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Costs o 'ob-related inju 'es dwarfing AIDS, study finds

BY BRENDA C. COLEMAN
THE ASSOCIATED PRESS

CHICAGO — Job-related injuries and illnesses are more common than most people believe, costing the nation far more than AIDS or Alzheimer's disease and at least as much as cancer or heart disease, a new report says.

"Occupational injuries and illnesses are an insufficiently appreciated contributor to the total burden of health-care costs in the United States," researchers say in today's issue of the *Archives of Internal Medicine.*

The researchers combined many sources of government and other data for what they believe

See **INJURIES,** Page 8A

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Injuries

• Continued from Page 1A

are the first national estimates of job-related injuries and illnesses in a single year.

In 1992, about 6,500 Americans died and 13.2 million were hurt from work-related causes, said the researchers, led by J. Paul Leigh of the economics department at San Jose State University in California.

That toll averages to 18 deaths and 36,000 injuries a day, compared with government estimates of 17 workers killed each day and 9,000 injured.

Occupational illnesses — such as lung diseases and lead poisoning — caused 60,300 deaths and 862,200 illnesses in 1992, the researchers said. That averages to 165 deaths and more than 2,300 new ailments daily, compared to government figures of 137 and 1,095 daily in those categories, respectively.

And the new report probably underestimates the totals because injuries and illnesses are undercounted, the researchers said.

In all, the direct costs of injuries and illnesses totaled $65 billion in 1992 ($178 million a day), the researchers said. Indirect costs — including lost wages — were $106 billion ($290 million a day), they said. That made the total $171 billion that year ($468 million a day.)

That's far more than the 1992 cost of AIDS — $30 billion — excluding the costs of administrating worker's compensation, Social Security or health insurance benefits. Occupational injuries and illnesses cost $155 billion, excluding those administrative outlays, the researchers said.

Similarly, the direct and indirect economic burden of Alzheimer's disease in 1992 was much less than work-related deaths and injuries. Alzheimer's totaled $67.3 billion, including administrative costs, the researchers said.

And for heart and all other blood-vessel diseases, the total was $164.3 billion. For cancer, it was $170.7 billion. For musculoskeletal diseases, such as arthritis and osteoporosis, it was $149 billion, researchers said.

"The authors make a very good case that the magnitude of the occupational health burden really rivals other major problems," said Dr. Linda Rosenstock, director of the National Institute for Occupational Safety and Health.

Her agency, part of the Centers for Disease Control and Prevention, helped pay for the research but didn't have a hand in its design or conclusions, and she wasn't involved in the work.

She said the report should encourage the nation to put a greater emphasis on workplace safety.

"We have tools for prevention here, in the workplace, that sometimes just don't exist for other illnesses," she said by telephone from Washington. "These are all inherently preventable illnesses and injuries."

EPA = (202) 260-2090
Phil = (202) 260 ~~[illegible]~~ -7778
Landrigan

Julia Roberts (212) 241-4803
-assistant
Mt. Sinai

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Occupational Injury and Illness in the United States Estimates of Costs, Morbidity, and Mortality (ARTICLE)

LEIGH, J. PAUL; MARKOWITZ, STEVEN B.; FAHS, MARIANNE; SHIN, CHONGGAK;
LANDRIGAN, PHILIP J.
Archives of Internal Medicine
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Objective: To estimate the annual incidence, the mortality, and the direct and indirect costs associated with occupational injuries and illnesses in the United States in 1992. Design: Aggregation and analysis of national and large regional data sets collected by the Bureau of Labor Statistics, the National Council on Compensation Insurance, the National Center for Health Statistics, the Health Care Financing Administration, and other governmental bureaus and private firms. Methods: To assess incidence of and mortality from occupational injuries and illnesses, we reviewed data from national surveys and applied an attributable risk proportion method. To assess costs, we used the human capital method that decomposes costs into direct categories such as medical and insurance administration expenses as well as indirect categories such as lost earnings, lost home production, and lost fringe benefits. Some cost estimates were drawn from the literature while others were generated within this study. Total costs were calculated by multiplying average costs by the number of injuries and illnesses in each diagnostic category. Results: Approximately 6500 job-related deaths from injury , 13.2 million nonfatal injuries , 60,300 deaths from disease, and 862,200 illnesses are estimated to occur annually in the civilian American workforce. The total direct ($65 billion) plus indirect ($106 billion) costs were estimated to be $171 billion. Injuries cost $145 billion and illnesses $26 billion. These estimates are likely to be low, because they ignore costs associated with pain and suffering as well as those of within-home care provided by family members, and because the numbers of occupational injuries and illnesses are likelyto be undercounted. Conclusions: The costs of occupational injuries and illnesses are high, in sharp contrast to the limited public attention and societal resources devoted to their prevention and amelioration. Occupational injuries and illnesses are an insufficiently appreciated contributor to the total burden of health care costs in the United States.

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MOST PEOPLE between the ages of 22 and 65 years spend roughly 40% of their waking hours at work. Some risk of injury or illness attends virtually every job held by the 120 million Americans who work./1,2/ Yet few studies/3,4/ have assessed or estimated the national incidence or prevalence of occupational injuries or illnesses. Even fewer studies/5-7/ have attempted to calculate the costs of either these injuries or illnesses. This is unfortunate, especially since costs have become a critical measure in the health care debate. Knowing costs is important, because it allows comparisons with such disparate health care conditions as acquired immunodeficiency syndrome, Alzheimer disease, circulatory diseases, cancer, and musculoskeletal conditions.

We report estimates of the numbers and direct and indirect costs ofjob-related injuries and illnesses in the United States in 1992. We summarize a recent report/8/ to the National Institute for Occupational Safety and Health on costs of occupational injuries and illnesses. Standard epidemiological, economic, and accounting techniques were applied to national sources of data to estimate incidence and costs of injuries and illnesses incurred at work.

This study appears to be unique in the literature. To our knowledge, no prior study uses national data to generate estimates ofthe burden and costs of occupational injuries and illnesses in the United States. Only 1 previously published study/9/ has attempted to estimate these combined costs of occupational injury and illness, butit was limited to Pennsylvania.

RESULTS

BURDEN OF OCCUPATIONAL INJURIES

We estimated that 6529 workers died from workplace-related injuriesin the United States in 1992. This point estimate was drawn from a range of 6063 to 10,000, which was determined by adjustments to totals of deaths caused by injury estimated by the Census,/2/ National Safety Council,/6/ Supplementary Data System and Bureau of Labor Statistics,/11/ National Traumatic Study,/12/ National Council,/13/ and the National Health Interview Survey./20/ The point estimate was closer to the lower bound, reflecting increased emphasison the Census, which provided the lower-bound estimate.

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

We estimated 13,247 million nonfatal injuries . Disabling injuries accounted for 6.09 million and nondisabling accounted for 7.15 million injuries . The following percentages of disabling injuries were in each workers' compensation category: 0.18% for permanent total, 12.507% for permanent partial, 30.94% for temporary total and partial, and 56.34% for 1 to 7 days of disability. This last categorywas necessary because workers' compensation required at least 3 and sometimes 7 days of work loss before any of the 3 categories--permanent total, permanent partial, and temporary total and partial--applied.

BURDEN OF OCCUPATIONAL DISEASE

We estimated that 817,000 to 907,400 new cases of occupational illnesses and 46,900 to 73,700 deaths resulted from occupational diseases in the United States in 1992 (Table 1 and Table 2). The midpoints for these estimates were 862,200 new cases of illness and 60,300 deaths.

Table 1 provides the results of applying the attributable occupational proportions ascribed to 5 major categories of disease and pneumoconioses. Cancer dominated these estimates because of its high overall incidence and because of the restriction of occupationally associated cardiovascular and cerebrovascular deaths to persons younger than 65 years.

Table 2 presents data on occupational morbidity. In the top of the table, established data sources provided estimates of readily recognized occupational diseases, including the Annual Survey/10/ (457,400 occupational illnesses), the Adult Blood Lead Surveillance program/76/ of National Institute for Occupational Safety and Health (14,250 workers with elevated blood lead levels), and public-sector employees (92,010 occupational illnesses). The numbers of cases of occupational disease among federal and nonfederal government workers were obtained by applying 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 rate was derived from federal and state data/74/ and R. Slighter (oral communication, September 1994).

In the bottom of Table 2 estimates are presented based on the proportion model. Assuming that 6% to 10% of cancers in adults aged 25 years and older estimated by the American Cancer Society are occupational in origin, then 66,790 to 111,310 new cases of cancer were caused by workplace factors in 1992.

Data for the national incidence for coronary heart disease are lessthan optimal, since they are extrapolated from the Framingham/77,78/ heart disease sample of approximately 5000 people. Nonetheless, thesedata 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 years, inclusive./77,78/ Approximately 78,000 of these half million myocardial infarctions arefatal. The Framingham database has also allowed an estimation of approximately 200,000 new cases of uncomplicated angina pectoris eachyear in the United States among people younger than 65 years./78/

Applying the proportional 5% to 10% range cited above, we estimated36,500 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 attributable to occupational risk factors.

Applying similar Framingham statistics,/77,78/ we estimate that 5050 to 14,400 strokes and transient ischemic attacks among people older than 24 years but younger than 65 years are associated with occupational exposures.

National data on the incidence of COPD are virtually nonexistent. The one estimate we found was 1.5 million new cases of COPD in 1984./79/ Given the rise of COPD mortality from 27.7 per 100,000 in the United States in 1984 to 34.1 per 100,000 in 1992,/24,95/ the estimate of 1.5 million is likely to be an underestimate of the annual number of new cases of COPD in the 1990s. Applying our estimated percentage of COPD attributable to occupational exposures, 10%, yields an estimate of 150,000 new cases of COPD.

