The Costs of Asbestos-associated Disease and Death

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THIS IS THE FIRST STUDY OF THE LOSSES borne by workers or their survivors as a result of death and disability from exposure to asbestos. It also provides information on the adequacy of the compensation that they receive for their losses.

Asbestos is one of the most hazardous substances to which the American worker is exposed. An asbestos-related death occurs every 59 minutes (Selikoff 1982). The number of disabling illnesses is believed to be much larger. The effects of asbestos occur over long periods of time, with disability or death typically occurring 20 or more years after exposure. In the past, workers' compensation laws, through limitations in the coverage of occupational illness and provisions that limited the time period in which a claim could be filed, severely restricted compensation to asbestos victims. Since workers' compensation laws also barred workers from suing their employers, thousands of workers filed product liability suits against asbestos manufacturers. In 1981, there were 25,000 suits pending and the number of suits filed continues to increase (*Economist* 1981). The courts have eliminated many earlier problems of proof making it easier for workers to win law suits. In addition, evidence that asbestos companies willfully failed to inform their workers has led courts to award punitive damages in addition to compensation for workers' losses (*Economist* 1981).

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In response to these events, two major producers have filed for Chapter 11 bankruptcy and Congress is considering the creation of a federal compensation system for asbestos victims. Both the nature of the problem and the best solution to it are the subject of a vigorous and partisan debate. Much of the difference among the parties cannot be objectively resolved unless more adequate information is obtained.

The changes that are made in prevention of, or compensation for, the health risks of asbestos are important not only for the asbestos firms and workers but also as a precedent for approaches to occupational diseases that are now only suspected or as yet unknown. It is important that these changes reflect an accurate knowledge of the specific problems in past approaches to asbestos.

Information on losses is needed to evaluate proposed changes in the approach to compensating victims and to estimate the benefits of reducing exposure to asbestos. The results presented in this paper provide a small portion of the information that is needed. Our estimates represent the loss of wages and household services caused by disability and death from asbestos to workers and their survivors. If data on medical care costs, administrative costs of social insurance programs, and the costs of litigation and regulation were available, estimates of social costs could be formulated. The limitation to private costs is dictated by the content of the data. Information on some of the important components of social costs is provided where the data permit. We present, for example, data on gross wage losses (that is, with taxes and worker consumption included) which are an important component of social costs.

The data are described in the next section. The remainder of the paper is divided into three parts. The first two present the methods and results on losses and compensation respectively. The final section considers the implications of both sets of results.

The Data[1]

Our data are taken from a cohort of 17,800 men who were members of the insulation workers' union (International Association of Heat and Frost Insulators and Asbestos Workers, AFL-CIO, Canadian Labor

[1] The material in this section is based on Selikoff 1982.

Confederation, CLC) on January 1, 1967. The risk of asbestos-related disease is higher for insulation workers than for any other occupation except for the employees of asbestos producers (Nicholson 1982).

The men were members of 120 union locals in the United States and Canada. Dr. Irving Selikoff and his associates at the Environmental Sciences Research Laboratory, Mt. Sinai School of Medicine, City University of New York, have monitored deaths among the workers since 1967. When a death occurs, a death certificate and additional clinical data are reviewed to determine the cause of death. Between 1967 and 1977, 2,271 insulation workers died. Of these deaths, 995 are attributed to exposure to asbestos in the workplace.

To obtain information on the economic and social consequences of the workers' deaths, surviving widows were interviewed between January and November 1980. Questions on all forms of income were asked for the year 1979 and recall error is at a minimum for those data. Questions on workers' compensation and tort suit awards and settlements were asked for all years, including 1979.[2] A total of 792 interviews were completed. Canadian workers are excluded because of the differences in compensation systems between the two countries. United States cases in which data are incomplete are also excluded. This study is based on the remaining 682 cases.

