision. Moreover, outside of academic economic departments, the Direct/Indirect is more popular. Finally, virtually all cost studies tally direct and indirect costs. Since one of our goals is to compare our costs of other health problems, the Direct/Indirect estimates were deemed more relevant than the WTP estimates.

In any case, it appears that WTP estimates would inflate our Direct/Indirect estimates by 300 to 600 or more percent. If we take our midpoint estimates above—roughly \$450 billion for injuries and \$286 billion for diseases—our WTP estimate would be \$736 billion. If we take the lowest estimates, our total would be \$568 billion. If we take the highest estimates (assuming \$4 million per death), our WTP estimate would be \$893. If instead of valuing life at the low end of the WTP estimates (\$4 million) we valued life at the high end (\$16 million), our WTP estimate would reach \$1.5 trillion. Since nominal GDP in 1992 was \$5,950.7 billion, these \$568, \$736, \$893 and \$1,500 billion estimates represent 10%, 12%,

15% and 25% of GDP. The disparities between our Direct/Indirect method estimates of roughly \$175 billion and these WTP estimates suggest that the value people put on pain and suffering (the largest cost we would not account for in our Direct/Indirect method estimate) is considerable. These estimates also indicate the fragile and speculative nature of the WTP numbers. If WTP death estimates were applied to the 2.2 million Americans who died in 1992, the total WTP costs for all deaths would exceed GDP by more than two trillion dollars.

Chapter 8
Workers' Compensation Costs Within
Occupations and Industries

**Outline for Chapter 8: Workers' Compensation Costs
Within Occupations and Industries**

- I. Introduction**
- II. Description of SDS**
- III. Method**
 - A. Introduction**
 - B. Cost Calculations**
 - C. Denominators**
- IV. Discussion**
- V. Conclusion**

Chapter 8: Workers' Compensation Costs Within Occupations and Industries

I. Introduction

This chapter uses the BLS's Supplementary Data System (SDS) to determine which occupations and industries generate the greatest and least costs. These cost rankings of occupations and industries may be useful for policy makers interested in targeting specific jobs for intervention and for individual employees interested in rankings of the overall risk associated with any particular job. The SDS data have a number of limitations as indicated in Chapter 2 and in Leigh (1995a). But for the purposes of this chapter, they appear to be unsurpassed by any other data set. First, they contain information on Workers' Compensation categories of disabilities (i.e., death, Permanent Total, Permanent Partial, Temporary Total and Partial, and Medical Only). Information from these categories can be matched to NCCI cost data to produce cost estimates within three-digit occupations and industries. Second, unlike the CFOI and the NTOF, the SDS includes diseases. The CFOI excluded some 18% of deaths judged to be due to diseases. Moreover, the CFOI and NTOF do not include non-fatal injuries. Third, they are superior to the newly released BLS Annual Survey data containing demographic information. The Annual Survey data do not contain WC disability categories that can be matched to NCCI data to calculate costs. In addition, the Annual Survey no longer releases data on fatalities.

Two drawbacks should be mentioned at the outset, however. First, these data are drawn from exclusively WC records. Our rankings and estimates will suffer to the extent that WC records do not reflect all job injuries and illnesses within all occupations and industries. As we saw in Chapter 2 and as explained in detail in Leigh (1995a), WC likely 1) underestimates deaths from motor vehicles, violent acts, and most diseases; 2) ignores many non-disabling injuries; and 3) does not comprehensively cover occupations such as miner, farm laborer, domestics, and the self-employed. Second, our analysis within this chapter only, stops with data from 1986. The SDS did collect some data from 1987 and 1988, but did not collect information on WC categories—the critical data for calculating costs.

We, nevertheless, believe the data presented in Tables 8.1 through 8.4 are unique. We are not familiar with any other study that attempts to rank occupations

or industries by costs of occupational injuries and illnesses. In this chapter, we matched the SDS cases in WC categories—death, Permanent Total, Permanent Partial, Temporary Total and Partial, and other—to NCCI average cost data by WC category from the same years. We then inflated the costs to bring them up to 1992. Except for the difference in the years, the procedure was similar to that outlined above for the overall national costs of injuries using the Direct/Indirect method. We do not eliminate diseases from the SDS, however.

In the following section, we will first describe the SDS data. Second, our method for calculating costs will be reviewed. Third, we will describe our method for calculating denominator data. Fourth, the tables of costs will be presented and discussed. The final section will summarize our results.

II. Description of SDS

The Supplementary Data System (SDS) was created by the Bureau of Labor Statistics (BLS) beginning in 1976 in an attempt to gain more national information on occupational injuries and illnesses (Root and Sebastian 1981; U.S. Bureau of Labor Statistics 1982, 1983; and U.S. Department of Labor 1992). The SDS data, in turn, were drawn from various states' Workers' Compensation (WC) records. Not all states in all years provided the SDS with information on job-related deaths. As a result, only eleven states are represented for the six years from 1979 through 1986: Arkansas 1981, 1983, 1985, 1986; Colorado, 1979-81, 1983, 1985; Delaware, 1979-81, 1983, 1985, 1986; Idaho, 1980, 1981; Iowa, 1981, 1983, 1985, 1986; Montana, 1979-81, 1983; New York, 1979-81, 1983, 1985, 1986; North Carolina, 1979-81, 1983, 1985, 1986; Oregon, 1983, 1985, 1986; Virginia, 1979; Wisconsin, 1979-81, 1983, 1985, 1986. These states contributed roughly 15% to 18% of the total national employment, depending on the year. On average, these states contributed to 16.36% of U.S. employment.

As indicated above, 1986 was the most recent documented year available with WC disability categories. Moreover, it appears that the BLS has ended the SDS effort, hence, 1986 will be the most recent year for some time to come. The BLS did not add any data to the SDS for 1982 or 1984.

The BLS placed the data on six computer tapes, one per year. The tapes were purchased from the National Technical Information Service (NTIS) in Springfield, Virginia. The necessary data on deaths, the four WC disability categories,

occupations, industries, age and gender, were read off of the tapes by a mainframe computer. Smaller files were then created and analyzed on personal computers.

The BLS investigators who organized the SDS believed that the data were representative of the nation.

By applying the percent of distribution of the SDS data to annual survey data, it is possible to arrive at estimated numbers of injuries and illnesses on a national basis by various characteristics. Despite differences in the number of cases among states, the percentage distributions of injuries and illnesses are relatively consistent across states--patterns that have been observed in several consecutive years of data for approximately 30 states. Observations, statistical tests, and the geographic and industrial diversity of the states (in the SDS) support the hypothesis that these data are representative of the national experience (U.S. Bureau of Labor Statistics 1982 and 1983).

Three files are available in the SDS. For this study, file #3, which includes fatalities and all "closed" cases (i.e., those not under appeal, was examined).

The SDS investigators list two limitations of the SDS. First, WC coverage and reporting requirements reflect the differences in state WC laws. Complete descriptions of these state differences in WC laws are available (U.S. Chamber of Commerce 1980-87). Second, the SDS, like the BLS Annual Survey reports from the 280,000 firms, suffers from the same degree of unidentified illnesses (Kane and Derstine 1992; National Research Council 1987).

The SDS data have been used in numerous BLS analyses. Perhaps the best introduction to the data is provided by Root and Sebastian (1981) who developed a job hazard index for roughly 60 occupations and 180 occupation and injury combinations. The index was created by accounting for the percent of total injuries contributed by a particular occupation or occupation-industry cell and dividing by the expected percent for that occupation or cell. They found that more than 99% of the injuries were not fatal. Occupations with the highest indexes were, in order, warehouse laborers, all other laborers, structural metal crafts workers (iron workers), roofers, sheetmetal workers and apprentices, construction laborers, freight handlers, millwrights, and truck drivers. Root and Sebastian also found that, overall, blue-collar work was twice to eight times as hazardous as white-collar work, depending on the industry examined.

Several government studies have made extensive use of the SDS data. These studies typically address one industry and compare its injury and illness record

to the average for all industries. Specific industries that have been studied include fabricated structural metal (Personick 1991a), longshore operations (Lettman 1989), roofing and sheetmetal (Personick 1990a), eating and drinking places (Personick 1991b), mobile homes (Personick and Daley 1989), motor vehicle manufacturing (Jordan 1992), poultry plants (Personick 1992b), logging (Personick 1992a), oil and gas field services (Personick 1992d), airlines (Personick 1992c), and retail stores (Campany and Personick 1992). Given that many of these studies have been published recently, it appears that the BLS continues to have confidence in the SDS.

III. Method

III.A. Introduction

For this study, data pertaining to the gender, occupation, industry, death, and disabilities are taken from the six SDS computer tapes. Occupations are coded using the 1970 U.S. Census codes. During the years covered by the SDS (1979 to 1986), 1970 codes were used for 1979 to 1983, and two years of data, 1985 and 1986, contain information using the 1980 codes. The 1970 codes were chosen since they corresponded to the four years available (1979-81, 1983) and since the BLS did not collect data from 1982 or 1984.

Industries were coded according to the 1972 and 1977 Supplement to the Standard Industrial Classification (S.I.C.) (Statistical Policy Division, 1977) using three-digit classifications. The same S.I.C. codes were used throughout 1979 to 1986. Consequently, industry data represent six years: 1979-81, 1983, 1985, 1986.

The guiding principle in selecting occupations and industries was to be as comprehensive as possible. The SDS information was generous: over 300 three-digit occupations and 400 three-digit industries were identified. There are no published tables that consistently provide employment (denominator) data for over 300 occupations and 400 industries. The most comprehensive published tables (from *Employment and Earnings*) were combined with unpublished employment data from the BLS. All denominator data derived from the same source BLS Household and Establishment employment data sources (U.S. Bureau of Labor Statistics 1979-1981, 1983, 1985, 1986).

III.B. Costs

The attractive feature of the SDS data (and the NCCI data), unlike any other data sets we have considered in our cost study, is that the SDS data (and the NCCI data) contain information on well-established WC disability categories: death, Permanent Total (PT), Permanent Partial (PP), Temporary Total and Partial (TTP) and Medical Only (MO). Information from these categories allowed us to match these SDS data to NCCI data on costs within each category.

Separate analyses were conducted on occupations and industries. The procedures were identical so we will describe in detail only how the industry costs were calculated. First, we calculated a cost figure for every WC case with information on industry in the SDS files from 1979 to 1986. These included 5498 deaths, 1379 PTs, 417,741 PPs, 1,218,375 TTPs, and 195,930 MOs. Each case was then multiplied by a direct cost and by an indirect cost component. The direct cost component was taken from an NCCI report entitled *Workers' Compensation Experience-Countrywide-Ultimate Report Basis* published in June, 1988. The NCCI report was identical to those described in Chapters 2 and 5. The data were for policy, not calendar year. The policy years applied to 1982, 1983 and 1984.

Data from this June 1988 NCCI Report were used to estimate the average medical expense for death, PT, PP, TTP, and MO. For example, the average medical expense for a fatality was \$7,708. We then multiplied \$7,708 by each fatality case in the SDS. The total medical expense for fatalities were then found to be \$42,278,584. But this number is not important for our purposes here. It applies to years from 1979 to 1986 and only covers 11 states. We are not interested in the total cost for all industries in this chapter. That was the subject of Chapters 5 and 6. Here we are concerned with the relative rankings of industries.

For deaths, TTPs, and MOs, the dollar medical costs were probably incurred within 12 months. For PTs and PPs, the medical costs could go on for a lifetime. But, as explained in Chapter 5, the NCCI estimates attempt to account lifetime expense. First, the NCCI Ultimate Reports contain actual dollar amounts (not estimates) on the first three to four years, when most of the costs are incurred. Second, actuaries working for insurance companies use statistical and accounting techniques to forecast what particular cases will generate in costs for the lifetime of the WC claim. These forecasts are then discounted and added into the Ultimate Reports. These forecasts represent the best estimates of actuaries most

familiar with the case. Economic theory suggests that those are exactly the estimates that should be used (i.e., those are the estimates that are generated by "the market" for WC insurance).

Two techniques were used to estimate indirect costs. The first mirrored the direct cost approach. The NCCI Ultimate Reports also have data on indemnity payments. These most typically reflect about 50% of the person's before-tax wage. We used .4, .5 and .6 for before-tax wage replacement rates for PTs, PPs and TTPs. These were the same rates we used in Chapter 5. These replacement rates are fairly reliable indicators of lost wages for PTs, PPs and TTPs. However, they are irrelevant for deaths. Widows of the deceased frequently receive lump sum payments and dependent children can receive benefits until they are 18 or 22, depending on their schooling choices.

To calculate the lost wages for PTs, PPs, and TTPs, we simply applied the same procedure to these SDS/WC data that we applied to our injury figures (Chapter 5). To calculate the lost wages for the deceased, we "backcasted" our average wage losses from Tables 5.5 and 5.6 (Chapter 5). We simply used an average. We did not adjust for age or gender. It is important to note that we did not adjust for fringe benefits, home production and all other indirect costs in Chapter 5. We could not, since these were calculated as aggregates and did not apply to any particular category of injury or illness.

The direct and indirect costs were calculated for each industry and occupation. The costs were then added and expressed as total costs for 1983 for industries and 1981 for occupations. Again, the industry data spanned 1979 to 1986 while the occupation data spanned 1979 to 1983.

The data applied to seven to 11 states, depending on the year. We wanted national estimates, so the SDS estimates were divided by .1636, assuming that on average, these seven to 11 states contributed 16.36% of total U.S. employment.

We also wanted to express the costs in 1992 dollars. We made this calculation with BLS data on a medical price index and on hourly wage data for 1981, 1983, and 1992. From 1983 to 1992, medical prices jumped roughly 90.1%. From 1981 to 1992, they jumped 100.2%. From 1983 to 1992, wages climbed 32%, and from 1981 to 1992, they climbed 46%. The 1983 and 1981 direct cost figures were then multiplied by 1.901 and 2.002 to estimate 1992 direct costs. A similar approach was taken with the indirect cost figures.

We created two measures of costs. One was overall costs; another was costs per capita or per worker. Tables 8.1 and 8.2 indicate only the overall contribution of an occupation or industry (i.e., those with more employees or incumbents will, other things equal, contribute more). Another way to consider the contribution of an occupation or industry is on a per worker basis. To make these calculations requires denominators (i.e., estimates of employment in the occupations and industries). Fortunately, these are available (Leigh 1995a). Tables 8.3 and 8.4 discussed below, present the costs based on a per worker basis.

III.C. Denominators

The calculation for a cost per worker or cost rate within an occupation or industry involves a ratio. The costs are in the numerator, and the estimated number of persons employed is in the denominator. The cost calculations were described above, while the estimated number employed is drawn from two sources: 1) unpublished tables on occupation and industry employment that the BLS provided to the authors; 2) tables from *Employment and Earnings* for industry employment. The occupation denominator data and some of the industry denominator data were drawn from unique tables, prepared by the BLS in March, May, and July 1993. The denominator data and corresponding calculations are provided in Leigh (1995a, Appendix A for occupations, Appendix B for industries).

The cost rate is easily understood if attention is restricted to a single occupation, say, lumberjacks. The calculation can be represented as in equation (8.1):

$$\text{cost rate for lumberjacks} = \frac{\sum_{t=1979}^{1983} \sum_{i=1}^I \text{Costs}_{it}}{\sum_{t=1979}^{1983} \text{USEmp}_t \times \text{StatesPercent}_t}$$

where $t = 1979, 1980, 1981, 1983$. Capital "I" indicates the number of states and varies by year: seven in 1979; seven in 1980; nine in 1981; and nine in 1983.

"Costs_{it}" is the total costs for lumberjacks in the i^{th} state in the t^{th} year.

"USEmp_t" is the number of employed lumberjacks in the year "t" for the U.S.

"States Percent" is the percent of national employment, contributed by the seven or nine states in year "t". The percentages of national employment and years are these: 17.11% (1979); 15.09% (1980); 17.11% (1981); 17.91% (1983). The 17.11% figure was the same in 1979 and 1981, despite the fact that information was not gathered from all of the same states in both years.

The numerator and denominator were summed over four years for the occupations and six years for the industries prior to the division. This is preferred over a separate technique that would have involved calculating a separate rate for each year and then summing yearly rates and finally dividing by four (for occupations) or six (for industries). Even though the years are not equal in their contributions, a sum of four (or six) ratios would give equal weight to each year. And since more data are available, for example, in 1983 than 1980, the information from 1983 ought to be weighted more heavily than information from 1980. Equation (8.1) does exactly that by summing over all the years prior to dividing.

The ratio in equation (8.1) was calculated for 423 occupations and 283 industries. The industry calculations add information from 1985 and 1986. Four and six years of data, rather than one or two, were used to increase the stability of the estimates.

Difficulties were encountered in attempting to obtain the denominator data. U.S. employment--or "USEmp" in equation (8.1)--for the occupations had to be derived from unpublished sources because government published statistics were either old or incomplete or non-existent. The best denominator data would have included employment within each of the 425, 1970 U.S. Census occupations for each state for each year. These data, however, were not available. The best available annual data for each year are in aggregate from the United States in *Employment and Earnings*. But 198 of the 425 three-digit occupations are excluded from *Employment and Earnings*. These 198 are, for the most part, small occupations (i.e., occupations with few incumbents). But "few" is relative. Longshore workers and stevedores were excluded from *Employment and Earnings* even though an estimated 57,900 persons were so employed in 1978 (U.S. Department of Labor 1981). Reliance on only the data from *Employment and Earnings* would have been too restricting.

Because the U.S. Census changed its definitions of most occupations in 1980, government use of the 1970 definitions began to disappear by 1982. We are unaware

of any government publication listing employment within all 425 three-digit 1970 census occupations for the separate years 1979-81 and 1983 in this study. The unpublished lists obtained from the BLS do not provide 1970 Census code data for 1983. Consequently, the 1983 denominators were determined by multiplying by a growth factor of 1.0064 since employment in the United States grew by .64% by 1982 to 1983.

The denominator data for the industries were easier to obtain. Most were drawn from *Employment and Earnings* (Bureau of Labor Statistics 1979-86). But the *Employment and Earnings* industry data were also incomplete. Again, the BLS provided unpublished employment data on a number of industries identified in Leigh (1995b, Appendix B). And *Employment and Earnings* does not miss nearly as many industries private sector (42) as occupations (198). Again, the data are national. To our knowledge no complete list of three-digit industry employment is available for each state in each year.

The industry data, unlike the occupation data, were restricted to private sector employment. Consequently, government "industry" classifications—S.I.C. codes 910 through 972—were not included in our per worker analysis. In cost rate industry calculations, persons identified as government employees were not analyzed (Table 8.4). They were included in the overall cost analysis (Table 8.2). The industries corresponding to education (S.I.C. 821 through 829), consequently, included only personnel and teachers from private schools. This restriction was necessary because 1) the SDS identified people by S.I.C. code, not census code when recording industries and 2) the BLS data on S.I.C. industries corresponded to private employment only.

In the analysis of the aggregate SDS statistics in Chapter 2, however, all of the persons from 1979 through 1986, working for private or public employers, were analyzed.

IV. Discussion

A unique feature of our study is the analysis of the occupations and industries that contribute the most to costs. Rankings of occupations and industries by total direct and indirect costs are presented in Tables 8.1 through 8.4. The data used to generate these rankings were drawn from a large BLS data set: the Supplementary Data System (SDS), explained above.

Two tables are presented for occupations and two for industries. In Tables 8.1 and 8.2, occupations and industries are ranked according to their overall contribution, without adjusting for employment within occupations or industries. That is, some occupations, such as managers and administrators, (not elsewhere classified or n.e.c.) may be high on the list simply because there are many people in the job. Tables 8.3 and 8.4 control for the number of people in the job. Tables 8.3 and 8.4 present the rates (i.e., costs divided by the number of people employed). Tables 8.1 and 8.2 identify the occupations and industries that contribute the most to overall costs. Tables 8.3 and 8.4 indicate the occupations and industries that contribute the most on a per capita basis. All four rankings are useful in identifying which jobs are contributing the most to costs.

Tables 8.1 through 8.4 present on the highest ranking 50 occupations and industries. The lists were shortened to 50 in the interest of brevity. The complete lists of 425 and 423 occupations (Tables 8.1 and 8.3) and 380 and 283 industries (Tables 8.2 and 8.4) are available from the first author. There are several reasons for the disparity in the numbers (425 versus 423 and 380 versus 283). First, the unpublished BLS lists on occupations were a little more comprehensive than the unpublished lists on industries. Second, and most important, government employees and industries were excluded from 8.4 but included in 8.2. We could not obtain consistent denominator data on all government industry sectors identified in the SDS files.

Occupations that contributed the most to the total volume of costs included truck drivers, miscellaneous operators and laborers, construction laborers, foremen, managers and administrators (not elsewhere classified: n.e.c.), nursing aides and orderlies, carpenters, and janitors. The industries that contributed the most to the total volume of costs were trucking, hospitals, restaurants and bars, grocery stores, schools, public safety, nursing facilities, motor vehicle manufacturing, construction, plumbing-heating-air-conditioning, meat products, and department stores.

Occupations high on the per capita or per worker list included not specified mechanics, general and construction laborers, press apprentices, carders, technicians (not elsewhere classified: n.e.c.), operators n.e.c., milliners, stone cutters, forge workers, lumberjacks, teamsters, motor workers in logging, garbage collectors, and warehouse workers. This list in Table 8.3 reinforces the view that

many of the most hazardous jobs carry the least pay. This is consistent with other research (Leigh 1995a) suggesting that many of the most dangerous jobs are not generally regarded as dangerous by the public. Also high on the per capita list are apprentices of all sorts. Their high ranking is consistent with the view that inexperienced employees suffer a high and disproportionate share of injuries.

The industries that contributed the most to costs on a per worker basis included logging camps, local transport, sanitary supplies, water supply, miscellaneous transportation services, leather tanning, car dealers, taxicabs, sawmills, engine manufacturing, steel foundries, and cut stone. Logging, transportation, taxicabs, sawmills, and cut stone have been found to be very hazardous in several studies (Leigh 1995a; Toscano and Windau 1993; U.S. Department of Labor, News April 1994).

The rankings in Tables 8.1 through 8.4 have a number of limitations that are detailed in Leigh (1995a). Space precludes us from an extensive discussion here. But, we will mention the three most serious limitations. First, WC undercounts injuries by roughly 55% and diseases by perhaps even more. Second, many occupations and industries were not well-represented in the SDS either due to WC exclusions or the fact that these eleven states may not have had significant employment within all occupations and industries. For example, a better data set than the SDS would undoubtedly have coal miners, merchant sailors, farmers, and military occupations, as well as self-employed persons in all occupations and industries, high on the lists. Finally, although the SDS collection effort ended in 1988, the WC categories (Permanent Total, Permanent Partial, and so on) were not available in 1987 or 1988.

V. Conclusion

Tables 8.1 through 8.4 present rankings of occupations and industries based on their WC costs. These rankings are limited. Only information from the SDS/WC data set was used. They do not reflect a compilation of the many data sources we identified in Chapters 2, 3, 5, and 6. This results in underestimates of the costs of coal mining and agriculture, and imparts an unknown bias due to the tendency of WC to underestimate injuries by 55% and diseases by more. Nevertheless, these rankings appear to be the only such lists available in the literature. Moreover, the rankings appear reasonable. Truck drivers, laborers, and mechanics, among

occupations; and trucking, meatpacking, and construction, among industries, contribute to a high percentage of all costs.