Lack of data on the numbers of new cases of renal and neurological disease that occur in the United States each year preclude application of the occupational attributable proportion approach to obtain estimates of occupational renal and neurological morbidity.

DIRECT AND INDIRECT COST ESTIMATES OF INJURIES

In 1992, injuries in the workplace generated a total of direct and indirect costs of $145.37 billion (Table 3). Direct costs of fatal and nonfatal injuries were $49.17 billion. While these costs were clearly substantial, they represented only 34% of total costs, with indirect costs contributing 66%. Costs can be further described within the broad direct and indirect categories as shown in Table 3. Of the $49 billion in direct costs, $25.1 billion was spent on physicians, hospitals, drugs, nursing homes, and rehabilitation providers; $5.7 and $8.9 billion covered medical and indemnity insurance administration expenses; $8.7 billion covered property damage; and $0.8 billion paid for police and fire services. The $96.2billion of indirect costs can also be disaggregated (Table 3): $68 billion in wage losses, $14 billion in fringe benefits, $8 billion inhome production losses, $5.2 billion for workplace training, and $0.3for time delays.

DIRECT AND INDIRECT ESTIMATES OF ILLNESSES

The economic cost of occupational disease in the United States is estimated to be $25.5 billion (Table 4) at midpoint with a range of $18.8 billion to $30.0 billion in 1992 dollars. Deaths alone from the5 major disease categories generate a midpoint estimate of $19.7 billion while newly diagnosed, reported illnesses alone generated a midpoint estimate of $5.8 billion. Of the $19.7 billion losses because of deaths, direct costs accounted for 54%, mortality costs for 36%, and morbidity costs for 10%. Direct costs included 92% of total losses for reported nonfatal occupational illness. The results are summarized in Table 4.

The distribution by diagnosis of total economic costs for fatal occupational diseases showed the greatest losses were associated withoccupational cancer ($9.4 billion), diseases of the circulatory system ($5.8 billion), and chronic respiratory disease ($3.9 billion). These 3 diseases accounted for 97% of the economic costs offatal occupational illness.

Total estimated costs of deaths caused by pneumoconiosis amounted to \$202 million. Total estimated costs for renal disorders amounted to \$151 million, with a range from \$15 to \$225 million.

SUMMARY OF COST

Table 4 summarizes the total costs associated with occupational injuries and illnesses in the Untied States in 1992. The estimated 6500 deaths from injury , 13.2 million nonfatal injuries , 60,300 deaths caused by disease, and 857,500 illnesses resulted in estimatedcosts of \$170.9 billion in 1992, roughly 3% of the gross domestic product.

SENSITIVITY ANALYSIS

Our sensitivity analysis is captured by the ranges of our estimates. These ranges relied on the lower and upper bounds for the number of injuries and illnesses as well as alternative ratio estimates for the costs of illnesses. Lower bounds involved exclusivereliance on the 3 most widely cited surveys: the Census,/2/ the Annual Survey,/10/ and the National Health Interview Survey. The estimates for each are 6063 deaths and 6.3 million and 8.7 million nonfatal injuries . At a lower-bound minimum, the Annual Survey needs to be adjusted to capture government employees, the self-employed, and farms with fewer than 11 employees. By applying the Annual Surveyrate (8.3 per 100 employees) to the number of full-time equivalent employed persons, we estimated 8.8 million injuries . Our lower-bound estimate for deaths was 6063 and our lower-bound estimate for nonfatal injuries was 8.75 million (8.75 was the average of 8.8 and 8.7). Now 6063 is 7% less than our preferred estimate of 6529 deaths and 8.75 million is 34% less than our preferred estimate of 13.25 million nonfatal injuries . Conservatively assuming that 34% is the relevant statistic, our lower-bound cost estimate would be \$96.6 billion.

Upper bounds rely on the National Safety Council's/6/ estimate for deaths adjusted for murders: 10,000; the Annual Survey,/10/ assuming the same percentage undercount of deaths in the Census applies to nonfatal cases: 19.8 million injuries ; and assuming that the percentage difference between the upper-bound nonfatal cases and our preferred estimate applies to costs: \$217 billion.

Ranges for occupational diseases were already estimated with the proportion model mentioned above: 46,899 to 73,681 deaths and 817,015to 907,385 for new cases of illnesses. To assess the reliability of our disease cost estimates, we (1) estimated morbidity costs using a second technique in which estimates were based on ratios of morbiditycosts to direct costs and (2) applied average cost figures to the ranges of disease estimates. We estimated our ratio as a linear function of the 1980 and 1985 ratios calculated by Rice and colleagues./80,81/ Our lower and upper bounds for cost were \$18.8 and\$30 billion. The lower-bound estimate is \$6.7 billion less than our point estimate of \$25.5 for diseases. This \$6.7 billion represents 3.9% of our point estimate for diseases and injuries .

That is, if we assume the smallest percentages apply in the proportionate attributable risk model (eg, 6% for cancer and 5% for circulatory disease) and if we apply the lowest average cost estimates, our totalcosts for both diseases and injuries would decrease by only 3.9% to $164.2 billion.

The ranges of all estimates are summarized in Table 5. Total costs for both diseases and injuries range from $115.7 to $247 billion.

The sensitivity analysis did not adjust for varying discount rates for the simple reason that the varying discount rates would not greatly alter the findings. The discount rates used only influenced mortality costs. Our preferred estimates of the costs of deaths caused by injury and illness--roughly $27 billion--represents roughly15% of total costs. Moreover, the bulk of these $27 billion--$19.7 billion--was attributed to illness. Deaths caused by illness tend to occur later, (eg, 65 years of age) than deaths from injury (eg, 25 years of age). This is important because varying discount rates will result in much greater variation in costs when dollars lost 30 or 40 years from now are compared with 5 to 10 years from now. In our estimates, much greater cost variation was associated with variation of the number and kinds of injuries and illnesses than with variationin discount rates.

COMMENT

Identifying the costs of occupational injury and disease in the United States has been an elusive goal. Our study represents, to our knowledge, the first attempt to estimate the national cost of occupational injury and illness using national data. Recent improvements in national data systems such as the Census/2/ and the Annual Survey/10/ provide increasing confidence that the overall magnitude of the problem can be approximated. Proper interpretation of national surveys, recognition of the deficiencies of workers' compensation reports, extensive examination of National Council cost data, and prudent application of an attributable proportion model to major causes of diseases provided the foundation for our study of thecivilian workforce in 1992. Any single source of data, such as the Annual Survey, National Institute for Occupational Safety and Health,workers' compensation, or National Health Interview Survey, underestimated the numbers of injuries and illnesses. Multiple data sources must be combined to provide comprehensive and reasonably accurate national estimates. In all, we considered 14 primary sourcesand more than 200 secondary sources, each of which had limitations. Indeed, in the medical costs literature, the heterogeneity of data has been singled out as the most serious of all limitations./4,6,81/

An advantage of our study is that we implicitly accounted for the severity of injuries by estimating the number of permanent total and permanent partial injuries as defined by workers' compensation authorities. Injuries resulting in permanent impairments are expensive. Future researchers will have even better estimates of severity since the Annual Survey/10/ now gathers and publishes data on days absent because of particular injuries and illnesses.

Because of the incomplete data, these estimates have important caveats. They tend to produce an underestimate of burden and costs ofoccupational illnesses and injuries . Our counts of the numbers of occupational injuries and illnesses tend to be low because they exclude injuries and illnesses among military personnel, use a conservative estimate (55%) of the degree to which workers' compensation undercounts occupational fatalities,/2/ restrict occupational cardiovascular and cerebrovascular morbidity and mortality to events among people younger than 65 years, and use data from a year of high unemployment (1992). Costs are concomitantly lowered, since their estimation relies on the counts of injuries and illnesses. In addition, costs tend to be underestimated because they omitted the costs of pain and suffering, used average medical cost data from the National Council database that excluded 2 high-cost states (California and New York), failed to include home care costs provided by the family, ignored the deleterious effect on children ofhaving a disabled or absent parent,/96/ and did not include the wage losses suffered by disabled workers hired into new, less lucrative jobs./97/ Other important sources of underestimation are failure to include lost workdays in years other than the one in which the occupational illness occurred, a well-described limitation/98/ of theAnnual Survey, and exclusion of costs to innocent bystanders, eg, airline crash. Finally, we did not allow for recurring injuries . For example, once the knee has been injured , it is easier to injure it again. If the second injury occurs at home, no percentage of the second one is assumed to be job related.

In calculating our medical expenses for injuries , we relied heavilyon cost data from workers' compensation because they were readily available and complete (ie, workers' compensation pays virtually 100%of medical bills). Baker and Krueger/99/ have argued that workers' compensation payments to physicians exaggerate true medical costs associated with an injury or illness. Yet the study by Baker and Krueger found that hospital costs (the bulk of all medical costs) were less for workers' compensation than for nonworkers' compensationinsurance and did not account for the cost of litigation and paperwork surrounding workers' compensation claims./100/

While the use of proportions of major categories of disease attributable to occupational exposures may be controversial, we attempted to use ranges that are plausible and consistent with present knowledge. Ranges of estimates of similar magnitudes have been used by occupational health researchers, including ourselves, instudying occupational disease in diverse geographical regions, including New York, Connecticut, Texas, New Jersey, Pennsylvania, andCanada./101-106/

Our study methods and results are consonant with the relatively fewstudies of occupational injury and illness costs that have been conducted to date. Hoskin et al/6/ applied an incidence-based approach to National Safety Council data and estimated the total costfor job-related injuries to be $115.9 billion in 1992. The discrepancy with our estimate

($145 billion) is largely the result of2 factors: (1) the National Safety Council explicitly ignored violentincidents (assault, murder, and suicide), and more important, (2) theNational Safety Council relied on the National Health Interview Survey estimate of nonfatal work injuries , which only captures roughly 60% of all nonfatal injuries . Interestingly, the relative proportions of the estimates of direct and indirect costs were similar in our study and the study by Hoskin et al./6/

Miller and Galbraith/5/ combined occupational injury statistics from 1989 with the National Council medical cost data to obtain an estimate of 11 million occupational injuries (disabling and nondisabling) in 1989. These injuries were associated with costs of $96.6 billion in 1990 dollars. Adjusting for the inflation rate between 1990 and 1992, their estimate was within 10% of the estimate derived from Hoskin et al./6/ Although many of our methods were similar to Miller and Galbraith,/5/ our cost estimates were higher inpart because our estimate of injuries , 13.25 million, was higher. In addition, we included occupational diseases, and we also assumed higher administrative costs.