Methods of Estimating Losses

Estimation of the costs of illness and death is always difficult. Data are typically incomplete and the concepts on which the procedure is based are the subject of controversy (Hodgson and Meiners 1982). The problems are especially severe when one deals with long latency, progressive conditions such as those that result from exposure to asbestos. Before describing the methods used in this study, we will consider some of the problems that we encountered.

Medical care expenses are an important component of private costs but one for which the data were not adequate. It was impossible to

[2] Since many of the widows referred to their files in answering these questions, recall error is likely to be small. A limited comparison of responses concerning workers' compensation payments to the agency records in one state indicated that survey responses on compensation were generally accurate, although there was some confusion concerning dates of filing and award.

separate third party payments from the direct costs to the families. In addition, the data on total costs are subject to recall error to an extent that we find unacceptable for inclusion in the study. One could attempt to obtain proxy measures of medical care costs from aggregate data. We chose not to do so because it would mix data whose application to this group is questionable with data that are unusually specific to the insulation workers and their families.

Losses in the "quality of life" are one of the consequences of serious illness and should be added to costs if appropriate measures can be found (Hodgson and Meiners 1982). Cost studies such as ours assume that the period of loss begins with the onset of total work disability. In fact, many chronically ill individuals continue to work (Berkowitz, Johnson, and Murphy 1976; Yelin, Nevitt, and Epstein 1980; Lambrinos 1981). Our estimates omit the years in which workers suffered reductions in the quality of life but continued to work.

Another source of losses from work through asbestos exposure is the "family contact effect," that is, exposure of family members to asbestos via contact with asbestos workers (Anderson et al. 1979). Family contact effects among the families whom we studied are not included in the data. The net effect of these omissions is that our estimates must substantially understate the costs of disease and death from asbestos.

Wage Loss Estimation

The wage rate that each worker would have earned had he completed his expected worklife was obtained for each year from the collective bargaining agreement of the labor union local to which the worker belonged. Expected wage income is estimated as the product of the wage rates and the average annual hours of work for all members of the insulation workers union.[3]

The expected worklife data are taken from the Bureau of Labor Statistics (BLS) estimates for men in the labor force (Smith 1982). The BLS worklife estimates equal the number of years in which, on average, a person who is alive at a given age can be expected to be

[3] After 1982, wage rates are estimated from trend equations calculated from the wage data for each of the 101 union locals. The median (across locals) annual average rate of change in wage rates is 6.9 percent.

a labor-force participant until the final age in the reference period. The estimates do not constrain the end of worklife to age 65.

A labor force participant is someone who is employed or is actively seeking employment. A bias is introduced when one equates a worklife year with a year of employment. To minimize this bias, we use hours-worked data from the reports of labor union locals to the National Asbestos Workers Medical Fund (Goldsborough 1982).

The usual assumption that expected worklife is continuous implies that an individual who is, for example, age 60 (expected worklife = 5.2 years) will participate in the labor work force in each year until age 65.2 and then permanently withdraw. The BLS estimates indicate only that this person would participate in 5.2 of the years between age 60 and age 76.[4] The distribution of expected worklives is presented in table 1. The median age at death or disability is 60 years. Without exposure to asbestos, these workers could be expected to have worked for an additional 5.2 years.

Taxes and Consumption

The net wage loss to workers or their survivors equals the gross wage loss minus taxes and (following the year of death) the income that the worker would have consumed had he lived. It is assumed that, on average, 17 percent of gross wage income would be paid in federal income taxes. That is the average rate for taxable income of $10,000 to $14,999 for the years 1969–1979 (U.S. Department of Commerce, Bureau of the Census 1981).[5] The FICA tax rates used are the published rates for the years 1950–1990 (U.S. Department of Commerce, Bureau of the Census 1981).