Table 8.1

**Total Direct and Indirect Costs by Private and Public Occupation
(Top 50 out of 425)**

<u>Rank</u>	<u>SIC Code</u>	<u>Description</u>	<u>Total Costs</u>
1	715	Truck Drivers	\$1,308,294,362
2	698	Misc. machine operators	846,948,215
3	788	Miscellaneous laborers	846,316,507
4	751	Construction laborers	698,442,256
5	694	Miscellaneous operatives	635,810,463
6	441	Foreman	582,109,927
7	245	Managers and administrators, nec	547,248,324
8	925	Nursing aides and orderlies	486,032,659
9	415	Carpenters	473,915,763
10	903	Janitors and sextons	461,582,259
11	602	Assemblers	454,329,838
12	785	Not specified laborers	454,249,570
13	753	Freight & material handlers	430,690,175
14	200	Sales representative, nec	373,219,293
15	902	Cleaners and char workers	345,259,004
16	473	Automobile mechanics	326,130,636
17	481	Heavy equipment mechanics	321,175,123
18	695	Not specified operatives	306,614,662
19	492	Miscellaneous mechanics	291,234,662
20	705	Delivery workers and route workers	283,079,594
21	944	Police and detectives	264,700,219
22	680	Welders and flame-cutters	264,179,105
23	916	Food service workers, nec	246,095,183
24	692	Machine operators, nec	236,880,224
25	962	Guards	231,954,299
26	822	Farm laborers, wage workers	230,440,065
27	762	Stock handlers	228,114,298
28	430	Electricians	218,777,706
29	770	Warehouse workers	218,440,259
30	912	Cooks, exec. private home	215,001,067
31	522	Plumbers and pipe fitters	188,114,205
32	495	Not specified mechanics	186,505,274
33	961	Firefighters and fire protection	186,271,105
34	643	Packers, exec. meat & produce	169,664,296
35	436	Excavating machine operators	168,812,165
36	755	Gardeners and groundskeepers	165,380,015
37	612	Cutting operatives, nec	158,880,821
38	461	Machinists	147,196,359
39	761	Lumberjacks	141,320,298
40	640	Miners, nec	139,271,569
41	662	Sawyers	137,041,020
42	915	Waiters	136,610,524
43	381	Stock clerk or storekeeper	131,440,079
44	631	Meat cutters, exec. mfg	129,881,727
45	374	Shipping and receiving clerk	127,820,163
46	610	Manufacturing inspectors	123,950,072
47	703	Bus drivers	122,915,146
48	075	Registered nurses	122,429,216
49	706	Fork lift operators	121,674,379
50	510	Painters, construction	119,321,576

Table 8.2

**Total Direct and Indirect Costs by Private and Public Industry
(Top 50 out of 370)**

<u>Rank</u>	<u>SIC Code</u>	<u>Description</u>	<u>Total Costs</u>
1	421	Trucking	\$ 998,718,285
2	806	Hospitals	938,206,329
3	581	Eating and Drinking Places	787,194,639
4	541	Grocery Stores	670,902,837
5	821	Elementary, Secondary Schools	606,146,354
6	922	Public Order and Safety	597,721,577
7	805	Nursing, Care Facilities	525,901,459
8	371	Motor Vehicles and Equipment	417,316,370
9	162	Hvy Construction, Exc. Highway	379,311,244
10	179	Misc. Special Contractors	336,667,871
11	154	Nonresidential Construction	332,357,378
12	171	Plumbing, Heating, Air Cond.	327,600,146
13	201	Meat Products	322,732,978
14	152	Residential Building Constr.	316,944,692
15	514	Groceries and Related Products	312,801,285
16	531	Department Stores	288,405,265
17	344	Structural Metal Products	265,901,726
18	508	Machinery, Eqpt, & Supplies	262,319,258
19	241	Logging Camps & Contractors	259,952,286
20	919	General Government, nec	255,133,728
21	242	Sawmills and Planing Mills	249,601,269
22	411	Local & Suburban Transport	244,330,764
23	251	Household Furniture	242,800,211
24	161	Highway, Street Construction	234,835,426
25	651	Real Estate Operators	234,307,267
26	174	Masonry, Stonework, Plastering	230,745,211
27	451	Certified Air Transportation	229,300,298
28	739	Misc. Business Services	217,780,299
29	173	Electrical Work	215,811,076
30	307	Misc. Plastics Products	213,224,823
31	822	Colleges and Universities	208,979,183
32	701	Hotels, Motels, Tourist Courts	206,044,217
33	331	Basic Steel Products	205,673,026
34	332	Iron and Steel Foundries	194,735,174
35	243	Millwork, Plywood, etc.	188,752,636
36	799	Misc. Recreational Services	183,721,052
37	734	Services to Buildings	182,899,715
38	551	New and Used Car Dealers	179,700,263
39	346	Metal Forgings and Stampings	179,300,025
40	478	Misc. Transportation and Services	178,910,154
41	481	Telephone Communication	161,632,706
42	208	Beverages	161,364,127
43	753	Automotive Repair Shops	154,343,776
44	356	General Industry Machinery	150,190,129
45	495	Sanitary Services	147,980,477
46	275	Commercial Printing	146,802,067
47	262	Paper Mills, Exc. Bldg Paper	145,284,415
48	205	Bakery Products	144,151,372
49	202	Dairy Products	143,934,727
50	176	Roofing and Sheet Metal Work	142,915,726

Table 8.3

**Total Costs Per Employee by Private and Public Occupation
(Top 50 out of 423)**

<u>Rank</u>	<u>SIC Code</u>	<u>Description</u>	<u>Total Costs Per Employee</u>
1	495	Not specified mechanics	9,420
2	780	Miscellaneous laborers	5,266
3	531	Press apprentices	3,086
4	670	Carders, Lappers, combers	2,963
5	173	Technicians, nec	2,282
6	695	Not specified operators	2,476
7	636	Milliners	2,231
8	546	Stone cutters and carvers	2,206
9	442	Forge and hammer workers	2,305
10	761	Lumberjacks	2,142
11	763	Teamsters	2,115
12	710	Motor operators; logging, mine, etc.	2,106
13	785	Not specified laborers	2,101
14	491	Mechanic, except auto	2,063
15	550	Structural metal crafts workers	1,854
16	633	Meat cutters, manufacturing	1,802
17	754	Garbage collectors	1,746
18	511	Painter apprentices	1,722
19	492	Miscellaneous mechanics	1,713
20	662	Sawyers	1,707
21	943	Elevator operators	1,626
22	704	Urban rail conductors	1,617
23	501	Millers	1,546
24	411	Apprentice masons	1,536
25	004	Therapy assistants	1,515
26	536	Sheetmetal apprentices	1,508
27	502	Millrights	1,561
28	626	Heaters, metal	1,326
29	656	Stamping press operatives	1,320
30	244	Wood Containers	1,305
31	751	Construction laborers	1,266
32	961	Firefighters and fire protection	1,228
33	694	Miscellaneous operatives	1,217
34	523	Plumber apprentices	1,212
35	671	Knitters, loopers, etc.	1,209
36	182	Dancers	1,206
37	770	Warehouse workers	1,200
38	614	Drillers, earth	1,162
39	416	Carpenter apprentices	1,156
40	404	Boilermakers	1,139
41	601	Asbestos workers	1,130
42	653	Precision machine operators	1,127
43	604	Bottling & canline operators	1,105
44	551	Tailors	1,102
45	692	Machine operators, nec	1,067
46	622	Furnace & smelter operators	1,042
47	434	Electrotypers or stereotypers	1,039
48	715	Truck drivers	1,014
49	603	Blasters and powder workers	1,010
50	650	Drill press operatives	1,002

Table 8.4

Total Direct and Indirect Costs Per Employee by Private (only) Industry
(Top 50 out of 283)

<u>Rank</u>	<u>SIC Code</u>	<u>Description</u>	<u>Total Costs Per Employee</u>
1	241	Logging Camps & Contractors	2,946
2	411	Local & Suburban Transport	2,462
3	495	Sanitary Supplies	2,318
4	494	Water Supply	1,986
5	478	Misc. Transportation Services	1,920
6	311	Leather Tanning & Finishing	1,487
7	551	New and Used Car Dealers	1,189
8	412	Taxicabs	1,152
9	242	Sawmills and Planing Mills	1,140
10	351	Engines and Turbines	1,099
11	332	Iron and Steel Foundries	1,002
12	328	Cut Stone and Stone Products	923
13	334	Secondary Nonferrous Metals	901
14	386	Photographic Equipment & Supplies	892
15	161	Highway, Street Construction	841
16	201	Meat Products	836
17	175	Carpentering and Flooring	822
18	243	Millwork, Plywood, etc.	819
19	202	Dairy Products	817
20	262	Paper Mills, Exc. Bldg Paper	806
21	179	Misc. Special Contractors	801
22	333	Primary Nonferrous Metals	792
23	421	Trucking	789
24	176	Roofing and Sheet Metal Work	762
25	251	Household Furniture	759
26	336	Nonferrous Foundries	750
27	316	Luggage	746
28	542	Meat, Freezer Provisioners	735
29	254	Partitions and Fixtures	721
30	244	Wood Containers	717
31	245	Wood Buildings, Mobile Homes	714
32	178	Water Well Drilling	710
33	208	Beverages	706
34	346	Metal Forgings and Stampings	692
35	343	Plumbing & Heating, Exc. Elec	689
36	493	Combination Utility Services	672
37	598	Fuel and Ice Dealers	652
38	162	Heavy Construction, Exc. Highway	649
39	177	Concrete Work	649
40	205	Bakery Products	648
41	249	Miscellaneous Wood Products	640
42	101	Iron Ores	635
43	327	Concrete & Plaster Products	618
44	154	Nonresidential Construction	612
45	518	Beer, Wine, Distilled Liquors	601
46	422	Public Warehousing	599
47	458	Air Transportation Services	590
48	252	Office Furniture	581
49	329	Nonmetallic Mineral Products	572
50	174	Masonry, Stonework, Plastering	556

Chapter 9

Who Pays?

Outline for Chapter 9: Who Pays?

- I. Introduction**
- II. Nominal Payment**
- III. Actual or Incidence Payment**
 - A. Who Pays for WC?**
 - 1. Introduction
 - 2. Theory
 - 3. Evidence
 - 4. Conclusion
 - B. Who Pays for all Non-WC Costs?**
- IV. Conclusion**

Chapter 9: Who Pays?

I. Introduction

Our analysis of who pays for occupational injuries and illnesses is split into two parts. In the first part, the nominal aspects of costs are considered and in the second the actual (or true or incidence) aspects of costs are considered. In the nominal view, the origin of funds is presumed to be with the agent that actually writes the check or signs the credit form or pays the cash. These costs have been referred to as "accounting," "legal," "out-of-pocket" or "nominal" costs in the literature. The most popular term appears to be nominal and we will use that term henceforth.

In the second part, the actual aspects of costs are considered. The actual payer may or may not be the nominal payer. Economic theory and empirical studies are reviewed pertaining to who actually bears the burden of occupational injury and illness costs. For example, the Social Security Administration writes the checks to cover Medicare bills. But Medicare is financed through payroll taxes on employers and employees. The employers may try to pass on some of the payroll taxes to consumers in the form of higher prices for the goods or services the employer sells. Medicare costs, therefore, may be actually paid by consumers, not employers. The "true" or "actual" payment is referred to as the incidence of the cost in the economics literature.

The format of the chapter is as follows: Section II discusses nominal payment. Section III considers actual or incidence payment. Two subsections appear in Section II: who pays for WC? and who pays for all non-WC costs? Within the WC payment subsection, we provide an introduction (III.A.1); theory (III.A.2); evidence (III.A.3); and conclusion (III.A.4). The chapter closes with a conclusion (Section VI).

II. Nominal Payment

Our analysis of nominal payment is constituted around Tables 9.1 and 9.2 which were drawn from the Health Care Financing Administration (Levit et al.

1994). Table 9.1 presents 1992 national health spending by who receives the payment. A familiar pattern emerges. Hospitals receive the most (37.3%) followed by physician services (19.7%), drugs (8.8%), and nursing home care (8.0%).

Table 9.1

National Health Expenditures, Billions of Dollars, 1992

	<u>Total</u>	<u>Percent</u>
Total	\$ 820.3	100%
I. Health Services and Suppliers	\$ 729.9	96.7%
A. Personal Health Care	729.7	89.0
1. Hospital Care	306.0	37.3
2. Physician Services	161.8	19.7
3. Dental Services	34.7	4.2
4. Other Professional Services	46.4	5.7
5. Home Health Care	16.8	2.0
6. Drugs	70.8	8.6
7. Vision Products	12.0	1.5
8. Nursing Home Care	65.5	8.0
9. Other Personal Health Care	15.8	1.9
B. Program Administration and Net Cost of Private Insurance	39.5	4.8
C. Government Public Health Activities	23.7	2.9
Research and Construction	29.0	3.3
Percent of GDP		13.6%

Source: Health Care Financing Administration, Office of the Actuary,
Data from the Office of National Health Statistics

Table 9.2

National Health Expenditures By Source of Funds, Billions of Dollars, 1992		
	Billion Dollars	Percent
Total	\$ 820.3	100%
I. Private Funds	\$ 462.3	56.4%
A. Consumer Payments	423.3	51.6
1. Out-of-Pocket	150.6	18.4
2. Private Health Insurance	272.7	33.2
B. Other Private Funds	39.5	4.8
II. Public Funds	357.5	43.6
A. Federal Funds	254.3	31.0
1. Medicare	138.3	16.9
2. Medicaid	68.3	8.3
3. Other Federal	47.8	5.8
B. State and Local Funds	103.2	12.6
1. Medicaid	39.7	4.8
2. Other State and Local	63.5	7.7
III. Total Medicaid (Federal and State)	\$ 108.0	13.2%

Source: Health Care Financing Administration, Office of the Actuary,
Data from the Office of National Health Statistics

Table 9.2 divides the spending up according to who pays the nominal cost. Private funds contribute the most (56.4%). Within the private funds rows, private health insurance contributes 33.2% and out-of-pocket expenses by consumers amount to 18.4%. Within the public funds rows, the federal government pays for 31% while state and local governments pay for 12.6%.

Table 9.3 is constructed assuming WC covers 45% of all medical expenses and the other 55% is paid for with the same percent identified in Table 9.2. These percents are not based upon a 100% total, however, but a 55% total. That is, in Table 9.2 all private funds (row I) were assumed to draw 56.4% out of a total of 100%. In Table 9.3, all private funds (row II) were assumed to draw 56.4% out of 55% (i.e., 31% of the total costs of occupational injuries and illnesses). For example, the 18.3% in row II.A.I. was calculated by multiplying .332 from Table 9.2 (row I.A.2) with .55, our assumed percent of non-WC payments.

In Chapter 2, we presented evidence that WC covered only roughly 45% of all injuries. WC tends to be a more generous payer than the medical insurance or direct consumers (patients), hence it could be argued that WC covers more than 45% of costs. However, WC covers only a small fraction of occupational diseases, especially diseases resulting in death, hence, it could be argued that the 45% assumption is too high. Since we are not aware of any studies that resolve these arguments, we continue to assume a 45 to 55% split between costs covered by WC and covered by all other carriers and consumers other than WC.

As can be seen from Table 9.3, the nominal direct cost for occupational injuries and illnesses is spread among many payers. This is an important point. Our nominal payment analysis suggests that many groups in the economy, not just employers and employees, pay for the cost of occupational injuries and illnesses.

Table 9.3

Direct Cost for Occupational
Injuries and Illnesses by Source

	<u>Billion Dollars</u>	<u>Percent</u>
Total	\$66.1747	100%
I. Workers' Compensation	29.7786	45.0
II. Non-Workers' Compensation	25.7649	55.0
A. Private Funds	20.5142	31.0
1. Private Health Insurance	12.1100	18.3
2. Out-of-Pocket and Other	8.4042	12.7
B. Public Funds	15.8819	24.0
1. Federal Funds	11.2497	17.0
2. State and Local	4.6322	7.0

Source: Current study

A unique row in Table 9.3 is II.A.2: Out-of-Pocket and Other. These nominal expenses are paid for by the injured or ill worker or by another private party. If we apply the same percentages available in Table 9.2 to our 55% of non-WC payment, we find that Out-of-Pocket spending by workers was 10% and spending by other private persons was 2.7%.

Table 9.4

**Summary of Injury and Illness Costs,
Abbreviated Version of Tables 5.7 and 6.1**

	Injuries, Billions of Dollars (Table 5.7)	Illnesses, Billions of Dollars (Table 6.1)	Total	Total Percent
I. Direct Costs Total	\$ 50.1046	\$ 16.0701	\$ 66.1747	38.1%
A. Medical costs for doctors, hospitals, drugs, and so on	25.0739			
B. Administration of WC (31%); and Medicaid, Welfare, Medicare, private insurance and others (16% combined)	5.7012			
C. Administrative costs on indemnity payments for WC (31%); and Social Security, Welfare, Private Insurance, Private Insurance (10% combined) (These percentages apply only to indemnity)	\$ 8.8645			
D. Property damage costs	\$ 8.7497			
E. Police and Fire Services	\$.7801			
F. Direct costs to inno third parties	\$.9322			
II. Indirect Costs	\$ 98.1837	\$ 9.4652	\$107.6489	61.8%
A. Lost earnings	\$ 68.1559			
1. Fatalities	2.5481			
2. Non-fatalities	65.6078			
B. Fringe benefits	\$ 14.3332			
1. Fatalities	.5556			
(16% women, 22% men)				
2. Non-fatalities	13.7776			
(21% everybody)				
C. Home production	\$ 8.2059			
1. Fatalities	.3067			
(see Tables 5.5 & 5.6)				
2. Non-fatalities	\$ 7.8992			
(same as average % for fatalities: 12.93%)				
D. Workplace training, restaffing, disruption	\$ 5.1986			
1. Fatalities	.0397			
2. Non-fatalities	5.1589			
E. Time delays	\$.3091			
1. Fatalities 3.7% of total	.0114			
2. Non-fatalities 96.3% of total	.2977			

F. Indirect costs to innocent third parties	\$ 1.9810			
1. Fatalities (3.7%)	.0733			
2. Non-fatalities (96.3%)	1.9077			
Grand Total	\$148.3883	\$25.5353	\$173.8245	100%

Source: Current study

Table 9.4 presents a combined and abbreviated version of the cost tables for injuries (Table 5.7) and diseases (6.1). The first column presents the costs of injuries. The second presents the costs of illnesses. The total appears in the third column of numbers. Finally, the percent contribution of each appears in the last column of numbers.

Table 9.5

Percentages Assumed in the Construction of Source
of Payment for Indirect Costs

Indirect Cost	1	2	3	4	5	6	7	8
	Workers' Compensation	Non-Workers' Compensation	Private	Health Insurance	Out-of-Pocket, Other	Public	Federal	State and Local
	.5x.45 =			.5x.183 =	(remainder)	.5x.24 =	.5x.17 =	.5x.07 =
A. Lost Earnings	22.5%	77.5%	65.5%	9.15%	56.35%	12.0%	8.5%	3.5%
B. Fringe Benefits	0	100.0%	100.0%	0	100.0%	0	0	0
C. Home Production	0	100.0%	100.0%	0	100.0%	0	0	0
D. Workplace Training	0	100.0%	80.0%	0	80.0%	20.0%	10.0%	10.0%
E. Time Delays	0	100.0%	100.0%	0	100.0%	0	0	0
F. Innocent Third Parties	0	100.0%	56.4%	33.2%	23.2%	43.6%	31.0%	12.6%

Source: Current study

THIS PAGE NUMBER AND SPACE RESERVED FOR TABLE 9.5

Table 9.5 presents the percentages we assumed to allow us to construct the overall source Table 9.6. In Table 9.5, columns 1 and 2 sum to 100%. Columns 1, 3, and 6 also sum to 100%. Finally, columns 1, 4, 5, 7, and 8 sum to 100%. The structure of these columns is identical to the structure of rows in Table 9.3. Consider the first row in Table 9.5—Lost Earnings. We assumed that WC would cover 45% of all persons and costs, but that indemnity would only pay for 50% of the before-tax wage (Ehrenberg and Smith 1991). Hence, the first cell is $.45 \times .5 = 22.5\%$. The second cell is simply $1 - .225$ or 77.5%. Except for the Out-of-Pocket cell, all other cells in row A multiplied percentages in Table 9.3 by .5, again assuming that any indemnity payments would cover only 50% of the before tax age. The cells and their corresponding multiplications are provided in the top half of row A. The cell that picked up all of the remaining cost was Out-of-Pocket and Other. This category would be composed primarily of the workers' and their families. The remaining costs comprise 56.35% of the total.

Fringe benefits and home production are assumed to generate the same percentages: 100% in the Out-of-Pocket and Other category. We assumed that fringe benefits and home production losses nominally fall on the worker and his or her family.

We assume that workplace training and disruption costs were nominally borne by the employer. But the employer may be private or public. We assume that 80% would be private, 10% federal government and 10% state and local government. The 80%, 10%, 10% percentages are also assumed for property damage.

We assume time delays would fall entirely on private individuals and thus 100% appears in the Out-of-Pocket, Other category.

Finally, costs to innocent parties are assumed to be spread across payer groups in proportion to these groups contribution to the overall medical expenses in Table 9.2.

After applying the percentages in Table 9.5 to indirect cost calculations from Chapter 5 and 6, we produced Table 9.6 which combines direct with indirect costs. Table 9.6 therefore summarizes our estimates of who nominally pays for occupational injuries and illnesses.

Table 9.6

Direct and Indirect Costs by Source, Nominal Payment

	<u>Billions of Dollars</u>		<u>Total</u>	<u>Percent of Total</u>
	<u>Direct</u>	<u>Indirect</u>		
Total	66.1747	107.6489	173.8236	100%
I. Workers' Compensation	29.7786	19.6297	49.4083	28.4
II. Non-Workers' Compensation	25.7649	88.0175	113.7824	65.5
A. Private Funds	20.5142	74.5421	95.0563	54.7
1. Private Health Insurance	12.1100	6.8613	18.9713	10.9
2. Out-of-Pocket, Other	8.4042	67.6807	76.0849	43.8
B. Public Funds	15.8819	13.4790	29.3609	16.9
1. Federal	11.2497	8.4171	19.6668	11.3
2. State and Local	4.6322	5.0586	9.6908	5.6

III. Actual or Incidence Payment

III.A. Who Pays for WC?

III.A.1. Introduction

Chelius and Burton (1992, 1994) present an exceptionally well-written, non-technical explanation of the theory and evidence on the incidence of who bears the burden of WC premiums. Our sections on WC are drawn directly from their articles. We are deliberately brief and we overlook a number of their points. We focus on the most salient features of their analysis. Readers are referred to the Chelius and Burton (1992, 1994) articles for more detail.

III.A.2. Theory

Three groups in the economy are most frequently assumed to bear the actual or incidence burden of WC premiums: employers, consumers, and employees. As a matter of law, payment falls entirely on the employer. That is, the insurance premium invoice is mailed to the employer and the employer writes the check to the WC insurance carrier.

The employer bears 100% of the nominal burden. But the nominal burden is not the true or actual burden. The true burden is referred to as the incidence of the WC premium in economics. The incidence of the WC premium need not be the same as the nominal burden of the WC premium.

Incidence analysis suggests that the employer may try to pass on the cost of the WC premium "up" to the consumer or "down" to the worker. If WC costs are passed "up," the firm will increase the price of its product or service to the consumer. If WC costs are passed "down," workers will receive lower wages.

The pass through mechanisms do not occur quickly. The firm does not immediately increase price or ask workers to take a pay cut the day after the WC premium increases. The pass through effects require months or even years. Moreover, when the premium is passed "down," firms will seldom ask workers to take a pay cut. They will simply not allow the wage to increase over time as fast as it otherwise would.

The ability of the firm to pass on the cost depends on consumers' sensitivities to price increases and workers' sensitivities to wage decreases. If the WC premium increase applied only to one firm, that firm may not have much success passing the cost on to either consumers or workers. Imagine that the premium hike applied to video rental store A but not to any other video store in your neighborhood. If firm "A" tried to pass on the cost to consumers, many or most consumers might begin to rent videos from an alternative store. On the other hand, if store A tried to hold the line on wage increases while all other stores were granting raises, store A might lose employees.

WC premium hikes, of course, generally apply to many firms simultaneously. It would appear that workers may not have many choices if virtually all firms lowered wages. The great majority of American workers work in firms or government agencies that are covered by WC. If a person has made the decision to work, it is difficult to find an employer who is not covered by WC, especially if that worker is seeking a job that pays more than the minimum wage.

Consumers also would appear to have few choices. But consumers can buy imports, save rather than spend, or buy goods and services from firms exempt from WC coverage; but perhaps most importantly, consumers can buy goods and services

from states with low WC costs (WC programs differ substantially across the states). Three arrangements exist: monopoly state insurers, state-run and private insurers existing side-by-side, and only private insurers. One monopoly insurer exists in each of six states: Nevada, North Dakota, Ohio, Washington, West Virginia, and Wyoming insurers. State-run insurers co-exist with private insurers in Arizona, California, Colorado, Idaho, Maryland, Michigan, Montana, New York, Oklahoma, Oregon, Pennsylvania, and Utah (Redja 1991). Evidence in Nelson (1992, 1993) demonstrates substantial variation across states in WC premiums and coverage. Again, WC frequently excludes small firms and especially small farms.