Neumark et al/9/ estimated the incidence cost of occupational injuries and diseases in Pennsylvania in 1987 through 1989. They extrapolated to the United States and found a mean estimate of $54.5 billion for illnesses and injuries . This estimate appears to be too low. Their total cost estimate for injuries alone--$17 billion for the late 1980s--was less than half the national costs of injury of workers' compensation in the same year./107/

Marquis/14/ estimated that 7 million Americans suffered injuries onthe job in 1989, and another 4 million had persistent disability in 1989 as a result of an injury that occurred prior to 1989. She estimated a total cost of $83 billion in 1989, including 40% for direct (medical) costs and 60% for cost of work loss. The study by Marquis/14/ has important limitations. It excluded fatalities, a considerable number of violent incidents, and minor injuries (involving 1-4 days of work loss). Minorities and the poor were also underrepresented--groups that are more likely than other groups to experience injuries on and off the job./108,109/

Finally, Webster and Snook/110/ estimated that the total workers' compensation costs of back injury and pain in the United States was $11.1 billion in 1986. If we assume (1) workers' compensation only captures 45% of all cases, (2) administrative costs add an additional21% for medical (our average of workers' compensation and nonworkers'compensation) and 16% for indemnity (our average of workers' compensation and nonworkers' compensation), (3) related direct and indirect costs (home production and workplace disruption, fringe benefits, and so on) were 27% (our average), and (4) an average medical and wage inflation of 35% from 1986 to 1992,/79/ then beginning with Webster and Snook's $11.1 billion, the adjusted 1992 estimate costs of back pain attributable to job-related factors wouldbe $49.2 billion. This $49.2 represents 34% of our total $145.37 billion. This compares favorably with the National Safety Council estimate of back pain contributing 31%. The close proximity of these 2 estimates provides 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.

The costs of occupational injuries and illnesses are large comparedwith other diseases. The direct and indirect costs of acquired immunodeficiency syndrome were estimated to be roughly $30.0 billion in 1992,/111,112/ excluding insurance administration costs. Our costs, also excluding administration, were roughly $155 billion.

Alzheimer disease was recently estimated to cost $20.6 billion in direct costs and $46.7 billion in indirect costs, including administration./113/

Cardiovascular and cerebrovascular disease are common and costly. The most reliable estimate of the costs of all circulatory disease dates to 1980. Rice et al/80/ estimated $32.5 billion in direct costsand $47.1 billion in indirect costs in 1980. To bring these 1980 estimates up to 1992 requires several assumptions, involving inflation and secular trends in the rates of these categories of disease as well as administration costs. With these assumptions, we calculated that the total costs for all circulatory diseases would be$164.3 billion in 1992. Similar calculations can be carried out for the costs of cancer./80/ We estimated a $170.7 billion cost for cancer in 1992.

The direct and indirect costs, including administration, of all musculoskeletal conditions was estimated to be $149 billion in 1992./114/

In summary, the medical costs of occupational injuries and illnesses appear to be much larger than those for acquired immunodeficiency syndrome. The total costs of occupational injuries and illnesses appears to be considerably larger than those for Alzheimer disease and are of the same magnitude as those of cancer, of all circulatory disease, and of all musculoskeletal conditions. These costs are high in part because so many people are at risk; 120 million people held jobs in the United States in 1992.

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Reprints: J. Paul Leigh , PhD, Department of Economics, San Jose State University, 1 Washington Sq, San Jose, CA 95192-0114.

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METHODS

INCIDENCE OF OCCUPATIONAL INJURIES , 1992

Deaths

Several primary and secondary sources of data were used to construct our estimate of deaths from injury . Primary sources included the Census of Fatal Occupational Injuries (Census),/2/ the Annual Survey of Occupational Injuries and Illnesses (Annual Survey),/10/ and the Supplementary Data System of the US Bureau of Labor Statistics,/11/ the National Traumatic Occupational Fatality Study (National Traumatic Study) of the National Institute for Occupational Safety and Health/12/; and the workers' compensation data of the National Council on Compensation Insurance (National Council)./13/ Secondary sources included the National Safety Council's Accident Facts/6/ and reports by Miller/4/ and Marquis./14/

The Census/2/ is regarded as a most reliable primary data source since it uniquely requires confirmation of a work-related death by 2 separate sources. However, like the National Traumatic Study,/12/ theCensus depends largely on death certificates, which are known to undercount work-related deaths by 10% to 40%./2,15-19/ We nevertheless judged that the Census and the National Traumatic Study provided the best data on civilian deaths and weighted them more heavily than all the other estimates in calculating our estimate. To obtain a summary estimate of the number of traumatic deaths in the United States in 1992, we adjusted all the death estimates from the literature except the one derived from the Census. The unadjusted (listed first) and adjusted (listed second) estimates were the following: the Census/2/ (6063, 6063); National Traumatic Study/12/ (5714, 6346); Annual Survey/10/ (2800, 5584); National Council/13/ (3306, 8306); Supplementary Data System/11/ (5601, 6994); National Safety Council/6/ (8500, 10,000); and Miller/4/ (11,900, 9678). The adjustments reflected deficiencies such as relying only on workers' compensation data, ignoring murders, ignoring deaths in small firms and among the self-employed, ignoring data from California, New York,and other states, and for our purpose, not reporting data for 1992. Apart from this last point about 1992, the authors of these studies acknowledge these deficiencies. To calculate our global estimates, weassigned different weights to the individual estimates as follows: Census (0.6), National Traumatic Study (0.2), and all others (0.04). We developed an econometric forecasting model to update all estimatesin the published literature to 1992.

Nonfatal Injuries

For nonfatal injuries we analyzed 3 primary sources--the Annual Survey,/10/ the National Council ultimate reports, and the National Health Interview Survey/20/--the same secondary sources identified above as well as studies by Miller/4/ and Marquis./14/ Each of the primary sources suffered from serious undercounts, especially the Annual Survey/10/--the primary data source most frequently cited in the literature.

The 1992 Annual Survey/10/ reflects questionnaire data reported by employers from a stratified sample of approximately 250,000 private-sector firms. The Annual Survey does not cover government workers, the self-employed, and farmswith fewer than 11 employees. Moreover, the Annual Survey is collected from private firms that facean economic incentive to underreport./21/ All these deficiencies leadto underestimates that range from just less than 50% to more than 70%. For example, the Census/2/ shows an undercount of deaths of 71%.Nelson et al/22/ demonstrate a 60% undercount for cumulative trauma disorders (conditions that are accounted for in our illness estimates). The data by Ruser/23/ indicate an undercount for all nonfatal injuries and illnesses of roughly 53% caused by economic incentives alone. We made adjustments for each of these factors. For example, we multiplied the incidence of work-related injuries among private-sector companies by the population of all civilian persons employed, including government workers, the self-employed, and farm workers. Another estimate that did not receive full weighting was generated by assuming that the percentage undercount of deaths in theAnnual Survey would be identical to the percentage undercount of nonfatal injuries . We reasoned that it would be more difficult to ignore a death than a nonfatal injury , hence a percentage estimate ofthe undercount on nonfatal injuries should be at least as great as a percentage estimate of the undercount of deaths.

The unadjusted (listed first) and adjusted (listed second) estimates as well as the assigned weights (listed third) were the following: Annual Survey,/10/ 6.3 million, 13.99 million, and 0.4; National Institute for Occupational Safety and Health,/12/ 4.7 million, 17.21 million, and 0.15; National Health Interview Survey,/20/ 8.7 million, 11 million, and 0.15; Marquis,/14/ 7 million, 13.2 million, and 0.15; and Miller,/4/ 11 million, 10.8 million, and 0.15. Again, each of these studies suffers deficiencies that the authors acknowledge. For example, the National Health Interview Survey likely misses a high percentage of assaults. Our adjustments attempted to account for each of these deficiencies.

We categorized injuries as traumatic deaths, disabling injuries , and nondisabling injuries . Disabling means that the injury resulted in at least 1 day of work loss, while nondisabling means no loss of afull workday. Within the disabling category, there are 3 workers' compensation categories: permanent total, permanent partial, and temporary total and partial. Although there are a few legal exceptions, permanent total generally means the person will never work again at any job. Permanent partial is the next most severe category, it means the person will probably never work again at the preinjury job, but, with training, may find a different job. Temporary total and partial means temporarily out of work or working at diminished capacity but fully anticipating returning to the preinjury job. Injuries were split into these workers' compensation categories so that they could be matched to reliable workers' compensation cost data. We did not categorize injuries by type, ie, head injury , amputation of fingers, and so on, since cost data for injuries categorized this way are not uniform, ie, they originate with studies using varied assumptions. Moreover, an accident could have resulted in more than

1 injury and classified by body part, eg, a car crash could cause a concussion and a finger amputation.