[4] One alternative to the usual assumption of continuity would be to use the probability of participation (conditional on survival) at each age to distribute labor force participation over the relevant ages. Both methods are biased. The choice between them depends upon how well each represents the true participation of the persons under consideration. The typical pattern of labor force participation for the insulation workers is one of continuous participation until retirement. The expected worklife (continuous) approach is, therefore, adopted.

[5] Since we apply the rates on taxable income to gross wage income, the effective rate is greater than 17 percent. This bias is partly offset by the fact that the insulation workers' wage income in many of the years considered is higher than the income bracket on which the tax rate is based.

TABLE 1
Distribution of Worklife Expectancies at Time of Death or Disability for Deceased Asbestos Insulation Workers

Expectancy in Years	Number	Percent
0– .9	38	5.5
1.0– 1.9	13	1.9
2.0– 2.9	54	7.9
3.0– 3.9	109	16.0
4.0– 4.9	103	15.1
5.0– 5.9	68	10.0
6.0– 6.9	36	5.3
7.0– 7.9	53	7.8
8.0– 8.9	27	4.0
9.0– 9.9	49	7.2
10.0–11.9	30	4.4
12.0–14.9	50	7.3
15.0–17.9	37	5.4
18.0 and Over	15	2.2
Total	682	100.0

Equivalence scales are used to estimate the income the worker would have consumed had he lived. We assume that the data on husband-wife households in which there are no children and the household head is aged 55 to 64 are appropriate. In such households, 40 percent of after-tax income is consumed by the worker (U.S. Department of Labor, Bureau of Labor Statistics 1968).

Loss of Household Production

Work in the household is an important source of real income, providing substitutes for market goods and services. Based on the average age of the insulation workers and the results of prior research we assume that each would (without disability or death) contribute one hour per day in household production (Walker and Woods 1976).

Opinions vary as to the appropriate price for the time spent in household production.[6] We adopt the federal minimum wage in each

[6] The suggestions include the opportunity cost to the individual (as measured by the expected wage rate), the market value of substitute services and the value of the services as perceived by other family members (Pottick 1978).

year as the estimate of the market value of household production time. This method, when compared with the alternative assumptions, yields a minimum estimate of the value of household production (Gauger and Walker 1980). The estimates, like those for wages, are reduced for consumption in the years following the worker's death.

The Discount Rate

One decision to be made concerning the discount rate is whether market rates or proxies for social time preferences are more appropriate. Since we estimate private costs, the market rate approach is used. The discount rate is set equal to the average yield on U.S. Treasury bonds. Observed rates are used through 1982 and trend values are used thereafter (U.S. Department of Commerce, Bureau of Economic Analysis 1978, 1981, 1982). Since interest income from Treasury bonds is taxable, the assumed tax rate (see above) is used to convert the rates to after-tax equivalents. The rates (tax-adjusted) increased from 1.93 percent in 1950 to 11.29 percent in 1982. Our trend projections decrease in value from 11.29 percent in 1982 to 10.2 percent in 1992 and thereafter.

Several authors argue that present-value calculations produce estimates that eliminate most of the costs of long latency illnesses. They also suggest that discounting future losses is inconsistent with public policy toward risks of death and disability (Ruttenberg and Bingham 1981). In recognition of these concerns we present our results in both absolute and present value terms. Present values are enclosed in brackets. Since most losses occurred prior to the base year (1982) the present values exceed the absolute losses.

Estimated Losses

Losses due to death are estimated for all cases in which the worker died prior to the end of his expected worklife. Present values are enclosed in brackets. There are 568 deaths for which losses to survivors could be estimated (table 2). The gross loss due to asbestos-related deaths is estimated to be $114,239,145 ($138,375,703). The average gross loss per worker household is $201,125 ($243,619).

