# Occupational Disease and Workers' Compensation: Coverage, Costs, and Consequences

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Most of the costs of occupational disease are not covered by workers' compensation. First, the authors estimated the deaths and costs for all occupational disease in 1999, using epidemiological studies. Among the greatest contributors were job-related cancer, chronic respiratory disease, and circulatory disease. Second, the authors estimated the number of workers' compensation cases, costs, and deaths for 1999, using data from up to 16 states representing all regions of the country. Unlike the epidemiological studies that emphasized fatal diseases, the workers' compensation estimates emphasized nonfatal diseases and conditions like tendonitis and hernia. Comparisons of the epidemiological and workers' compensation estimates suggest that in 1999, workers' compensation missed roughly 46,000 to 93,000 deaths and $8 billion to $23 billion in medical costs. These deaths and costs represented substantial cost shifting from workers' compensation systems to individual workers, their families, private medical insurance, and taxpayers (through Medicare and Medicaid). Designing policies to reduce the cost shifting and its associated inefficiency will be challenging.

**Key Words:** Economics, OSHA, employment.

In 1992, occupational diseases were estimated to cause roughly 49,000 to 74,000 deaths (Leigh et al. 1997). By contrast, leukemia caused 19,272 deaths; homicide, 25,488 deaths; AIDS/HIV, 38,813 deaths; diabetes, 50,067 deaths; and stroke, 143,769 deaths (Kochanek and Hudson 1994; U.S. Bureau of the Census 1997). Most observers believe that unlike injuries, occupational disease is

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inadequately covered by workers' compensation (WC) (Barth 2004; Biddle et al. 1998; Burton and Spieler 2001; McCluskey 1998). To our knowledge, however, no study has attempted to document the lack of WC coverage. To understand the extent of WC coverage and noncoverage of disease, we (1) used epidemiological data to estimate the deaths and medical costs associated with occupational disease; (2) used WC data to estimate the cases, costs, and deaths; and (3) compared the two estimates to show the amount of cost shifting. Because of the complexity of developing these estimates, we used multiple data sources and emphasized ranges of estimates. These estimates and comparisons make up the bulk of this article. In the final sections, we suggest some policy proposals to reduce the cost shifting and also list some limitations.

Before presenting our estimates, we review workers' compensation (Boden 1995). WC is the oldest widely adopted social insurance program in the United States. Employers (i.e., those who do not self-insure) pay premiums to insurance companies, which, in turn, pay benefits to injured workers and reimburse medical providers. Before WC, in the 1910s, for example, injured workers could sue employers. Awards were unpredictable, however, according to Howard (2002), and the laws favored employers. "In some cases injured workers and their families became paupers who sought shelter in local poorhouses, thus shifting the burden to the larger community" (Howard 2002, 30). The WC laws removed workers' right to sue in return for quick, reliable benefits that were typically 30 to 66 percent of the preinjury wage. The workers' "exclusive remedy" to an injury was to file a WC claim, not to sue the employer. WC was (and is) no-fault insurance. Between 1880 and 1930, most rich countries established WC systems. The United States, Canada, and Australia are among the few rich countries that established different WC systems across many jurisdictions (states), whereas most rich countries have only one federal system (Howard 2002).

## Epidemiological Estimates

### *Population Attributable Risks (PARs) and Deaths*

There is a large literature in medicine estimating the prevalence of chronic fatal diseases occurring later in life that are caused by occupational exposures earlier in life. The earliest reviews of this literature were limited to cancer and a few well-established carcinogens, for example,

asbestos, arsenic, benzene, chromium, nickel, and petroleum. Doll and Peto (1981) and Bridbord et al. (1978) estimated that 4 and 20 percent, respectively, of total cancer mortality was due to occupational factors. Markowitz et al. (1989) and Leigh et al. (2000) expanded the list of diseases to include circulatory, chronic respiratory, renal, and neurologic diseases. The most recent reviews (Nurminen and Karjalainen 2001; Steenland et al. 2003) provided estimates for specific cancers such as lung, bladder, and leukemia and added new job-related diseases such as tuberculosis and hepatitis C. These reviews are extensive. For example, Markowitz et al. (1989), Markowitz (2000), Steenland et al. (2003), and Nurminen and Karjalainen (2001) listed 53, 107, 172, and 337 references, respectively. Whereas the great majority of studies in the first three reviews were American, the majority of studies in Nurminen and Karjalainen (2001) were European. In these reviews, the number of deaths was estimated by multiplying the population attributable risk percentages (PARs) for job-related deaths by the number of deaths in the United States or Finland for given age ranges. All disease age ranges had a lower limit of age 25, and all except circulatory disease had no upper limit. Most often, circulatory disease had an upper age limit of 65.

PAR methodology has been applied to many diseases and causes, not just to those relating to occupation (Rothenberg and Hahn 1996). For example, smoking has been estimated to have a PAR of 32 percent for pneumonia among adults (Almirall et al. 1999). The interpretation of this figure is that if smoking were eliminated, the prevalence of pneumonia would decline by 32 percent among adults.

PAR is usually estimated according to the following formula:

$$\text{PAR} = \frac{\text{P(RR} - 1)}{1 + \text{P(RR} - 1)} \tag{1}$$

where P is the proportion in the population exposed to a given agent (e.g., smoking, benzene); and RR is the relative risk of the disease or death for the exposed persons compared with that for persons not exposed. Relative risks are frequently estimated with logistic regressions and log-of-the-odds ratios (odd ratios).

Strict criteria are used to determine job relatedness. For example, in assessing cancer, Steenland et al. (2003) and Markowitz (2000) relied on only those studies identifying job-related exposures identified by the International Agency for Research on Cancer (IARC). For lung cancer, these include arsenic, asbestos, beryllium, cadmium, chromium, diesel fumes, environmental tobacco smoke, nickel, radon, and silica. Korn

et al.'s 1987 study of chronic obstructive pulmonary disease (COPD) is one on which reviewers rely (Leigh et al. 2000; Steenland et al. 2003). Korn and colleagues tested the lung function of a random sample of more than 8,500 adult men and women in six U.S. cities. Roughly 31 percent had been exposed to occupational dust. Korn and colleagues estimated a 1.5 odds ratio for reduced lung function in persons in dust-exposed occupations. Using odds ratios and relative risks, they estimated a 14 percent PAR (range 5% to 24%) for COPD due to occupation among adults age 25 to 74 years old. The reviewers excluded a number of studies not meeting these strict criteria. For example, Steenland et al. (2003) eliminated studies of job-related carbon monoxide exposure. Most studies indicate that excessive exposure to carbon monoxide is required to result in heart disease. But most workers are not exposed to excessive amounts (50 parts per million, time-weighted average).

Table 1 presents epidemiological estimates, with the diseases listed in the first column. The order of these diseases roughly corresponds to the frequency of WC claims to allow for comparisons across tables. The second column lists the number of deaths in 1999 associated with each disease within an age bracket, whether or not it was job related (Hoyert et al. 2001). The third column presents the PARs derived from Leigh et al. (1997), Markowitz (2000), and Leigh et al. (2002) for the upper limit of chronic respiratory disease. Point and range estimates are included. The last column presents the products of the PARs with the second column.

The occupational diseases causing the greatest numbers of deaths are, in order, cancer, chronic respiratory disease, and circulatory disease. The range for 1999 was 46,405 to 94,024 deaths.

Estimates for 1985 are presented at the bottom of the table and were used for comparison with a 1985 and 1986 sample of WC estimates (Leigh and Miller 1998).

### *Costs*

Costs can be categorized as direct and indirect. Direct costs include payments for hospital, physician, and allied health services; rehabilitation; nursing home care; home health care; medical equipment; and insurance administration. Indirect costs refer to productivity losses, which include wage losses, household production losses, and employer productivity losses, which include recruiting and training replacements for diseased workers.