Consumers' demand for all products and services produced by firms covered by WC would appear to be fairly unresponsive to increases in price and workers would be unresponsive to wage drops. But what is critical for the economic theory of incidence is which group is least responsive. That is, if workers are less likely to respond to a wage drop than consumers are likely to respond to a price increase, workers will ultimately bear more of the cost than consumers. Economic theory, therefore, cannot resolve the issue. Theory does, however, suggest how empirical tests should be made to assess the incidence of WC costs. Economists have turned to empirical tests to resolve who actually pays for WC costs.

III.A.3. Evidence

Chelius and Burton's (1994) exhaustive review of the empirical studies reaches a "radical" (p. 25) conclusion: the lion's share, perhaps all of the costs of WC are passed down to workers in the form of lower wages.

They review three categories of empirical studies that support this conclusion. First, they consider studies that examine employer and employee responses to changes in all labor costs. These studies show that, for example, middle-aged male workers will continue working virtually regardless of the wage. Second, they consider studies of payroll taxes, such as Social Security taxes. One study, in particular, presented some convincing evidence. In Sweden, payroll taxes grew from 6% in 1950 to 40% in 1979. The study found that within one year of each payroll tax hike, roughly 50% had been shifted to workers in the form of lower wages (or lower wage raises).

These studies on tax-shifting for the payroll tax are especially important focus since a considerable portion of the costs of job-related injuries and illnesses are nominally paid by Social Security Disability Insurance and Medicare, both of which are financed with a payroll tax.

The second and third sets of studies are drawn from the compensating wage for job risks literature (see Chapter 4). These studies tend to show that the more generous the WC benefits are, the lower the compensating wage generated in the labor market. The trade-off between WC costs and wages was almost one-to-one in this literature. That is, one more dollar of annual WC costs was almost equally matched by one less dollar in an annual earned wage.

Redja (1991) concurs with this view. Redja suggests that since the WC insurance premium is based on the firm's payroll, "its economic effects may be similar to those of a payroll tax and current research suggests that in the long run, most payroll taxes are borne by labor" (p. 303). In other words, Redja suggests that workers receive lower wages than they otherwise would without WC premiums being charged to employers.

III.A.4. Conclusion

Chelius and Burton (1994) conclude that empirical studies show that the highest percentage of increasing WC costs are borne by workers, not firms or consumers. The evidence they cite is compelling. Nevertheless, it is not complete.

Apparently, little evidence is available on that portion of the WC premium that is passed on to consumers. Moreover, employers seem to be especially resistant to increases in WC premiums. It would appear that if all of the WC costs were passed on to workers, employers would not be so annoyed by WC premium increases. Finally, as indicated in our literature review of the WTP studies (Chapter 4), most compensating wage studies have a number of serious limitations.

We, therefore, assume the following incidences for WC costs:

Employers:	10%
Consumers:	10%
Workers:	80%

It is important to note that "workers" in this analysis applies to all employees covered by WC. This does not only include injured or ill workers. That is, even if an employee were never to have a job-related injury or illness, he or she would nevertheless pay for WC through lower wages.

In Table 9.6, we calculated that \$49.4083 billion would be nominally paid by WC. These \$49.4083 billion can be split among our three "actual" payment groups as follows:

Employers:	$.1 \times X = \$4.9408$ billion
Consumers:	$.1 \times X = \$4.9408$ billion
Workers:	$.8 \times X = \$39.5266$ billion

III.B. Who Actually Pays for Non-WC Costs?

In Table 9.6, we identified four non-WC payers who share the cost: private health insurance, Out-of-Pocket and Other; federal government; and state and local government. There are a number of reasons for this lack of complete coverage including the fact that many small firms with one to five employees are frequently exempt from WC laws. But workers in these firms can be injured or become ill and when they do, they frequently receive benefits from Social Security or Welfare. These small firms essentially pass on the cost of workplace safety and health to society at large (Rejda 1991).

Private health insurance, if it is derived as a fringe benefit from the job, would have essentially the same effects as WC. It is another labor cost to the employer, just like WC. But not all private health insurance is derived from employment. Health insurance paid by an individual worker would be nominally and actually paid by him or her. We, therefore, assumed the following split among employers, consumers and workers for private health insurance: 8%, 8%, 84%.

The great majority of federal contributions would be derived from Social Security and Medicare payroll taxes. Hence, we assumed the same percentages for the federal category as for the WC category: 10%, 10%, 80%.

State and local contributions would likely come from general, not payroll tax revenues. We assumed an even three-way split: 33%, 33%, 33%.

We assumed that the lion's share of Out-of-Pocket and Other contributions would fall on workers (80%). Most of the nominal costs of Out-of-Pocket and Other also fall on workers. We assumed firms would be successful in shifting some of their nominal costs onto consumers (5%), some to workers (5%) but retain half (10%). Our percentages for Out-of-Pocket and Other would then be 10%, 5%, 85%. These are summarized in Table 9.7.

Table 9.7			
Assumed Percentages of Incidence Allocation			
Nominal Payment Category	Incidence (actual) Payment Category		
	Employer	Consumer	Worker
I. Workers' Compensation	10%	10%	80%
II. Non-Workers' Compensation			
A. Private Funds			
1. Private Health Insurance	8%	8%	84%
2. Out-of-Pocket, Other	10%	5%	85%
B. Public Funds			
1. Federal	10%	10%	80%
2. State and Local	33%	33%	33%

If the percentages in Table 9.7 are applied to the nominal payer amounts in Table 9.6, we can generate the incidence of costs in Table 9.8.

Table 9.8

Incidence of Costs		
<u>Category</u>	<u>Billions of Dollars</u>	<u>Percent</u>
Employer	\$ 19.1206	11%
Consumer	\$ 15.6441	9%
Worker	\$139.0589	80%
Total:	\$173.8236	100%

IV. Conclusion

As Tables 9.6 and 9.8 indicate, the costs of occupational injuries and illnesses are spread throughout the economy. We regard this conclusion as one of the most important in our study. While a large share of costs are borne by the injured and ill workers and their families, a sizable percentage, nevertheless, is borne by the economy at large. This is especially true for all categories of employees, regardless whether they ever experience an injury or illness. The evidence suggests that wages drop for all employees as the costs of occupational injuries and illnesses rise. Since so many people are in the "worker" category (roughly 120 million in 1992), or have family members who are, all of us share at least some portion of these costs.

Chapter 10
Limitations and Assumptions

Outline for Chapter 10: Limitations and Assumptions

- I. Introduction**
- II. Limitations**
 - A. Fraudulent Claims**
 - B. Generous WC Benefits Increase Injuries**
 - C. More Injuries Occur at Home than at Work**
 - D. WC Medical Costs Exaggerate True Medical**
 - E. Total and Average Costs Versus Marginal Costs**
 - F. Full Employment**
 - G. Incidence and Prevalence Costs**
- III. List of 36 Consequential Assumptions**
 - A. Introduction**
 - B. List**
- IV. Conclusions**

Chapter 10: Limitations and Assumptions

I. Introduction

In this chapter we discuss some of the limitations, assumptions and advantages of our study. Space prohibits us for discussing all conceivable limitations and advantages and every assumption we made. We, therefore, selected the limitations that were the most controversial and the assumptions that resulted in substantial variations in our estimated counts of injuries and diseases and in our costs.

Three sections follow this one. In Section II, we consider the limitations and criticisms of our study and our rebuttals to these criticisms. Limitations include the following:

- A. Fraudulent claims;
- B. Generous WC benefits increase injuries;
- C. More injuries occur at home than at work;
- D. WC medical costs exaggerate true medical;
- E. Total and average costs versus marginal costs;
- F. Full employment;
- G. Incidence and prevalence costs;

In Section III, we list 36 of the most important assumptions and note whether they result in a high or low estimate for numbers of injuries and illnesses and for costs. The chapter closes with a conclusion (IV).

II. Limitations

II.A. Fraudulent Claims

A popular perception is that many job-related injuries and illnesses are fraudulent. This perception is especially strong when a WC claim is involved. For example, some people fake back pain or exaggerate the pain they feel, hoping to qualify for WC benefits. It is, nevertheless, fair to say that the extent of the fraud, whether big or small, has never been carefully documented.

Questions of fraud have been addressed in a closely-related area, however--the Social Security Disability Insurance (SSDI) program. In the early 1980s, the Reagan administration began making it difficult for people to qualify for SSDI. From 1980 to 1982, the number of new successful claims dropped 25%. At the same time, more than 20% of cases of persons receiving benefits were reviewed and denied. Most of those among the 20% who appealed, won their appeal. The aggressive Reagan policies ended in 1984 when Congress enacted new legislation governing SSDI (Bound 1989).

John Bound (1989) tested the hypothesis that a high percentage of SSDI recipients were able to work. He analyzed persons who were denied benefits. Presumably, an even higher percentage of those who were denied benefits as opposed to those who were awarded benefits would have the ability work. Social Security data on prime-age men rejected from SSDI showed, however, that fewer than 50% went back to work. Moreover, among those who did find work, their earnings were 30% less than their pre-disability earnings.

Boaz and Muller (1990) considered the fraud issue from a different perspective. They analyzed roughly 11,000 people in the Social Security Administration's Retirement History Survey (RHS). They found that self-reported health status was not only a strong predictor of early retirement, but of premature death as well. The probability of dying "within two years after retiring and the probability of seeking medical care at the time of retiring are much higher especially for those who report work-limiting health problems before age 65." Similar results were found for those who applied for SSDI, regardless whether they were eventually awarded benefits (Boaz and Muller 1990).

Both the Bound (1989) and Boaz and Muller (1990) studies suggest that reports of extensive fraud in the SSDI program were exaggerated. They also suggest that future WC research ought to investigate the health outcomes of persons who had their WC claims rejected.

It is often alleged that "job-stress" claims dominate WC caseloads. Stress claims were increasing significantly, during the 1980s, especially in California. But nationwide, stress claims are not significant. Burton estimated them to be one-half of one percent of all WC claims in the late 1980s (Burton 1988).

Elisburg (1994) points out that the majority of stress cases are not terribly controversial. Elisburg identifies three categories of stress claims. The first type of stress claim involves a mental problem that resulted from a traumatic injury in the workplace. Many suicides fall into this category. A formally active person becomes a quadriplegic as the result of a job-related injury, and subsequently commits suicide a year or two later. The second category involves a mental condition that leads to a job-related injury. For example, a sudden noise could result in paralysis that, in turn, could result in physical injury.

The third category is the most controversial. A mental condition in the worker could result from an incident at the job that may not have resulted in any physical injury to the worker filing the claim. But even within this category, many of the cases would appear reasonable. For example, Elisburg (1994) cites one case in which a worker suffered a severe anxiety reaction after accidentally running over and killing a fellow employee.

Nevertheless, it is likely that some WC claims are fraudulent perhaps especially some of those involving allegations of job stress. We should not exaggerate those fraud cases. The great majority of WC injuries involve clear on the job-accident with clear outcomes, i.e., broken bones, severed fingers, concussions and so on (see VI.B. in Chapter 2).

It could also be that many legitimate claims are denied or, more frequently, never filed. We saw in Chapter 2 that WC counts of injuries underestimate other independent counts of injuries by, on average, 55%. That is, WC accounts for only roughly 45% of all workplace injuries (Toscano and Windau 1993; Parker et al. 1994; National Health Interview Study-Occupational Health Supplement 1988; Hensler et al. 1991; Marquis 1992; Cone et al. 1991; Stout and Bell 1990). Most of the undercounts result from institutional factors. Self-employed people, most farm workers, most household workers, and many workers in small firms are not covered by WC laws. Some of the undercount also involves the nature of the injury. A worker must either be attended to by a medical professional or disabled from work for at least three days. If the worker is seen in-house by the company medical professional and if only one or two days are lost, then the incident may never be

recorded as a WC compensable injury. It could also be that the employer would allow a worker a day to recover from a relatively minor injury that would not require medical treatment. A smashed big toe that did not result in a fracture, but did result in the loss of a toenail, can hobble someone for a day. Since the loss of a toenail would not require a medical visit, such an injury would not be recorded by WC. Since such minor injuries are more numerous than ones resulting in a medical visit of more than three work loss days, it is not surprising that the total number of WC cases would underestimate the actual number of cases.

Some employers offer bonuses to employees who do not report injuries. According to a *Wall Street Journal* study, these bonus schemes are especially prevalent in poultry plants—an industry that has experienced rapid growth since consumers have increased their demand for chicken, ironically, for health reasons (Horwitz 1994).

The WC experience rating scheme for large employers is sometimes alleged to create an incentive to reduce injuries. Recent research suggests, however, that firms that are experienced-rated are much more likely than others to appeal WC board decisions (Hyatt and Kralj 1995).

WC might underestimate total injuries and illnesses for another reason: the WC insurer or company manager might discourage a worker from filing a claim. Rejda (1991), a business professor, suggests that workers often receive advice only from company supervisors or WC insurance agents. The agents also perform the function of judges in accepting or denying the claim, controlling the payment, and terminating the benefit. Moreover, the legal resources available to employers may exceed those available to injured workers.

A worker may conceal a job-related injury. Legally, a worker cannot be fired for filing a WC claim. But many workers are afraid of employer reprisal (O'Loughlin 1993; Roy 1992). Workers, especially new workers, want to make a good impression. Most employees realize that reliability is highly regarded by virtually all employers. Excessive absences can harm the chances for promotions. Most employees, even if they desire to quit, want a strong recommendation from their current employer. Excessive absences would jeopardize that recommendation.

There is ample evidence that the great majority of Americans have a strong work ethic. As real wages have declined since 1973, our hours at work have increased (Mishel and Bernstein 1994; Schor 1991).

A final argument surrounding fraudulent claims involves Smith's (1992) observation that injuries more frequently occur on Mondays than any other day of the week. Smith hypothesized that some workers may have actually been injured over-the-weekend, but claimed to their employer that the injury occurred on Monday, thus, qualifying them for WC benefits. As we indicated in Chapter 2, however, Smith ignored the medical literature showing at least part of the increase of incidents on Mondays could be attributed to the body's physiological response to the re-introduction of job hazards. This would be especially true on Mondays following vacations.

There are undoubtedly fraudulent claims filed by workers. We do not rely on the WC count of injuries or illnesses as the gold standard in our study. We merely use the WC statistics as another estimate. Our view is this: there are fraudulent claims, but there are also legitimate claims that are never filed. We believe that the legitimate claims that could have been filed exceed fraudulent claims.

II.B. Generous WC Benefits Increase Injuries

Some investigators have maintained that generous WC benefits would, ironically, result in more injuries occurring. Presumably, workers are aware of the WC benefits they qualify for in the event of an injury. If those benefits are sufficiently generous, some workers may not take as much precaution at work than if the benefits were stingy. This is the so-called "moral hazard" problem identified in the insurance literature. Studies on this "moral hazard" problem were mentioned in Chapter 2. Ruser (1992, 1993) found that generous WC benefits increased non-fatal (but not fatal) injury rates while Cheadle et al (1994) did not find that they increased injury rates.

None of these studies have addressed a mutual causality statistical problem. Positive partial correlations between injury rates and generous benefits do not necessarily imply that generous benefits result in more injuries. It could be that state legislatures and insurance commissioners who establish the benefits are

simply responding to constituencies. Injured workers who vote may let their elected representatives know that they want generous benefits. The more injured or ill workers there are in a state, other things equal, the larger the constituency that would support generous benefits. Leigh (1985b) found that the estimated effect of generous benefits on injury and illness rates is less after accounting for mutual causality bias than before accounting for it.

Another problem not addressed by researchers who allege a strong "moral hazard" effect concerns the WTP and Direct/Indirect estimates found here.

We found in our review of the WTP literature that virtually all WTP estimates of values of life, injuries and diseases were two to six or more times greater than the direct and indirect costs of the same lives, injuries and diseases. It would appear that the average WTP cost to the individual would far exceed the WC benefits, especially given that WC covers only roughly 50% of the before-tax wage (Ehrenberg and Smith 1991, p. 203). But there is some variation across people in their WTP estimates. Nevertheless, the size of the disparity between WTP estimates and Direct/Indirect estimates suggests that not a great number of workers would find it profitable to experience an injury or illness, and subsequently collect benefits.

II.C. More Injuries Occur at Home than at Work

The number of injury deaths not job-related exceeds job-related injury deaths by roughly 15 or 20 to 1 (Rice et al. 1989; Hensler et al. 1991; Baker et al. 1992; National Safety Council 1993). The number of non-fatal injuries away from work exceeds those at work by factors of between 6:1 to 14:1 (Hensler et al. 1991; National Safety Council 1993). These disparities have lead some investigators to comment that being at work is much safer than being at home.

But these statistics are misleading. First, there were over 250 million persons living in the United States in 1992 of whom only roughly 120 held jobs. Moreover, those who work are not a random sample of Americans. People with jobs tend to be 20 to 65 years old and more likely to be male than female. Children and the elderly would not likely be among those who experienced a job-related injury.

Moreover, most of the time (awake and asleep) of those who work is spent away from work.

To accurately assess whether "home" (i.e., not at work) is more dangerous than work, we need to restrict our attention to a group most likely to be employed and express risk as per hour of exposure. Hensler et al. (1991) attempted to make such a comparison for men who held jobs. They did not control for hours of exposure, however. They found that these men were more likely to be injured on-the-job than anywhere else and that these injuries were more likely to be serious (i.e., disabling and costly), than any injuries they experienced away from their jobs. Had Hensler et al. controlled for hours of exposure, work hours would have been found to be far more hazardous than home hours. This is true, simply because most working people spend less time at work than away from work. Assuming eight hours of sleep, and 40 hours a week of work, the work/non-work percent would be 36%. Thus, for those who work, it is likely that work is more dangerous than home.

II.D. WC Medical Costs Exaggerate True Medical Costs

In recent years, WC medical costs were estimated to have increased one and one-half times faster than general medical costs (Nelson 1992). Some investigators have argued that this evidence suggests that WC pays more than the true medical costs associated with an injury or illness (Durbin, Corro, and Helvacian 1993). Hospitals and doctors, for example, may charge a higher price to WC insurers than to all other insurers for the same injury or illness.

But there are other reasons for the fast increase in aggregate WC costs. During the 1980s, when most of WC versus all other medical cost comparisons were done, the economy was contracting in 1981 but was expanding in late 1983 through 1989. As the economy expands, more people are put back to work. In the 1970s, WC did not expand as rapid as other medical costs (Boden and Fleischman 1989), and the economy suffered two serious recessions: 1973-74 and 1979.

As employment expanded, the number of injuries undoubtedly increased for three reasons. First, as a matter of arithmetic, the more people who work, the more the number of injuries. Second, as the economy expands, more workers put in

overtime and each employed worker has greater exposure to hazards. This overtime factor is doubly important because fatigue increases with overtime. Third, many of the newly-hired employees were not likely to have much experience at the job. As we indicated in Chapter 2, a number of studies suggest that inexperienced workers suffer a disproportionate number of job-injuries (Division of Labor Statistics and Research 1985; Chelius 1979).

WC pays virtually 100% of the medical bill. Injured or ill workers do not pay a co-payment or have a deductible. Most other insurers have co-payments and deductibles and these are sometimes not paid by consumers for a variety of reasons including lack of income.

In addition, the kinds of injuries and illnesses paid for by WC are not typical when compared to general medical spending. For example, men are more likely than women to receive WC. In addition, roughly 98% of WC incidents involve injuries, many requiring ambulance services and emergency care. General medical spending is not so highly concentrated among injuries. Moreover, even within injuries, WC injuries are likely to be more severe than non-WC injuries (Hensler et al. 1991; Marquis 1992; National Safety Council 1993; Miller and Galbraith 1994; Rossman and Miller 1991). As mentioned above, the worker faces incentives not to report, and if he or she reports and especially seeks indemnity payment, then the injury or illness must be viewed as serious by people other than the worker and his or her doctor (i.e., the WC board).

II.E. Total and Average Costs Versus Marginal Costs

Our study on direct and indirect costs presents total and average costs, all the direct and indirect cost studies we are familiar with calculated total and average costs, not marginal costs.

Our attention to total and average costs rather than marginal costs is appropriate, however. We seek to generate overall cost figures which then maybe compared to overall cost figures for other diseases, injuries and other activities.

If our study had been concerned with, for example, evaluating OSH engineering standards, the appropriate cost would be marginal, not average or

total. Presumably, few standards eliminate risk altogether. A standard might cut risk by a tenth or a quarter, but rarely, if ever, by 100%. The total and average cost concepts most appropriately to cutting risk by 100%. The marginal cost applies to marginal cuts of 5%, 10%, or 20%.

II.F. Full Employment

The largest component of indirect costs are lost wages. But whether lost wages represent a true cost depends upon economic conditions. If there is a substantial amount of unemployment, then the worker sustaining the injury or illness might be easily replaced with someone currently unemployed. Since the unemployed replacement had no wages prior to acquiring the job, the loss to the economy from the injured workers' production may be zero.

The implicit assumption in all prior work on the lost wages component of indirect costs, and the explicit assumption here, is that the economy is operating at full employment. This means that no direct, easy replacement of the injured or ill worker is readily available. The replacement must come from a different sector in the economy, necessitating a drop in output from that sector.

This is a reasonable assumption. It underpins the common sense idea that people are a valuable resource. If this were not true, then a number of counter-intuitive (and incorrect!) conclusions could be drawn about costs in the economy. For example, business groups often complain of the overall costs of environmental regulations. Businesses must spend more than they otherwise would, for example, on machinery in a cotton mill that reduces the amount of cotton fiber circulating in the plant. These new machines are costly. The manufacturers of the machines must pay people to produce the machines. Presumably, without the added spending on the new machines, these people would have been employed elsewhere in the economy. The fact that they are induced into building new cotton mill machinery presumably means that output elsewhere in the economy must have decreased. But if these workers had been unemployed, then the cost to the economy would be zero. We would have the perverse result that environmental and OSH standards create jobs and therefore do not result in any net loss to the economy.

The implicit assumption behind the argument of the costs of EPA and OSHA regulations is that the economy is operating at full employment. A cleaner environment or safer workplace is not free. It must be paid for.

We, therefore, invoke the same Full Employment assumption used by business groups in our analysis of the costs of lost wages.

II.G. Incidence and Prevalence Costs

As a practical matter, our estimates of costs in prior chapters will not be greatly influenced by whether we use incidence or prevalence cost methods. Variations in the estimates of total injuries and illnesses as well as assumptions about medical and indirect costs are much more likely to cause variability in our total cost estimates than any differences arising from applying a prevalence or incidence cost method.

Nevertheless, some readers may be interested in pursuing the theoretical differences in prevalence and incidence methods. We did discover a difference of opinion in studies of costs. Miller and Galbraith (1994) held that in the Steady State, incidence equals prevalence. Hensler et al. (1991) argued that in the Steady State incidence would be smaller than prevalence due to discounting by the real interest rate. We side with Hensler et al. (1991), and present the following example to help support our view.

To understand the controversy, it is important to define the Steady State. A Steady State occurs when the same number and type of injuries and illnesses occur year after year. Before proceeding with our example, we should consider the likelihood of this assumption holding. It is extremely unlikely. This again underscores our statements above that real world estimation of injuries and illnesses, as well as assumptions regarding costs, wages and so on figure much more prominently in our final estimate of total cost than whether we chose the incidence or prevalence method to calculate costs.

Nevertheless, to explain the difference, consider Table 10.1 which describes one possible Steady State. In Table 10.1, we assume that one injury occurs each year, and that the injury lasts two years. In the third year, the worker fully recovers.

Six years and five injuries are considered in Table 10.1. Years appear down the horizontal side and injuries across the top of Table 10.1. Only one accident occurs each year. The resulting injury requires two years to heal so that the cost last two years. We assume that treatment costs and all costs and prices double every year. This increase in cost is purely inflationary. It does not reflect any improvement in the treatment.

The first injury generates a \$1 cost in year 1 and a \$2 cost in year 2. The total cost for the injury would be \$3. But this would not be the present value cost in year 1. Discounting for inflation only in year 1 would require that we divide the year 2 cost by 2. We divide by 2 because we know that inflation doubles prices every year in our example. Hence, the year 1 present value of costs associated with injury number 1 would be 2.

Table 10.1

Incidence Versus Prevalence in the Steady State

	1	2	3	4	5	
<u>Year</u>						<u>Prevalence Cost</u>
1	1					1
2	2	2				4
3		4	4			8
4			8	8		16
5				16	16	32
6	-	-	-	-	32	32
1) Incidence Cost:						
no discount:	3	6	12	24	48	
2) Present value after discounting for inflation:	2	4	8	16	32	
3) Present value after discounting for inflation and after 4% real interest rate:	1.98	3.96	7.92	15.84	31.69	

The prevalence cost in year 1 would be \$1. Here, the prevalence cost is less than the incidence cost. But year 1 is not the Steady State, i.e., our exercise begins with year 1 and no prior injuries are allowed into year 1.