Losses due to disability before death are calculated for 391 of the 568 workers who died before the end of expected worklife. The

TABLE 2
Absolute and Present Value (1982) of Estimated Wage and Household Production Loss among Insulation Workers Due to Disability and Death from Asbestos-associated Diseases

Item	Gross Loss	Net Loss
Loss due to death (N = 568)		
Gross Wage Loss	$109,130,490	$ 109,130,490
Less Estimated Taxes		$ −25,326,622
After-tax Wage Loss		$ 83,803,868
Less Consumption Deduction		$ −32,025,643
Net Wage Loss		$ 51,778,225
Household Production Loss	$ 5,108,655	$ 5,108,655
Less Consumption Deduction		$ −3,065,193
Net Household Production Loss		$ 2,043,462
Absolute Value of Loss	$114,239,145	$ 53,821,687
Mean Value	$ 201,125	$ 94,757
Present Value of Loss	$138,375,703	$ 61,193,177
Mean Value	$ 243,619	$ 107,735
Loss due to Total Disability (N = 468)		
Gross Wage Loss	$ 13,711,455	$ 13,711,455
Less Estimated Taxes		$ −3,020,731
After-tax Wage Loss		$ 10,690,724
Household Production Loss	$ 504,637	$ 504,637
Absolute Value of Loss	$ 14,216,092	$ 11,195,361
Mean Value	$ 30,376	$ 23,922
Present Value of Loss	$ 24,378,116	$ 19,198,090
Mean Value	$ 52,090	$ 41,022
Total Loss Due to Disability and Death (N = 645)		
Absolute Value of Loss	$128,455,237	$ 65,017,048
Mean Value	$ 199,155	$ 100,802
Present Value of Loss	$162,753,819	$ 80,391,267
Mean Value	$ 252,331	$ 124,637

remaining 177 workers suffered no significant period of disability prior to their death. A second group of 77 workers died after worklife ended but were disabled during part of their worklife years. The disability losses (see table 2) are, therefore, calculated for 468 workers (that is, 391 plus 77). The gross loss is $14,216,092 ($24,378,116). The gross loss due to disability and death from asbestos-associated disease is $128,455,237 ($162,753,819) for 645 workers (that is, 568 plus 77).

These estimates provide information on the costs that could have been avoided had exposure to asbestos been reduced in the years in which this cohort of workers were employed. The average gross loss is $252,331 (present value, 1982).[7] This is a partial measure of the social benefit from saving the life of one worker. We know, because of the omission of important cost categories, that the social benefit (that is, the reduction in the cost of death) is substantially higher than this amount. These 645 deaths are a small fraction of the total number of asbestos-related deaths during the period 1967–1978. It is estimated that the death toll for all occupations (including insulation workers) during this period was 67,489 workers (Nicholson 1982).[8] If the losses of the insulation workers are representative of those in other occupations, the gross loss for 1967–1978 totals 17.1 billion dollars. The effects of past exposure do not end in 1978. Nicholson predicts that 353,295 workers will die from 1978 through 2027 as a result of exposures from 1940 to 1979. The gross loss due to death (1979 through 2027) from asbestos exposures that occurred between 1940 and 1979, therefore, is $309 billion ($46.5 billion).[9] Social costs are higher by an amount that we cannot estimate at this time. The magnitude of these losses indicates that the potential savings to effective methods of reducing current and future exposures are substantial.

The deaths that will continue to occur from past (1940 to 1979) exposures cannot be prevented. The primary economic issue for these families is, therefore, how they are able to compensate for the losses that they suffer. The extent to which insulation workers' families are compensated for their losses is, therefore, the next question that we discuss. The relevant losses in this context are the "net losses," or

[7] The gross loss estimate is nearly equal to the average payment in tort liability suits for asbestos ($233,000 in 1980 dollars, $276,827 in 1982 dollars using the Consumer Price Index as the adjustment). This figure was used by Paul McAvoy (1982) in projecting the expected liability of insurance carriers for asbestos-related deaths and as one of several possible values for social cost. Our results indicate that McAvoy's "best estimate" of social costs is too low.