The source estimates, Annual Survey/10/ through Miller and Galbraith,/5/ were used to generate one global estimate of all disabling and nondisabling injuries . The global estimate was then decomposed into workers' compensation categories based on percentagesdrawn from National Council reports./13/

INCIDENCE OF OCCUPATIONAL ILLNESS

Deaths

An estimate of annual deaths attributable to occupational diseases was obtained by combining 2 approaches. The numbers of deaths attributable to occupation-specific causes in 1992 are recorded in the mortality statistics gathered by the National Center for Health Statistics./24,25/ These occupation-specific causes include mesothelioma and the pneumoconioses, for which all, or virtually all,cases can be attributed to occupational exposures./26/

Since few diseases are caused solely by occupational exposures, a second approach was used--an attributable risk proportion model. In this method, percentages of deaths in major disease categories are attributed to occupational exposures. Given the uncertainty in knowledge of the exact proportions of deaths attributable to occupation, ranges and point estimates of proportions of deaths were used, including 6% to 10% of cancer, 5% to 10% of cardiovascular and cerebrovascular disease, 10% of chronic respiratory disease, 100% of pneumoconioses, and 1% to 3% of nervous system disorders and renal disorders. In estimating these deaths, we ignored decedents aged 24 years or younger for all categories of deaths, and for circulatory diseases we also excluded decedents older than 65 years.

Rationale for Attributable Risk Proportion Model

Selection of these ranges of attributable proportions is based on literature in occupational medicine and related disciplines. The estimate of 6% to 10% of all cancer attributable to occupational exposures is grounded in part on specific studies of selected cancersand in part on general trends in human and animal cancer research. Atleast a dozen case-control studies, after controlling for cigarette smoking, collectively show that 10% to 33% of all types of lung cancer in men are attributable to occupational exposures./27-39/ Applying a narrower range of point estimates, 15% to 20%, to the 91,405 deaths from lung cancer among men in the United States in 1992yields a total of 13,711 to 18,281 deaths in men from lung cancer caused by occupational agents. These deaths from lung cancer represent 2.7% to 3.5% of all deaths from cancer in the United Statesin 1992. A similar analysis of deaths from another well-documented occupational cancer, bladder cancer, provides an estimate that 21% to27% of deaths from bladder cancer for men are attributable to occupation in the United States./40,41/ Since there were 7123 deaths caused by bladder cancer among US men in 1992, 1496 to 1923 deaths caused by bladder cancer, or approximately 0.3% of all deaths caused by cancer, were attributable to occupational agents. Together bladdercancer and lung cancer among men alone accounted for approximately 3%to 4% of all deaths caused by cancer in the United States in 1992.

Four sets of research findings in occupational cancer in the last 10 to 15 years support the proposition that the percentage of cancer caused by occupation is significantly higher than the 3% to 4% specifically caused by cancer of the lung and bladder. First, recent studies have increased the likelihood that a number of well-known toxins or exposures are human carcinogens. Included in this category are silica and fiberglass and lung cancer/42/; electromagnetic radiation and vinyl chloride and brain cancer/43,44/; andorthotoluidine and bladder cancer./45,46/ For other common agents,limited evidence has accumulated to support a causative role in cancer. Among these agents are formaldehyde, 1,3 butadiene, and perchloroethylene./42/

Second, a number of studies demonstrate increased risks of cancer for specific occupations without clear identification of the suspect agents. Examples include farmers with lymphoma/47,48/ and firefighters with brain cancer./49-51/ Third, toxicological assays inanimals completed in the last 2 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 1 rodent species./52/ Among the most important agents that showed evidence of carcinogenicity in experiments conducted by the National Toxicology program are methylene chloride, tetrachloroethylene, and propylene oxide./52/ While there is considerable disagreement about the significance of the results of animal testing for human cancer,/53/ demonstration of carcinogenicityin animals is still considered evidence of likely carcinogenicity in humans./54/ Collectively, these studies suggest that the problem of occupational cancer may be larger than is recognized when only established human carcinogens are considered.

Fourth, side smoke from cigarettes is a likely carcinogen in some jobs. Clear patterns exist in occupations concerning cigarette use. Waitresses, bartenders, laborers, auto mechanics, welders, and kitchen workers, among others, report high cigarette use in recent surveys and in surveys from 20 years ago. On the other hand, teachers, physicians, nurses, dentists, clergy, and librarians, amongothers, report low cigarette use in the same surveys./55-57/

The estimate of 5% to 10% of cardiovascular and cerebrovascular disease is based on a number of studies showing that job strain or psychosocial stress causes excess morbidity and mortality/58,59/ and that selected common chemical exposures, such as lead, carbon monoxide, and solvents, adversely affect the heart./60,61/ We restrict our estimates of occupational cardiovascular and cerebrovascular disease to people aged 64 years and younger, because the long-term effects of cardiotoxic exposures are not well studied. Our 5% to 10% range for ages 25 through 64 years corresponds to a 0.6% to 1.2% range for all deaths from circulatory disease for all ages.

A number of large, well-performed, population-based studies/62-69/ consistently show that exposure to 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 chronic obstructive pulmonary disease (COPD). Other studies relatespecific occupational exposures, principally coal, silica, grain dust, and cadmium,/65/ and specific occupations to excess mortality from COPD./68,69/ To recognize the likelihood that occupational exposures play a limited but definite role in death caused by COPD, we assign an estimate of 10% mortality caused by COPD to occupationalexposures.

Renal toxic effects have been associated with occupational exposureto lead and mercury, glycol ethers, and other organic solvents./70,71/ Neurological disorders stemming from the workplace exposures have been caused by pesticides, heavy metals, many organic solvents, and other organic agents./72,73/ The quantitative burden ofrenal and neurological disease that these exposures impose is not known. We therefore assign a conservative range of 1% to 3%. Continued on next page

Morbidity

To estimate the number of acute and relatively well-recognized chronic occupational diseases (ie, dermatitis, repetitive strain injuries), the following data sources were used: the Annual Survey,/10/ the public-sector employee health and safety programs,/74/ the National Hospital Discharge Survey, and R. Slighter(US Dept of Labor, oral communication, September 1994).

The limitations of the Annual Survey/10/ are well recognized and are believed to produce a significant underestimate of occupational diseases./75/ The Annual Survey data counts illnesses of current employees. Retired persons are ignored. Yet many cancers, respiratorydiseases, cases of pneumoconioses, and so on do not manifest themselves until retirement. For example, we estimated 150,000 new job-related cases of COPD, and the Annual Survey/10/ counted 717 cases in 1992.

The Adult Blood Lead Epidemiology and Surveillance program,/76/ maintained by the National Institute for Occupational Safety and Health since 1992, collects adult blood lead data (blood lead level, <greater than or equal to>1.20 umol/L [<greater than or equal to>25 ug/dL]) from 20 states. Since these 20 states contain 60% of the US population and are among the most heavily industrialized states (eg, California, Illinois, New Jersey, New York, Pennsylvania, and Michigan), it is reasonably estimated that they contain 75% of all individuals who have elevated blood lead levels in the United States.The number of cases of lead poisoning recorded in the Adult Blood Lead Epidemiology and Surveillance program is adjusted upward by one third to allow a national estimate.

To obtain an estimate of the number of new cases of major chronic diseases, including cancer, chronic respiratory disease, and cardiovascular and cerebrovascular disease, we applied the same percentages to morbidity estimates as we did to mortality estimates as noted in the previous section. Numbers of new cases of these diseases in the general population were obtained from established data sources/76-81/ and from the American Cancer Society (S. Montgomery, written communication, March 2, 1995). Again, we also restricted analyses to persons aged 25 years and older, and in the case of cardiovascular and cerebrovascular diseases, to persons younger than 65 years.

COSTS

Theory

We adopted the direct and indirect or human capital method for calculating costs. The direct and indirect method is the most widely used method in the medical and legal literature in large part becauseestimates are available and reliable./80,81/

Direct costs represent actual dollars spent or anticipated to be spent on providing medical care to an injured or ill person as well as on property damage, police and fire services, and administrative costs for delivering indemnity benefits. Medical costs include physicians' andnurses' services, hospital charges, drug costs, rehabilitation services, ambulance fees, payments for medical equipment, and supplies. Indemnity benefit costs do not include the benefits themselves, rather they include the administration costs associated with providing workers' compensation indemnity or Social Security disability payments to injured or sick workers and their families. Property damage includes costs of damage to vehicles, machine, buildings, and so on directly associated with the injuries and illnesses.

The largest indirect costs include the injured or sick workers' lost earnings, fringe benefits, and home production. Other indirect costs include employer costs associated with retraining and restaffing, coworker costs of lost productivity, and time delays.

Two approaches can be used in estimating the costs of injury or illness by the direct and indirect method: prevalence and incidence techniques. Prevalence-based costs provide an estimate of the burden in a base year as a result of the prevalence of injury or disease. Included are the injury or illness costs during the base year whetherthey had their onset in the base year or any time prior to the base year. Incidence-based costs represent the lifetime costs resulting from a new injury or illness originating in the base year. In the aggregate, incidence costs in a given base year reflect the likely course of an injury or a disease and its duration, including survivalrates, medical care that will be used, and costs for the duration of the injury or diseases. We used the incidence method for all injuriesand morbidity estimates of reported incident disease. We used the prevalence method for the estimates of deaths caused by diseases and morbidity obtained by the proportionate attributable risk calculations described earlier.