TABLE 1
Occupational Disease Death Estimates from Epidemiological Analysis

| Disease | All Deaths within Age Limit, 1999 | Population Attributable Risks (PARs), Point Estimate, and Range[a] | Estimated Job-Related Deaths, Point, and Range |
|---|---|---|---|
| 1. Circulatory disease,[b] | 109,712 | 7.5%[c] | 8,228 |
| ages 25 to 64 | | (5% to 10%) | (5,486 to 10,971) |
| 2. All pneumoconioses,[d] | 1081 | 100%[e] | 1,081 |
| coal workers' pneumoconiosis, | 409 | 100% | 409 |
| asbestosis, | 449 | 100% | 449 |
| silicosis, | 102 | 100% | 102 |
| all other pneumoconioses | 121 | 100% | 121 |
| 3. Cancer,[f] | 546,616 | 8%[g] | 43,729 |
| ages 25 and over | | (6% to 10%) | (32,797 to 54,662) |
| 4. Chronic respiratory disease,[h] | 123,743 | 10%[i] | 12,374 |
| ages 25 and over | | (5% to 20%) | (6,187 to 24,748) |
| 5. Renal (kidney) disease,[j] | 35,241 | 2%[k] | 705 |
| ages 25 and over | | (1% to 2%) | (352 to 1057) |

TABLE 1—*Continued*

| Disease | All Deaths within Age Limit, 1999 | Population Attributable Risks (PARs), Point Estimate, and Range[a] | Estimated Job-Related Deaths, Point, and Range |
|---|---|---|---|
| 6. Nervous system disease,[l] ages 25 and over | 50,182 | 2%[m] (1% to 3%) | 1004 (502 to 1505) |
| Total point estimate and range, 1999 | | | 67,121 (46,405 to 94,024) |
| Total point estimate[n] and range, 1985 | | | 55,317 (39,022 to 75,326) |

[a]PARs are drawn from Leigh et al. 1997 and Markowitz 2000. The upper bound of 20% is drawn from Kreiss's contribution on chronic respiratory disease in Leigh et al. 2002.
[b]ICD-9 codes are 401 to 9404 (hypertension, hypertensive heart and renal disease), 410 to 414 (ischemic heart disease), 430 to 438 (cerebrovascular disease), and 440 (atherosclerosis). ICD-9 applies to years 1998 and before. ICD-10 codes, which apply to 1999, are I11 (hypertensive heart disease), I13 (hypertensive heart and renal disease), I10, I12 (essential primary hypertension and hypertensive renal disease), I20 to I25 (ischemic heart disease), I60 to I69 (cerebrovascular disease), and I70 (atherosclerosis).
[c]For reference, see Nurminen and Karjalainen 2001, point estimates of 7% for women and 14% for men. See Steenland et al. 2003 for 4% to 10% for largest exposure category contributing to 62% of job-related circulatory disease deaths.
[d]ICD-9 codes are 500 (coal workers' pneumoconiosis), 501 (asbestosis), 502 (silicosis), and 503 to 506 (all other pneumoconioses). ICD-10 codes are J60 to J66 and J68.
[e]For reference, 100% for Nurminen and Karjalainen 2001 and 100% for Steenland et al. 2003.
[f]ICD-9 codes are 140 to 290 (malignant neoplasms), and ICD-10 codes are C00 to C97.
[g]For reference, see Nurminen and Karjalainen 2001, point estimates of 2% for women and 14% for men. See Steenland et al. 2003, 6% to 13% for lung cancer, which comprise roughly 75% of all job-related cancer deaths. Other cancer ranges from 0% to 90%.
[h]ICD-9 codes are 490 to 496, and ICD-10 codes are J40 to J47.
[i]For reference, see Nurminen and Karjalainen 2001, 4% to 18% for both genders. See Steenland et al. 2003, 5% to 24% range.
[j]ICD-9 codes are 580 to 589 (nephritic, nephritic syndrome, and nephrosis), and ICD-10 codes are N00 to N07, N17 to N19, and N25 to N27.
[k]For reference, see Nurminen and Karjalainen 2001, point estimates of 2% for women and 18% for men. See Steenland et al. 2003, 3% to 5%.
[l]ICD-9 codes are 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), and 359.4 (toxic myopathy). There was no perfect match for each ICD-9 and ICD-10. Parkinson's is the largest category, and it also has a clear ICD-9 and ICD-10 match. We used Parkinson's as the typical occupational disease within Nervous System Disorders to estimate deaths in 1999. (This was not required for 1985, since ICD-9 codes were available for 1985.) From 1992 to 1999 the number of Parkinson's deaths increased by 86.3%. We estimate that Nervous System Disorders would increase from 26,936 to 50,182. The figure of 26,936 is from Leigh et al. 2000.
[m]For reference, see Nurminen and Karjalainen 2001, point estimates of 2% for women and 5% for men.
[n]See Table 1 in unpublished appendix.
*Sources:* Hoyert et al. 2001, except for pneumoconiosis, which is from National Center for Health Statistics 2003.

Table 2 shows the cost estimates using the PAR approach and cost-of-illness methodology (Hodgson and Meiners 1982). The estimates relied on a ratio of hospital days multiplied by national estimates of medical spending (see equation 2). The numerator of the ratio was hospital days attributed to a given disease, and the denominator was the total number of all hospital days attributed to all diseases and injuries. The ratio was a percentage of all hospital days for all diseases and injuries attributed to a particular disease. This hospital-day ratio acted as an anchor in the estimation of medical costs. Because hospitalization data are collected annually and are standardized according to the same definition (days in hospital), they permit comparisons across diseases. Similar annual data are not available for drug use or most other categories of spending, such as durable medical products (e.g., wheelchairs). Moreover, hospitalizations are the most expensive category of medical care, accounting for 40 percent of all medical costs (Eberhardt et al. 2001). Physicians' services are second, at 22 percent.

Most studies assume that the amount of money spent on all other direct costs is proportional to the number of days spent in the hospital. But this assumption is controversial for most occupational diseases. For example, asthma requires a great amount of outpatient care but comparatively little inpatient care (Leigh et al. 2002). We adjusted for these varying expenses, as indicated by our inpatient (*$inpatient adjustment*) and outpatient (*$outpatient adjustment*) categories in equation 2.

Our estimates relied on a formula best illustrated with a specific example. We chose cancer (ICD-9 codes 140–209):

$$\begin{aligned} (2) \qquad \$occupationalcancer = {} & (\$ntlspend - \$dental) \\ & \times (cancerdays/totaldays) \times cancerPAR \\ & + \$inpatient\ adjustment \\ & + \$outpatient\ adjustment \end{aligned}$$

where *$occupationalcancer* is our estimate of the medical dollars spent for occupational cancer; *$ntlspend* is the national spending on medical care; *$dental* is the spending on dental services; *cancerdays* is the number of days in the hospital attributed to persons 25 years of age or older with cancer; *totaldays* is the number of days in the hospital attributed to all disease and injuries in the United States; and *cancerPAR* is the PAR