[8] These projections do not include deaths from asbestosis, deaths from exposure in the armed services, bystander effects, or deaths from environmental exposures (Nicholson 1982, 71).

[9] Future costs are estimated as the product of mean gross loss ($201,125) per death and number of projected deaths assuming that loss per death increases at the same rates as the median annual rate in insulators' wages (that is, 6.9%).

the gross loss adjusted for taxes and the amount that the worker would have consumed had he lived. The average net loss per household from death and disability prior to death is $100,802 ($124,637) (N = 645).

A complete evaluation of the adequacy and equity of compensation is beyond the scope of this study. The results presented in the next section provide, however, the first evidence on the overall adequacy of the compensation "system" for asbestos-related death.

Compensation for Losses

Method

An evaluation of the adequacy of benefits requires that one identify which of the sources of household income are attributable to death or disability. The sources that can be attributed to the worker's death are: tort suit awards, Social Security survivor's benefits, veteran's (widow's) benefits, workers' compensation benefits, survivor's benefits from private pensions, and public assistance. Public assistance and veteran's pensions are included because the families would not have met the income tests for these programs had the workers lived.

Data on disability and death benefits which were paid in installments are available only for 1979. The evaluation of benefit adequacy is, therefore, restricted to widows whose husbands' expected worklife included the year 1979. There are 249 widows who meet this criterion. The workers represented by these data died at a younger age than the full cohort. Age at death (median) was 53 and expected worklife is 9.9 years.

The measure of benefit adequacy is the "replacement ratio," defined as the ratio of total (death-related) benefits to the net loss to the household. Benefits are equal to cash benefits received during 1979 plus any income imputed from a prior lump sum payment.

Lump sum payments from workers' compensation or tort suits are allocated over the years from time of death to the end of expected worklife in the following manner. It is assumed that the award was made in the first year of the loss period; that the survivor uses the interest earned on the lump sum plus some portion of the capital amount to offset the loss in each year; and that no more than the

amount of loss is consumed in any year. The assumption of an award during the first year of loss eliminates the problem created by the fact that many lump sum awards and settlements include retroactive payments for losses prior to the date of award.

The income available in each year is calculated as follows:

$$\text{Income} = \text{Interest Income} + \text{Capital Consumption}$$

Where:

$$\text{Interest Income}^* = (\text{Capital} - \text{Net Loss})(r)(a);$$

$$\text{Capital Consumption} = \text{Interest Income} - \text{Net Loss};$$

r = the interest rate (equal to the rates on Treasury bonds);

a = the proportion of the year included in expected worklife.

The initial capital stock equals the lump sum payment minus fees to attorneys. In years in which interest income exceeds net loss the differential is added to capital stock. In years in which interest income is less than net loss, the difference is consumed from capital. The replacement ratio is estimated as the ratio of imputed income (1979) to net loss (1979).

Results

The widows received compensation either in the form of cash benefits in 1979 or, by imputation, income from a prior lump sum payment. Cash benefits were the only type of compensation received by 109 widows. An imputed income was the only compensation to 6 widows. There were 9 widows who received cash benefits plus an imputed income. In total, therefore, 124 of the worker's survivors received compensation in 1979 and 125 widows were not compensated in any way. Total net losses were $3,401,094 and total compensation was $777,637. The sources of compensation are outlined in table 3.

The data in table 3 demonstrate that less than one-half of the compensation for this occupational disease is paid by workers' compensation and common law tort awards. Approximately 56 percent of the compensation paid in 1979 was obtained from social insurance

* Always ≥ 0.

TABLE 3
Compensation Payments by Source (1979)

Source	Amount	Percent
Workers' Compensation Cash Payments: $207,263 Imputed Income: $ 9,752	$217,015	27.9
Tort Suits & Settlements (Imputed Income)	$123,924	15.9
Social Security Benefits	$228,072	29.3
Private Pensions	$183,148	23.6
Veteran's Benefits	$ 24,718	3.3
Welfare	$ 760	0.0
Total	$777,637	100.0

($N = 124$)

or private pensions that are not specific to work-related disability or death. The fact that the common law and workers' compensation provide such a small proportion of the payments to the victims of occupational illness from asbestos is a serious indictment of both approaches.