Direct and Indirect Cost Application: Injuries

Estimation of the costs of injuries required multiplying the numberof injuries in each category by the average costs of such injuries . Direct average costs for medical care were drawn from the National Council/13/ ultimate reports. Lifetime medical costs (1992 dollars) for deaths were valued at $20,120, for permanent total at $132,419, for permanent partial at $17,920, for temporary total and partial at $3250, and for no work loss at $275. The medical expenses were drawn from workers' compensation accounts and did not require adjustment since workers' compensation paid virtually 100% of medical bills in 1992, ie, no copayments or deductibles were charged to clients.

The calculation of the indirect costs was based on a variety of sources, including National Council indemnity data and federal government data on employment, earnings, and mortality. Home production, as well as hiring, training, and workplace disruption, costs were priced in accord with estimates in the literature./82,83/ Indirect costs for fatalities required a present value calculation. We assumed that persons who died would have earned what others of thesame age and gender earned./5,81/

The distribution of deaths by age and sex were estimated with information from the Census./2/ These age and sex data were combined with information of wages, probabilities of survival to age 75 years,as well as the employment within those categories./84/ The present value formula we used was similar to the one used by Rice et al./81/PVDeath = 75n=yPy,s,nX[Ms,n+Hs,n+Fs,n]XLFPRs,n/X(1+g)n-y(1+r)n-y ,where PVd/eath/ indicates present discounted value of loss because of deathfrom injury per person; Py,s,n/, probability that a person of a certain sex and age will survive to a certain age; y, age at which the person was injured ; s, sex of person; n, age of person; Ms,n/, mean annual earnings of employed persons of a certain sex and age; Hs,n/, annual value of household production for person of sex and age; and LFPRs,n/, labor force participation rate: proportion of the population by sex and age that are employed in the labor market. The LFPR of 1 was for injured (not ill) persons who were working and older than 65 years; Fs,n/, fringe benefits by sex and age; g, rate of increase in labor productivity assumed to be 1%; and r, real discount rate assumed to be 4%.

The LFPR requires comment. Most people retire at or before the age of 65 years. We assumed that persons who died before the age of 65 years would have an LFPR of typical persons now older than 65 years, eg, 0.161 for men and 0.803 for women. However, a few of our injury decedents, before death, were older than 65 years and working. For these people we assumed an LFPR of 1.0, ie, we assumed that they would have continued working until the age of 75 years. We assumed noone would work beyond the age of 75 years. M represents average annual earnings for full-time and part-time employees. H represents the annual value of household production. Home production included changing diapers, reading to children, home repairs, building cabinets, plumbing repairs, and so on. Estimates on home production were drawn from Douglas et al/82/ and updated to 1992 using an inflation index. A rate of fringe benefits of 22% for men and 16% forwomen was used. The disparity reflects the greater likelihood that men were employed full-time.

The National Council/13/ figures also provided indemnity benefits that were used to estimate wage losses. The indemnity benefits themselves were not added to wage losses. The indemnity benefits wereadjusted assuming workers' compensation paid to clients for the following rates: 40% of pretax wages for permanent total conditions; 50% for permanent partial conditions and 60% for temporary total and partial conditions./85-87/ Fringe benefits were assumed to be 21% of the pretax wage for men and women combined.

Insurance administrative costs were assumed to range between 10% and 31% of medical expenses depending on the type of insurance. Private workers' compensation was assumed to have the highest/88/ andMedicare was assumed to have the least./89/ Estimates on the cost of property damage, time delays, and police and fire services were drawnfrom Blincoe and Faigin./90/

Direct and Indirect Cost Application: Disease

There are no national studies, to our knowledge, that describe the amount of hospital, physician, nursing, or other medical care required to treat patients with disease attributable to occupational risk factors. We therefore constructed our estimates, using availablenational expenditure data, and assuming disease-specific treatment patterns similar to the general population.

Using the National Hospital Discharge Survey,/91/ we calculated thetotal number of days spent in the hospital by patients with a primarydiagnosis for disease cost for diseases categories included in the attributable risk calculations of occupational diseases. Total days of hospitalization by disease group were transformed to obtain standardized proportions of national hospital utilization attributable to each occupational disease. We applied these disease-specific proportions to the national health expenditure accounts (minus nursing home costs), estimated by disease category bythe Health Care Financing Administration,/92/ 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./93/ These cost estimates, using diagnosis-specific nursing home length-of-stay data, were added to medical expenditure estimates.

Indirect costs were estimated using age-specific and sex-specific mortality data from the same sources identified above in the discussion of indirect costs of deaths caused by injury . By applying the occupational attributable proportions for deaths caused by disease, the present value of the indirect costs of premature mortality attributable to occupational disease was estimated for the base year 1992. Finally, we projected national disease-specific trends over time in the ratios of morbidity costs to direct costs andmorbidity costs to mortality costs/80,81/ to obtain an estimate of the morbidity costs for the occupational disease. All indirect costs estimates are presented in 1992 dollars and apply the same assumptions regarding age-specific LFPRs, discount rates, and administrative costs used to estimate the economic costs of occupational injury with one exception: we did not allow an LFPR of 1.0 for any persons older than 65 years for our disease estimates. Instead, we applied national averages for sex-specific rates for persons older than 65 years with occupational disease./84/ The 1.0 rate was used only for deaths caused by injury to those who before death were older than 65 years and working.

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 disease, carpal tunnel syndrome, and others, as reported to the Bureau of Labor Statistics./94/ Industry-specific wage rates were applied to lost work time to obtain an estimate of indirect costs. Direct costs were based on estimates obtained from published data from the National Council./13/

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Occupational Injuries Among Working Adolescents in New York State

Renate Belville, MA; Susan H. Pollack, MD; James H. Godbold, PhD; Philip J. Landrigan, MD, MSc

Objective.—To determine the number, distribution, determinants, and health consequences of occupational injuries among working adolescents in New York State.

Design.—A retrospective, population-based analysis of New York State workers' compensation award data and the Annual Demographic File, a supplement to the US Bureau of the Census Current Population Survey.

Participants.—Adolescents, aged 14 through 17 years, who received workers' compensation awards for occupational injury from 1980 through 1987.

Main Outcome Measures.—(1) Numbers, types, and rates of occupational injuries in working adolescents by age, sex, industry, and occupation; (2) health consequences of injury, especially disability and death; and (3) secular trends in injury award rates.

Results.—A total of 9656 adolescents were compensated for occupational injuries; 4201 compensated adolescents (43.5%) suffered permanent disability; 31 working adolescents died. The annual mean rate of compensated occupational injury was 28.2 per 10 000 adolescent workers. Rates were higher in males than in females and ranged from 8.2 per 10 000 in 14-year-old male workers to 46.8 per 10 000 in 17-year-old male workers. Highest rates by industry were seen in manufacturing (49.0/10 000 adolescent workers) and agriculture (46.2/10 000). Unskilled labor was the most dangerous occupation (52.3/10 000).

Conclusion.—Occupational injuries are a substantial and underrecognized contributor to the continuing epidemic of injury among adolescents.

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INJURY is the leading cause of lost years of life and a major cause of morbidity and disability among adolescents in the United States.[1-9] The contribution of occupational injuries to the epidemic of adolescent injury has not been adequately studied.

Each year, more than 100 occupational fatalities are estimated to occur among working adolescents.[10] Amputations, burns, fractures, eye injuries, and electrocutions have been reported.[11-15] In 1980, more than 23 000 adolescents in 24 states filed workers' compensation claims for occupational injuries,[5] and in 1988, more than 30 000 work-related injuries and illnesses were reported among children and adolescents in 26 states.[16]

More than 4 million children and adolescents are legally employed in the United States.[17] The conditions under which they work must comply with state child labor protection laws and with federal wage, hour, and safety regulations specified by the Fair Labor Standards Act of 1938. Except in agriculture, which the Fair Labor Standards Act regulates only to the age of 16 years, it prohibits work with dangerous machinery and toxic substances for children less than 18 years old in all industries. At age 14 years, adolescents may deliver newspapers, stock supermarket shelves, ring up and bag groceries, pump gas, and wash cars. However, work with most power tools, including meat slicers, pizza dough kneaders, and carpentry equipment, is prohibited. Construction work and work as assistant on a vehicle is prohibited until age 18.[18-20]

In violation of state and federal child labor laws, an additional large number of adolescents are employed illegally. Both US citizens and undocumented immigrants work for long hours at less than the legal minimum wage and on dangerous, prohibited machinery.[21] In 1988, the US General Accounting Office reported a 145% increase in detected violations of federal child labor law over the preceding 5 years.[16] The General Accounting Office estimated that 18% of 15-year-old workers were illegally employed.[22] A 1988 survey of 1106 high school students with work experience revealed that 24% had been asked to work "off the books."[23] An analysis of fatalities among working children by the Occupational Safety and Health Administration found that 70% involved violations of either the Occupational Safety and Health Act and/or the Fair Labor Standards Act.[10]

In New York State, approximately 428 000 adolescents aged 14 through 17 years are employed each year (Tom Corban, written communication, March 1989; unpublished data from the March 1985, 1986, and 1987 Current Population Surveys conducted by the Bureau of Labor Statistics of the New York State Department of Labor). To determine the distribution, determinants, and health consequences of occupational injury in this population, we performed an epidemiologic analysis of workers' compensation data.

METHODS

Injury Data

Data on injuries among working adolescents aged 14 through 17 years were obtained from the New York State Workers' Compensation files for the years 1980 through 1987. Workers' compensation data in New York State are entered in a computerized file at the time of closure of each case after legal criteria for eligibility have been satisfied and the workers' compensation board has determined the amount of the award.[24] Rejected claims are not entered into the computer files and are not available by age, sex, industry, or other identifying criteria.