TABLE 2
Cost-of-Illness Estimates for Fatal Diseases and Osteoarthritis

| Disease | PAR | Direct (Medical) Costs, in billions[a] | Indirect Costs, in billions (lost wages, fringe benefits, home production)[b] |
|---|---|---|---|
| 1. Circulatory disease, ages 25 to 64 | 7.5% | $3.09 | $2.35 |
| | (5% to 10%) | ($2.06 to $4.12) | ($1.56 to $3.13) |
| 2. Pneumoconiosis, including asbestos, silicosis, and byssinosis | 100% | $0.06 | $0.22 |
| 3. Cancer, including mesothelioma | 8% | $4.45 | $5.84 |
| | (6% to 10%) | ($3.34 to $5.56) | ($4.38 to $7.30) |
| 4. Respiratory disease, including COPD and asthma | 10% | $3.04 | $1.93 |
| | (5% to 20%) | ($1.52 to $6.08) | ($0.97 to $3.86) |
| 5. Infectious, contagious diseases | 0 | 0 | 0 |
| 6. Silicosis included in item 2 | — | — | — |
| 7. All other diseases for workers' compensation lists (including AIDS and mental illness) | 0 | 0 | 0 |
| 8. Renal (kidney) disease | 2% | $0.10 | $0.15 |
| | (1% to 3%) | ($.05 to $.15) | ($0.07 to $0.22) |
| 9. Nervous system disorders | 2% | $0.09 | $0.10 |
| | (1% to 3%) | ($0.05 to $0.14) | ($0.05 to $0.15) |
| 10. Other pneumoconioses included in item 2 | — | — | — |
| 11. Osteoarthritis[c] | 9.4% | $4.52 | $4.28 |
| | (5% to 15%) | ($2.41 to $7.22) | ($2.27 to $6.82) |
| 12. Total with point estimate | | $15.35 | $14.87 |
| 13. Lower bound | | $9.49 | $9.52 |
| 14. Upper bound | | $24.73 | $21.70 |

[a]Calculations appear in the unpublished appendix, tables 2 through 9.
[b]Calculations appear in the unpublished appendix, tables 2 through 9.
[c]ICD-9 code is 715. Age range is all ages, but osteoarthritis is rare under age 30. See Leigh, Seavey, and Leistikow 2001.

for cancer. The number of hospital days was taken from the National Hospital Discharge Survey (National Center for Health Statistics 2001).

Medical cost calculations for fatal diseases are available in seven detailed tables in an appendix available from the authors. These calculations also provide separate estimates for men and women. For this article, however, we combined the male and female estimates.

In addition to fatal diseases, Table 2 shows job-related osteoarthritis. Job-related osteoarthritis refers to job-related injuries earlier in life that can result in osteoarthritis later in life. For instance, a knee injury at age 30 can result in knee osteoarthritis and knee replacement surgery at age 70. The figures in Table 2 are updates (to 1999) of the 1994 figures used in Leigh, Seavey, and Leistikow 2001.

The following diseases generate the following medical costs: cancer ($3.3 billion to $5.6 billion), osteoarthritis ($2.4 billion to $7.2 billion), circulatory ($2.1 billion to $4.1 billion), and chronic respiratory disease ($1.5 billion to $6.1 billion). Our combined estimate for all diseases is $9.5 billion to $24.7 billion in medical costs. We prefer range rather than point estimates to acknowledge the imprecision associated with PAR methodology.

Table 2 also shows the estimated indirect costs, which were calculated using 1992 figures updated to 1999. This update multiplied the 1992 indirect costs estimate by one plus the percentage increase or decrease in job-related deaths for the given disease and by one plus the wage inflation from 1992 to 1998. Note that these indirect costs do not depend on WC payments but are intended merely to capture lost wages, lost home production, lost fringe benefits, and employer costs. A formula for the current value of lost earnings due to death was used in the calculations.

Indirect costs are somewhat controversial. For example, retirees typically have little or no job-related earnings to lose. As a result, we wanted to emphasize our medical cost estimates, which are more directly comparable to WC medical costs than indirect costs are comparable to WC indemnity benefits.

## Workers' Compensation Estimates

We contacted 48 state WC offices by e-mail and, most frequently, by telephone to obtain data on the numbers of WC cases. North Dakota and the District of Columbia did not respond, and Virginia's data available on the

Internet were rich enough to forgo personal contact. (A table in the unpublished appendix lists the state WC offices and personal contacts.) We obtained data on the number of cases, the dollar amount (costs), and the number of deaths. Most of our efforts were spent on costs and deaths, since they were the most difficult to obtain and most germane to our study.

We obtained "number of cases" within disease categories for 16 states: Arkansas (1996), California (1998), Colorado (1999), Maine (1999), Minnesota (1999), Mississippi (2002), New Mexico (2002), New York (2002), North Dakota (2000), Oregon (1999), Rhode Island (1999), South Carolina (2002), Texas (1999), Virginia (2001), Washington (1999), and Wisconsin (2002). Most of the data were from 1999. At least three states were from each of the four regions (Northeast, South, Midwest, and West). Apart from these 16 states, most states did not have the "nature of illness" details for the "numbers of cases" by disease that we required. In sum, 8.05 percent of all WC cases were attributed to diseases, illnesses, or conditions.

Although we included carpal tunnel syndrome (CTS) in all our nonfatal disease tables, medically speaking, CTS is neither an acute injury nor a disease but a cumulative injury. We listed it as a disease only because the Bureau of Labor Statistics (BLS) and WC boards list it as a disease.

Table 3 presents data on the WC coverage of diseases, which are listed in the first column, and the total numbers of WC claims are in the second column.

Table 4 gives the total dollar amount of WC spending by disease in seven states. These seven were the only ones we could find that offered detailed cost data by disease. The states and year of raw data were California (1998), Florida (1999), Maine (1999), Minnesota (1999), Virginia (2001), Washington (1999), and Wisconsin (2002). We forecast and "backcast" costs to 1999 based on changes in both the overall WC spending in each of these states (Williams, Reno, and Burton 2003) and the volume of WC claims across 1998 to 2002 provided by the states' WC bulletins. Details of our calculations are in the unpublished appendix. Each region (Northeast, South, Midwest, and West) is represented by at least one state. A critical number unique to this table appears at the bottom: The amount spent on disease was 6.88 percent of the total WC spending in these seven states.

We believe that the illness statistics from the *Annual Survey* of the Bureau of Labor Statistics (BLS) largely reflect the WC illnesses. The *Annual Survey* relies on private firms to report cases to the BLS once a

TABLE 3
Number of Workers' Compensation Disease Claims in 16 States[a]

| | Number of Cases[b] |
|---|---|
| 1. Inflammation (e.g., tendonitis) | 15,984 |
| 2. Carpal tunnel syndrome | 15,878 |
| 3. Hernia | 12,378 |
| 4. Dermatitis | 3,103 |
| 5. Loss of hearing due to disease | 2,715 |
| 6. Respiratory disorders | 2,706 |
| 7. Mental stress | 2,272 |
| 8. All other occupational diseases | 1,285 |
| 9. Poisoning (chemical, metal, other) | 1,281 |
| 10. Infection | 1,082 |
| 11. Mental disorders | 866 |
| 12. Myocardial infarction | 528 |
| 13. Asbestosis | 215 |
| 14. Vascular loss | 197 |
| 15. Vision loss | 158 |
| 16. Dust disease (all other pneumoconioses) | 133 |
| 17. VDT-related disease | 96 |
| 18. Angina pectoris | 77 |
| 19. Cancer, including mesothelioma | 52 |
| 20. Contagious diseases | 30 |
| Total disease cases (1 to 20) | 61,036 |
| Percentage contribution of all diseases (not just 1 through 20) to total WC cases | 8.05% |
| Total for all WC injuries and illnesses | 759,330 |

[a]The states are Arkansas (1996), California (1998), Colorado (1999), Maine (1999), Minnesota (1999), Mississippi (2002), New Mexico (2002), New York (2001), North Dakota (2000), Oregon (1999), Rhode Island (1999), South Carolina (2002), Texas (1999), Virginia (2001), Washington (1999), and Wisconsin (2002). At least three states from each of the four regions (Northeast, South, Midwest, and West) are represented. Most states reported data only for disabling cases, that is, those involving three to seven lost WC workdays. Some states (Arkansas, California) also include a "medical only" category. Therefore, the unit of measurement (at least one lost day in BLS; three to seven lost days in WC) is not the same for Tables 3 and 5.