Years 2, 3, 4, and 5, on the other hand, are Steady State years, that is, years in which one new injury occurs and one old injury is recovering. Our example ends with year 6 which is not a Steady State year, since no new injury is allowed in that year. In the Steady State years, prevalence costs and inflation-free (the present value) incidence costs are identical: 4, 8, 16, 32.

Our inflation-only discounting example suggests that Miller and Galbraith (1994) were right: incidence equals prevalence. But discounting almost always accounts for a real interest rate. In our procedures in Chapters 5 and 6, we assumed a 4% real discount rate. If we here assume a real rate of .04, then future dollars should be divided by 2.04 not 2. The dollar totals are seen in the last row. Notice now that in the Steady State years (2 through 5) that the incidence cost is slightly less than prevalence cost.

Our discounting of future dollars for deaths in Chapters 5 and 6 implicitly removes inflation by using earnings data from 1992. We assume persons would have followed the age and gender profiles of earnings displayed by people who were alive in 1992 and in the labor market. We also account for a real interest rate of 4% (and a productivity rate of 1%). Consequently, in a Steady State, our indirect cost incidence costs should be less than our prevalence costs.

But this incidence/prevalence cost analysis is unlikely to explain much of the disparity between, for example, our incidence injury cost estimates and Hensler's et al. (1991) prevalence injury cost estimate. There are simply too many additional assumptions of more consequence that separate the two estimates. For example, Hensler et al. (1991) ignore all assaults and murders.

There is an additional problem for medical costs. We use the actuarial estimates. These are based on methods which must account both for inflation and the real discount rate, since they are market-based, that is, they are used for real business decisions. As a result, the medical costs calculations should also contain the same effect. Incidence costs should be less than prevalence costs.

We turn next to the more important assumptions that were relied on in our analysis.

III. Assumptions

III.A. Introduction

Our most serious limitation was that there was no single source of data available to provide all of the information we required. We had to analyze data from a variety of sources. In all, we considered 14 primary sources and over 300 secondary sources. Each source had limitations and numerous assumptions had to be made in calculating our final estimates.

In this section, we mention the major assumptions of the study. We do not elaborate on these assumptions here. Rather, we refer the reader to the place in the text where the assumption is invoked and discussed. A word precedes our list of each assumption below. The word "Low" indicates that this assumption would result in a lower estimate than would otherwise be obtained with alternative assumptions. The word "High" indicates the assumption led to a higher estimate than would have been obtained with alternative assumptions. Note that Low assumptions out-number High assumptions: 31 Lows, 4 Highs and 1 of unknown bias. Moreover, each High assumption receives quite a bit more attention and justification in the text referenced than the Low assumptions. We invoked high estimate assumptions, only when we believed there was overwhelming evidence to support them.

III.B. List of Consequential Assumptions

1. High. We based much of our incidence-based estimate of injury deaths on prevalence-based death estimates in the CFOI and the NTOF. There is, in fact, a downward secular time trend in injury deaths hence, other things equal, incidence deaths should be slightly smaller than prevalence deaths in 1992 (Chapters 2, II.A.1 and 2).

2. Low. We selected our year of analysis to be 1992, a high unemployment year. Incidence of injuries and illnesses are less in high than low unemployment years. (This assumption is made throughout the text).

3. Low. We omitted injuries and illnesses among military personnel. Toscano and Windau (1993) estimated that military personnel residing in the United States

accounted for 2.6% of all job-related deaths. This assumption is made throughout the analysis.

4. Low. In the final tally of estimates of injury deaths, we ignored our adjustment to the CPOI that accounted for race and ethnic disparities (Chapter 2, Section II.C.).

5. Low. We used the NHIS estimates without adjusting for people who were in hospitals or nursing homes. The NHIS did not interview people who were institutionalized (Chapter 2, III.A.3.).

6. Low. We did not adjust the Hensler et al. (1991) and Marquis (1992) estimates to account for their underestimate of minor injuries, an underestimate they acknowledged (Chapter III.B.1.).

7. Low. In estimating the number of non-fatal injuries, we gave equal weight to all studies despite our highest confidence in the BLS's Annual Survey and its corresponding relatively high estimate (13.991 million) (Chapter 2, III.C.).

8. Low. We ignored the trend toward longer recovering times for injuries. We used the NCCI cost figures from 1988 to 1990, to create our injury figures for 1992. Since average costs per injury will increase with longer recover times, the use of the 1988-90 average cost data underestimated average costs for 1992 (Chapter 5, II.A.).

9. Low. We used NCCI average medical cost data that excluded California and New York. But California and New York had higher average medical costs than the rest of the nation, and they are the two most populous states (Chapter 5, II.A.).

10. Low. We did not adjust for current employment status in the present value of earnings tables. We merely adjusted for the Labor Force Participation Rate (LFPR). In so doing, we undervalued the earnings of those currently employed. That is, those currently employed are not a random sample of all persons in the labor market. Those currently employed probably had better lifetime employment prospects than all persons in the labor force. All persons in the labor force included those persons unemployed (Chapter 5, II.2. and throughout Chapter 6).

11. Low. We assumed that fringe benefits were equal to 20% of the wage. Most studies show fringe benefits to be in the 25% range (Chapter 5, II.1.).

12. Low. Since we applied the LFPR to home production, we greatly underestimated home production among those over age 65 (Chapter 5, II.B.2.).

13. Low. In estimating the value of lost specific human capital, we used the median rather than the mean for tenure with the firm. The length of tenure with the firm is likely to be skewed to the right. The mean would be larger than the median. The mean, in fact, would give a more accurate picture of the overall loss of tenure with the firm. However, direct evidence on mean length of tenure was not available.

14. Low. In calculating the costs to the firm, we included the workplace disruption costs associated with experiencing anxiety with the death of a co-worker. We did not include the costs of workplace disruption associated with increased strike frequencies (Leigh 1983), absences, or sabotage rates that are associated with high injury rates (Chapter 5, II.B.3.).

15. Low. In assessing the NSC's death estimates, we assumed that their "allocative factors" accounted for 100% of the death certificate undercount (Chapter 2, II.B.1.).

16. Low. We used a 15% rather than a 20% underestimate of violent deaths by the NSC (Chapter 2, II.B.1.).

17. Low. We did not add any damage costs for injuries producing arthritis (Chapter 2, IV.).

18. High and Low. We used the same percentage factor to calculate insurance administrative costs for medical costs as for indemnity costs in WC. It is probably the case that more litigation and thus more administrative costs surround indemnity rather than medical benefits. We, thus, overestimated insurance administrative costs for medical care and underestimated it for providing indemnity (Chapter 5, II.A and B.).

19. Low. In calculating property damage, we assumed only 18% of all fatal and non-fatal injuries involved vehicle crashes. Most studies find more than 20% (Chapter 5, II.B.3.).

20. Low. We chose 1990 as the cost year for the NCCI studies. The greatest amount of cost were probably generated in 1988 or 1989. Obviously, the same number inflated from 1988 to 1992 would be larger than that number inflated from 1990 to

1992. That is, more total inflation was generated from 1988 to 1992 than from 1990 to 1992 (Chapter 5, II.A and B.).

21. Low. We chose a 55% rather than a 60% undercount for WC even though most studies showed a 60% undercount was more plausible (affects all estimates and made throughout Chapters 2 and 5).

22. Low. We used a 31% WC administrative cost estimate using Nelson's (1992, 1993) data. Burton's (1994) statistics indicated a 38% rate.

23. Low. We assumed only \$5 billion of spending on indemnity for injuries not covered by WC. Nelson (1992, 1993) estimates \$27.5 billion of indemnity spending by WC. We also know that WC, in general, covered less than half of all injuries. Hence, assuming only \$5 billion of non-WC indemnity spending was quite low. Social Security Disability benefits, private disability, Welfare and so on all contribute to non-WC indemnity payments.

24. High. We added 1500 deaths to the NSC estimate to account for violent deaths. We felt this was justified given that the NSC explicitly ignores violent deaths (Chapter 2, II.B.1).

25. Low. We did not include the costs of family caregiver's time nor the health problems that occur among caregivers. These costs are undoubtedly large but are difficult to estimate (Max, Webber and Fox, 1995); Boaz and Muller, 1992. Roy (1992) and McFloyd and Flanagan (1993) document the deleterious psychological consequences on spouses and children resulting from care for and living with seriously injured or ill husbands or wives or parents.

26. Low. We assumed different before-tax wage-replacement rates of .4 for PTs, .5 for PP's and .6 for TTPs. Overall, our assumptions lead to a before-tax wage-replacement rate of roughly .51. This is a little higher than the .5 assumption generally made in the literature (Ehrenberg and Smith 1991). Had we assumed a .5 rate for all WC categories, our estimates of wage loss (the largest category in indirect costs) would have been larger than the one we obtained (Chapter 5).

27. Low. Hearing loss and reproductive problems were omitted from our disease and illness calculations. Moreover, we did not assume any deaths or illnesses resulted from workers who worry about layoffs. As corporate

restructuring continues so do feelings of job insecurity that, in turn, could lead to increased colds, flus, cancers and circulatory disease (Heaney et al. 1993; Marriot et al. 1994; Lihicinio et al. 1995). They were omitted because we do not have reliable national estimates for these (Chapter 6).

28. Low. Small proportions (1% to 3% to 10%) were used when we attempted to estimate morbidity and mortality from the major diseases (Chapter 6).

29. Low. Occupational cardiovascular morbidity and mortality was limited to events among people less than 65 years old because the extension of the occupational impact on cardiovascular disease after retirement is uncertain (Chapter 6). Nevertheless, it is likely that job-strain would have increased circulatory disease risks prior to retirement and hastened the heart attack or stroke occurring after retirement.

30. Low. We ignored pain and suffering costs. Lawsuits involving non-fatal injuries almost always involve some payment for pain and suffering. A rule of thumb frequently cited is that pain and suffering equal three times the non-administrative medical expenses (Ferguson, 1995). In our case, this would mean adding another roughly \$100 billion to our costs. The WTP estimates would not require any adjustment. If we assume that the difference between the WTP estimates and the Direct/Indirect estimates is due to pain and suffering, then pain and suffering would add an additional \$300 billion to \$700 billion.

31. We assumed that once the injured or ill worker was re-employed, no more lost wages would need to be accounted for. However, most permanently impaired workers do not earn their old wage at the new job. They experience permanent wage loss for the rest of their working lives (Abt Associates 1989; Berkowitz 1990; Jacobson, Lalonde and Sullivan 1993; Bound 1989).

32. Low. Pneumoconiosis is underdiagnosed (Selikoff et al., 1979).

33. Low. In estimating days of work loss for diseases, we used the BLS Annual Survey data that were restricted to a 12 month calendar year. But many serious illnesses can generate workloss for much longer than 12 months. Olernick et al. (1993) showed that the BLS data misses as much as 7% of workdays lost.

34. Low. No diseases were allowed for persons less than 25 years old. We disallowed any consequences of workers bringing carcinogens home with them (on

clothing, for example) and exposing children we also disallowed job-related miscarriages (Olsham et al 1991).

35. High. For our disease costs, we assumed that deaths would be mutually exclusive of morbidity.

36. Low. Children reared in families where one parent is disabled acquire less education and consequently earn less lifetime income than children whose parents are not disabled (Haveman and Wolfe, 1994).

IV. Conclusion

This chapter first discusses seven general limitations for our study. These include issues surrounding fraudulent WC claims, generous WC benefits that discourage injury prevention, home versus work injuries, generous WC medical benefits, total average and marginal costs, full employment, and incidence and prevalence costs. The chapter also details 36 of the most important assumptions we made. Thirty-one (31) assumptions resulted in our producing estimates that were lower than would otherwise be obtained with more generous assumptions.

Chapter 11
Comparison with Other Health Problems

Outline for Chapter 11:

Comparisons with other Health Problems

- I. Costs of AIDS, Alzheimer's disease, back pain, circulatory diseases and cancer
- II. Re-allocation between circulatory disease and occupational injuries and illnesses
- III. Conclusion

Chapter 11: Comparisons with other Health Problems

In the first section of this chapter, we will compare our costs with costs of other diseases. In the second, we will indicate how the economic laws of diminishing returns and increasing opportunity costs suggest medical dollars might be reallocated between heart disease and occupational injuries and illnesses.

I. Costs of AIDS, Alzheimer's Disease, Back Pain, Circulatory Diseases and Cancer

Our costs are large when compared to other diseases. The medical costs of AIDS were estimated to be roughly \$7.0 billion in 1992 (Hellinger 1992). These AIDS costs did not include insurance administration costs. Our medical only direct costs for injuries (only) above were \$30.8 billion—over four times the costs for AIDS. We are not familiar with any recent estimates of indirect costs for AIDS, but these are likely to be large for the same reason that job-related injury indirect costs are large: people die at relatively young ages.

Alzheimer's disease was recently estimated to generate \$20.6 billion in direct costs and \$46.7 billion in indirect costs (Ernst and Hay 1994). Again, our direct cost estimate was \$66.2 billion and our indirect estimate was \$107.6 billion for injuries only.

Circulatory diseases—heart attack, stroke, and high blood pressure—are responsible for more deaths than any other disease or injury. Unfortunately, the most reliable estimate of the costs of all circulatory diseases dates back to 1980. Rice et al. (1985) estimated \$32.5 billion in direct costs and \$47.1 billion in indirect costs in 1980. The American Heart Association (1992) attempted to adjust these estimates to reflect inflation and changes in the numbers of people with heart diseases from 1980 to 1982. The American Heart Association (1992) attempted to adjust these estimates to reflect inflation and changes in the numbers of people with heart diseases from 1980 to 1982. The American Heart Association estimate for 1992 was \$108.9. But the Association did not fully account for the mortality aspect of indirect costs. We, therefore, apply our own extrapolations of the Rice et al. (1985) 1980 estimates.

To bring these 1980 estimates up to 1992 requires several assumptions: 1) A 154% increase in general medical prices (U.S. Department of Commerce 1993); 2) A

2% reduction in the number of people with circulatory diseases from 1980 to 1992 (National Center of Health Statistics 1994); 3) A 70% increase in economy-wide prices for indirect costs (U.S. Department of Commerce 1993); 4) An additional 10% factor over and above the general medical inflation rate to account for special cost increases in the treatment of heart and stroke disease (e.g. Coronary Artery Bypass Surgery. The calculation appears as follows:

Direct costs: $\$32.5 \times (2.54 - .02 + .10) = \$ 85.15$

Indirect costs: $\$47.1 \times (1.70 - .02) = \$ 79.10$

Total $\$164.28$

The total costs for all circulatory diseases would then be \$164.28 billion in 1992. The Rice et al. (1985) estimates for 1980 did not include our cost categories of property damage, home medical care, workplace retraining, but these are relatively small compared to the categories Rice et al. did include. Moreover, property damage is not likely to be great for diseases and workplace retraining would also be small for heart disease patients who most frequently die in retirement. Hence, \$164.28 does provide us with a reasonable cost comparison figure.

Note that in 1992, direct costs exceed indirect costs. This is the result of the more rapid increase in medical than wage inflation and the general trend towards heart disease developing later in life. The American Heart Association (1992) estimates also found direct costs to exceed indirect costs in 1992.

Similar calculations can be carried out for the costs of cancer (Rice et al. 1985). All of the assumptions above apply except those pertaining to the growth in the number of persons afflicted. The National Center for Health Statistics (1994) study suggests an increase of roughly 33% in the number of people afflicted with cancer from 1980 to 1992. We will assume that expenses for cancer therapy grew 10% over general medical inflation from 1980 to 1992. The calculations are:

Direct costs: $\$13.05 \times (2.54 + .33 + .10) = \$ 38.76$

Indirect costs: $\$65.0 \times (1.70 + .33) = \$131.95$

Total $\$170.71$

The indirect costs of cancer are greater than the indirect costs of circulatory disease due to the greater prevalence of cancer deaths than circulatory heart disease deaths among the young.

We again face the problem that Rice et al. (1985) excluded property damage, home medical care and workplace disruption, but this \$170.71 figure provides some degree of comparison to our estimate of costs of occupational injuries and illnesses.

II. Re-allocation Between Circulatory Disease and Occupational Injuries and Illnesses

We have made the point that occupational injuries and illnesses may cost as much as all circulatory (heart and stroke) diseases. This does not necessarily imply that if, for example, Congress and the President find an additional one million dollars of unallocated preventive medicine spending, that they should spend it reducing occupational injuries and illnesses. Since these one million dollars could be used for either of the two problems, the relevant question is this: where will the dollars of spending generate the greatest cost savings—in circulatory disease or occupational injuries and illnesses? A definitive answer to this question would require information on marginal costs (See Section II.E, Chapter 10). A suggestive answer can nevertheless be made with information on average and total costs.

Two of the most important lessons of economics involve the laws of diminishing returns and of increasing opportunity costs. These laws are so widely accepted that they are discussed in the opening chapters of virtually every introductory economics text. In our context, suppose that one billion dollars is being spent on the prevention of heart disease. The law of diminishing returns suggests that the first, say, million dollars spent on reducing heart disease will probably yield a larger reduction in risk than the last million dollars spent (from 999 million to 1,000 million dollars).

An analogy might help explain the idea. Suppose that heart disease risk can be reduced through jogging. The law of diminishing returns suggests that the decrease in risk would be greater for the sedentary person (who never jogged) who now decides to jog 15 minutes a day as opposed to the active person (who used to

jog one hour a day) who now jogs one hour and fifteen minutes. The 15 additional minutes to the sedentary person would likely reduce his risk more than the 15 additional minutes would reduce the risk of the active person.

The law of increasing opportunity costs extends the law diminishing returns to the production of two goals. Imagine our two goals' are winning horse races and basketball games. The law of increasing opportunity costs states that some factors (land labor or capital) were more suitable in the winning of races than in the winning of games. Short persons can play basketball, but they are not as likely to score as many points or win as many games as tall persons. Tall persons can ride horses, but they are less likely than short persons to win horse races. If total wins are to be maximized, we should allow short persons to specialize as jockeys, and tall persons to specialize as basketball players.

In our context, the goals would be the production of health free from heart disease or free from occupational injuries and illnesses. The law of increasing costs relies on the notion of the substitutability of factors. The word "factor" here means something that helps produce health—such as cardiologists for heart disease and safety experts for occupational safety and health. The safety experts may have special abilities to spot safety hazards. These abilities may not be possessed by cardiologists. Cardiologists may have abilities that safety experts do not possess. To produce more health free from heart disease could eventually require that some safety experts be trained as cardiologists. But these new cardiologists may not have the same intrinsic cardiologist abilities as the old cardiologists. In a similar vein, to produce more health free from occupational injuries and illnesses would eventually require that cardiologists be trained as safety experts. But these new experts may not have as much ability as the old experts in spotting occupational hazards.

The experts and the cardiologists are "factors." They are different and possess different abilities. People who freely choose to become cardiologist probably have more ability in those tasks than people who are forced out of a safety expert job into a cardiologist job. Likewise, cardiologists forced into a safety expert job would probably not make good safety experts.

As we require more and more production of health free from heart disease, we essentially reach a point where factors more adept in the production of health free from occupational injuries and illnesses are forced into heart disease risk reduction. The point is that some factors (land labor, or capital) are more suitable in producing health free from heart disease than in producing health free from occupational injuries and illnesses.

If our goal is to prevent both heart disease and occupational injuries and illnesses, then some balance of factors or resources between these two preventive activities would be warranted. This plea for balance is especially strong given that the total costs of the two problems is roughly equivalent. But there does not appear to be a balance. Far more resources appear to be applied to heart disease than occupational injuries and illnesses.

By virtually any measure---research dollars, numbers of cardiologists versus occupational medicine physicians, paperback self-help books, news articles, television shows, and so on---physicians, politicians, nurses, authors, media representatives, health advisors, and American consumers spend far more attention on heart disease than occupational injuries and illnesses. If some of these heart disease dollars and attention were directed at occupational injuries and illnesses, we might experience a slight increase in heart disease costs but a much larger reduction in occupational and injury and illness costs.

But the heart disease costs analysis above is merely an example of an application of the laws of diminishing returns and increasing costs. We do not wish to signal out heart disease as getting too much public and scientific attention. Our analysis could equally be applied to AIDS, Cancer, Alzheimer's disease or any other health problem. Our point is simple: a re-allocation of resources from any of a number of health problems to occupational safety and health might result in a net gain in lives saved and injuries and illnesses avoided.

III. Conclusion

In summary, occupational injury and illness costs exceed those for AIDS and Alzheimer's disease and are on a par with those for all heart diseases and stroke

as well as those for cancer. By virtually any measure, occupational injuries and illnesses do not receive the same scientific, government, medical, media or public attention commanded by AIDS, Alzheimer's, Heart disease and Cancer. Some re-allocation of resources for any one of the former to occupational injuries and illnesses might improve the overall health of the nation.

Chapter 12

Conclusion

Chapter 12: Conclusion

The summary of our study appears in Chapter 1. Here, we simply underscore our most important conclusions.

Occupational injuries and illnesses are expensive. Costs are greater than for AIDS, and rival those for heart and stroke diseases, and all cancers.

The costs are high because so many people are at risk. One hundred twenty (120) million people held jobs in 1992. Any of the 120 million could have suffered a job-related injury or illness.

While the lion's share of costs are experienced by the injured or ill workers and their families, all Americans share in these costs. Firms experience them as premiums for WC and health insurance, as workplace disruptions, and as property damage. Consumers experience them as higher prices. Workers experience them as lower wages. Taxpayers experience them as high taxes for Medicare and Medicaid.

Despite the high cost, the great numbers of people at risk, and the fact that so many of us must pay, occupational injuries and illnesses do not receive the attention they deserve. The NIOSH receives one of the lowest levels of funding of any of the health research institutes in the country. No private charities are available to fund research on OSH. Heart disease has the American Heart Association; Cancer has the American Cancer Society; AIDS has the Ryan White institute; and so on. Occupational injuries and illnesses do not have a corresponding charitable foundation.

The federal government's flagship health statistics publication *Advanced Data on injury-related data visits* (Schappert 1994), hospitalizations (Hall and Owings 1994) and emergency room visits (Burt 1995), for example, do not include any categories for occupational injuries.

A cursory view of medical articles in newspapers, stories on television, best-selling medical self-help books and so on, reveals far more attention to AIDS, heart disease, cancer and so on than to job-related injuries and illnesses.

The 120 million Americans who work for a living and the nearly 20 million

firms, charities, hospitals, and governments that employ them deserve greater attention to the cost of occupational injuries and illnesses.

References

- Abt Associates. Status Report: Persons with Disabilities. Toronto Ontario, Ministry of Citizenship, 1989.
- Adams PF, Benson V. Current estimates from the National Health Interview Survey, 1991. National Center for Health Statistics. Vital and Health Statistics, 10(184), Hyattsville MD, 1992.
- Alexander BH, Franklin GM, Wolf, MF. The sexual assault of women at work in Washington State, 1980 to 1989. American Journal of Public Health, 1994;84(4):640-642.
- Allen SG. Compensation, safety, and absenteeism: evidence from the paper industry. Industrial and Labor Relations Review 1981;34:207.
- Alleyne BC, Stuart P, Cooper R. Alcohol and other drug use in occupational fatalities. Journal of Occupational Medicine, 1991;33(4):196-200.
- American Cancer Society (Department of Epidemiology and Statistics). Personal communication. Ms. Sheryl Montgomery, March 2, 1995.
- American Heart Association. Heart and Stroke Facts: 1995 Statistical Supplement. 1994.
- American Heart Association. Heart and Stroke Facts, 1992, American Heart Association Publishers, Dallas, Texas 1992.
- American Lung Association (Epidemiology & Statistics Unit). Trends in Chronic Bronchitis and Emphysema: Morbidity and Mortality, January, 1995.
- American Medical Association. Physician Characteristics and Distribution in the U.S., 1992, AMA Publishers, Chicago,awL, 1992.
- American National Standards. Method of Recording Basic Facts Relating to Nature and Occurrence of Work Injuries. Z16.2, American National Standards Institute, Inc., New York, NY, 1962.
- Anderson JJ, Felson DT. Factors associated with osteoarthritis of the knee in NHANES I. American Journal of Epidemiology, 1988;128:179-189.
- Ansberry C. Workplace injuries proliferate as concerns push people to produce. Wall Street Journal, July 16, 1989. A-1.
- Arnould RJ, Nichols LM. Wage-risk premiums and workers' compensation: a refinement of estimates of compensating wage differentials. Journal of Political Economy, 1983;91:332-340.
- Ashford NA. Crisis in the Workplace. M.I.T. Press, Cambridge, Mass, 1976.
- Atkinson SE, Halversen R. The valuation of risk to life: evidence from the market for automobiles. Review of Economics and Statistics, 1990;72(1):133-136.
- Baker DB, Landrigan PJ. Occupational exposures and human health. Medical Clinics of North America, 1990;74(2):441-460.
- Baker EL. Sentinel Event Notification System for Occupational Risks (SENSOR): the concept. American Journal of Public Health 1989;79(Suppl):18-20.
- Baker SP, Samkoff JS, Fisher RS, VanBuren CB. Fatal occupational injuries. Journal of the American Medical Association, 1982;248:692-697.