The extent to which the compensatory payments replace the widows' loss of income is the subject of the next section. Cash benefits and imputed incomes are considered separately. The data on cash benefits are not subject to recall error and do not require any estimation on our part. The incomes imputed from lump sum awards involve recall error and are based on assumptions concerning annual consumption.

The Adequacy of Cash Benefits

One hundred and nine widows received cash benefits as their sole form of compensation in 1979. Their total net loss equals $1,457,036 and total cash benefits equal $582,964. The uncompensated loss for one year for the 109 widows is, therefore, $874,072, or an average of $8,019 per household. Median benefits equal $4,368; median net losses totaled $14,602. The median replacement ratio is 0.31, with individual ratios ranging from 0.04 to 2.91.

The losses of the nine widows who received a cash benefit and imputed income from a lump sum payment were similar to the cash beneficiaries (median net loss equal to $14,597). The median replacement

ratio for the cash portion of their compensation is 0.58. The addition of imputed incomes (all from tort awards) is sufficient, in all cases, to fully compensate the widows for their losses in 1979. The longer term results are discussed in the next section.

Impact of Lump Sum Settlements

Of the 249 widows, 103 received a lump sum settlement or award at some time following their husband's death. The median lump sum award was $18,381 after attorneys' fees, and the awards ranged from $1,000 to $240,000.

By 1979, only 15 of the original 103 lump sum recipients had capital with which to offset some part of their losses. Two of the 6 widows who did not receive cash benefits obtained their lump sum payment from workers' compensation and the other 4 from a tort settlement. Interest income plus some consumption of capital in 1979 would have replaced net loss for 4 of the 6 widows. The replacement ratios for the other 2 equal 0.43. With one exception, these 6 widows would have exhausted their capital before the end of the loss period.

Lump sum payments may include amounts awarded for pain and suffering (tort), for wage losses due to disability prior to death, and for medical care costs. Because the estimates of losses are limited to after-tax wage loss in a year following the worker's death, it is likely that the replacement ratios calculated for income imputed from lump sum payments are overstated. That is, some of the losses for which the benefit was paid are excluded from our estimates, thereby biasing the replacement ratio upward.

The 9 widows who received imputed tort income and cash benefits from other sources are uniquely well compensated. If their cash benefits continued at the 1979 level, only 2 would exhaust their capital before the last year of loss. The remaining 7 would be compensated for their losses and retain substantial capital amounts at the end of the loss period.

If one combines the results for all widows ($N = 124$) who received some compensation, the estimated replacement ratio in 1979 ranges from 3.9 percent to 290.5 percent with a median of 34.3 percent. In other words, the widows (for whom our data on compensation are most complete) bore approximately 66 percent of the annual loss (net taxes and the workers' consumption) due to their husbands' deaths.

TABLE 4
Compensation for Losses (1979)

Type of Compensation	Number of Recipients	Amount Received	Net Losses	Replacement Ratio			Uncompensated Losses
				Min.	Median	Max.	
Cash Benefits Only	109	$582,984	$1,457,036	0.04	0.33	2.91	$ 874,052
Cash Benefits Plus							
Imputed Income (Tort)	9	$135,503	$ 135,503	1.0	1.0	1.0	-0-
Cash		(60,977)	—	(0.19)	(0.37)	(0.67)	—
Imputed		(74,526)	—	(0.37)	(0.63)	(0.81)	—
Imputed (Tort) Only	4	$ 49,398	$ 60,390	0.42	0.71	1.00	$ 10,992
Imputed (WC) Only	2	$ 9,752	$ 31,092	0.17	0.30	0.42	$ 21,340
Total	124	$777,637	$1,684,021	0.04	0.34	2.91	$ 906,384
No Benefits	125	-0-	$1,717,073	—	—	—	$1,717,073
Total	249	$777,637	$3,401,094	-0-	-0-	2.91	$2,623,457