[b]State departments, bureaus, and divisions for workers' compensation and for industry and industrial relations use the ANSI codes for classifying disease. The BLS codes are similar, but the ANSI and BLS codes do not match perfectly. Reporting and publishing data on accepted or denied WC claims were inconsistent across the states. The following states reported data on accepted claims (only): California, Maine, Minnesota, New York, Oregon, Virginia, Washington, and Wisconsin. The following states combined accepted with denied claims: Arkansas, Colorado, Mississippi, New Mexico, North Dakota, Rhode Island, South Carolina, and Texas. A high percentage of claims were likely accepted in these states. For example, in North Dakota, 91.2% were accepted and 8.8% were denied. In Colorado, 21.5% were denied in 1999. We included Arkansas through Texas in this table to broaden our representation of the United States.

TABLE 4
Costs of Workers' Compensation Disease Claims in Seven States[a]

| Disease | Workers' Compensation Costs (in thousands of 1999 dollars) |
|---|---|
| 1. Carpal tunnel syndrome | $131,069 |
| 2. Inflammation | $118,770 |
| 3. Hernia | $59,306 |
| 4. Mental stress | $36,860 |
| 5. Loss of hearing | $28,407 |
| 6. Myocardial infarction | $16,599 |
| 7. Respiratory disorders | $11,446 |
| 8. All other occupational diseases | $9,948 |
| 9. Infection | $9,509 |
| 10. Mental and psychiatric disorders | $7,076 |
| 11. Dermatitis | $6,548 |
| 12. All poisoning | $5,524 |
| 13. Vision loss | $5,233 |
| 14. Angina pectoris | $3,193 |
| 15. Cancer | $2,613 |
| 16. Asbestosis | $2,334 |
| 17. VDT-related diseases | $2,171 |
| 18. Vascular loss | $2,088 |
| 19. Dust disease, silicosis, pneumoconiosis, byssinosis | $2,063 |
| 20. Contagious diseases | $1,225 |
| Total for 1 through 20 | $461,982 |
| Percent of total WC spending to all diseases (not just 1 through 20) | 6.88% |
| Total WC spending on injuries and diseases | $6,787,078[b] |

[a]The seven states are California, Florida, Maine, Minnesota, Virginia, Washington, and Wisconsin. Maine has categories in BLS codes. The BLS codes do not precisely coincide with the ANSI categories that the six other states use. Maine's data are therefore not included in each separate category in this table, but they are included in the percent of total WC spending. At least one state from each region (Northeast, South, Midwest, and West) is represented. All cases were compensated by WC; therefore, no "denied" claims are included in this table.
[b]This estimate excludes many "all others" and "not elsewhere classified" categories that could not be attributed to either exclusively injury or illness.

year, and it is likely that managers and owners view the BLS records as similar to workers' compensation records. Conscientious managers and owners would want the documents to be consistent and would want to avoid discrepancies. Every year, the Occupational Safety and Health Administration (OSHA) audits the injury and illness records of roughly

250 firms (Conway and Svenson 1998), and if the OSHA and BLS records do not match the WC records, firms can be fined. Firms therefore have an incentive to make sure that the OSHA and BLS records are consistent with the WC records. Oleinick and Zaidman (2004) found that the estimates in the BLS's *Annual Survey* closely mirror the Minnesota workers' compensation estimates for injuries and illnesses resulting in days away from work. Mississippi's state statistics on WC are identical to those the state sends to the BLS (personal communication, Scott Clark, Mississippi WC Commission, December 8, 2003).

Table 5 contains data from the BLS's *Annual Survey* (U.S. Bureau of Labor Statistics 2001). Although the BLS does not use the International Classification of Diseases (ICD-9 or ICD-10) to categorize its data, the BLS categories are somewhat similar to the ANSI/WC categories. Overall, the BLS uses the following categories for diseases, illnesses, and disorders: (1) systemic diseases and disorders; (2) infectious and parasitic diseases; (3) neoplasms, tumors, and cancer; (4) symptoms, signs, and ill-defined conditions; (5) other diseases, conditions, and disorders; and (6) multiple diseases, conditions, and disorders. Within these broad categories the BLS allows for some specific diseases. Table 5 lists the specific diseases with the greatest number of cases. All diseases (in the BLS's diseases, illnesses, and disorders—which we refer to as simply diseases) account for 7.88 percent.

The most striking aspect of Tables 3, 4, and 5 is their similarities. (1) Inflammation, carpal tunnel syndrome, and hernia lead the lists. (2) Most diseases are acute. (3) Cancer is near the bottom of the lists. (4) Nearly all the diseases listed in Tables 3, 4, and 5 have well-known occupational causes. For example, tendonitis can be caused by repetitive motions on an assembly line. Hernia can result from heavy lifting. Infection can result from exposure to a virus such as hepatitis C on a blood-stained needle. Loss of hearing results from chronic, excessive noise. (5) Most of these workers' compensated diseases are not life threatening. (6) Most important, the total contribution of disease to the total number of WC cases or to their costs is similar: 8.05 percent, 6.88 percent, and 7.88 percent.

## *WC Deaths*

Table 6 offers aggregate estimates of estimated annual WC deaths in 15 states between 1990 and 2002 (panel A) and in eight states in 1985 and

TABLE 5
Number of Illness Cases Reported by Private Industry to the U.S. Bureau of Labor Statistics' Annual Survey

| Disease[a] | Prevalence and Number of Cases Involving Days Away from Work, 1999[b] |
|---|---|
| 1. Rheumatism (bursitis, synovitis, tendonitis, tenosynovitis, ganglion) | 28,588 |
| 2. Carpal tunnel syndrome | 27,922 |
| 3. Digestive system disease (hernia) | 27,267 |
| 4. Disorders of the eye (adnexa, welder's flash) | 7,133 |
| 5. Dermatitis | 5,529 |
| 6. Other diseases, conditions, and disorders, including anxiety, stress, and neurotic disorders | 5,027 |
| 7. Symptoms involving nervous and musculoskeletal systems | 3,771 |
| 8. Dorsopathies, including sciatica and lumbago | 3,026 |
| 9. Respiratory system diseases, excluding pneumoconiosis | 2,076 |
| 10. Infections and parasitic disease (chicken pox, viral disease, and scabies) | 1,504 |
| 11. Infections of the skin | 1,335 |
| 12. Edema, including dropsy | 1,183 |
| 13. Loss of consciousness not due to heat | 1,032 |
| 14. Headache, except migraine | 907 |
| 15. Multiple diseases, conditions, and disorders | 698 |
| 16. Disorders of the ear | 532 |
| 17. Myocardial infarction, heart attack | 517 |
| 18. Musculoskeletal system, n.e.c. | 336 |
| 19. Disorders of the skin | 282 |
| 20. Osteopathies | 150 |
| 21. Stroke | 160 |
| 22. Angina | 85 |
| 23. Pneumoconioses | 82 |
| 24. Tuberculosis | 14 |
| Total for 1 through 24 | 119,156 |
| Percent contribution of all diseases (not just 1 through 24) to total number of cases | 7.88% |
| Total for all injuries and illnesses | 1,702,470 |

[a]No 1999 data on cancers were available, although data for earlier years are available. The number of cases (and corresponding year) are 45 (1993), 54 (1994), and 560 (1995).
[b]The BLS data likely include a small percentage of WC claims that eventually were denied by insurance carriers. In general, the numbers in Table 5 might appear low compared with the WC statistics from 16 states in Table 3. But the BLS data in Table 5 are restricted to cases with at least one day of work loss, whereas the WC statistics in Table 3 are likely to have many "medical only" claims with no work loss.
*Source:* BLS's Annual Survey: http://www.bls.gov/iif/oshwc/osh/case/ostb0925.pdf (data extracted March 28, 2004). The BLS and WC/ANSI categories do not precisely match.