- , Meyers AH, Smith GS. Injury prevention in the workplace. In Proceedings of the Johns Hopkins University Conference on Research in Work, Health, and Productivity. New York: Oxford University Press, 1990.
- , Conroy C., Johnston JJ. Position Papers from the Third National Injury Control Conference: Setting the Agenda in the 1990s. U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, 1992.
- , O'Neil B, Ginsburg MJ, Li G. The Injury Fact Book, Second Edition, Oxford University Press, New York, 1992.
- Barancik JJ, Kramer CF, Thode HC, Jr. Epidemiology of non-fatal occupational injuries: magnitude of the problem. In: Annual meeting abstracts, New York: American Public Health Association, 1990:163.
- Barron JM, Black DA, Lowenstein MA. Job matching and on-the-job training. Journal of Labor Economics 1989; 7(1):5-20.
- Barry J. Women production workers: low pay and hazardous work. American Economic Review, 1985;75(2):262-265.
- Barth PS. Compensation of asbestos-associated disease: a survey of asbestos insulation workers in the United States and Canada. Chapter 5, in Selikoff IJ, ed. Disability Compensation for Asbestos-Associated Disease in the United States. New York Environmental Sciences Laboratory, Mount Sinai School of Medicine of the City University of New York, 1982.
- Barth PS, Hunt HA. Workers' Compensation and Work-Related Illnesses and Diseases. Cambridge, MA, MIT Press, 1980.
- Bartrop RW, Luckhurst E, Lazarus L, Kiloh LG, & Penny R, 1977. Depressed lymphocyte function after bereavement. Lancet, 1977;1(8016), 834-836.
- Bauman KE, Emmett SE. Tobacco use by black and white adolescents: The validity of self-reports. American Journal of Public Health 1994;84(3):394-398.
- Beatty M, Zook E, Russell R, Kinhead L. Grain auger injuries: the replacement of the corn picker injury? Plastic Reconstruction Surgery, 1982;96-102.
- Becker EH. Self-employed workers: an update for 1983. Monthly Labor Review, 1984;107(7):14-18.
- Becklake MR. Occupational exposures and airways disease. In Rom W (ed): Environmental and Occupational Medicine. Boston: Little, Brown Publishers, 1992;453-463.
- Behrman JR, Wolfe BL. Does schooling make women better nourished and healthier? Journal of Human Resources, 1989;24:644-663.
- Behrens VW, Brackbill RM. Worker's awareness of exposure: Industries and occupations with low awareness. American Journal of Industrial Medicine, 1993;23: 687-701.
- Beli A, Denmead E. OSHRC Rules against Caterpillar for record keeping failures. Cal-OSHA Reporter, 1993;20(13):5569-70.
- Bell CA, Stout NA, Bender TR, Conroy CS, Crouse WE. Fatal occupational injuries in the U.S., 1980 through 1985. Journal of the American Medical Association 1990;263:3047-3050.
- Belville R, Pollack SH, Godbold JH, Landrigan FJ. Occupational injuries among working adolescents in New York state. Journal of the American Medical Association, 1994;269(21):2754-2759.

- Benhamou S, Benhamou E, Flamant R. Occupational risk factors of lung cancer in a French case-control study. British Journal of Industrial Medicine, 45:231-133, 1988.
- Bennett JD, Passmore DL. Correlates of coal mine accident and injuries: A literature review. Accident Analysis and Prevention, 1984, 16:37-45.
- Berger MC, Leigh JP. Schooling, self-selection, and health. Journal of Human Resources, 1989;24:433-455.
- Berger MC, Gabriel PF. Risk aversion and the earnings of U.S. immigrants and natives. Applied Economics, 1991;(23):311-318.
- Berk A, Paringer L, Mushkin SJ. The economic cost of illness fiscal 1975. Medical Care Sept 1978, (16(9):785-790.
- Berkowitz M, Burton JF. Permanent Disability Benefits in Workers' Compensation. W.E. Upjohn Institute, Kalamazoo, Michigan, 1987.
- Berkowitz M. Returning Injured Workers to Employment: An International Perspective. Geneva: International Labor Office, 1990.
- Bieliasskas LA. Stress and Its Relationship to Health and Illness. Boulder, Colorado, Westview Press, 1982.
- Blair A, Zahm S, Pearce NE, et al. Clues to cancer etiology from studies of farmers. Scandinavian Journal of Work and Environmental Health. 18:209-215, 192.
- Blanc P. Occupational asthma in a national disability survey. Chest, 1987;92:613-617.
- Blincoe LJ, Faigin BM. The economic cost of motor vehicle crashes, 1990. Washington, D.C., U.S. Department of Transportation, National Highway Traffic Safety Administration, 1992; Report No. DOT-HS-807-876.
- Blincoe LJ, Luchter S. The economic cost to society of motor vehicle accidents. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1993; report DOT-HS-806-34.
- Boaz RF, Muller CF. The validity of health limitations as a reason for deciding to retire. Health Services Research, 1990;25(2):361-386.
- Boaz RF, Muller C. Paid work and unpaid help by caregivers of the disabled and frail elders. Medical Care, 1992; 30:149-158.
- Boden LI, Fleishman CR. Medical Costs in Workers' Compensation: Trends and Interstate Comparisons. WC-89-5, Workers' Compensation Research Institute, Boston, MA, 1989.
- Boglioli LR, Taff ML. Deaths at the workplace: accidents or homicides? American Journal of Forensic Medical Pathology, 1990;11(1):66-70.
- Boglioli LR, Taff ML, Lukash LI. Harness racing injuries and deaths: Report of a fatal accident and review of 178 cases. American Journal of Forensic Medicine and Pathology, 1987;8:185-207.
- Borysenko JZ. Behavioral-psychological factors in the development and management of cancer. General Hospital Psychiatry, 1982;4:69-74.
- Bound J. The health and earnings of rejected disability insurance applicants. American Economic Review, 1989;79(3):482-503.

- Brand S, Hoskin AF. Allocation Factor Investigation. Statistics Department of National Safety Council, Itasca, IL, 1993.
- Bresnitz EA, Frumkin H, Hodgson M, Needleman C, Neumark B, Rubenstein H. Occupational Disease and Injury in Pennsylvania. Report to the Pennsylvania Department of Health, Harrisburg, PA, June 1990.
- Bridbord K, Decoufle P, Fraumeni JF, Hoel DG, Hoover RN, Rall DP, Saffiotti U, Schneiderman MD, Upton AC, Day N. Estimates of the fraction of cancer in the United States related to occupational factors. Washington, D.C.: National Cancer Institute and National Institute for Occupational Safety and Health, 1978.
- Brodner P. Outrageous Misconduct: The Asbestos Industry on Trial, New York: Patheon Books, 1985.
- Brown C. Equalizing differences in the labor market. Quarterly Journal of Economics, 1980;94:113-134.
- Brown C, Hamilton J, Medoff J. Employers Large and Small. Harvard University Press, Cambridge MA, 1990.
- Bryant RR. Job search and information processing in the presence of non-rational behavior. Journal of Economic Behavior and Organization, 1990;14:249-260.
- Buchanan DJ. Studies of blood alcohol in the workers of a Zambian copper mine. Alcohol and Alcoholism, 1989;23(3):238-242.
- Bunch J, Barrachough B, Nelson B, Sainsburg. Suicide following death of parents. Social Psychiatry, 1971;6:191-193.
- Burkhart G, Schulte PS, Robinson C, Sieber WK, Vossenas P, Ringen K. Job tasks potential exposures, and health risks of laborers employed in the construction industry. American Journal of Industrial Medicine, 1993; 24:414-425.
- Burrough B, Lubove SH. Some concerns fudge their safety record to cut insurance costs. Wall Street Journal, Dec. 2, 1986, p. A1.
- Burstein JM and Levy BS. The teaching of occupational health in US medical schools: Little improvement in nine years. American Journal of Public Health 84: 846-849, 1994.
- Burt CW. Injury-related visits to hospital emergency departments. U.S., 1992, Advance Data from Vital and Health Statistics, no. 261, Hyattsville, Maryland: National Center for Health Statistics, 1995.
- Burton JF, Schmidle TP. Workers' Compensation Year Book, Horsham, Pennsylvania, LRP Publications, 1994.
- Burton JF. Workers' compensation costs, 1960-1992: the increases, the causes, and the consequences. Workers' Compensation Monitor, 1993;6(2):1-23.
- Burton JF. The compensability of workplace stress. Workers' Compensation Monitor, 1988;1:12.
- Buskin SE, Paulozzi IJ. Fatal injuries in the construction industry in Washington State. American Journal of Industrial Medicine, 1987; 11:453-460.
- Campany SO, Personick ME. Profiles in safety and health: retail stores. Monthly Labor Review, 1992;115(9):9-16.

- Castillo DN, Jenkins EL. NIOSH Alert: Request for Assistance in Preventing Homicide in the Workplace. DHHS NIOSH 93-109. National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1993.
- Castillo DN, Jenkins EL. Industries and occupations at high risk for work-related homicide. Journal of Occupational Medicine 1994, 36(2):125-132.
- Castillo DN, Landen DD, Layne LA. Occupational injury deaths of 16-17 years olds in the U.S. American Journal of Public Health, 1994;84(4): 646-649. (Avg. deaths = 67 in 10 years. CPOI said 39 in 1992).
- Center for Disease Control. Fatal occupational injuries: Texas, 1982. Morbidity and Mortality Weekly Report, 1985;34(10):130-134.
- Center for Disease Control. Premature mortality in the United States: Public health issues in the use of years of potential life lost. Morbidity and Mortality Weekly Report 1986, 35 (Suppl 25):1S-11S.
- Center for Disease Control. Premature mortality due to unintentional injuries - United States, 1983, Morbidity and Mortality Weekly Report, 1986b;35:353-356.
- Center for Disease Control. Occupational homicides among women-United States, 1980-1985. Morbidity and Mortality Weekly Report 1990;39(32):544-5, and 551-2.
- Center for Disease Control. Update: Work-related electrocutions associated with hurricane Hugo, Puerto Rico. Morbidity and Mortality Weekly Report, 1989a;38:718-720, and 725.
- Center for Disease Control. Cost of Injury-United States: a report to Congress, Morbidity and Mortality Weekly Report, 1989b;38:743-6.
- Center for Disease Control. Update: YPLL before age 65. Morbidity and Mortality Weekly Report, 1991;40(4):60-62.
- Center for Disease Control. Surveillance for occupationally acquired HIV infection--U.S., 1981-1992. Morbidity and Mortality Weekly Report, 1992;41(43):823-825.
- Center for Disease Control. Occupational Injury Prevention. Morbidity and Mortality Weekly Report, 1992;41(RR-6):21-26.
- Centers for Disease Control and Prevention. Health Conditions Among the Currently Employed: United States, 1988. U.S. Department of Health and Human Services, July 1993.
- Cheadle A, Franklin G, Wolfhagen C, Savarino J, Liu PY, Salley C, Weaver M. Factors influencing the duration of work-related disability: population-based study of Washington State Workers' Compensation. American Journal of Public Health, 1994;84(2):190-196.
- Chelius JR. Economic and demographic aspects of the occupational injury problem. Quarterly Review of Economics and Business, 1979;19(2):65-70.
- . Workplace Safety and Health: The Role of Workers' Compensation. Washington, DC: The American Enterprise Institute for Public Policy Research, 1977.
- , Burton JF. Who actually pays for Workers' Compensation? Workers' Compensation Monitor, 1992;5(6):25-35.
- , Burton JF. Who actually pays for Workers' Compensation?: The empirical evidence. Workers' Compensation Monitor, 1994;7(6):20-27.

- Chowdhury NH, Fowler C, Mycroft FJ, et al. Adult blood lead epidemiology and surveillance--United States, 1992-1994. Morbidity and Mortality Weekly Report, 43:483-485, 1994.
- Cimini MH, Becker EH. Census of fatal occupational injuries. Results for 32 states, 1991. Compensation and Working Conditions, 1993;45(2):1-13.
- Clemmer DI, Diem JE. Major mishaps among mobile offshore drilling units. International Journal of Epidemiology, 1995;14:106-12.
- Collins JG and National Center for Health Statistics. Persons injured and disability days due to injuries. United States, 1980-81. Vital and Health Statistics, Series 10, No. 149, DHHS Pub. No. (PHS) 85-1577. Public Health Service, Washington, D.C., U.S. Government Printing Office, March 1985.
- . National Center for Health Statistics. Types of injuries and impairments due to injuries, United States. Vital and Health Statistics, Series 10, No. 159, DHHS Pub. No. (PHS) 87-1587. Public Health Service, Washington, D.C., U.S. Government Printing Office, Nov. 1986.
- Collins JG, Thornberry OT. Health characteristics of workers by occupation and sex, U.S. 1983-85. Advanced Data: Vital Health Statistics, April 25, 1989;168:DHHS publication (PHS):89-1250.
- . Types of injuries by selected characteristics: United States, 1985-87. National Center of Health Statistics. Vital Health Statistics 1990;10(175).
- Colorado Department of Health. Colorado population-based occupational injury and fatality surveillance system report, 1982-1984. Denver: Health Statistics Section, Colorado Department of Health, 1988.
- Committee on Injury Scaling, American Association for Automotive Medicine. Abbreviated injury scale, 1985 revision. Arlington Heights, Illinois: American Association Automotive Medicine, 1985.
- Committee on Trauma Research. Injury in America: A Continuing Public Health Problem. Washington DC: National Academy Press, 1985.
- Cone, JE, Daponte A, Makofsky D, Reiter R, Becker C, Harrison RJ, Balmes J. Fatal injuries at work in California. Journal of Occupational Medicine, 1991;33:813-817.
- Cooper BS, Rice DP. The economic cost of illness revisited. Social Security Bulletin 1976; 39(2):21-36.
- Cooper C, McAlindon T, Coggan D, Egger P, Dieppe P. Occupational activity and osteoarthritis of the bones. Annals of the Rheumatic Diseases 1994;53: 90-93.
- Copeland AR. Fatal occupational accidents--the first year Metro Dade County experience, 1979-1983. Journal of Forensic Sciences, 1985;30:494-503.
- Correa P, Pickle LW, Fontham E, et al. The causes of lung cancer in Louisiana. In: Mizell M, Correa P, (Eds). Lung cancer: causes and prevention. Deerfield Beach: Verlag Chemie International, 73-82, 1983.
- Cotter DM, Macon JA. Deaths in industry, 1985: BLS survey findings. Monthly Labor Review. 1987;110(4):45-47.
- Council of Economic Advisors, Economic Report of the President, Washington, D.C.: U.S. Government Printing Office, 1992.
- Creech JL and Johnson MN. Angiosarcoma of liver in the manufacture of polyvinyl chloride. Journal of Occupational Medicine. 16:150, 1974.

- Crock S, Del Valle C, Mandel MJ. What's deadlier, a toxic workplace or low pay? Business Week, 1992;100-101.
- Croft P, Cooper C, Wickham C. Osteoarthritis of the hip and occupational activity. Scandinavian Journal of Work and Environmental Health, 1992;18:59-63.
- Cullen MR, Cherniak MG, Rosenstock L. Occupational medicine, part II. New England Journal of Medicine, 1990;322:675-683.
- Cummings K, Maizlish W, Rudolf L, Dervin K, Ervin, A. Occupational disease surveillance: Carpal tunnel syndrome. Morbidity and Mortality Weekly Report, 1989;38:485-489.
- Cutler SJ, Scotto J, Devesco SS, Connelly RS. Third national cancer survey: An overview of available information. Journal of the National Cancer Institute 1974; 53(6):1565-1575.
- Dammar L, Larsson LG. Occupation and male lung cancer: a case-control study in Northwestern Sweden. British Journal of Industrial Medicine, 44:446-453, 1987.
- Daniell WE. Renal and bladder disorders. In: Textbook of Clinical Occupational and Environmental Medicine. (L Rosenstock and M Cullen, Eds.) 401-422, 1994.
- Danzon PM. Hidden overhead costs: Is Canada's system really less expensive? Health Affairs, 1992;11(1):21-43.
- Davis H. Workplace homicides of Texas males. American Journal of Public Health 1987;77:1290-1293.
- . The accuracy of industry data from death certificates for workplace homicide victims. American Journal of Public Health, 1988;78:1579-1581.
- , Honchar PA, Suarez L. Fatal occupational injuries of women, Texas 1975-84. American Journal of Public Health, 1987;77(12):1521-1527.
- Davis MA, Ettinger WH, Neuhaus JM, Chu SA, Hauck WW. The association of knee injury and obesity with unilateral and bilateral osteoarthritis of the knee. American Journal of Epidemiology, 1989;130:278-88.
- Davis JM, Somerville SM, Wallace DM. Occupational risks of bladder tumor case identified during 10 years interviewing of patients. British Journal of Urology, 1976;48:561-566.
- Demers PA, Heyer NJ, Rosenstock. Mortality among firefighters from three northwestern United States cities. British Journal of Industrial Medicine, 49:664-670, 1992.
- , Checkoway H, Vaughan TL, et al. Cancer incidence among firefighters in Seattle and Tacoma, Washington. Cancer Causes and Control. 5: 129-135, 1994.
- DeVol KR. Income Replacement for Long-Term Disability: the Role of Workers' Compensation and SSDI, Cambridge, MA: Workers' Compensation Research Institute SP-86-2, December 1986.
- Dickens WT. Differences between risk premiums in union and non-union wages and the case for occupational safety regulation. American Economic Review, 1984;74(2):320-323.
- . Occupational safety and health and irrational behavior: a preliminary analysis, in John D. Worrall and O. Appel (Eds.). Workers' Compensation Benefits: Adequacy, Equity, and Efficiency, Ithaca, NY: Industrial and Labor Relations Press of Cornell University, 1985;19-40.

- . Assuming the can opener: hedonic wage estimates and the value of life. Journal of Forensic Economics 1990;3(3):51-59.
- , Katz L. Inter-industry wage differences and industry characteristics, in Kevin Lang and Johnathan Leonard (Eds.). Unemployment and the Structure of Labor Markets, London: Basil Blackwell, 1987.
- Dillingham A. The influence of risk variable definition on value-of-life estimates. Economic Inquiry, 1985;14:277-294.
- Division of Labor Statistics and Research. California Work Injuries and Illnesses, 1984. Division of Labor Statistics and Research, State of California, San Francisco, CA, June 1985.
- Doebbert G, Riedmiller KR, Kizer KW. Occupational morality of California women. Western Journal of Medicine, 1988;149:734-740.
- Doll R, Peto R. The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in the United States today. New York: Oxford University Press; Journal of the National Cancer Institute, 1981;66:1191-1308.
- Dorsey S. Employment hazards and fringe benefits: further tests for compensating differentials, in J.D. Worrall (Ed.). Safety and the Work Force, Ithaca, NY: Industrial and Labor Relations Press of Cornell University, 1983.
- Douglas JB, Kenney GM, Miller TR. Which estimates of household production are best? Journal of Forensic Economics, 1990;4(1):25-46.
- Duleep HO. Measuring the effect of income on adult mortality using longitudinal administrative record data. Journal of Human Resources. 1986;21(2):238-251.
- Durbin DL, Corro D, Helvacian MM. Workers' compensation medical expenditures price vs. quantity: Implications for a medical price index. Paper presented at the Twelfth Annual Seminar on Economic Issues in Workers' Compensation, Wharton School, University of Pennsylvania, November 1993.
- Edmondson MB. Caustic alkali ingestions by farm children. Pediatrics, 1987;79(3):413-6.
- Ehrenberg RG, Smith RS. Modern Labor Economics: Theory and Policy. Harper Collins Publishers Inc., New York, 1991.
- Elisburg D. Workplace stress: legal developments, economic pressures, and violence. Workers' Compensation Monitor, 1994;7(6):12-19.
- Ernest RL, Hay J. The U.S. economic and social costs of Alzheimers disease revisited. American Journal of Public Health, 1994;84(8): 1261-64.
- Fahs MC, Markowitz SB, Fischer E, Shapiro J, Landrigan PJ. Health costs of occupational disease in New York State. American Journal of Industrial Medicine 1989; 16: 437-449.
- Farer KS and Schieffelbein CW. Respiratory Diseases. In: Closing the Gap. The Burden of Unnecessary Illness. (Eds. RW Amler and HB Dull). pp. 115-124, Oxford University Press, New York, 1987.
- Farrell P, Fuchs VR. Schooling and health: the cigarette connection. Journal of Health Economics, 1982;1:217-230.
- Faucett J, Rempel D. VDT-Related musculoskeletal symptoms interactions between work, posture and psychosocial work factors. American Journal of Industrial Medicine, 1994;26: 597-612.

- Feinstein JS. The relationship between socioeconomic status and health: a review of the literature. The Milbank Quarterly, 1993;71(2):279-322.
- Fine LJ and Rosenstock L. Cardiovascular disorders. In: Textbook of Clinical Occupational and Environmental Medicine. (L Rosenstock and M Cullen, Eds.).389-400, 1993.
- Fisher A, Chestnut LG, and Violette DM. The value of reducing risks of death: a note on new evidence. Journal of Policy Analysis and Management, 1989;8(1):88-100.
- Fox AJ, Adelstein AM. Occupational mortality: work or way of life? Journal of Epidemiology and Community Health, 1978;32:73-78.
- Fox JA, Levin J. Firing back: The growing threat of workplace homicide. The Annals of the American Academy of Political and Social Science, 1994;536:16-30.
- Fraser GB. Preventive Cardiology. Oxford Univ. Press, 1986, New York, NY.
- Freedman W. The Law and Occupational Injury, Disease and Death. Quorum Books, Westport, Conn. 1990.
- French MT. Estimating the full cost of workplace injuries. American Journal Public Health, 1990;80(9):1118-9.
- Friedman B. An act to amend Section 6401.7 of the California Labor Code, relating to employment. Assembly Bill 3230, introduced 24 February 1994 to the California Legislation, Sacramento.
- Fuchs VR. Some economic aspects of mortality in developed countries. In: Perlman M, ed. The Economics of Health and Medical Care. London: MacMillan: 1974.
- . Time preference and health: an exploratory study. In: Fuchs, V.R. ed. Economic Aspects of Health. Chicago: University of Chicago Press; 1982.
- . Poverty and health: asking the right questions. The American Economist, 1992;37(2):12-18.
- Ferguson TW. A triple threat to California's Tort bar. Wall Street Journal, April 18, 1995:A19.
- Garen J. Compensating wage differentials and the endogeneity of job riskiness The Review of Economics and Statistics. 1988;70(1):9-16.
- Gerberich SG, et al. Olmstead Agricultural Study (OATS): report to the Centers for Disease Control. Atlanta: Centers for Disease Control, 1990.
- Gerberich SG, Gibson RW, Carr P. Minnesota Injury Prevention and Control Program I. Minneapolis: Minnesota Department of Health, 1987.
- Gerberich SG, Gibson RW, Carr P. Minnesota Injury Prevention and Control Program II. Minneapolis: Minnesota Department of Health, 1990.
- Gibson RL. Occupational medicine in the eighties: decade of change. Journal of Occupational Medicine, 1983;3(3):391-408.
- Gill A. Incorporating the causes of occupational differences in studies of racial wage differentials. Journal of Human Resources, 1994;29(1):20-41.
- Goldberg RL, Bernstein L, Garabrant DH, Peters JM. Fatal occupational injuries in California, 1972-1983. American Journal of Industrial Medicine, 1989;15:171-185.