Workers' compensation files contain information on the age and sex of each compensated adolescent, the industry and occupation in which each injury occurred, the source and nature of injury, the extent of injury, and the estimated indemnity cost. Disability may be permanent or temporary. Permanent disability includes fatal injuries, as well as injuries that permanently incapacitate an adolescent (partially or fully), injuries that result in partial or complete loss of vision or hearing, and injuries resulting in the loss or loss of use of any limb or appendage. Temporary disabil-

From the Division of Environmental and Occupational Medicine, Department of Community Medicine, Mount Sinai School of Medicine, New York, NY

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Reprint requests to the Division of Environmental and Occupational Medicine, Department of Community Medicine, Mount Sinai School of Medicine, One Gustave L. Levy Pl, Box 1045, New York, NY 10029 (Dr Belville).

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Health Costs of Occupational Disease in New York State

Marianne C. Fahs, PhD, MPH, Steven B. Markowitz, MD, Ellen Fischer, PhD, MPA, Judy Shapiro, BA, and Philip J. Landrigan, MD, MSc

Occupational diseases and deaths are costly events. They are responsible for: 1) direct medical costs; 2) indirect costs, resulting from lost production, foregone opportunities, and diminished investment; and 3) non-economic costs, including pain and suffering, disrupted careers, and devastated families. To develop a partial estimate of the total costs of occupational disease in New York State, we have examined four categories of illness: occupational cancer, chronic respiratory disease and the pneumoconioses, cerebrovascular and cardiovascular disease, and end-stage renal failure. We base our partial estimate on the human capital approach to the costs of these illnesses. Using the best measures available, including both incidence and prevalence statistics, mortality records, and a variety of financial data, we employ two cost accounting techniques of the human capital approach, the incidence method, and the prevalence method. Our analysis shows that these four occupational illnesses are costing New York over $600 million per year. This figure is a pragmatic but conservative, lower-bound estimate of the relative magnitude of total economic costs of occupational disease in New York State. The largest proportion of these costs (80%) is due to occupational cancer. The failure of the health care system to recognize the costs of occupational disease precludes recognition of the economic benefits which would result from preventing these illnesses. This study, it is hoped, will stimulate advances in epidemiological and economic approaches to resolve this important measurement problem.

Key words: economics, cost-of-illness, direct costs, indirect costs, expenditures, human capital approach, earnings loss, occupational cancer

INTRODUCTION

Occupational disease is a serious problem in our society. The economic costs associated with occupational disease affect health care costs to the entire American economy. The problem is especially acute in New York State, which contains close to one-tenth of the nation's total workforce [Landrigan, 1989]. However, little em-

Division of Health Economics (M.C.F.), Division of Environmental and Occupational Medicine (S.B.M., E.F., J.S., P.J.L.), and Division of Epidemiology, Department of Community Medicine, Mount Sinai School of Medicine, City University of New York, New York.
Address reprint requests to M. Fahs, Ph.D., M.P.H., Box 1043, Mount Sinai School of Medicine, 1 Gustave Levy Place, New York, NY 10029.
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pirical information is available on the actual burden to society which is due to the costs of occupational disease [Salkever, 1985; U.S. Congress, 1985; Johnson and Heler, 1983]. With such knowledge, the potential savings produced by more effective prevention activities could be estimated. This report is an attempt to develop figures on the costs of occupational disease in New York State by using a variety of statistical data sources and estimating techniques. The study, it is hoped, will stimulate advances in epidemiological and economic approaches to this important measurement problem.

Concern over the lack of data regarding the costs of occupationally related disease is not new. In 1981, the Institute of Medicine strongly urged that longitudinal surveys of workers be initiated to analyze prospectively the costs of occupational illness, by type of worker, by industry, and by diagnosis [Institute of Medicine, 1981]. Yet data on expenditures by diagnosis for occupationally related disease remain unavailable in any cohesive form representative of worker populations.

Estimates of the economic costs of occupational disease have at least two purposes. First, economic estimates can play a role in informing the political and administrative decision-making processes which shape occupational health policy. Second, economic estimates can illuminate value judgments. Public and private responsibility for worker health is diffused when the assumptions that underlie industrial health policies remain implicit. Economic analyses can make those assumptions explicit, through contrasting the benefits and costs of alternative occupational health policies. For these two reasons, economic analysis can be used as a tool to encourage rational health and labor policies.

In 1986, the New York State Legislature and the State Department of Labor requested that a study be undertaken to identify and analyze the economic costs of occupationally related disease in New York State. This paper reports the results of that study. It is the first analysis, to our knowledge, to provide an indication of the relative magnitude of the health care costs of occupational illness in a defined population of workers.

METHODOLOGY

Many theoretical and practical problems confront the analyst who approaches the task of collecting and analyzing information on the health costs of occupational disease. Foremost among these problems is that the estimation of the economic costs of occupational illness depends to a great extent on the available data relating disease to occupational hazards. Owing to well-documented idiosyncrasies in the manner by which the majority of occupational diseases are managed and recorded, accurate data on incidence, prevalence, and medical costs are difficult to secure [Institute of Medicine, 1981; Levinson, 1979].

There are problems also with the methods used to estimate the costs of illness [Hodgson and Meiners, 1982; Scitovsky, 1982; Ashford, 1982; Rice and Hodgson, 1982; Robinson, 1986; Torrance, 1986]. Human life does not have a single established market value. In general, economic calculations do not present complete estimates of the true costs of illness. The intangible aspects of disability, such as loss of self-esteem, pain, and emotional harm suffered by a patient's family and friends, are immeasurable.

A complete measure of the economic costs for all occupationally related disease in New York is impossible, at present, without improved epidemiological data and data on expenditures by age, sex, and diagnosis. This state of affairs forces the analyst to piece together a model of incidence, prevalence, and economic cost. By using a combination of methodologic approaches, chosen for their appropriateness by the fit between method and data availability, it has been possible to assemble the first reliable lower-bound estimate of the economic costs of selected occupational diseases in New York State.

Epidemiologic estimates indicate that at least 35,000 new cases of occupational disease and at least 5,000 deaths caused by these diseases occur each year in the state [Markowitz et al., 1989]. These estimates provide the basis for calculations of the economic costs to New York State associated with those workers who are made ill by occupational exposure. The derivation of the epidemiologic estimates is described in a companion article [Markowitz et al., 1989]. In this report we present the economic calculus used to derive the costs of these illnesses.

Estimates of the economic costs of illness and death associated with occupationally related cancer and, to a more limited extent, with stroke, heart disease, the pneumoconioses, chronic respiratory disease, and renal failure are based on the human capital approach to the calculation of the costs of illness [Rice, 1966; Cooper and Rice, 1976; Rice et al., 1985; Parsons et al., 1986; Oster et al., 1984; Hartunian et al., 1981]. It is currently the most widely used method to calculate the cost of illness. The human capital method measures the value of actual resources foregone and output lost due to illness and disease, such as lost earnings or costs of medical treatment.

With this method, costs are divided into direct and indirect costs. Direct costs are the value of resources that could be allocated to other uses in the absence of occupational disease. They include expenditures for hospitalization, physicians' services, nursing home care, drugs, medical appliances, and related items. Indirect costs are the value of the lost output of workers and retirees suffering premature death or disability. These costs are measured in terms of the wages that would have been earned by these individuals if they had not contracted an occupational disease. In addition to earnings loss, indirect costs include the loss of household production services caused by disability and death from occupational disease. Values for housekeeping services performed by men and women are assigned according to the market wages that would be paid to hired workers for those services.

One difficulty with the human capital method is that it may greatly underestimate the cost of illness for those people, such as retirees, who are not currently in the labor force and therefore do not incur a large wage loss when they die. Another difficulty is that it tends to reinforce existing income distributions. To the extent that market imperfections result in an inequitable distribution of wages and salaries for certain groups (e.g., women and minorities), economic costs for these groups will tend to be underestimated.

With the human capital approach, the partial costs of occupational disease are estimated by using two different cost accounting techniques, the incidence method and the prevalence method. The incidence method focuses on the total cost stream over the patient's remaining lifetime following the onset of disease. By following the stream of disease-related events over the course of an individual's life and, in the case of death, by estimating the difference in life expectancy and the loss of output associated with becoming ill, the incidence method allows calculation of the full economic impact of becoming ill. Because not all costs occur in the same year, the value for future cost components of illness, disability, or death must be adjusted to be equivalent to the value of current cost components. This is done by discounting. Discounting causes higher values to be assigned to current costs and lower values to be assigned to those occurring in the future. In summary, using the incidence approach, one is able to assess the full annual economic impact attributable to disease incidence. For decision makers evaluating the impact of disease prevention programs, it is the method of choice [Hartunian et al., 1980].

The prevalence method is the more commonly used accounting strategy, due to the less extensive data requirements. This approach is primarily concerned with costs occurring during a fixed period of time, normally a calendar year. The cost of disease prevalence is measured by the cost of the resources consumed as a result of the disease during 1 year and by the value of the lost productivity resulting from morbidity and premature mortality caused by the disease during that year. The future costs of the premature mortality are discounted and assigned to the year in question.

Neither the prevalence nor the incidence method is superior in all circumstances [Hartunian et al., 1980]. Each contributes a useful basis for comparison. Generally, the prevalence approach will yield slightly higher estimates, due to the difference in discounting (the higher the discount rate, the greater the discrepancy). The numerical differences between the two methods will tend to disappear for conditions that are limited in duration (mesothelioma), or for conditions with relatively high direct and morbidity costs (asbestosis) as opposed to proportionately greater mortality costs (hemorrhagic strokes). While either method can be deemed unsuitable for some analyses (for instance, the incidence method is misleading when annual treatment costs are declining over time), in the conditions studied below, both methods are appropriate and will yield valid estimates of total economic costs.