TABLE 6
Number of Workers' Compensation Deaths, across States and Compared with Epidemiological Estimates

Panel A: Across 15 States, 1990 to 2002

| State | Years of Raw Data | Estimated Annual WC Deaths[a] | 1999 Percentage of States' Population Contribution to U.S. Population[b] | 1999 Percentage of Epidemiological Deaths Missed by WC[c] |
|---|---|---|---|---|
| California | 1992–1993 | 116.58 | 12.15% | 98.6% |
| Colorado | 1998–2000 | 10.07 | 1.49% | 99.0% |
| Connecticut | 1994 | 27.00 | 1.20% | 96.6% |
| Florida | 1998–2002 | 14.40 | 5.54% | 99.6% |
| Kansas | 1995–2002 | 7.38 | 0.97% | 98.9% |
| Maine | 1993–2002 | 19.10 | 0.46% | 93.8% |
| Minnesota | 1995–2001 | 13.80 | 1.75% | 98.8% |
| Mississippi | 2002 | 17.70 | 1.02% | 97.8% |
| Missouri | 1997–2002 | 5.83 | 2.00% | 99.6% |
| New Mexico | 1995–2002 | 0.76 | 0.63% | 99.8% |
| North Carolina | 1997–2002 | 16.01 | 2.81% | 99.2% |
| Oregon | 1990–1999 | 2.10 | 1.22% | 99.7% |
| Rhode Island | 1992–2001 | 0.60 | 0.36% | 99.8% |
| Virginia | 2001–2002 | 11.00 | 2.52% | 99.3% |
| Washington | 1999–2001 | 16.67 | 2.11% | 98.8% |
| Total | | 278.98 | 36.25% | 98.9% |

Panel B: BLS Supplementary Data System, 1985 and 1986, Seven States

| | Estimated Annual Deaths[d] | Percentage of Contribution to U.S. Population of These Seven States | Percentage of Epidemiological Deaths Missed by WC |
|---|---|---|---|
| Total for seven states | 262.5 | 16.44% | 97.1% |

[a]See Table 11 in the unpublished appendix for calculations of several states that had a category for "nature of illness not assigned." In these cases we assumed that the same percentage of "assigned" deaths in injury and illness categories applied to "not assigned" categories, thereby explaining the figure of 17.70 for 2002 for Mississippi. This table relied on state information that reported only compensated or accepted claims for more than 95% of cases that may eventually be denied.
[b]We used population rather than persons in labor force, since many deaths occur after age 65.
[c]The following formula was applied: 1 minus ((A/B)/67,121), where A = Estimate of WC Deaths; and B = 1999 percentage contribution to U.S. population. The estimate assumes each individual state is representative of the United States. Clearly, each alone would not be representative, but these estimates provide a range. For the U.S. lower bound, the denominator in the formula was 46,405; for the upper bound, it was 94,024.
[d]The 1985 estimates are in Table 1 of the unpublished appendix. Adjustments were made for increasing and decreasing deaths by disease from 1985 to 1992 to 1999.

1986 (panel B). The 1990–2002 data came from our personal contacts with WC boards and offices in 15 states. Detailed data for each state is available in our unpublished appendix. This set of 15 states contains at least three from every region (Northeast, South, Midwest, and West), and the year most often covered by these data was 1999.

The data in the third column are estimates of annual deaths. For those states with multiple years, we simply added up all the deaths and divided them by the number of years. We also adjusted for deaths in the "nonassigned" category of the same state bulletin (see note a). The greatest number of annual deaths was estimated for California (116.58), and the least was for Rhode Island (0.60). The last column estimates the lack of WC coverage, assuming that each individual state was representative of the entire United States. The lower and upper bounds for lack of coverage are 93.8 percent (Maine) and 99.8 percent (New Mexico and Rhode Island). The last row indicates the annual estimate for all these states combined (278.98). The lack of coverage estimate for the United States is 98.9 percent, in the last row. These figures indicate—assuming that these 15 states are representative of the nation—that each year WC misses 98.9 percent of occupational disease deaths.

The data from 1985 and 1986 are from the BLS's Supplementary Data System (SDS) (Leigh and Miller 1998) and are shown in panel B. The states included and the corresponding years are Arkansas (1985–86), Colorado (1985), Delaware (1985–86), Iowa (1985–86), New York (1985–86), North Carolina (1985–86), and Wisconsin (1985–86). The SDS was designed to provide the BLS with a cross section of WC claims that would be representative of the United States (Root and Sebastin 1981). Although the 1985 and 1986 data are old, they are consistent with the 1990–2002 data. WC captured roughly 3 percent (100% minus 97.1%) of the deaths estimated with epidemiological studies (Table 1).

Table 7 considers the same death data comparisons, which are now expressed in disease categories. Roughly half the asbestosis deaths were estimated to be covered by WC. Less than 5 percent and frequently less than 1 percent of all other disease deaths were estimated to be covered by WC.

## *Total WC Costs for Disease*

Williams, Reno, and Burton (2003) estimated that national WC spending (benefits paid) in 1999 was $44.335 billion, of which

TABLE 7
Workers' Compensation Deaths across Diseases and Compared with Epidemiological Death Estimates, 1999 Only

| Disease[a] | Workers' Compensation | | | Deaths from Table 1 Epidemiological Analysis | Difference[b] |
|---|---|---|---|---|---|
| | Estimated Number of Deaths | Percentage Contribution to U.S. Population by the 15 States | Estimate for U.S. | | |
| 1. Circulatory disease | 136.17 | 36.25% | 375.6 | 8228 | −7852 |
| 2. Asbestosis | 63.40 | 36.25% | 174.9 | 449 | −274 |
| 3. Cancer, including mesothelioma | 53.73 | 36.25% | 115.1 | 43729 | −43,614 |
| 4. Respiratory: COPD, asthma | 15.72 | 36.25% | 43.4 | 12374 | −12,331 |
| 5. Infections, contagious disease other than AIDS/HIV | 4.50 | 36.25% | 12.4 | 0 | +12.4 |
| 6. Silicosis | 1.06 | 36.25% | 2.9 | 102 | −99.1 |
| 7. All others from Workers' Compensation appendix table 6: poisoning, AIDS, byssinosis, mental illness, other diseases, radiation | 4.40 | 36.25% | 12.1 | 0 | +12.1 |
| 8. Renal (kidney) disease | 0 | — | 0 | 705 | −705 |
| 9. Nervous system disease | 0 | — | 0 | 1004 | −1004 |
| 10. All other pneumoconiosis, including coal workers' pneumoconiosis | 0 | — | 0 | 530 | −530 |
| 11. Total | 278.98 | 36.25% | 736.4 | 67,121 | −66,385 |
| 12. U.S. WC estimate, 736.4, comparison with epidemiological lower bound (46,405) | — | — | 736.4 | 46,405 | −45,669 |
| 13. U.S. WC estimate, 736.4, comparison with epidemiological upper bound (94,024) | — | — | 736.4 | 94,024 | −93,288 |

[a]1985–86 ranking: circulatory, asbestosis, silicosis, pneumoconioses, respiratory conditions.
[b]Difference: WC U.S. estimate minus U.S. epidemiological estimate.