- Goodman AL, Holder HD, Nishiura, F. Alcoholism treatment offset effects: a cost model. Inquiry, 1991;28:168-178.
- Goodman P. Absenteeism. Jossey-Bass, San Francisco, 1984.
- Goodman RA, Sikes RK, Rogers DL, Mickey JL. Fatalities associated with farm tractor injuries: an epidemiologic study. Public Health Reports, 1985;100(3):329-33.
- Gottschalk LA. Hope and other deterrents to illness. American Journal of Psychotherapy, 1985;39(4):515-524.
- Graham JD, Chung BH, Evans JJ. Poorer is riskier. Risk Analysis, 1992;12:333-337.
- Graitcer PL. The development of state and local injury surveillance systems. Journal of Safety Research, 1987;18:191-198.
- Graves EJ. 1992 Summary: National Hospital Discharge Survey. Vital and Health Statistics of the Centers for Diseases Control. No. 249, April, 1994.
- Green GP, Becker KH (Eds). Employment and Earnings. U.S. Department of Labor, Bureau of Labor Statistics, 1994.
- Greer DF. Business, Government and Society, 3rd Edition, MacMillan, New York, 1992.
- Haan M, Kaplan GA, Camacho, T. Poverty and health: Prospective evidence from the Alameda County Study. American Journal of Epidemiology. 1987;125:989-98.
- Haines F. The show must go on: the response to fatalities in multiple employer workplaces. Social Problems, 1993;40(4):547-563.
- Hales T, Seligman PJ, Newman SC, Timbrook CL. Occupational injuries due to violence. Journal of Occupational Medicine, 1988;30:483-487.
- Hall JH, Owings JF. Hospitalizations for injury and poisoning in the U.S., 1991. Advance Data from Vital and Health Statistics, no. 252, Hyattsville, Maryland: National Center for Health Statistics, 1994.
- Hammond EC, Selikoff IJ, Seidman H. Asbestos exposure, cigarette smoking and death rates. Annals of the New York Academy of Sciences, 330:473-490, 1979.
- Hannan MI, Naimark A, et al. Occupational physical demands, knee bending, and knee osteoarthritis: results from the Framingham Study. Journal of Rheumatology, 1991;18:1587-92.
- Harber P, Bloswick D, Beck J, Pena L, Baker D, Lee, J. Supermarket checker motions cumulative trauma risk. Journal of Occupational Medicine, 1993;35(8):805-811.
- Harford T, Grant B, Dawson D. Alcohol use among employed men and women. Alcoholism: Clinical and Experimental Research. 1992;16(2):146-48.
- Harlen WR, Parsons PE, Thomas JW, et al. Health care utilization and costs of adult cardiovascular conditions, United States, 1980. National Medical Care Utilization and Expenditure Survey. National Center for Health Statistics. DHHS Pub. No. 89-20407, Series C, Analytic Report No. 7:1980.
- Harris JS. Source of payment for the medical cost of motor vehicle injuries in the United States, 1990. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1992; report no. DOT-HS-807-800.

- Hartunian NS, Smart CN, Thompson MS. The Incidence and Economic Cost of Major Health Impairments. D.C. Heath and Company, Lexington, MA: 1981.
- Haveman R, Wolfe B. Succeeding Generations: On the Effects of Investment in Children, Russel Sage, New York, NY, 1994.
- Heaney CA, Israel BA, Schurman SJ, Baker EA, House JS, Hugentobler. Industrial relations, worksite stress reduction and employee well being. Journal of Organizational Behavior 1993, 14:498-510.
- Hellinger FJ. Forecasts of the costs of medical care for persons with HIV: 1992-95. Inquiry 1992;29, 536-65.
- Hensler DR et al. Compensation for Accidental Injuries in the United States. R-3999-HHS-ICJ, Santa Monica CA: Rand Institute for Civil Justice, 1991.
- Hewlett SA. When the Bough Breaks. Basic Books, New York, NY, 1990.
- Hilaski HJ. Understanding statistics on occupational illnesses. Monthly Labor Review, 1981;104(3):25-29.
- Hochberg MH, Lawrence RC, Everett DF, Coraon-Huntley J. Epidemiological associations of pain in OA of the knee: data from the EFNHS. Seminars in Arthritis and Rheumatism, 1989;18(4):4-9.
- Hodgson TA. Health care expenditures for major diseases in 1980. Health Care Financing Review, 1984;5(4):86-98.
- Hodgson TA, Meiners M. Cost of illness methodology: A guide to current practices and procedures. Milbank Memorial Fund Quarterly 1982; 60(3): 429-462.
- Hoiberg A, Blood C. Age-specific morbidity and mortality rates among U.S. Navy enlisted divers and controls. Undersea Biomedical Research; 1985;12(2):191-203.
- Holman RG, Olszewski A, and Maier RV. The epidemiology of logging injuries in the Northwest. Journal of Trauma, 1987;100:325-328.
- Honchar P, Suarez L. Death certificates as a surveillance tool for fatal occupational injuries. Presented at the Fifth International Symposium on Epidemiology in Occupational Health, September 1986, Los Angeles, CA.
- Horwitz T. Nine to Nowhere: These jobs are dull, dead-end, sometimes dangerous; they show how 90's trends can make work grimmer for unskilled workers. Wall Street Journal, December 1, 1991, p. A1, A10.
- Hoskin AF, Leigh JP, Planek TW. Estimated risk of occupational fatalities associated with hazardous waste site remediation. Risk Analysis, 1994;14(6):1011-1017.
- Huff J and Rall DP. Relevance to humans of carcinogenesis results from laboratory animal toxicology studies. In: Macy-Rosenau>Last Public Health & Preventive Medicine (JM Last and RB Wallace RB, Eds). 13th Edition, 433-440, 1992.
- Hyatt DE, Kralj B. The impact of workers' compensation experience rating on employer appeals activity. Industrial Relations, 1995;34(1):95-106.
- Illis WR, Swanson GM, Satariano ER, Schwartz, AG. Summary measures of occupational history. American Journal Public Health, 1987;77:1532-1534.
- International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Overall Evaluations of Carcinogenicity. Supplement 7. 440 pp. Lyon, France: IARC, 1987.

International Journal of Epidemiology, 17:397-406, 1988.

Institute of Medicine. Costs of environment-related health effects: A plan for continuing study. National Academy Press, Washington, DC, 1981.

Institute of Medicine. Role of the primary care physician in occupational and environmental medicine. National Academy Press, Washington, DC, 1988.

Ippolito PM and Mathios AD. Information, advertising, and health choices: a study of the cereal market. Rand Journal of Economics, 1990;21(3):459-480.

Jack TA, Zak MT. Results from the first census of fatal occupational injuries, 1992. Compensation and Working Conditions, 1993;45(12):1-14.

Jacobson LS, LaLonde RJ, Sullivan DG. The Costs of Worker Dislocation. W.B. Upjohn Institute, Kalamazoo, Michigan, 1993.

Jagger J, Hunt EH, Brand-Elnaggar J, Pearson RD. Rates of needlestick injury caused by various devices in a university hospital. New England Journal of Medicine, 1988;319:284-8.

Jenkins FL, Kisner SM, Fosbroke DE, Layne LA, Stout NA, Castillo DN, Cutlip PM, Cianfrocco R. Fatal Injuries to Workers in the United States, 1980-1989: A Decade of Surveillance. National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1993.

Johnson WG, Heler E. The cost of asbestos-associated disease and death. Milbank Memorial Fund Quarterly 1983;61:210-221.

Jones JB, Armstrong CW, Woolard D, Miller GB. Fatal occupational electrical injuries in Virginia. Journal of Occupational Medicine, 1991;37(1):57-63.

Jordan B. Safety and health risks of manufacturing motor vehicles and equipment. Compensation and Working Conditions, 1992;44(11):1-3.

Justice B. Who Gets Sick? St. Martin's Press, New York, 1988.

Kalleberg AL. America at Work: National Surveys of Employees and Employers. A Report to the U.S. Department of Labor, Social Science Research Council. Contract No. J9P5 0067, New York, NY, 1986.

Kaminski R, Brockert J, Sesito J, Frazier T. Occupational information on death certificates. American Journal of Public Health, 1981;71:525-526.

Kane JJ, Derstine B. Fatal occupational injuries: test results from the BLS census. Compensation and Working Conditions, 1992;44(1):3-9.

Kannel WB and Thom TJ. Incidence, Prevalence and Mortality of Cardiovascular Diseases. Chapter 8 In: The Heart, 8th ed. (Ed. W Hurst), McGraw Hill, 1994.

Karasek R, Theorell T. Healthy Work: Stress, Productivity, and the Reconstruction of Working Life. New York: Basic Books,, 1990.

Karasek RA. Job demands, job decision latitude, and mental strain: Implications for job redesign. Administrative Science Quarterly, 24:285-308, 1979.

Karlson TA, Baker SP. Fatal occupational injuries associated with motor vehicles. In: Proceedings of the 22nd Conference of the American Association for Automotive Medicine, Vol. 1. Arlington Heights, IL: American Association for Automotive Medicine, 1978;229-241.

Kasl SV. Epidemiological contributions to the study of work stress. In Cooper CL, Payne R, editors. Stress at Work. Chichester, England. Wiley 1978.

- Keeney RL. Mortality risks induced by economic expenditures. Risk Analysis. 1990;10:147-159.
- Kemna HJMI. Working conditions and the relationship between schooling and health. Journal of Health Economics, 1987;6:189-210.
- Kenkel DS. Health behavior, health knowledge and schooling. Journal of Political Economy, 1991;99:287-305.
- Kiecolt-Glasser J. et al. Distress and DNA repair in human lymphocytes. Journal of Behavioral Medicine, 1985;8:31-320.
- Kirscher T, Nelson J, Burdo H. The autopsy as a measure of accuracy of the death certificate. New England Journal of Medicine, 1985;313:1263-1269.
- Klein BP, Jensen RC, and Sanderson LM. Assessment of workers' compensation claims for back strains/sprains. Journal of Occupational Medicine 1984;26:443-448.
- Kjuus H, Langard S, Skjeerven A. A case-referent study of lung cancer, occupational exposures and smoking. Scandinavian Journal of Work and Environmental Health. 12:2-3- 209, 1986.
- Knapik K, Ang P, Reynolds K, Jones B. Physical fitness, age and injury incidence in infantry soldiers. Journal of Occupational Medicine, 1993;35(6):598-603.
- Kniesner JJ, Leeth JD. Compensating wage differentials for fatal injury risk in Australia, Japan, and the U.S. Journal of Risk and Uncertainty, 1991;4(1):75-90.
- Kobayashi S. Occupational asthma due to inhalation of pharmacological dusts and other chemical agents with some reference to other occupational asthma in Japan. In Yamamura Y et al. (eds): Allergology. Amsterdam: Excerpta Medica, pp. 124-132, 1974.
- Korn RJ, Dockery DW, Speizer FE, Ware JH, Ferris BG, Jr. Occupational exposures and chronic respiratory symptoms. A population-based study. American Review of Respiratory Disease, 1987;136:296-304.
- Kraus JF. Fatal and non-fatal injuries in occupational settings: A review. Annual Review of Public Health, 1985;6:403-418.
- . Homicide while at work: persons, industries, and occupations at high risk. American Journal of Public Health, 1987;77(10):1285-1289.
- , Fife D. Incidence, external causes, and outcomes of work-related brain injuries in males. Journal of Occupational Medicine, 1985;27:757-760.
- , Macurda J, Sahl J, Anderson C. Work-related fatal injuries in older California workers, 1979-1985. Journal of Occupational Accidents, 1990;12: 223-235.
- Krant A. Estimates of the extent of morbidity and mortality due to occupational diseases in Canada. American Journal of Industrial Medicine 1994;25: 267-78.
- Korn RJ, Dockery DW, Speizer FE et. al. Occupational exposures and chronic respiratory symptoms. American Review of Respiratory Disease 136: 298- 304, 1987
- Kristensen TS. Cardiovascular disease in the work environment: a critical review of the epidemiologic literature on chemical factors. Scandinavian Journal of Work and Environmental Health, 1989;15:245-264.
- Kutscher RE. Outlook 2000: projections, summary and emerging issues. Monthly Labor Review, 1989;112-42-65.

- Krzyanowski M, Kauffman P. The relation of respiratory symptoms and ventilatoru function to moderate occupational exposure in a general population: results from the French PAARC study of 16,000 adults. International Journal of Epidemiology, 1988; 17:397-406.
- Landen DD, Hendricks SA. Effect of recall period on reporting of at-work injuries. Scandinavian Journal Work Environmental Health, 1992;18 Suppl:18-20.
- Landrigan PJ, Markowitz SB. Current magnitude of occupational disease in the United States: Estimates from New York State, Annals of the New York Academy of Sciences, 1989;572:27-45.
- Landrigan PJ. Toxic exposures and psychiatric disease--Lessons from the epidemiology of cancer. Acta Psychiatrica Scandinavica. 37:6,1983.
- Landrigan PJ, Goyer RA, Clarkson TW, et al. The work-relatedness of renal disease: Summary of the working group on renal diseases. Archives of Environmental Health 39:225, 1984.
- Landrigan PJ, Graham DG, Thomas RD. Environmental neurotoxic illness: Research for prevention. Environmental Health Perspect. 102:117-120, 1994..
- Lave CA and Train K. A disaggregate model of auto-type choice. Transportation Research A, 1979;13A:1-9.
- Layne JA, Castillo DN, Stout N, Cutlip P. Adolescent occupational injuries requiring hospital emergency department treatment: a nationally representative sample. American Journal of Public Health, 1984;84(4): 657-660.
- Lebowitz MD. Occupational exposures in relation to symptomatology and lung function in a community population. Environmental Research, 1977;14-59-67.
- Lebowitz MD. The trends in airway obstructive disease mortality in the Tucson epidemiological study. American Review of Respiratory Disease, 1989;140:S35-S41.
- Leigh JP. Compensating wages for occupational injuries and illness. Social Science Quarterly, 1981;62(2):772-778.
- . Risk preference and the inter-industry propensity to strike. Industrial and Labor Relations Review, 1983;36(2):271-185.
- . The effects of unemployment and the business cycle on absenteeism. Journal of Economics and Business, 1985a;37(2)159-170.
- . An analysis of workers' compensation using data on individuals. Industrial Relations, 1985b;24(2):247-256.
- . Hazardous occupations, stress and heart attacks. Social Science and Medicine, 1986a;23(11):1181-1185.
- . Who chooses risky jobs? Social Science and Medicine, 1986b;23(1):57-64.
- . Accounting for tastes: correlates of risk and time preference. Journal of Post-Keynesian Economics, 1986c;9(1):17-31.
- . Individual and job characteristics as predictors of industrial accidents. Accident Analysis and Prevention, 1986d;18(3):209-216.
- . Compensating wages for risk of death: comment. Economy Inquiry, 1986e;24(3):505-508.

- . Estimates of the probability of job-related deaths in 347 occupations. Journal of Occupational Medicine 1987a;29:510-519.
- . Gender, firm size, industry, and estimates of the value of life. Journal of Health Economics, 1987b;6:511-519.
- . Occupation and coronary disease: schooling as a confounder. Journal of the American Medical Association, (letter), 1988a;259:157-158.
- . Odds ratios of job-related deaths. British Journal of Industrial Medicine, 1988b;45:158-166.
- . Firm size and injury rates in manufacturing industries. Journal of Community Health, 1989a;14(1):44-52.
- . Specific illnesses and working conditions which contribute to absenteeism. Journal of Occupational Medicine, 1989;31(9):793-797.
- . A ranking of jobs based upon the blood pressures of incumbents. Journal of Occupational Medicine, 1991b;33(8):853-861.
- . No evidence on compensating wages for occupational fatalities. Industrial Relations, 1991a;30(3):382-395.
- . Schooling and use of seat belts. Southern Economic Journal, 1990;57:195-207.
- . Employee and attributes as predictors of absenteeism in a national sample of workers. Social Science and Medicine, 1991c;33(2):127.
- . Occupations, cigarette smoking, and lung cancer, December, 1993, unpublished manuscript.
- . Multidisciplinary findings on socioeconomic status and health (letter). American Journal of Public Health, 1993;83(2):289-290.
- . Causes of Death in the Workplace, Quorum, Westport, Conn., 1995a.
- . Compensating wages, value of a statistical life, and inter-industry differentials. Journal of Environmental Economics and Management, 1995b;28:83-97.
- . Dangerous jobs and heavy alcohol use in two national probability samples. Alcohol and Alcoholism, 1995c;30(1):71-86.
- . Causes of permanent partial injuries and illnesses within occupations and industries. Manuscript, San Jose State University, 1995d.
- . Costs of Injuries. Chapter 5. In Costs of Occupational Injuries and Illnesses. NIOSH Final Report. Contract #U60CCU902886-07, Internal Document, 1995.
- . Folsom RN. Estimates of the values of accident avoidance at the job depend on the concavity of the equalizing differences curve. Quarterly Review of Economics and Business, 1984;24:55-66.
- . Gill A. Do women receive compensating wages for job-related death? Social Science Quarterly, 1991;72(4):727-737.
- . Fries JF. Occupation, income, and education as independent covariates of arthritis in four national probability samples. Arthritis and Rheumatism, 1991a;34:984-995.
- . Fries JF. Education level and rheumatoid arthritis: evidence from five data centers. Journal of Rheumatology, 1991b;18:24-34.

- , Fries JF, Hubert HB. Gender and race differences in the correlation between body mass and education. Journal of Epidemiology and Community Health, 1991;46:191-196.
- , Fries JF. Disability in occupations in a national sample. American Journal of Public Health, 1992;82(11):1517-1524.
- , Jiang WY. Liver cirrhosis deaths within occupations and industries in the California occupational mortality study. Addiction, 1993;88:(6): 767-779.
- , Lubeck DP, Farnham PG, Fries JF. Hours of work and employment status among HIV patients AIDS, 1995.
- Lemen RA, Mazzuckelli LF, Niemeir RW, Ahlers HW. Occupation Safety and Health Standards. Annals of the New York Academy of Sciences, 1989;572:100-106.
- Lemrow N, Adams D, Coffey R, Farley D. The 50 most frequent diagnosis-related groups (DRGs) diagnoses, and procedures: statistics by hospital size and location. Hospital Studies Program Research Note 3, Washington DC: Agency for Health Care Policy and Research, 1990.
- Lerchen ML, Wiggins CL, Samet JM. Lung cancer and occupation in New Mexico. Journal of the National Cancer Institute, 79:639-645, 1987.
- Lettman A. Disabling injuries in longshore operations. Monthly Labor Review, 1989;112(10):37-38.
- Levin LI, Zheng W, Blot WJ, et al. Occupation and lung cancer in Shanghai: a case-control study. British Journal of Industrial Medicine, 45:450-458, 1988.
- Levit KR, Cowan CA, Lazenby HC, McDonnell CR, Sensenig AL, Stiller, JM, Won OK. National health care spending trends, 1960-1993. Health Affairs, 1994;13(5):14-31.
- Levy BS, Wegman DH. Recognizing Occupational Diseases, in Levy BS and Wegman DH, editors. Occupational Health. Little, Brown and Co., Boston, MA 1983.
- Lewinsohn HC, Meigs JW, Teta MJ, Flannery JT. The influence of occupational and environmental asbestos exposure on the incidence of malignant mesothelioma in Connecticut. IARC Publication, 1980;30:655-660.
- Lewis RJ, Cooper SP. Alcohol, other drugs, and fatal work-related injuries. Journal of Occupational Medicine, 1989;31(1):23-28.
- Lincinio J, Gould PW, Wong M-L. A molecular mechanism for stress-induced alternations in susceptibility to disease. Lancet 1995;346 (8967): 104-106.
- Linn BS, Linn MW & Jensen MD. 1982. Degree of depression and immune responsiveness [Abstract]. Psychomatic Medicine, 1982;44(1):128-129.
- Low SA, McPheters LR. Wage differentials and risk of deaths: an empirical analysis. Economic Inquiry, 1983;21(2):271-280.
- Lown B. Sudden cardiac death. Circulation, 1979;60:1593-1602.
- Macon JA. BLS' 1982 survey of work-related deaths. Monthly Labor Review. 1984;107(3):43-45.
- Maguire SR. Employer and occupational tenure: 1991 update. Monthly Labor Review, 1993;166(6)45-56.

- Maier S., Laudenslager, M., & Ryan, S. Stressor controllability, immune function, and endogenous opiates. In J. Overmeier & S. Brush (Eds.). Affect, Conditioning and Cognition: Essays on the Determinants of Behavior, 1985, pp. 183-201, Hillsdale, NJ: Erlbaum.
- Malkiel BG. A Random Walk Down Wall Street, Norton, New York, 1991.
- Manning W, Keller E, Newhouse J. The Taxes of sin: Do smokers and drinkers pay their way? Journal of the American Medical Association, 1988;261:1604-1609.
- Manning WG, Keeler EB, Newhouse JP, Sloss EM, Wasserman J. The Costs of Poor Health Habits. Harvard University Press. Cambridge, MA, 1991.
- Manski CF, Sherman L. An empirical analysis of household choice among motor vehicles. Transportation Research A, 1980;14A:349-366.
- Marin A and Psacharopoulos G. The reward for risk in the labor market: evidence from the United Kingdom and a reconciliation with other studies. Journal of Political Economy, 1992;90:827-853.
- Marine WM, Derstine B, Jack JA. Analysis of toxicology reports from the 1991 Census of Fatal Occupational Injuries (CFOI). Compensation and Working Conditions, 1993;45(2):14-20.
- Marine WM, Garrett C, Keefer SM, Vancil R, Hoffman R, McKenzie L. Occupational injury deaths in Colorado, 1982-1987. Denver: Colorado Department of Health, 1990.
- Markowitz, SB, Landrigan, PJ, Fahs, M, Garibaldi, K, Gleaton, K. Occupational Disease in New Jersey. Report to the New Jersey Department of Health, December 1989.
- Markowitz SB, Fischer E, Fahs MC, Shapiro J, Landrigan PJ. Occupational disease in New York State: a comprehensive examination. American Journal of Industrial Medicine, 1989;16:417-435.
- Marquis MS. Economic Consequences of Work-Related Injuries, number CT-103, Rand Institute of Civil Justice, Santa Monica, California, May 1992.
- Marriott D, Kirkwood BJ, Stough C. Immunological effects of unemployment. The Lancet, 1994;344(8916):269-70.
- Marsh B. Workers at risk: Chance of getting hurt is generally far higher at smaller companies. Wall Street Journal, 1994:A1, A8.
- Mason RW. Disability among American workers, 1987. NIOSH. Division of Standards, Development and Technology Transfer, Cincinnati, Ohio, 1989.
- Mathews DA, Cottingham E, Talbott D, Kuller LH, Siegel JM. Stressful work conditions and diastolic blood pressure among blue-collar factory workers. American Journal of Epidemiology, 1987;126:280-290.
- Matte TD, Baker EL, Honchar PA. V. The selection and definition of targeted work-related conditions for surveillance under SENSOR. American Journal of Public Health, 79:21-25, 1989.
- Matte TD, Hoffman RE, Rosenman KD, Stanbury M. Surveillance of occupational asthma under the SENSOR model. Chest (Supplement). 98:173S-178S, 1990.
- Max W, Rice DP. Shooting in the dark: estimating the cost of firearm injuries. Health Affairs, 1993;12:171-185.
- Max W, Webber P, Fox P. Alzheimer's disease: the unpaid burden of caring. Journal of Aging and Health, 1995, 7(2):179-199.