The 125 widows without compensation in 1979 incurred significant losses. The median net loss is $14,215. They are not, however, poor in the sense of being dependent on public assistance for their support. The possible answers to this apparent anomaly include the possibility that our estimates of lump sum consumption prior to 1979 are overstated because of cash benefits that were received but are not included in the data. Some of the widows may rely upon their own wage income, support from their children, or the wages of a spouse if they have remarried. Private compensatory strategies such as these are common responses to losses due to disability (Johnson and Murphy 1975). The questions that are raised deserve further investigation.

The results indicate that costs of death and disability have been borne primarily by asbestos workers and their families. The current compensation system is inadequate even when, as in our results, compensatory payments are compared to cost estimates that are defined to be less than total costs to workers and survivors. The "system" imposes more than two-thirds of net losses or approximately 84 percent of gross wage loss on the families of the affected workers. Social insurance is a primary source of the compensation that is paid, leaving producers with a very small share of the total. The system is inadequate in terms of compensation and shifts much of the burden of the compensation that is paid to taxpayers rather than asbestos producers.

It is also possible that the replacement ratios are low because the probability of recovery was lower during the study years than would now be true. In considering that possibility, one should remember that the insulation workers are likely to have better-than-average recovery rates relative to other high-risk groups such as employees of asbestos producers and shipyard workers. The insulation workers were members of a well-organized union and had access to expert medical advice on the link between asbestos and illness. Since many other workers, during the study period, had yet to learn of the facts, the success of the insulation workers in tort suits and compensation claims was probably high relative to other occupational groups.

Conclusions

Asbestos exposure has been killing workers for more than 60 years. Even if exposures were eliminated, exposures during the period from

1940 to 1979 will result in 420,784 deaths by 2027. The experience of insulation workers who died from asbestos between 1967 and 1979 indicates that the average gross loss per death is $201,125 ($243,619). If these averages are applied to asbestos-related deaths in other occupations, the total gross loss from death between 1967 and 1979 is $17.1 billion dollars. The deaths that occur between the years 1979 through 2027 will add $309.3 billion dollars to this total. The total cost of asbestos-related death is higher by an amount equal to the costs of medical care, litigation costs, and the administrative costs incurred by social agencies that cope with the problems of the workers' survivors. None of these costs are included in our estimates. The bill for the human costs of nearly 40 years of asbestos exposure, therefore, is a figure well in excess of the 326 billion dollars that we estimate.

The question of who has and who will pay these costs is important for the workers' families. It is also an important determinant of incentives for the prevention of death from asbestos. The method of compensation that will provide an optimal set of incentives for prevention cannot be determined from this study. The results do, however, describe a situation which is not likely to be optimal. The current approaches to compensation impose more than two-thirds of the private costs of disability and death on the widows of the workers. The adequacy of compensation varies widely within this group with differences in access to tort suit awards, workers' compensation, and social insurance. Whatever the reasons for these differences, the fundamental fact is that the current approaches to compensation do not provide adequate benefits for the losses that these families have suffered.

We have said little concerning the pain and suffering of the workers and of their families because these costs are not measurable. The concept of such losses, however, is not foreign to economic analysis and it should be understood that their omission simply supports our contention that our estimates are conservative.

The tragedy of the asbestos experience is that generations of workers have been subjected to an unnecessarily large risk of disability and death, and they and their survivors have not been adequately compensated for their pecuniary losses. Unless we fully understand the true costs of asbestos, the reasons for the failure of the compensation system, and the relationship between compensation and incentives for prevention, the tragedy will probably be repeated for workers who deal with other toxic substances in the workplace.

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