$25.294 billion was paid as indemnity (cash) benefits and $19.041 billion as medical benefits. Their theoretical definition of medical benefits is nearly the same as our theoretical cost-of-illness definition of medical costs. Our practical attempts to estimate "medical benefits" and "medical costs" are somewhat different, however, and our theoretical definitions of indemnity (cash) benefits and indirect costs differ substantially. As a result, a narrow comparison of WC "medical benefits" and cost-of-illness "medical costs" would be more appropriate than a broad comparison of total benefits (including indemnity) and total costs (including indirect costs). We therefore focused on the $19.041 billion of WC medical benefits.

This $19.041 billion includes the costs of hospitals, physicians, and pharmaceutical administration but not the cost of insurance administration. The cost-of-illness estimate includes the "government administration and net cost of health insurance." That amount was roughly 5.9 percent of the total medical expenditures in 1999 (U.S. Department of Commerce 2001), 6.3 percent above nonadministrative spending, not accounting for administration. But WC insurance administration cost is a higher percentage and can be estimated as the ratio of premiums to benefits minus one. In 1999, according to Williams, Reno, and Burton (2003), that would be $55.173 billion to $44.335 billion minus 1, which yields 0.244. Assuming the same administration percent applies to WC medical benefits (alone), WC medical administration would be 24.4 percent times $19,041, or $4,646. Total WC medical costs would therefore be $23.687 billion.

To estimate WC spending on illnesses only, we multiplied $23.687 billion by our previous estimates of the contribution of disease to all WC counts of cases, WC costs, and BLS estimates of counts. The resulting percentages are 8.05 percent (WC number of claims), 6.88 percent (WC costs), and 7.88 percent (BLS number of cases). Our estimates for WC spending on disease in 1999 are, therefore, $1.907 billion (WC claims), $1.630 billion (WC costs), and $1.867 billion (BLS cases).

## Comparing Epidemiological Estimates with WC Estimates

Table 8 compares the epidemiological estimates and the WC estimates and also gives point estimates as well as lower and upper bounds. Panel A

TABLE 8
Comparison of Epidemiological and Workers' Compensation Estimates

| Panel A: Deaths | | | |
|---|---|---|---|
| 1999 Epidemiological[a] | 1999 Workers' Compensation[b] | | Percentage of Epidemiological Estimate Missed by Workers' Compensation Estimate[c] |
| Point: 67,121 | Point | 736 | 98.9% |
| | Lower bound | 121 | 99.8% |
| | Upper bound | 4,152 | 93.8% |
| Lower bound: 46,405 | Point | 736 | 98.4% |
| | Lower bound | 121 | 99.7% |
| | Upper bound | 4,152 | 91.1% |
| Upper bound: 94,024 | Point | 736 | 99.2% |
| | Lower bound | 121 | 99.9% |
| | Upper bound | 4,152 | 95.6% |
| 1985 Epidemiological | 1985 Workers' compensation[d] | | |
| Point: 55,317 | | 1,597 | 97.1% |
| Lower bound: 39,022 | | 1,597 | 95.9% |
| Upper bound: 75,326 | | 1,597 | 97.9% |

TABLE 8—*Continued*

| Panel B: Medical Costs, 1999 | | | | |
|---|---|---|---|---|
| | | | Percentage of Epidemiological Estimate Missed by WC Estimate | |
| Epidemiological[e] | Workers' Compensation[f] | | Epidemiological Costs Only as Denominator | Epidemiological and WC Estimate Combined as Denominator |
| Point: $15.35 billion | Middle | $1.867 | 87.8% | 89.2% |
| | Low | $1.630 | 89.4% | 90.4% |
| | High | $1.907 | 87.6% | 88.9% |
| Lower bound: $9.49 billion | Middle | $1.867 | 80.3% | 83.6% |
| | Low | $1.630 | 82.8% | 85.3% |
| | High | $1.907 | 80.0% | 83.3% |
| Upper bound: $24.73 billion | Middle | $1.867 | 92.5% | 93.0% |
| | Low | $1.630 | 93.4% | 93.8% |
| | High | $1.907 | 92.3% | 92.8% |
| Panel C: Minimum and Maximum Estimate of Percentage Missed by WC, 1985 and 1999 | | | | |
| Deaths: 91.1% to 99.9%<br>Medical Costs: 80.0% to 93.8% | | | | |

[a]Epidemiological estimates are from Table 1.
[b]The years intermittently covered by the 15 states were 1990 to 2002. The most frequently used year for data was 1999.
[c]WC estimates are from Tables 6 and 7. States were ranked by lowest to highest WC coverage. Our lower-bound estimate was New Mexico (0.76/.0063 = 121) with 121 estimated WC illness deaths, and our upper-bound estimate was Maine (19.1/.0046 = 4,152) with 4,152 estimated illness deaths. This percentage was calculated as (1 − (A/B)), where A is the WC estimate; and B is the epidemiological estimate.
[d]1985 WC death data are from Table 6.
[e]1999 epidemiological cost data are from Table 2.
[f]The middle estimate, $1.867, relies on BLS counts of illness cases (Table 5). The low estimate, $1.630, relies on WC costs in seven states (Table 4); the high estimate, $1.907, relies on WC counts of illness cases (Table 3). We used the terms "middle," "low," and "high" because we had only three estimates.

gives the annual death estimates from, roughly, 1999 and 1985, and panel B gives estimated medical costs. This panel contains two "percent" columns that correspond to two different denominators. The first denominator is the epidemiological cost estimate alone, and the second combines the epidemiological with the WC cost estimates. Two arguments apply. The first asserts that nearly all fatal disease costs would be missed by the WC estimates. As a result, the "true" costs would be both epidemiological and WC estimates. The second argument asserts there would be a significant overlap between the epidemiological and WC estimates and that the best estimate of costs would be the epidemiological one. Although we believe that the first argument is more likely, we present estimates corresponding to the two denominators.

Panel C shows a range of estimates for deaths and costs. We estimated WC misses from 91.1 percent to 99.9 percent of deaths and from 80.0 percent to 93.8 percent of medical costs.

Several conclusions can be drawn from Table 8. First, WC coverage is especially weak for diseases that result in death. Second, if WC death coverage is especially low, then by comparison, WC coverage of nonfatal illnesses must be better. Most of the illnesses generating the greatest number of cases and costs in Tables 3, 4, and 5 are not fatal, such as carpal tunnel syndrome, hernia, tendonitis, anxiety, stress and neurotic disorders, disorders of the eye, and dermatitis. Third, and most important, WC covers only a small amount of the costs of occupational disease. The highest estimate is 20.0 percent of those costs.

## Why Is the Coverage for Deaths So Poor?

Most nonfatal illnesses are manifested while the person is still working, whereas many fatal ones become manifest after age 50 and during retirement. WC authorities find it easier to unequivocally declare that a nonfatal illness, rather than a fatal illness, is job related. The BLS states that the *Annual Survey*

> measures the number of new work-related illness cases that are recognized, diagnosed, and reported during the year. Some conditions (for example, long-term latent illnesses caused by exposure to carcinogens) often are difficult to relate to the workplace and are not adequately recognized and reported. These long-term latent illnesses are believed

> to be understated in the survey's illness measures. In contrast, the overwhelming majority of the reported new illnesses are those that are easier to directly relate to workplace activity (for example, contact dermatitis or carpal tunnel syndrome). (U.S. Bureau of Labor Statistics 2001, 9)

## Who Pays When Workers' Compensation Does Not?

The most important conclusion from Table 8 is that WC shifts a significant portion of costs to all other payers. The highest percentage of WC coverage is 20.0 percent. The corresponding medical cost estimate is $9.5 billion (and 20% of $9.5 billion is $1.9 billion). This suggests that at a minimum, $7.6 billion ($9.5 billion minus $1.9 billion) and possibly as much as $23.1 billion ($24.73 billion minus $1.63 billion) in medical costs alone are being shifted onto employees and their families, other non-WC private insurance carriers, Medicare, Medicaid, and other payers.