- McCarthy PS. Consumer demand for vehicle safety: an empirical study. Economic Inquiry, 1990;28(3):530-543.
- McFloyd VC, Flanagan CA. Economic stress: effects on family life and child development, Jossey-Bass Inc., San Francisco, 1993.
- McGarity TD, Shapiro SA. Workers at Risk: The Failed Promise of the Occupational Safety and Health Administration, Praeger, Westport, Conn., 1993.
- McGinnis JM, Foege WH. Actual causes of death in the U.S. Journal of the American Medical Association, 1993;270(18):2207-2212.
- Melius JM, Sestito JP, Seligman PJ. IX. Occupational disease surveillance existing data source. American Journal of Public Health, 79:46-52, 1989.
- Melius JM, Sestito JP, Seligman PJ. IX. Occupational disease surveillance with existing data source. American Journal of Public Health, 79:46-52, 1989.
- Menchik PL. Economic status as a determinant of mortality among non-white and white older males: or does poverty kill? Population Studies, 1993;47:427-436.
- Mendeloff JM. The role of OSHA violations in serious workplace accidents. Journal of Occupational Medicine, 1984;26:353-60.
- Mendeloff JM, Kagey BT. Using occupational safety and health administration accident investigation to study patterns in work fatalities. Journal of Occupational Medicine, 1990;32(11):1117-1123.
- Meng R. How dangerous is work in Canada? Estimates of job-related fatalities in 482 occupations. Journal of Occupational Medicine, 1991;33:1084-1091.
- Mensch BS, Kandel DB. Under-reporting of substance use in a national longitudinal youth cohort, individual and interviewer effects. Public Opinion Quarterly 1988;52:100-124.
- Merva, M., Fowles, R. Effects of diminished economic opportunities on social stress: heart attacks, strokes, and crime. Manuscript. Economic Policy Institute, Washington, D.C., 1993.
- Miller TR. The plausible range for the value-of-life: Red Herrings among the Mackerel. Journal of Forensic Economics, 1990; 13:17-40.
- , Galbraith M. Estimating the Costs of U.S. Occupational Injuries in the United States. Accident Analysis and Prevention, in press.
- . The costs of highway crashes, DC: U.S. Department of Transportation, Federal Highway Administration, 1991; report no. FHWA-RD-91-055.
- , Blincoc LJ. Incidence and cost of alcohol-involved crashes in the U.S. Accident Analysis and Prevention, 1994;26(5):583-592.
- . Injuries to workers and their dependents. Journal of Safety Research 1995, 26(2):75-86.
- , Pindus, NM, Douglas, JB, Rossman, SB. Databook on Nonfatal Injury: Incidence, Costs, and Consequences. Washington D.C., Urban Institute Press and University Press of America, 1995.
- Mincer J. On-the-job training: costs, returns, and some implications. Journal of Political Economy, 1962 70 (Supplement):50-79.
- Minter SG. When is suicide compensable? Occupational Hazards, 1993:57.

- Mishel L, Bernstein J. The State of Working America 1992-1993. Economic Policy Institute Series, Armonk, NY, M.E. Sharpe, 1993.
- Mitchell OS. The relation of age to workplace injuries. Monthly Labor Review, 1988;111:8-13.
- Mohr DL, Clemmer DI. The "accident prone" worker: An example from heavy industry. Accident Analysis and Prevention, 1988; 20:123-127.
- Monson RR. Occupational Epidemiology 2nd Edition. CRC Press, Boca Raton, Florida, 1990.
- Moore MJ, Viscusi WK. Doubling the estimated value of life: results using new occupational fatality data. Journal of Policy Analysis and Management, 1988;7(3) 476-490.
- Morabia A, Markowitz S, Garibaldi K, and Wynder EL. Lung cancer and occupation: results of a multicentre case-control study. British Journal of Industrial Medicine, 49:721-727, 1992.
- Moses LN, Savage I. The effect of firm characteristics on truck accidents. Accident Analysis and Prevention 1994, 26(2):173-179.
- Mueller, BA, Mohr, DL, Rice, JC, and Clemmer DI. Factors affecting individual injury experience among petroleum drilling workers. Journal of Occupational Medicine, 1987;29:126-131.
- Murphy DJ, Seltzer BL, and Yesalis CE. Comparison of two methodologies to measure agricultural occupational fatalities. American Journal of Public Health, 1990;80:198-200.
- Murphy LR. Job dimensions associated with severe disability due to cardiovascular disease. Journal of Clinical Epidemiology, 1991;44(2):155-166.
- Mushkin SJ, Collings Fd'A. Economic costs of disease and injury. Public Health Reports Sept 1959; 74(9):795-809.
- National Cancer Institute of Canada: Canadian Cancer Statistics 1989. Toronto, Canada: National Cancer Institute of Canada, 1989.
- National Center for Health Statistics. Advance Report of Final Mortality Statistics, 1991. Monthly Vital Statistics Report. 42:2, Supplement, August 31, 1993.
- National Center for Health Statistics. Health, United States, 1993. US Government Printing Office, Washington, 1994.
- National Center for Health Statistics. Persons injured and disability days due to injuries, United States 1980-1981. Vital and Health Statistics, 510(149), Hyattsville, Maryland, Public Health Service, 1985.
- National Center for Health Statistics. Proceedings of the Workshop on Needs and Resources for Occupational Mortality Data. Vital and Health Statistics. Series 4, No. 26, DHHS Pub. No. (PHS) 88-1463, 1988.
- National Center for Health Statistics: Health, United States 1988. DHHS Pub. No. (PHS) 89-1232, Public Health Service. Washington: U.S. Government Printing Office, March 1989.
- National Center for Health Statistics. Advance report of final mortality statistics, 1991. Monthly Vital Statistics Report: 42(2), Suppl. Hyattsville, Maryland: Public Health Service, 1993.

- National Center for Health Statistics. Health, United States, 1988. DHHS Pub. No. PHS 89-1232. Public Health Service, Washington, U.S. Government.
- National Center for Health Statistics. Health, United States 1992. Hyattsville, MD: Public Health Service, 1993.
- National Committee for Injury Prevention and Control. Injury prevention: meeting the challenge. American Journal of Preventive Medicine (Suppl), 1989; 5(3):177-91.
- National Council on Compensation Insurance (NCCI). Workers' Compensation Experience-Countrywide - Ultimate Report Basis Exhibit 5B. Boca Raton, FL, May 1992 and May 1993.
- National Council on Compensation Insurance. Workers' Compensation Back Claim Study, NCCI Boca Raton, Florida, 1992. Printing Office, March 1989.
- National Heart, Lung and Blood Institute. Personal communication, Mr. Thomas Thom, March 2, 1995.
- National Hospital Discharge Survey database, 1991.
- National Highway Traffic Safety Administration. General estimates system, 1990: a review of information on police-reported traffic crashes in the United States. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1991; report no. DOT-HS-807-781.
- National Highway Transportation Safety Administration. Fatal Accident Reporting System 1989: a Decade of Progress. Washington DC: U.S. Department of Transportation, 1991.
- National Institute for Occupational Safety and Health (Division of Respiratory Disease Studies). Work-Related Lung Disease Surveillance Report. Cincinnati, Ohio August, 1994.
- National Institute for Occupational Safety and Health. National Occupational Exposure Survey. Cincinnati, Ohio 1992.
- National Institute for Occupational Safety and Health. National Traumatic Occupational Fatalities, 1980-85, Morgantown, WV, 26505, 1989.
- National Institute for Occupational Safety and Health. National Traumatic Occupational Fatalities, 1980-85, DHHS (NIOSH) Pub. No. 89-116, Morgantown, WV, 1989.
- National Institute for Occupational Safety and Health. National Occupational Exposure Survey: Analysis Management Interview (vol. 3). Atlanta: Centers for Disease Control, 1990.
- National Institute for Occupational Safety and Health (NIOSH). Fatal Injuries to Workers in the U.S., 1980-1989: A Decade of Surveillance. U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Washington, D.C., August 1993.
- National Research Council. National Academy of Sciences. Counting Injuries and Illnesses in the Workplace: Proposals for a Better System. Washington, DC, National Academy Press, 1987.
- National Research Council. Toxicity Testing Strategies to Determine Needs and Priorities. National Academic Press, Washington, 1984.
- National Research Council (Committee on Neurotoxicology and Models for Assessing Risk). Environmental Neurotoxicology. National Academy Press, Washington, D.C. 1992.

- National Safety Council. Accident Facts. Chicago, IL, 1989.
- National Safety Council. Accident Facts. Chicago, IL, 1990.
- National Safety Council. Accident Facts. Chicago, IL, 1991.
- National Safety Council. Accident Facts, 1992 Edition. Itasca, IL, 1992.
- National Safety Council. Accident Facts, 1993 Edition. Itasca, IL, 1993.
- National Toxicology Program. Seventh Annual Report on Carcinogens, Summary 1994. U.S. Department of Health and Human Services. Research Triangle Park, North Carolina.
- Nelson WJ, Emont SL, Braekhill RM, Cameron LL, Peddicord J, Fiore MC. Cigarette smoking prevalence by occupation in the U.S. Journal of Occupational Medicine, 1994;36(5):516-523.
- . Workers' compensation: 1984-88 Benchmark Revisions. Social Security Bulletin, 1992;55(3):41-58.
- . Workers' compensation: coverage, benefits, and costs, 1989. Social Security Bulletin, 1993;56(35):68-74.
- Neumark D, Johnson RW, Bresnitz EA, Frumkin H, Hodgson M, Needleman C. Costs of occupational injury and illness in Pennsylvania. Journal of Occupational Medicine, 1991;33(9):971-976.
- Newhouse JP, Friedlander LJ. The relationship between medical resources and measures of health: some additional evidence. Journal of Human Resources, 1990;15:201-217 New Jersey Department of Health, Cancer Registry, 1992.
- New Jersey Workers Compensation Board data, 1990.
- New York Workers' Compensation Board. Compensated Cases Closed, 1988. Office of Research & Statistics. New York, NY 1993.
- O'Loughlin M. Are your employees afraid to report injuries? Safety and Health, 1993;148(6):50-52.
- O'Neill CM. Reich calls for safer workplaces. AFL-CIO News, 1993;3. Occupational Health Working Group. Occupational Disease in Connecticut. February, 1990.
- Occupational Health Working Group. Occupational Disease in Connecticut, 1991: An Assessment of the Magnitude of Occupational Disease. Workers Compensation Commission Statistical Division. Hartford, CT February 1990.
- Office of Technology Assessment (Congress of the United States) Neurotoxicity. Identifying and Controlling Poisons of the Nervous System. U.S. Government Printing Office, Washington, April, 1990.
- Office of Workers' Compensation Program, U.S. Department of Labor. Personal communication, Mr. Ralph Slighter. September 13, 1994.
- Office of Construction and Engineering. Analysis of Construction Fatalities- The OSHA Data Base 1985-1989. U.S. Dept. of Labor, Occupational Safety and Health Administration, November 1990.
- Office of Management and Budget. Standard Industrial Classification Manual. Washington, DC., 1987.
- Office of Technology Assessment. Preventing Illness and Injury in the Work- place. U.S. Congress, Office of Technology Assessment OTA-H-256, Washington D.C., 1985.

- Ohio Industrial Commission. Ohio 1987 Occupational Injury and Illness Statistics. Columbus OH: Division of Safety and Hygiene, 1987.
- Oi W. Labor as a quasi-fixed factor. Journal of Political Economy. 1962;70: 738-55.
- Oleinick A, Guire KE, Hawthorne VM, et al. Current methods of estimating severity for occupational injuries and illnesses: data from the 1986 Michigan comprehensive compensable injury and illness database. American Journal of Industrial Medicine. 1993;23:231-252.
- Oleinick, A, Gluck, JV. Critique of Neumark's estimate of costs of occupational injury and illness. Journal of Occupational Medicine 1992;34(10):969,972-4.
- Oleske DM, Brewer RD, Doan P, Hahn J. An epidemiologic evaluation of the injury experience of a cohort of automotive parts workers: a model for surveillance in small industries. Journal of Occupational Accidents 1989;10(4):239-53.
- Olsen CA. An analysis of wage differentials received by workers on dangerous jobs. Journal of Human Resources. 1981;16:167-185.
- Olsen O, Kristensen TS. Impact of work environment on cardiovascular diseases. Journal of Epidemiology and Community Health. 1991;45:4-10.
- Olsham AP, Taschke K, Baird PA. Paternal occupation and congenital anomalies in offspring. American Journal of Industrial Medicine 1991;20:447-75.
- Olson DK, Gerberich SG. Traumatic amputations in the workplace. Journal of Occupational Medicine. 1986;28(7):480-5.
- Oster G, Golditz M, Kelly A. The Economic Costs of Smoking and the Benefits of Quitting. Lexington Books. D.C. Health and Company, 1984.
- Osterweis M, Kleinman A, Mechanic D. Pain and Disability: Clinical, Behavioral and Public Policy Perspectives. Institute of Medicine, National Academy Press, Washington, D.C., 1987.
- Oxman AD, Muir D, Shannon S, et al. Occupational dust exposure and chronic obstructive pulmonary disease. A systematic overview of the evidence. American Review of Respiratory Disease. 148:38-48, 1993.
- Park CH, Wagener OK, Winn DM, Pierce JP. Health conditions among the currently employed: U.S., 1988. National Center for Health Statistics. U.S. Government Printing Office, Washington, D.C. Vital and Health Statistics 1993;19(186).
- Parker DL, Carl WR, French LR, Martin FB. Characteristics of adolescent work injuries reported to the Minnesota Department of Labor and Industry. American Journal of Public Health. 1994;84(4):606-611.
- Parkinson DK, Gauss WF, Perper JA, Elliot SA. Traumatic workplace deaths in Allegheny County, Pennsylvania, 1983 and 1984. Journal of Occupational Medicine. 1986;28(2):100-102.
- Parsons PE, Lichtenstein R, Berki SE, et al. Cost of illness, United States, 1980. National Medical Care Utilization and Expenditure Survey. National Center for Health Statistics. DHHS Pub No. 86-20403, Series C, Analytic Report No. 3: 1986.
- Pastorino U, Berrubi F, Gervasio A, et al. Proportion of lung cancers due to occupational exposure. International Journal of Cancer. 33:231-127, 1984.
- Paulozzi LJ. Fatal logging injuries in Washington state; 1977 to 1983. Journal of Occupational Medicine. 1987;29(2):103-108.

- Pease WS. The role of cancer risk in the regulation of industrial pollution. Risk Analysis, 1992;12(2):253-265.
- Pearce N and Reif JS. Epidemiologic studies of cancer in agricultural workers. American Journal of Industrial Medicine, 18:133-148, 1990.
- Pedersen PA, Weeke ER. Epidemiology of asthma in Denmark. Chest, 1987;91(Suppl 6):107S-114S.
- Pennsylvania Department of Health. Occupational Disease and Injury in Pennsylvania, Pennsylvania Division of Environmental Health, Harrisburg, PA, June 1990.
- Personick MB. Injury and health experience in logging. Compensation and Working Conditions, 1992a;44(8):1-3.
- . Safety and health in roofing and sheetmetal. Monthly Labor Review, 1990a;113(9):27-32.
- . Safety and health: fabricated structural metal. Monthly Labor Review, 1991a;114(12):3-8.
- . Safety and health in eating and drinking places. Monthly Labor Review, 1991b;114(6):19-26.
- . Injury and illness experience in logging. Compensation and Working Conditions, 1992a;44(8):1-3.
- . Safety and health conditions in poultry plants. Compensation and Working Conditions, 1992b;44(10):1-3.
- . Safety and health risks of airline employees. Compensation and Working Conditions, 1992c;44(5):1-2.
- . Work injuries in oil and gas field services. Compensation and Working Conditions, 1992d;44(6):1-2.
- , Daley JR. Profiles in occupational hazards: work hazards of mobile homes. Monthly Labor Review, 1989;112(7):15-20.
- , Jackson EC. Injuries and illnesses in the workplace, 1990. Monthly Labor Review, 1992;115(4):37-38.
- Peto R and Schneiderman M. Quantification of Occupational Cancer. Banbury Report #9. Cold Spring Harbor Laboratory, 1981.
- Piacentini JS. EBRI Databook on Employee Benefits. Employee Benefit Research Institute, Education and Research Fund, Washington, DC, 1990.
- Plant, M.A. Drugs in Perspective. Hodder and Stoughton publishers, London, 1986.
- Podolsky DM, Richards D. Investigating the role of substance abuse in occupational injuries. Alcohol and Health Research World, 1985;9(4):42-45.
- Policy Analysis, Inc. Evaluation of Cost of Illness: Ascertainment Methodology. Final Report for the National Center of Health Statistics, Hyattsville, MD. DHHS Pub No. 233-79-2048. December 1981.
- Pollack ES, Keimig DG eds. Counting injuries and illnesses in the workplace: proposals for a better system. Committee on National Statistics, National Research Council. Washington, DC: National Academy Press, 1987.
- President's Report on Occupational Safety and Health. U.S. Government Printing Office, Washington, D.C, 1972.

- Public Health Service. Healthy People 2000: National Health Promotion and Disease Prevention Objectives: Full Report, with Commentary. Washington DC: U.S. Government Printing Office, 1991:DHHS Publication No. (PHS) 91-50212.
- Purschwitz MA, Field WE. Scope and magnitude of injuries in the agricultural workplace. American Journal of Industrial Medicine, 1985;18:179-192.
- Putz-Anderson, V. (editor). Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs. Taylor and Francis Publishers, Philadelphia, PA, 1986.
- Rabkin J, Williams J, Remien R, Goetz R, Kertzner R, Gorman JM. Depression, distress, lymphocytes subsets, and HIV symptoms. Archives of General Psychiatry, 1991;48:111-119.
- Rall, DP, Hogan, MD, Huff, JB, Schwetz A, and Tennant RW. Alternatives to using human experience in assessing health risks. Annual Review of Public Health, 8:355-385, 1987.
- Reardon J. Safety and health experience of pilots and flight attendants. Monthly Labor Review, 1992;115(4):18-24.
- Reardon J. Injuries and illnesses among bituminous and lignite coal miners. Monthly Labor Review, 1993;116(10):49-55.
- Reich MR, Frumkin H. An overview of Japanese occupational health. American Journal of Public Health, 1988;78(7):809-16.
- Reilly MS. Mortality from occupational accidents to United Kingdom fishermen 1961-1980. British Journal of Industrial Medicine, 1985;42:806-814.
- Rejda GE. Social Insurance and Economic Security. Prentice-Hall, Englewood Cliffs, NJ. 1984 and 1991.
- Rice DP. Estimating the cost of illness. Health Economic Series. U.S. Department of Health Education and Welfare. PHS Pub. No. 974-6. Public Health Service, No. 6. Washington, DC: 1966.
- , Feldman JJ, White KL. The current burden of illness in the United States. Institute of Medicine, National Academy of Sciences, Washington, DC: 1976.
- , Hodgson TA, Kopstein AN. The economic costs illness: A replication and update. Health Care Financing Review 1985; 7(1): 61-80.
- , Hodgson TA, Sinsheimer P, Browner W, Kopstein AN. The economic costs of the health effects of smoking, 1984. The Milbank Quarterly 1986; 64(4): 489-547.
- , Hodgson TA, Capell F. The economic burden of cancer, 1985: United States and California. Chapter 3. In Cancer Care and Cost. DRGs and Beyond. Scheffler RM, Andrews NC (eds.). Health Administration Press Perspectives, Ann Arbor, MI, 1989, pp. 39-59.
- , MacKenzie EJ, and Associates. Cost of Injury in the United States: a Report to Congress, San Francisco: Institute for Health and Aging, University of California, and Injury Prevention Center, The John Hopkins University, 1989.
- , Hodgson TA, Kopstein AN. The economics of illness: a replication and update. Health Care Financing Review 1985;7:61-80.
- Richardson S. Workplace homicides in Texas, 1990-91 in Fatal Workplace Injuries in 1991: A Collection of Data and Analysis. U.S. Dept. of Labor, Bureau of Labor Statistics, Report 845, 1993;39-44.

- Rivara F. Fatal and non-fatal farm injuries to children and adolescents in the United States. Pediatrics, 1985;76(4):567-73.
- Robertson LS, Keeve JP. Worker injuries: the effects of workers' compensation and OSHA inspections. Journal of Health, Politics, Policy and the Law, 1983;8:581-97.
- Robinson CC, Kuller LH, Perper J. An epidemiologic study of sudden death at work in an industrial county, 1979-1982. American Journal of Epidemiology, 1988;128(4):806-820.
- Robinson JC. Racial inequality and the probability of occupation-related injury and illness. Milbank Quarterly, 1984;62:567-590.
- . Philosophical Origins of the economic value of life. Milbank Quarterly, 1986; 64:133-55.
- . The rising long-term trend in occupational injury rates. American Journal of Public Health, 1988;78:276-281.
- . Hazardous occupations within the job hierarchy. Industrial Relations, 1988;27(2):241-250.
- . Toil and toxins: Workplace Struggles and Political Strategies for Occupational Health. University of California Press, Berkeley, 1991.
- . Worker responses to workplace hazards. Journal of Health Politics, Policy and the Law, 1987;12(4):665-82.
- Roche LM. Economic costs of occupational injury fatalities in New Jersey i 1992. Compensation and Working Conditions 1995; 47(3):1-5.
- Roche LM. Use of employer illness reports for occupational disease surveillance among public employees in New Jersey. American Journal of Industrial Medicine, 35:581-586, 1993.
- Ronco G, Ciccone G, Mirabelli D, et al. Occupation and lung cancer in two industrialized areas of Northern Italy. International Journal of Cancer. 41:354-358, 1988.
- Rosenman KD, Trimbath L, Stanbury M. Surveillance of occupational lung disease: Comparison of hospital discharge data to physician reporting. American Journal of Public Health,. 80:1257-8, 1990.
- Rosenstock L. Occupational medicine: Too long neglected. Annals of Internal Medicine. 95:664, 1981.
- Rothstein MA and Cooper SP. Occupational Injury and Illness in Texas. Report to the Texas Legislature. University of Houston Health Law and Policy Institute, March 1993.
- Rogot E, Sorlie PD, Johnson NJ. Life expectancy by employment status, income, and education in the National Longitudinal Mortality Survey. Public Health Reports, 1992;107:4:457-460.
- Rolle L. Using improved data on work-related vehicle fatalities in Washington state. Fatal Workplace Injuries in 1991: A Collection of Data and Analysis. U.S. Department of Labor, Bureau of Labor Statistics, Report 845, April 1993.
- Root N, Daley JR. Are women safer workers? A new look at the data. Monthly Labor Review, 1980;103:3-10.

- Root N and Sebastian D. BLS develops measure of job risk by occupation. Monthly Labor Review, 1981;104(10):26-30.
- Rosenberg HM, Burnett C, Maurer J, Spirtus R. Mortality by Occupation, Industry, and Cause of Death: 12 Reporting States, 1984. Monthly Vital Statistics Report: Vol. 42, No. 4 Suppl, Hyattsville, MD: National Center for Health Statistics, 1993.
- Rossignol AM, Locke JA, Boyle CM, Burke JF. Epidemiology of work-related burn injuries in Massachusetts requiring hospitalization. Journal of Trauma, 1986;26:1097-1101.
- Rossignol M, Pineault M. Fatal occupational injury rates: Quebec, 1981 through 1988. American Journal of Public Health, 1993;83(11):1563-1566.
- Rossmann SB, Miller TR, Douglas JB. The Costs of Occupational Traumatic and Cumulative Injuries. Research report supported by the NIOSH and CDC (CDC Grant No. R49/CCR 303675-02), (NTIS PB92-141399) March 1991.
- Roy R. The Social Context of the Chronic Pain Sufferer. University of Toronto Press, Toronto, 1992.
- Rubin LB. Families on the Fault Line: America's Working Class Speaks about the Family, the Economy, Race, and Ethnicity. Harper Collins, New York, 1994.
- Ruble R. An evaluation of certificates of death as a source of data on fatal work injuries: the Indiana experience. Fatal Workplace Injuries in 1991: A Collection of Data and Analysis. U.S. Department of Labor, BLS, Report 845, April 1993:30-33.
- Ruchlin HS, Melcher LA, Alderman MH. A comparative economic analysis of work-related hypertension care programs. Journal of Occupational Medicine, 1984 26(1): 45-49.
- Runyan CW, Baker SP. Occupational motor vehicle injury morbidity among municipal employees. Journal of Occupational Medicine, 1988;30(11):883-6.
- Runyan CW, Loomis D, Butts J. Practices of county medical examiners in classifying deaths as on the job. Journal of Occupational Medicine, 1994;36(1):36-41.
- Ruser JW. Workers' compensation and the distribution of occupational injuries. Journal of Human Resources, 1993;28(3):593-617.
- . Workers' compensation and occupational injuries and illnesses. Journal of Labor Economics, 1991;19(4):325-350.
- , Smith RS. The effect of OSHA records-check inspections on reported occupational injuries in manufacturing establishments. Journal of Risk and Uncertainty, 1988;1(4):415-435.
- Russell J, Conroy C. Representativeness of deaths identified through the injury-at-work item on the death certificate: implications for surveillance. American Journal of Public Health, 1991;81:1613-1618.
- Sagan LA. The Health of Nations, Basic Books, New York 1987.
- Schade WJ, Swanson GM. Comparison of death certificate occupation and industry data with life-time occupational histories obtained by interview. American Journal of Industrial Medicine, 1988;14:121-136.
- Schappert SM. National ambulatory medical care survey: 1992 summary. Advance Data from Vital and Health Statistics: no. 253, Hyattsville, Maryland: National Center for Health Statistics, 1994.