In this exploratory study, the choice of method depends on data availability. When the data allow a choice between methods, both are employed. The reliability of the results is presented and only the more conservative estimate is entered in the total. This approach provides a pragmatic but conservative, lower-bound estimate of the relative magnitude and reliability of total economic costs of occupational disease in New York State.

DATA SOURCES

Cancer

Although relatively few incidence-based studies of cost of illness exist [Policy Analysis, 1981; Oster et al., 1984; Hartunian et al., 1981], one such study has estimated the costs of cancer in the United States [Hartunian et al., 1981]. If these estimates are updated to 1985 dollar figures by using the New York region medical care price index [Bureau of Labor Statistics, 1988], adjusted to incorporate the differential in New York State hospital and physician costs compared to U.S. averages, and applied to New York cancer incidence estimates by age and sex [Markowitz et al., 1989], a preliminary estimate of the cost of occupational cancer in New York can be calculated.

The economic data were derived initially from two studies that analyzed cancer treatment costs for a random sample of 10% of all individuals diagnosed with cancer during the Third National Cancer Survey, the most recent study of the costs of cancer treatment undertaken by the National Cancer Institute [Cutler et al., 1974]. In one study, 8,500 patients or surviving relatives were interviewed to obtain information about costs for physicians, drugs, and special nursing care. In the other, 6,322 patients were surveyed to establish hospitalization and payment patterns for inpatient care. The limitations of these studies have been well documented [Hartunian et al., 1981; Cromwell and Mitchell, 1976]. Nonetheless, these two studies of the treatment costs of cancer constitute the basis for the most comprehensive incidence-based estimate of the economic costs of cancer available [Hartunian et al., 1981].

The use of the prevalence approach to calculating the costs of occupational cancer is hampered by the lack of a complete data base for medical care expenditures by diagnosis, age, and sex in New York State. However, one very important component of a prevalence-based approach is available. Complete data on hospital discharges and length of stay are available for New York in 1985 by age, sex, and diagnosis [SPARCS, 1986]. Since hospital costs compose a significant portion of direct medical expenditures for cancer, these data provide another perspective on the magnitude of the costs of occupational disease in New York State.

The advantage of using primary New York State data on hospital discharge and length of stay is that these numbers represent actual experience in New York State rather than projections estimated from other secondary data sources. The disadvantage is that it is not possible to determine how many individual patients are represented in the discharge data. It is therefore not possible to follow completely the prevalence approach to cost of illness estimation, which includes an estimate of the aggregate losses in productivity due to individual morbidity and mortality, in addition to other direct costs of medical treatment apart from hospitalization costs, such as physician fees, drugs, and nursing home costs.

Coronary Heart Disease and Stroke

The same study that calculated incidence-based costs of cancer also calculated incidence-based costs of coronary heart disease and stroke [Hartunian et al., 1981]. Unfortunately, neither age-specific incidence nor prevalence rates are available for these conditions in New York State; data are available only for crude annual death rates. Applying average incidence-based costs (averaged over age and sex categories) to gross death rates underestimates the full costs in two ways: 1) the number of cases is too low (since more people acquire coronary heart disease and cerebrovascular disease than die from them); and 2) the cost per case estimate is too low since those who die from these diseases would tend to be the more severe, and therefore more expensive, cases. Nevertheless, this partial estimate of the costs of coronary heart disease and stroke is a useful supplement to our heuristic model.

Pneumoconioses

To supplement these estimates further, it is possible to obtain discharge data for all hospitalizations in New York State in 1985 due to the pneumoconioses [SPARCS, 1986]. These chronic lung diseases include asbestosis, silicosis, and coal workers' pneumoconiosis [Parkes, 1982]. The pneumoconioses are recognized as virtually 100% work-related and so represent a valid and reliable data source for hospital costs of occupational disease. By applying daily average hospital costs to the hospital days directly attributable to the pneumoconioses, an estimate of hospital costs for some respiratory disease can be calculated.

In addition, the total costs of medical care for chronic respiratory diseases have been reported in the literature [Toevs et al., 1984]. These costs are adjusted and updated to New York State 1985 dollars and applied to the estimated number of occupationally related chronic respiratory diseases in New York. Estimates from different sources provide an indication of the reliability of the results.

End-Stage Renal Failure

A partial estimate of the economic costs (the direct medical costs) of renal failure has been made by the Social Security Administration [Davis, 1983]. If these figures are adjusted and updated to New York regional costs and 1985 dollars and applied to estimates of the incidence of occupationally related renal failure in New York, another element in the composite can be presented.

RESULTS

Cancer: The Incidence Method

The incidence approach requires that data on expenditures be disaggregated by age, sex, and diagnosis. Using annual average cancer deaths reported separately by age and sex for 1976–1980 by the New York State Cancer Registry of the New York State Department of Health [Burnett, 1982], the age-sex distribution of cancer incidence in New York State can be derived and applied to the 6,580 cases of cancer in New York State that in the early 1980s are estimated to be occupationally induced each year [Markowitz et al., 1989]. For each incidence category (defined by age and sex), an estimate of the direct costs per patient can be applied.

To obtain an estimate of the average direct costs of occupational cancer per patient in New York State, published cost estimates were averaged over specific cancer diagnostic categories to obtain average direct costs per person by age and sex. These are average lifetime direct costs (1975 dollars). However, in 1975, New York hospital costs per day were 63% greater than average U.S. costs. Average physician fees were 11% higher [AMA, 1976 and 1986]. Since hospital costs make up 60% of total cancer treatment costs and physician fees make up 29% [Rice et al., 1985], it is possible to adjust the U.S. data to better reflect actual New York costs. These adjusted cost estimates are then applied to the New York incidence estimates and adjusted to 1985 dollars by using the medical care price index specific to the New York region. Future costs were discounted 6%.

As shown in Table I, the annual total direct costs for medical treatment for occupational cancer in New York State are estimated to be $205.7 million. However, this figure greatly underestimates the total economic costs of occupational cancer since an important component is missing, the costs of lost production. Again, estimates have been presented in the literature of foregone earnings per patient owing to cancer, by age, and sex [Hartunian et al., 1981]. These estimates are made by imputing lost productivity owing to cancer morbidity and mortality over the patient's expected life span, and comparing this to expected productivity and life expectancy of a matched cancer-free population. These estimates were adjusted to take into account the 12.3% difference in average annual pay between New York workers and the average worker [Bureau of Labor Statistics, 1988]. Future lost earnings are discounted at 6%. Total annual foregone earnings are approximately $291.3 million. These results are shown in Table II.

TABLE I. Estimated Lifetime Direct Costs of New Cases of Occupational Cancer by Age and Sex in New York State, 1985*

Age	Males	Females	Total
15–34	2,343,897	2,211,846	4,555,743
35–54	15,791,364	18,377,478	34,168,842
55–64	25,565,996	24,614,778	50,180,774
65–74	32,239,404	27,830,977	60,070,382
75+	28,113,513	28,569,537	56,683,050
Total	$104,054,274	$101,604,616	$205,658,790

*All costs are in 1985 dollars, adjusted by using the medical care component of the consumer price index for New York. Future costs are discounted at 6%. The calculations assume that the age distribution for occupational cancer is the same as the age distribution of total adult cancer deaths (excluding cancer deaths in the 0–15 age group). Sources: New York State Department of Health, [1982a]; Hartunian et al. [1981]; Bureau of Labor Statistics [1988]; American Hospital Association [1986]; American Medical Association [1976 and 1986].

TABLE II. Estimated Present Value of Lifetime Foregone Earnings Owing to Occupational Cancer by Age and Sex, New York State, 1985*

Age	Male	Female	Total
15–34	20,276,837	11,309,662	31,586,499
35–54	90,235,330	64,776,891	155,012,221
55–64	47,997,446	33,898,089	81,895,535
65–74	7,272,900	11,985,952	19,258,853
75+	638,950	2,919,534	3,558,484
Total	$166,421,463	$124,890,128	$291,311,591

*Future earnings are discounted at 6%. Sources: Table I; Hartunian et al. [1981]; Bureau of Labor Statistics [1988].

Cancer: The Prevalence Method Using Hospital Discharges

In 1985 in New York, there were 205,964 discharges for cancer (ICD codes 140–208), accounting for 2,688,910 hospital days [SPARCS, 1986]. If 10% of these hospital days were for cancer resulting from occupational causes [Markowitz et al., 1989], then 268,891 inpatient days were due to occupational cancer. At a cost of $466 per hospital day [AHA, 1986], occupational cancer costs approximately $125.3 million in annual direct hospital costs alone. Hospital costs make up 63% of total treatment costs for cancer [Rice et al., 1985]. Therefore, based on primary New York State data, total direct costs for cancer in New York are $198.9 million. This figure corresponds closely to the $205.7 in direct treatment costs as derived earlier under the incidence method by using adjusted secondary cost data.

In particular, the prevalence method can be used to study one specific cancer diagnosis in New York, mesothelioma. Mesothelioma is a particularly lethal cancer caused, in virtually every case, by exposure to asbestos. In New York in 1985, 4,004 cancer inpatient days were attributed specifically to mesothelioma [SPARCS, 1986]. The total hospital cost for mesothelioma was $1,865,864. Again, assuming that hospital costs make up 63% of direct costs and that these are 40% of total economic costs (following the incidence-based estimates of cancer costs), mesothelioma cost New York State $7.4 million in 1985.