Injured workers and their families probably bear the greatest cost because they must pay deductibles, copayments, and the entire medical bill when insurance is not available. They also must absorb most of or all the indirect costs, that is, the lost wages and lost home production due to disability or death. Moreover, we did not include lost quality of life or pain and suffering categories in our estimates of costs. But the injured worker and his or her family also experiences pain and suffering. Jury awards in non-WC cases suggest that lost quality of life or pain and suffering can be equal to or greater than the sum of medical (direct) costs and lost productivity (indirect) costs (Rodgers 1993). Private health insurance (unrelated to WC), Medicaid, and the Veterans Administration likely also absorb some of these medical costs, and private disability insurance and government welfare programs absorb some of the lost wages cost.

Much of the spillover medical costs are likely to be paid by Medicare. Most of the death toll for cancer and COPD does not occur until after age 65. Morbidity from these diseases follows a similar pattern: Heavy use of hospitals, doctors, and drugs greatly expands after a person turns 65. Roughly 29 percent of all cancer deaths occur before age 65, with 71 percent after age 64 (Hoyert et al. 2001). Approximately 13 percent

of chronic obstructive pulmonary disease deaths occur before age 65, with 87 percent after that age (Hoyert et al. 2001).

## Is There a Problem? What Should Be Done?

The problem is one of insurance and cost shifting. WC insurance premiums do not reflect all the costs of occupational disease, and the WC market is creating an inefficient amount ("too much") of occupational disease. As much as $7.6 billion to $23.1 billion in annual medical costs are not paid by WC, in addition to indirect and "pain and suffering" costs. But whereas documenting the size of the problem is feasible, suggesting practical policies to ameliorate it is difficult. In this section we (1) illustrate three similar problems and related policies, (2) offer one policy for osteoarthritis, and (3) discuss suggestions for policies dealing with fatal occupational diseases.

The United States has faced similar problems and has enacted policies to resolve them. Three examples are (1) the Black Lung Trust; (2) the combination of the Radiation Exposure Compensation Act of 1990, Energy Employees Occupational Illness Compensation Program, and nuclear weapons tests compensation programs; and (3) the tobacco settlement.

The federal Black Lung Trust, established in 1969, provides medical and indemnity (cash) benefits to current and retired coal miners stricken with coal miners' pneumoconiosis (black lung disease), and their survivors. The benefits paid out in 2001 totaled $873 million (Williams, Reno, and Burton 2003). A substantial portion ($394 million) was paid with a per-ton coal tax on coal companies.

The Radiation Exposure Compensation Act of 1990 and the Energy Employees Occupational Illness Act of 2000 provide one-time payments ($50,000 to $150,000) and pay some medical benefits to persons with certain cancers and other diseases. These persons were exposed during the Cold War to radiation, beryllium, or silica while working on nuclear weapons testing or in uranium mines. The Radiation Act paid roughly $571 million from its inception in the early 1990s to April 2003 (Williams, Reno, and Burton 2003). The Energy Employers Act did not begin making payments until 2001 (after our target 1999 year). In 2001, the benefits paid amounted to $67 million. Both of these programs are financed from federal general revenue.

The 1998 Master Tobacco Settlement (MTS) allowed for substantial funds to be transferred from the major tobacco manufacturers to the states' Medicaid programs (Cutler et al. 2002; Daynard et al. 2001; Gross et al. 2002). Unlike the provisions of the Black Lung Trust and the Radiation or Energy Programs, under the MTS, the states are not required to determine whether the specific death or disease whose benefits were paid by Medicaid was tobacco related. Instead, the states merely must present statistical evidence that a certain number and amount of Medicaid claims for, say, COPD were tobacco related (Cutler et al. 2000; Derthick 2001). In addition, the U.S. Justice Department is suing the tobacco companies to help pay Medicare costs related to smoking (U.S. District Judge Gladys Kessler 2000).

As these three examples illustrate, the problems of insurance, cost shifting, and spillovers are not unique to the occupational diseases in this study. Moreover, there is precedent for designing policies through either direct government spending (energy employees) or taxes or payments from industry to governments (Black Lung, tobacco settlement).

The policies designed to address the occupational diseases highlighted in our study should distinguish between osteoarthritis and fatal diseases. Although designing a practical policy to address osteoarthritis is possible, designing a practical policy to address fatal diseases will be more difficult.

WC systems and insurance companies already collect data on the type of injury and the body part affected. The medical literature suggests that hip and knee injuries are the most likely to develop osteoarthritis. Under our proposed job-related osteoarthritis policy, the WC insurer would notify the worker that his or her knee or hip might later develop osteoarthritis and, if so, the worker could file a new claim with the WC insurer. Our osteoarthritis policy would also require the insurer to notify Medicare, which could also file a future claim. For example, the injured worker might develop osteoarthritis during retirement and seek medical care such as hip replacement surgery. Our osteoarthritis policy would not require that the WC insurer pay the full medical cost of the osteoarthritis, since the worker might have reinjured the knee or hip away from the job some time after the initial job-related injury. In accordance with this osteoarthritis policy, WC insurers would be required to hold sufficient reserves for osteoarthritis medical care that might be needed 30 years in the future. Thirty years is a long time, but WC insurers are accustomed to dealing with long time horizons for permanent disabilities. In addition,

reinsurance companies and government guaranty associations exist to ensure the long-term survival of WC markets. WC insurers would likely raise their current premiums to cover the future costs of osteoarthritis. Finally, the "exclusive remedy" doctrine would still apply under our job-related osteoarthritis policy. Workers could not sue employers for pain and suffering associated with osteoarthritis.

We now discuss the issues surrounding practical policies to address fatal occupational diseases. The first issue is whether these fatal disease costs can be better addressed by existing WC systems that vary by state (premiums) or by a new federal program (taxes). Some people argue that the various state WC systems provide flexibility in tailoring programs to meet the state's needs. But these differences could lead to a "race to the bottom" in attempts to attract or keep businesses in the state. Moreover, it would be difficult to adjust premiums to reflect long-term exposure to, say, benzene, if employers changed their WC insurers from year to year. Finally, the existing state WC systems have not dealt effectively with asbestosis and silicosis. Consider again these diseases in the WC Table 7 and the epidemiological Table 1. WC missed 274 of 449 asbestosis deaths and 99 of 102 silicosis deaths. Stanburg et al. (1991) and Rosenman, Reilly, and Henneberger (2003) found similarly poor WC coverage for asbestosis and silicosis in different data sets.

A federal program would avoid a "race to the bottom" and could collect taxes from employers for long-term exposure. The tax could be kept in a fatal occupational disease trust, although problems involving federalism may preclude the practical implementation of a federal program (Derthick 2001).

The second issue is assessing premiums and taxes. Which firms or industries should pay, and how much should they pay? (Chang 1993). The most promising approach would be to base the payment on the employee's exposure to hazards. For example, in 1989 the Environmental Protection Agency (EPA) established its Toxic Release Inventory (TRI) program, in which firms are required to report the type and amount of toxins they release into the air and waterways. Unfortunately, OSHA does not have an equivalent program (personal communication with William Perry at OSHA, Washington, D.C., April 2, 2004). The EPA's list of roughly 180 chemicals are derived from OSHA's Carcinogen Listing of Individual Chemicals (www.epa.gov/tri/whatis.htm, accessed March 24, 2004). The list includes, for example, asbestos, benzene, benzide, beryllium, cadmium, and chromium. Individual firms might be assessed

premiums or federal taxes based on the amount and type of toxins they release. The premiums and taxes would then be based on scientific assessments of the cancer links among a particular amount of exposure, that person's chance of developing cancer, and the medical costs associated with a particular cancer. These assessments could be made by WC insurers or a new federal department within OSHA. Individual workers could be matched to exposures using Medicare and Social Security data, which already match persons with employers.