- Scheffler RM, Andrews NC. Cancer Care and Cost: DRGs and Beyond. Health Administration Press Perspectives, Ann Arbor, MI: 1989.
- Schleifer, S.J., Keller, S.E., Camerino M., Thornton, J.C., and Stein, M. Suppression of lymphocyte stimulation following bereavement. Journal of the American Medical Association, 1983;250(3):374-377.
- Schnall PL, Landsbergis PA, and Baker D. Job Strain and Cardiovascular Disease. Annual Review of Public Health, 15:381-411, 1994.
- Schoenberg JB, Sternhagen A, Mason TJ, et al. Occupation and lung cancer risk among New Jersey white males. Journal of the National Cancer Institute, 79:13-21, 1987.
- Schneider RC, Kennedy JC, Plant ML, Fowler PJ, Hoff JT, and Matthews LS. Sports Injuries: Mechanisms, Prevention, and Treatment. Baltimore, MD, Williams and Wilkins, 1985.
- Schnitzer PG, Landen DD, Russel JC. Occupational injury deaths in Alaska's fishing industry, 1980 through 1988. American Journal of Public Health, 1993;83(5):685-6.
- Schor, Juliet. The Overworked American. Harvard University Press, Cambridge, MA, 1991.
- Scitovsky A. Estimating the direct cost of illness. Milbank Memorial Fund Quarterly/Health and Society 1982; 60(3): 463-491.
- Seeman M, Seeman, AZ, Bardoza A. Powerlessness, work, and community: a longitudinal study of alienation and alcohol use. Journal of Health and Social Behavior, 1988;29:185-198.
- Sehgal E. Occupational mobility and job tenure in 1983. Monthly Labor Review, 1984;107(10):18-23.
- Seligman PJ, Halperin WE, Mullan RJ, Frazier TM. Occupational lead poisoning in Ohio surveillance using workers' compensation data. American Journal of Public Health, 1986;76(11):1299-302.
- Seligman PJ, Newman SC, Timbrook LL, Halperin WE. Sexual assault of women at work. American Journal of Industrial Medicine, 1987;12:445-450.
- Seligman PJ, Sieber WK, Pedersen DH, Sundin DS, Frazier TM. Compliance with OSHA record-keeping requirements. American Journal of Public Health, 1988;78(9):1218-9.
- Selikoff IJ, Churg J., and Hammond EC. Asbestos exposure and neoplasia. Journal of the American Medical Association, 188:22, 1964.
- , Hammond EC and Seidman H. Mortality experience of workers in the United States and Canada, 1943-1976. In: Health Hazards of Asbestos Exposure. I.J. Selikoff and EC Hammond (Eds.). Annals of the New York Academy of Sciences, 330:91-116, 1979.
- , Lee D. Asbestos and Disease. Academic Press, Orlando, Florida, 1978.
- , Seidman H. Asbestos-associated deaths among insulation workers in the United States and Canada, 1967-1987. In: The Third Wave of Asbestos Disease: Exposure to Asbestos in Place. (PJ Landrigan and H. Kazemi, Eds.). Annals of the New York Academy of Sciences, 1991, 643:1-14.

- Sellers C. and Markowitz S. Reevaluating the carcinogenicity of ortho- Toluidine: A new conclusion and its implications. Register of Toxicology and Pharmacology, 16:301-317, 1992.
- Shilling S, Brackbill RM. Occupational health and safety risks and potential health consequences perceived by U.S. workers, 1985. Public Health Reports, 1987;102 (1):36-48.
- Silverman, D.T., Levin, L.I., Hoover, R.N., Harge, P. Occupational risks of bladder cancer in the United States: I. Journal of the National Cancer Institute, 1989;81:1472-1480.
- Silverman, D.T., Levin, L.I., Hoover, R.N., Harge, P. Occupational risks of bladder cancer in the United States: I. Nonwhite men Journal of the National Cancer Institute, 1989;81:1480-1483.
- Silverstein, B.A., Fine, W., Armstrong, T.J. Occupational factors and carpal tunnel syndrome. American Journal of Industrial Medicine 1987;11:343-358.
- Silvestri G, Lubasiewicz J. Outlook 2000: projections of occupational employment, 1988-2000. Monthly Labor Review, 1989;112:42-65.
- Sinks T, Mathias CGT, Halperin W, Timbrook C, Newman S. Surveillance of work-related cold injuries using workers' compensation data. American Journal of Public Health, 1988;30(6):492-502.
- Slovič, Paul. The psychology of protective behavior. Journal of Safety Research, 1978;10(2): 58-68.
- Slovic, P, Fischhoff B, Lichtenstein S, Rating the risks. Environment 1979;21:14-20,36-39.
- Smart, BD. Progressive approaches for hiring the best people. Training and Development Journal, 1987;41(9):46:53.
- Smith GS. Injuries as a preventable disease: the control of occupational injuries from the medical and public health perspective. Ergonomics, 1987;30(2):213-20.
- , Kraus JF. Alcohol and residential, recreational, and occupational injuries: a review of the epidemiological evidence. Annual Review of Public Health, 1988;9:99-122.
- Smith RS. Intertemporal changes in work injury rates. Proceedings of the 25th Annual Meeting. Industrial Relations Research Association, Madison, WI, 1973;107-74.
- . Compensating wage differentials and public policy: a review. Industrial and Labor Relations Review, 1979;32:339-352.
- . Have OSHA and Workers' Compensation made the workplace safer? in Leven D, Mitchell OS, Sherer PD (editors). Research Frontiers in Industrial Relations and Human Resources. Industrial Relations Research Association, University of Wisconsin, Madison, 1992.
- . The feasibility of an injury tax approach to occupational safety. Law and Contemporary Problems, 1974;38(4):730-744.
- . Mostly on Mondays: is Workers' Compensation covering off-the-job injuries? in Benefits, Costs, and Cycles in Workers' Compensation, eds. Philip S. Borba and David Appel, Boston: Kluwer Academic Publishers, 1990;115-28.
- . The Occupational Safety and Health Act: Its Goals and Its Achievements. Washington, D.C.: American Enterprise Institute, 1976.

- . Compensating wage differentials and public policy: a review. Industrial and Labor Relations Review, 1979;32:339-352.
- Social Security Administration. Social Security Bulletin, Annual Statistical Supplement, 1988, Washington, D.C.: U.S. Government Printing Office, 1989;305.
- Sorock GS, Smith EO, Goldoft M. Fatal occupational injuries in the New Jersey construction industry, 1983 to 1989. Journal of Occupational Medicine, 1993;35(9):916-921.
- Staller, JM, Sullivan, BP, Friedman, EA. Value of life estimates - too imprecise for courtroom use: a note. Journal of Forensic Economics, 1994;7(2):215-219.
- Stallones RA and Downs TA. A critical review of Estimates of the Fraction of Cancer in the United States, Related to Occupational Factors. Prepared by Research Statistics, Inc. under contract from the American Industrial Health Council, Houston, TX, and B.F. Goodrich Company, 1978.
- Stayner L, Smith R, Thun M, et al. A dose-response analysis and quantitative assessment of lung cancer risk and occupational cadmium exposure. Annals of Epidemiology, 2:177-194, 1992.
- Stanbury M, Goldoft M. Use of OSHA inspections data for fatal occupational injury surveillance in New Jersey. American Journal Public Health, 1990;80(2):200.
- Stellman S, Boffetta P, Garfinkel L. Smoking habits of 800,000 American men and women in relation to their occupations. American Journal of Industrial Medicine, 1988;13:43-58.
- Sterling TD, Weinkam JJ. Changes in smoking characteristics by type of employment from 1970 to 1979/80. American Journal of Industrial Medicine, 1987;11:539-561.
- Stern Y, Garland B, Tatemichi TK, Tang MX, Wilder D, Mayeux R. Influence of education and occupation on the incidence of Alzheimer's Disease, Journal of the American Medical Association, 1994;271(13):1004-1010.
- Stock SR. Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limbs: a meta-analysis. American Journal of Industrial Medicine 1991;19:87-107.
- Stone PW. Traumatic occupational fatalities in South Carolina, 1989-90. Public Health Reports, 1993;108(4):483-488.
- Stout N, Bell C. Effectiveness of source documents for identifying fatal occupational injuries: a synthesis of studies. American Journal of Public Health, 1991;81(6):725-728.
- Stout N. Fatal occupational injuries in U.S industries, 1984: comparison of two national surveillance systems. American Journal of Public Health, 1988;78(9):1215-1217.
- Subcommittee of the Committee on Government Operations, 98th Congress, 2nd Session. Report on Occupational Illness Data Collection: Fragmented Unreliable, and Seventy Years Behind Communicable Disease Surveillance. U.S. Government Printing Office, Washington, D.C, 1984.
- Subcommittee of the Committee on Government Operations, 99th Congress, 2nd Session. Occupational Health Hazard Surveillance: 72 Years Behind and Counting. U.S. Government Printing Office, Washington, 1986.
- Suruda A, Emmett EA. Counting recognized occupational deaths in the U.S. Journal of Occupational Medicine, 1988;30(11):868-872.

- Talbott ED. Noise-induced hearing loss and high blood pressure. In Millar JD, ed. NIOSH Grants, Research and Demonstration Projects: 1987 Annual Report, CDC, Atlanta, 1988.
- Tanaka, S., Wild DK, Seligman PJ, Halperin WE, Behrens VJ, Putz-Anderson V. Prevalence and work-relatedness of self-reported carpal tunnel syndrome among U.S. workers - analysis of the occupational health supplement data of 1988 National Health Interview Survey. American Journal of Industrial Medicine, 27:451- 470, 1995.
- Tanaka S, Seligman P, Halperin W, et al. Use of workers' compensation claims data for surveillance of cumulative trauma disorders. Journal of Occupational Medicine 30(6):488-492, 1988.
- Taubman P and Rosen S. Healthiness, education, and marital status in Fuchs VR. (ed). Economic Aspects of Health, University of Chicago Press, Chicago, 1982.
- Taylor DE. Absences from work among full-time employees. Monthly Labor Review, 1981;104-68.
- Taylor L, Davis L, Brooks, D. Surveillance of fatal occupational injuries in Massachusetts: The response of next-of-kin, in Fatal Workplace Injuries in 1991: A Collection of Data and Analysis. U.S. Dept. of Labor, Bureau of Labor Statistics, Report 845, Service publication 88-115, April 1993.
- Thaler R and Rosen S. The value of saving a life evidence from the labor market, in N. Terleckyj (Ed.). Household Production and Consumption. New York: National Bureau of Economic Research, 1975.
- Theriault GP. Cardiovascular disorders, in Levy, B.S. and Wegman, D.H., editors, Occupational Health, Little, Brown publishers, Boston, 1988, p. 432.
- Thorpe KE. Inside the black box of administrative costs. Health Affairs 1992;11(2):42-55.
- Thun MJ, Schnorr TM, Smith AB, et al. Mortality among a cohort of US cadmium production workers--an update. Journal of the National Cancer Institute, 74:325-333, 1985.
- Tinsley LC. State workers' compensation: significant legislation in 1991. Monthly Labor Review, 1992;113(1):57-63.
- Toscano GA. The BLS census of fatal occupational injuries. Compensation and Working Conditions, 1991;43(6):1-2.
- Toscano G, Windau J. Fatal work injuries: results from the 1992 national census. Monthly Labor Review, 1993;116(10):39-48.
- Toscano G, Derstine B, Jack T, Kenestat A, Windau J, Zak M. Fatal Workplace Injuries in 1993: A Collection of Data and Analysis. Report 891. U.S. Department of Labor, U.S. BLS, Washington, D.C. June 1995.
- Totman R. Social Causes of Illness. New York: Patheon Books, 1979.
- U.S. Bureau of the Census: 1982 Census of Agriculture: State Files and Public Use Data Tapes. Washington DC: U.S. Department of Commerce, Bureau of the Census; 1984.
- U.S. Bureau of the Census: Population 1970: Alphabetical Index of Industries and Occupations. Washington DC: U.S. Department of Commerce, Bureau of the Census; 1971.

- U.S. Bureau of the Census: Occupational Classification System 1980. Publication PHC80-R3, Washington DC: U.S. Department of Commerce, Bureau of the Census; Publication PHC80-R3, 1982.
- U.S. Bureau of the Census. Detailed Occupation of the Experienced Civilian Labor Force by Sex for the U.S. and Regions, 1980 and 1970. Bulletin number C 3.223/12:80-S 1-15. U.S. Department of Commerce. U.S. Government Printing Office, Washington D.C. 1984.
- U.S. Bureau of the Census: County Business Patterns (State Files and Public Use Data Tapes). Washington DC: U.S. Dept. of Commerce, Bureau of the Census; 1980-1985.
- U.S. Bureau of the Census. Statistical Abstract for the U.S., 1990, (110th edition), Washington D.C., 1990.
- U.S. Bureau of the Census. Statistical Abstract for the U.S., 1992, (112th edition), Washington D.C., 1992.
- U.S. Bureau of the Census. Statistical Abstract for the U.S., 1993, (113th edition), Washington D.C., 1993.
- U.S. Bureau of the Census. Current Population Reports, Series P60-184. Money Income of Households, Families and Persons in the U.S. in 1992. U.S. Government Printing Office, Washington, D.C., 1993.
- U.S. Bureau of the Census. The Relationship Between the 1970 and 1980 Industry and Occupation Classification Systems. Technical Paper 59, U.S. Government Printing Office, Washington DC, 1989.
- U.S. Bureau of Labor Statistics, U.S. Department of Labor. Occupational Injuries and Illnesses in the United States by Industry, 1991, May 1993.
- U.S. Bureau of Labor Statistics. Survey of Occupational Injuries and Illnesses, 1992. U.S. Department of Labor, May 1994a.
- U.S. Bureau of Labor Statistics, U.S. Department of Labor. Occupational Injuries and Illnesses in the United States, 1992, Prepublished data, December 1994b
- U.S. Bureau of Labor Statistics, Fatal Workplace Injuries in 1993: A Collection of Data and Analysis. Report 891 . Washington D.C., June 1995
- U.S. Bureau of Labor Statistics, U.S. Department of Labor. Revised Occupational Safety and Health Survey, 1992. Prepublished data, January 1995.
- U.S. Bureau of Labor Statistics. News: The Employment Situation, June 1994. USDL 94-326, U.S. Dept. of Labor, Washington DC., July 8, 1994.
- U.S. Bureau of Labor Statistics. Occupational Injuries and Illnesses in the U.S. by Industry, 1987. Bulletin 2424. Department of Labor, U.S. Government Printing Office, Washington DC. May 1989.
- U.S. Bureau of Labor Statistics. Occupational Injuries and Illnesses in the U.S. by Industry, 1989. Bulletin 2379. U.S. Department of Labor, Government Printing Office, Washington, DC. April 1991.
- U.S. Bureau of Labor Statistics. Occupational Injuries and Illnesses in the U.S. by Industry, 1990. Bulletin 2399. Department of Labor, U.S. Government Printing Office, Washington DC. April 1992.
- U.S. Bureau of Labor Statistics. Occupational Injuries and Illnesses in the U.S. by Industry, 1991. Bulletin 2328. Department of Labor, U.S. Government Printing Office, Washington DC. May 1993.

- U.S. Bureau of Labor Statistics. Occupational Injuries and Illnesses in the U.S. by Industry, 1992. Summary 94-3. Department of Labor, U.S. Government Printing Office, Washington, DC., May 1994.
- U.S. Bureau of Labor Statistics. News: Work Injuries and Illnesses by Selected Characteristics, 1992. USDL-94-213. U.S. Department of Labor, April 26, 1994.
- U.S. Bureau of Labor Statistics. Occupational Injuries and Illnesses in the U.S. by Industry, 1985. Bulletin 2278, U.S. Department of Labor, U.S. Government Printing Office, Washington DC, May 1987.
- U.S. Bureau of Labor Statistics, Employer Cost Indexes and Levels, 1975-1988 Bulletin 2319 (Washington, D.C., December 1988), Table 10.
- U.S. Bureau of Labor Statistics. Supplementary Data System, Data Files User's Guide, 1980 Edition. National Technical Information Service. Springfield, VA, 1982.
- U.S. Bureau of Labor Statistics. Employment and Earnings, U.S. Department of Labor, U.S. Government Printing Office, Washington DC, 1979, 1980, 1981, 1982, 1985, 1986, 1991, 1992, and 1993.
- U.S. Bureau of Labor Statistics, Bulletin 2370, supplement to Employment and Earnings, July 1991.
- U.S. Chamber of Commerce, Employee Benefits, 1992, Table 4, U.S. Government Printing Office, Washington, D.C., 1993b.
- U.S. Chamber of Commerce. Analysis of Workers' Compensation Laws, U.S. Chamber of Commerce, Washington DC., 1980-1992.
- U.S. Congress, House Subcommittee of Committee on Government Operations chaired by Tom Lantos. Hearings on Underreporting of Occupational Injuries and Its Impact on Workers' Safety, pt. 1, 100th Congress, 1st session, 1987, March 19, 1987.
- U.S. Department of Commerce, County Business Patterns (State Files and Public Use Data Tapes), Washington, DC: Bureau of the Census 1980-1988.
- U.S. Department of Commerce, Bureau of the Census. Current Population Reports Series P-60. Money Income of Households, Families, and Persons in the U.S., 1992. U.S. Government Printing Office, Washington, D.C., 1993.
- U.S. Department of Health and Human Services, 1988. Current Estimates from the National Health Interview Survey, U.S. 1987. Data from the National Health Survey Series 10, No. 166, Washington, D.C., U.S. Department of Health and Human Services, 1988.
- U.S. Department of Health and Human Services, Agency for Health Care Policy and Research. 1987 National Medical Expenditure Survey. NCHS, Hyattsville, MD 1994.
- U.S. Department of Health and Human Services. Catalog of Electronic Data Products. National Centers for Health Statistics, Hyattsville, Maryland July 1992, DHHS Publication No. (PHS) 92-1213.
- U.S. Department of Health and Human Services. The Health Consequences of Smoking. Cancer and Chronic Lung Disease in the Workplace. A Report of the Surgeon General. U.S. Public Health Service, Office on Smoking and Health, Rockville, Maryland, 1985.
- U.S. Department of Health and Human Services. Morbidity and Mortality Weekly Report. 42(39):757-772, 1993.

- U.S. Department of Health and Human Services. Vital and Health Statistics: Health Conditions among the Currently Employed: United States, 1988. Series 10, No. 198, July 1993.
- U.S. Department of Health and Human Services. Vital and Health Statistics: Detailed Diagnoses and Procedures, National Hospital Discharge Survey, NCHS, Hyattsville, MD 1991.
- U.S. Department of Health and Human Services, National Center for Health Statistics. Life Tables, Vital Statistics of the U.S., 1990. Volume II, Sec. 6, Pub NO. 94-1104, Washington, D.C., 1994.
- U.S. Department of Health and Human Services, National Center for Health Statistics. National Nursing Home Survey, NCHS, Hyattsville, MD 1985.
- U.S. Department of Health and Human Services, National Center for Health Statistics. Work Table 1. Death from Each Cause by 5-year Age Groups, Race and Sex: United States, 1991. Vital Statistics of the U.S., annual and unpublished data, Washington, D.C., 1993.
- U.S. Department of Health and Human Services. "The Health Consequences of Smoking. Cancer and Chronic Lung Disease in the Workplace." A Report of the Surgeon General. U.S. Public Health Service, Office on Smoking and Health, Rockville, Maryland, 1985.
- U.S. Department of Labor. The Availability and Use of Data on Occupational Injuries and Illnesses. Report to the House and Senate Appropriations Committees. July 1994.
- U.S. Department of Labor, News, Bureau of Labor Statistics, Washington, D.C., April 26, 1994.
- U.S. Department of Labor. Occupational Safety and Health Statistics, Chapter 14, in BLS Handbook of Methods. Bureau of Labor Statistics, Bulletin 2414, U.S. Government Printing Office, Washington, D.C., Sept. 1992.
- U.S. Department of Labor, Bureau of Labor Statistics, The National Industry-Occupation Employment Matrix, 1970, 1978, and Projected 1990, Vol. 2, Bulletin 2086, L2.3:2086/v.2, U.S. Government Printing Office, Washington DC. April 1981.
- U.S. National Center for Health Statistics, 1988. Current Estimates from the National Health Interview Survey, U.S. 1987. Data from the National Health Survey Series 10, No. 166, Washington, D.C., U.S. Dept. of Health and Human Services, 1988.
- Vena JE, Fiedler RC. Mortality of a municipal-worker cohort: IV. Fire fighters. American Journal of Industrial Medicine, 11:671-684, 1987.
- Viegi G, Prediletto R, Paoletti P, et al. Respiratory effects of occupational exposure in a general population sample in North Italy. American Review of Respiratory Disease, 143:510-515, 1991.
- Vineis P, Thomas T, and Hayes RB, et al. Proportion of lung cancers in males, due to occupation, in different areas of the USA. International Journal of Cancer. 42:851- 856, 1988.
- Vingard E, Alfredson L, Goldie I, Hogstedt C. Occupation and osteoarthritis of the hip and knee: a register based cohort study. International Journal of Epidemiology, 1991;30:1025-1031.
- Viscusi WK. Labor market valuations of life and limb: empirical evidence and policy implications. Public Policy, 1978;26:359-386.

- . Fatal Tradeoffs: Public and Private Responsibilities for Risk, Oxford University Press, New York 1992.
- . Employment Hazards: An Investigation of Market Performance. Cambridge, Mass, Harvard University Press, 1979.
- . The value of risks to life and health. Journal of Economic Literature, 1993;31(4):1912-1946.
- . Mortality effects of regulatory costs and policy evaluation criteria. The Rand Journal of Economics, 1994;25(1):94-109.
- , Moore MJ. The quality-adjusted value of life. Economic Inquiry, 1988;26:369-388.
- , Moore MJ. Workers' compensation: wage effects, benefit inadequacies, and the value of health losses. Review of Economics and Statistics, Vol. 69 1987;69:249-261.
- Wagener DK, Winn DW. Injuries in working populations: Black-white differences. American Journal of Public Health, 1991;81(11):806-810. Ward W, Carpenter A, Markowitz S, Roberts D, and Halperin W. Excess number of bladder cancers in workers exposed to ortho-Toluidine and Aniline. Journal of the National Cancer Institute, 83:501-506, 1991.
- Ward W, Carpenter A, Markowitz S, Roberts D, and Halperin W. Excess number of bladder cancers in workers exposed to ortho-Toluidine and Aniline. Journal of the National Cancer Institute, 83:501-506, 1991.
- Washburn AE, Harlow DW and Fahy RF. U.S. firefighter deaths. Fire Command, 1987;12:20-34.
- Webster BS, Snook SH. The cost of compensable low back pain. Journal of Occupational Medicine, 1990;2(1):13-15.
- Webster BS, Snook SH. The cost of compensable upper extremity cumulative trauma disorders. Journal of Occupational Medicine 36(7):713-715, 1994.
- Wildarsky A. Richer is safer. The Public Interest, 1980;60:23-29.
- Williams DR. Socioeconomic differentials in health: a review and redirection. Social Psychology Quarterly, 1990;53(2):81-99.
- Windau J, Rosenman K, Anderson H, Hanrahan M, Rudolph L, Stanbury M, Stark A. The identification of occupational lung disease from hospital discharge data. Journal of Occupational Medicine. 33:1060-1066, 1990.
- Windau J and Goodrich D. Testing a census approach to compiling data on fatal work injuries. Monthly Labor Review, 1990;113:12:47-49.
- Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. American Journal of Public Health, 1992;82:816-820.
- Wish P. Review and Preview: 1990 and 1991. Best's Review of Property and Casualty Insurance, 1991;9(9):14-24.
- Wong O., Whorton MD, Folliart DE, Ragland D. An industry-wide epidemiologic study of vinyl chloride workers, 1942-1982. American Journal of Industrial Medicine. 20:317-334, 1991.
- Woolhandler S, Himmelstein DU. The deteriorating administrative efficiency of the U.S. Health Care System. New England Journal of Medicine, 1991;324(18):1535-1258.

World Health Organization. International classification of diseases: Manual on the International Statistical Classification of Diseases, injuries, and causes of death. 9th Revision, Geneva, Switzerland, 1977.

Xu S, Christiani DC, Dockery DW and Wang L. Exposure-response relationships between occupational exposures and chronic respiratory illness: A community-based study. American Review of Respiratory Disease, 145:413-418, 1992.

Zorn EW, Harrington JM, Goether H. Ischemic heart disease and work stress in West German sea pilots. Journal of Occupational Medicine, 1977;19:726-766.

Zwerling C, Sprince NL, Ryan J, Jones MP. Occupational injuries: comparing the rates of male and female postal workers. American Journal of Epidemiology, 1993;138(1):46-55.