Coronary Heart Disease and Stroke: The Incidence Method Using Death Rates

In 1985 in New York State, there were 10,200 deaths from cerebrovascular disease (stroke) and 72,100 deaths from ischemic heart disease. These two disease categories account for 81% of all deaths due to cardiovascular disease in New York State [New York State Department of Health, 1982b]. Attributing 1–3% of these deaths to occupational disease [Markowitz et al., 1989] results in 102 to 306 deaths from stroke and 600 to 1,800 deaths from coronary heart disease being attributed each year to occupational hazards in New York. These estimates do not include other important categories of cardiovascular disease associated with occupational risk factors such as diseases of pulmonary circulation, hypertension with heart disease, hypertension with renal disease, arteriosclerosis, and others. Fortunately, well-researched economic studies have been published for coronary heart disease and cerebrovascular disease [Hartunian et al., 1981], so that limiting the analysis of costs of cardiovascular disease to these two disease categories allows the application of economic estimates.

Average total per capita costs for completed strokes (including hemorrhagic and infarctive but excluding transient ischemic attacks) are estimated to be approximately $58,518 (1985 dollars) in New York State; published data [Hartunian et al., 1981] and an adjustment methodology similar to that detailed in the previous section were used. This per capita cost is made up of $24,413 in direct costs and $34,105 in indirect costs. These economic estimates are negatively biased, since death rates underestimate incidence rates. The lower bound of costs due to occupationally related stroke deaths in New York in 1985 is thus conservatively estimated to be between $6 million and $18 million. Actual costs are likely to be much higher.

Total economic costs of work-related heart disease are obtained by combining and averaging the direct and indirect costs for the three major categories of coronary heart disease (CHD) for which economic data are available (myocardial infarction, coronary insufficiency, and angina pectoris, uncomplicated). The total cost per CHD patient in New York is estimated to be $47,281 in 1985 dollars, adjusted for differentials in New York wages, hospital costs, physician fees, and other medical prices. Approximately 25% of these costs are direct costs, with the remaining 75% due to earnings foregone as a result of heart disease, where lost future earnings are discounted at 6%. The total lower-bound estimate of the costs of occupational heart disease in New York thus ranges from $28,368,600 to $85,105,800. Again, actual costs are likely to be significantly higher.

End-Stage Renal Disease: Direct Costs Only

The annual direct cost of medical care for end-stage renal disease (ESRD) was estimated in 1982 to be approximately $26,000 per patient [Davis, 1983]. Adjusting this figure to 1985 dollars by using the medical care component of the consumer price index for the New York region, the average estimated cost of direct medical care for patients with ESRD is approximately $33,000 per year. Epidemiologic estimates [Markowitz et al., 1989] attribute 18 to 56 ESRD-related deaths per year in New York State to occupational causes. Thus, the estimate of the direct cost of ESRD due to occupational exposures ranges between $594,000 and $1,848,000.

TABLE III. Estimated Direct and Indirect Costs per Person of Various Occupational Disease Diagnostic Categories in 1985 in New York State*

Diagnosis	Indirect cost[a]	Direct cost	Total cost
Cancer[b]	$44,272	$31,255	$75,527
Coronary heart disease[c]	36,062	11,219	47,281
Stroke[c]	34,105	24,413	58,518
End-stage renal disease[c]	—	33,000	33,000[d]
Chronic respiratory disease[c]	—	8,058	8,058[d]
Pneumoconiosis[e]	—	6,009	6,009[d]

*Sources: Tables I and II; Toevs et al. [1984]; SPARCS [1986].
[a]Present value of future costs, discounted at 6%
[b]Cases.
[c]Deaths.
[d]Direct costs only.
[e]Hospital discharges.

Chronic Respiratory Disease: Direct Costs Only

Between 120 and 400 deaths per year in New York State are attributable to occupationally related chronic respiratory disease [Markowitz et al., 1989]. In a recent study of the cost of care for patients with chronic lung disease in Seattle, Washington, investigators found that the average patient used a total of $6,979 in direct health care resources over 1 year [Toevs et al., 1984]. Approximately one-half of these costs were for hospital care where hospital days per patient year average 10.1 days. Adjusting these data to New York State prices, between $966,960 and $3,223,200 is the estimate of direct medical care expenses per year for occupationally related chronic lung disease deaths in New York State. Once again, these estimates, based only on mortality, are low.

Pneumoconioses are lung diseases found in workers exposed to occupational dusts, such as asbestos fibers, silica, and coal dust. They result in virtually every instance from occupational exposure. In New York, the average annual number of hospital discharges for the pneumoconioses is 599, and approximately 7,724 annual in-patient days are attributable to these diseases (ICD codes 500–505). At a cost of $466 per day, hospital costs for the pneumoconioses were $3,599,384 in 1985.

A summary of the cost estimates per worker can be found in Table III. Table IV presents total costs by disease by using the high and low ends of the range of estimated occupationally induced incidence rates for New York State.

SUMMARY AND CONCLUSIONS

The partial economic cost of occupational disease in New York State is conservatively estimated to be approximately $600 million per year. For comparison purposes, this is the equivalent of fully one-third of the net total corporate income taxes collected by the state during the 1985 fiscal year [U.S. Bureau of the Census, 1986]. As staggering as these annual costs are, they are underestimates of the lost opportunities they represent. The true costs of occupational cancer are higher by an amount equal to the pain and suffering of all the victims and their families.

Many assumptions went into the estimation techniques used to derive this cost figure. While it is beyond the scope of this article to present all of them here,

TABLE IV. Estimated Cost of Occupational Diseases in New York State by Diagnostic Category 1985*

Diagnosis	No. of cases/deaths	Cost per case	Total cost
Cancer	6,580[a]	75,527[b]	496,960,000
Coronary heart disease	600–1,800[c]	47,281[b]	28,368,600–85,105,800
Stroke	102–306[c]	58,518[b]	5,968,836–17,906,508
End-stage renal disease	18–56[c]	33,000[d]	594,000–1,848,000
Chronic respiratory disease	120–400[e]	8,058[d]	966,960–3,223,200
Pneumoconiosis	599[3]	6,009[f]	3,599,384
Total[g]			$535,490,810–$605,419,680

*Details of the data concerning the number of cases/deaths (column 2) are provided in a companion article [Markowitz et al., 1989]. Sources: Markowitz et al. [1989]; Table III.
[a]All cases.
[b]Indirect and direct costs.
[c]Deaths only.
[d]Direct costs only; indirect cost estimates are not available.
[e]Hospital discharges.
[f]Hospitalization cost only.
[g]Because chronic respiratory disease and the pneumoconioses are not mutually exclusive, the total includes only the pneumoconioses cost estimates.

extensive discussions can be found in the two studies which serve as background for our economic estimates [Markowitz et al., 1989; Hartunian et al., 1981]. In every case, however, our economic assumptions err on the conservative side. Probably the most critical assumption, however, is the calculation of incidence. An error in overall estimation of incidence would bias all costs proportionately, since costs per person are simply multiplied by incidence to arrive at total costs. In any event, it can be concluded from these data that the total annual cost of occupational illness in New York is massive.

By far the greatest proportion (80%) of the costs which we have examined in this analysis is due to occupationally induced cancer. Since the accuracy of the estimate of total costs substantially depends on the accuracy of the cancer estimate, it is important to test the sensitivity of our results to the assumptions used in the model to estimate cancer costs. Confirmation of the direct cost portion of the incidence-based estimate is given by the prevalence-based estimates obtained by using an independent data source specific to New York State. National data provide another rough confirmation. Cancer costs the United States over $69 billion per year in 1985 dollars [Rice et al., 1985]. If 10% of all cancers are due to occupational risk factors, occupational cancer is costing the nation approximately $6.9 billion per year. Since approximately 8% of American workers live in New York State, the proportionate costs of occupational cancer in New York are $550 million per year. This result is within 10% of the results we obtained by using more accurate diagnostic and expenditure data.

In summary, the annual costs of occupational cancer in New York State are estimated to be $500 million (1985 dollars). These costs are made up of $31,000 in direct treatment costs per affected worker and $44,000 in indirect costs following productivity losses.

The total annual economic costs of occupational heart disease and stroke in New York State are estimated to be between $34 million and $103 million, depending upon whether 1% or 3% of diagnoses in these categories are attributed to occupational exposure. The direct and indirect costs per worker with coronary heart disease are $11,000 and $36,000, respectively. Direct and indirect costs per stroke victim are $24,000 and $34,000, respectively.

Total costs for end-stage renal disease and chronic respiratory disease range from $.5 million to $2 million and from $1 million to $3 million respectively, again depending upon the fraction of cases of these diseases attributed to occupation. Due to data constraints, only direct costs per worker can be estimated for end-stage renal disease ($33,000) and chronic respiratory disease ($8,058). For the pneumoconioses, hospitalization costs alone are $6,000 per admission.

DISCUSSION

Clearly, the costs associated with occupational illness are enormous. Available data show only a small portion of the total economic costs that would constitute a comprehensive estimate of occupational disease costs in New York State. The model presented here attempts to make the most use possible of the limited information contained in a variety of published secondary estimates of occupational disease incidence, health care expenditures, and primary hospital discharge data in New York State.

The results obtained from this composite model are meant to be illustrative, to provide a glimpse of the total magnitude of the cost of occupational disease currently borne in New York State. They are conservative estimates. It follows that the total economic burden to New York State of all occupational disease is much higher, although it is impossible to say how much higher without better data.

A systematic effort is needed to gain consistent information on the full costs of occupational disease. Analysis of the true costs of occupational disease can help in planning public and private efforts toward prevention. It is critical to continue efforts toward that end.

Moreover, as recommended by the Institute of Medicine, longitudinal surveys of patients in a prospective study of the costs of occupational illness by diagnosis should be undertaken. In addition, research efforts should be directed toward the analysis of the cost-effectiveness of alternate program development and intervention strategies. Finally, research should be begun to analyze the contribution of the costs of occupational disease to the growing crisis in medical care cost inflation. The results of this investigation could provide politically powerful leverage for policy initiatives to improve the prevention of occupational disease.

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