The third issue is paying for the medical care. Because of the complexity of this problem, one option is to develop a policy that applies only to Medicare. Medicare could track a person's employment and exposure history and determine what portion of the medical bill should be paid by which WC insurer or by the Fatal Occupational Disease Trust. Again, the "exclusive remedy" doctrine would be retained.

Although each of these issues would be challenging, this should not detract from the primary point of our study, that the existing WC systems are not paying for the bulk of occupational diseases and that these costs are substantial. Debate should begin on these issues.

## Limitations

We already noted the limitations of the PAR methodology (Leigh et al. 2000). For example, some causes of diseases act synergistically; that is, smoking and benzene together may increase the risk of lung cancer by much more than either one would separately. In this case, PARs may sum to more than 100 percent. Nevertheless, PAR methodology is used throughout medical research (whether or not it is occupational) to assess the importance of different causes of disease.

The PARs attributed to occupational exposures vary in the scientific literature, and we have emphasized the imprecision of these estimates by presenting ranges. Nevertheless, the PARs used in Table 1 were drawn from a review of 107 studies (Leigh et al. 2000), of which more than 80 percent pertained to the United States, with the remainder from economically developed countries such as Japan and those within Europe. In addition, two independent and recent reviews for occupational disease had more than 400 citations (Nurminen and Karjalainen 2001; Steenland et. al. 2003). Our PARs in Tables 1 and 2 favorably compare with and are frequently lower than those in these two reviews (see Table 1, notes i through n).

Our range for occupational deaths accounts for roughly 2 to 4 percent of all disease deaths among persons over age 24 (and 1% to 2% of all disease and injury deaths, regardless of age). Our cost range, $9.5 billion to $24.7 billion, represents only roughly 1 to 2 percent of all medical spending in 1999. Overall, we believe 1 to 4 percent is a modest amount to attribute to occupations (in which most people spend a large percentage of their waking hours from age 25 through 64). Finally, even if we assumed the lowest PARs in Table 8, at least $7 billion of medical costs each year would not be paid by WC.

A possible limitation involves the compensating wage hypothesis, which holds that workers in dangerous jobs receive a wage premium to offset their exposure to risks. If the premium were high enough, no costs would need to be shifted, as the firms would be absorbing the costs by paying high wages. Viscusi (1992), Viscusi and Aldy (2003), and others found support for the hypothesis when job risks were measured as injury deaths. But Black and Kniesner (2003) found the support to be fragile and dependent on the measure of injury deaths and statistical model used in the estimation. Finally, Dorman and Hagstrom (1998), Leigh (1995), and Jennings and Kinderman (2003) did not find any support. Dorman and Hagstrom and also Leigh pointed out that what appear to be compensating wages are more likely to be "rents" paid to workers in industries that historically have paid wages above equilibrium. These industries include transportation, public utilities, construction, and manufacturing. This is the so-called interindustry wage differentials hypothesis. The most compelling evidence is present in several samples of male and female clerks who theoretically should not be receiving any compensation wages, regardless of the industry in which they work. Although clerk jobs have low occupational death rates, Leigh (1995) found strong positive correlations between wages and industry death rates for clerks that were similar to the correlations among blue-collar workers. But this is evidence of interindustry differentials, not compensating wages.

The best answer to the compensating wage hypothesis criticism is that little evidence has been found for the hypothesis when risks are measured as disease deaths or disabilities (Leigh 1981). In fact, even the strongest advocate of the hypothesis acknowledges that it is unlikely to work for diseases, since information about diseases associated with particular jobs is so poorly disseminated (Viscusi 1992, 8). We therefore reject the idea that the compensating wage hypothesis undermines our argument that the cost shifting is considerable.

The second limitation pertains to nonfatal disease. Our WC estimates for (mostly) nonfatal disease, $1.63 billion to $1.9 billion, are likely less than the true medical costs of nonfatal occupational disease. First, firms have economic incentives to underreport illnesses. Second, workers may fear the stigma of filing a claim, and many never do so. Biddle et al. (1998) estimate that more than half of persons with nonfatal occupational illnesses do not file for WC. A full accounting for the underreporting would likely increase the estimate of the size of the cost shifting (Leigh, Marcin, and Miller 2004).

The third limitation involves the Radiation Exposure Compensation Program and the Energy Employees Occupational Illness Compensation Program. We did not include either of these in our calculations. But in the 1990s the Radiation Program paid only roughly $7 million per year, and the Energy Employees Program did not pay anything until 2001, two years after our target 1999 year.

The fourth limitation has to do with the variation across states regarding which diseases are compensable. According to the U.S. Chamber of Commerce's Analysis of Workers Compensation Laws, 44 states and the District of Columbia allow "all diseases" to be compensated by workers' compensation. Within the remaining six states, the potential set of diseases is broad. For example, in Virginia, compensable diseases are "all occupational disease and some ordinary disease of life under unusual evidentiary standards of proof" (U.S. Chamber of Commerce 2002, 37). But within WC, "potential" is far from "actual." In general there must be an unimpeachable link between exposure at a specific job and a corresponding disease. This is easily established when, for example, poison oak causes a life-threatening inflammation in the lungs of a forest firefighter. But it is far more difficult when exposure to benzene from 1975 to 1985 causes a leukemia death in 1999. One of the exceptions to this unimpeachable link rule is circulatory (heart and stoke) disease. A number of states, including California, allow firefighters and police officers (or their survivors) to collect WC benefits after myocardial infarction (heart attack), whether or not it occurs on the job.

Time is an important dimension in establishing the unimpeachable link. First, the greater the length of time is between employment and disease, the less likely it is that the disease will be compensated. The states' laws are inconsistent. For example, in New Mexico, death from asbestos must occur within two years of exposure, but in North Carolina, death must be within ten years. But in Florida, death must occur within

350 weeks (six to seven years) of last exposure, whereas in Alabama, it must be within three years. In Illinois, for radiation exposure, death must be within 25 years. Second, the states' laws vary regarding the amount of time the worker is exposed. In Arizona, asbestosis exposure must be for at least two years, but in Colorado, Maine, and Indiana, exposure must last at least 60 days. Because of the variation in laws across states, our approach was to measure which diseases were and were not actually compensated in a representative sample of states.

The last limitation refers to indirect costs. Indirect costs are difficult to calculate for retired persons. Our approach thus far has been conservative, emphasizing medical costs. But surely the indirect costs are considerable. For example, cancer can disable people of working age. Indeed, in 1999 roughly 3,106,000 hospital days were attributed to cancer for people aged 45 to 64 years old. This was 57 percent as many hospital days as were attributed to persons over age 64. Multiplying by our PAR point estimate of 8 percent yields 248,500 days in the hospital among persons aged 45 to 64. Days in the hospital and days recuperating are days not working. In addition, our circulatory disease deaths and costs applied to persons aged 65 and younger. Finally, WC wage-replacement rates have been criticized for being inadequate (Biddle, Boden, and Reville 2001), and a full accounting for indirect costs would likely greatly increase our estimate of cost shifting.

## Summary

We have presented what appears to be the first estimate of the deaths and costs of occupational diseases that are and are not covered by workers' compensation. Given the latency of these diseases, many of the deaths and costs affect retired persons. Medical cost shifting of extraordinary size ($7.6 billion to $23.1 billion) results from the lack of WC coverage for diseases. Whereas the theoretical solution to this cost shifting is simple (raise premiums or taxes), its practical implementation may be difficult.

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