

ARTICLES

Current Methods of Estimating Severity for Occupational Injuries and Illnesses: Data From the 1986 Michigan Comprehensive Compensable Injury and Illness Database

Arthur Oleinick, MD, JD, MPH, Kenneth E. Guire, MS,
Victor M. Hawthorne, MD, M. Anthony Schork, PhD, MPH,
Jeremy V. Gluck, PhD, MPH, ByoungHo Lee, PhD, MS,
and Samuel La, MS

National and state estimates of the severity of occupational injuries and illnesses (severity = lost work time = missed work days + restricted work days) have come from the annual Survey of Occupational Injuries and Illnesses (Survey) produced by the U.S. Bureau of Labor Statistics. However, we show that the Survey practice of collecting injury information soon after the accident year reduces substantially the accuracy of missed work day estimates, which constitute 85.3% of the Survey lost work time estimate. To develop an independent estimate of missed work days, the research team created the Michigan Comprehensive Compensable Occupational Injury Database (Michigan Database) by linking state files with injury characteristics to files with workers' compensation information for injuries occurring in 1986. The measure of missed work time (days, weeks, or years) is the cumulative duration of compensation from the "date disability commenced," noted on the first payment form, through follow-up to March 1, 1990. Cumulative missed work time has been calculated or estimated for 72,057 injured workers, more than 97% of the 73,609 Michigan workers with compensable occupational injuries in 1986 identified through the close of the study. Our "best" estimate of missed work days, to follow-up, attributable to both fatal and nonfatal compensable occupational injuries and illnesses is 7,518,784, a figure four times that reported for Michigan by the Survey. When insurance industry data on disbursements are also considered, the estimate of missed work days increases to 8,919,079, a figure 4.75 times that reported by the Survey. When insurance data on reserves for future payments are also considered, the estimate of missed work days increases to 16,103,398, a figure 8.58-fold greater than that obtained for Michigan in the Survey. The Michigan data suggest that the national Survey may have failed to identify almost 373 million of 421 million missed work days in the private sector that have resulted, or will result, from 1986 occupational injuries. The present federal/state system for estimating occupational injury severity by measuring lost work days seriously underestimates the magnitude of the problem. The current policy of obtaining incidence

Departments of Environmental and Industrial Health (A.O., J.V.G., S.L.), Biostatistics (K.E.G., M.A.S.), and Epidemiology (V.M.H.), University of Michigan, Ann Arbor.

Department of Civil Engineering, University of Ulsan, Ulsan, South Korea (B.L.).

S. La is now with Texas Instruments, Dallas.

Address reprint requests to Dr. A. Oleinick, Department of Environmental and Industrial Health, University of Michigan, Ann Arbor, MI 48109.

Accepted for publication June 25, 1992.

and severity data from the same Survey should be reconsidered. We recommend that national estimates of injury severity be obtained from representative states by using state compensation data and that such estimates be used to evaluate current prevention and rehabilitation strategies. The redesigned occupational safety and health Survey (ROSH Survey) should be revised to permit linkage to compensation data. © 1993 Wiley-Liss, Inc.

Key words: ROSH Survey, disability estimates, Survey of Occupational Injuries and Illnesses, workers' compensation, data linkage

INTRODUCTION

National and state estimates of the incidence and severity of occupational injuries and illnesses have been the product of a Federal-State cooperative program that involves an annual national sample survey of employers' OSHA 200 logs of occupational injuries and illnesses (Survey) [BLS, 1988a]. The federal component has been provided by the Bureau of Labor Statistics (BLS) and, since 1991 [BLS, 1991], has also involved the federal Occupational Safety and Health Administration (OSHA), both in the Department of Labor. The content and sampling frame is the product of collaborative planning, while the Survey is conducted either by BLS or the individual states that are responsible for their own occupational safety and health program under the Occupational Safety and Health Act. The State of Michigan, which administers its own occupational safety and health program, conducts the Survey for BLS in Michigan, forwards the results to Washington, DC, for inclusion in the national estimates, and also publishes state data annually [MIOSHA, 1988a].

The annual incidence of occupational injuries or illnesses is calculated from the count of occupational injuries or illnesses and a count of the average number of full-time equivalent employees in the business establishments surveyed. The severity of nonfatal occupational injuries or illnesses is estimated from the number of lost work days, which is further subdivided into missed work days and days of restricted work activity.

The Survey requires the employer to transcribe, from the mandatory OSHA 200 log, the number of occupational fatalities, the number of nonfatal occupational injuries and illnesses, and the number of lost work days, if any, for the nonfatal events [OSHA, 1989a]. For workers who remain disabled at the time of the survey, the employer is required to predict the number of future lost work days that will be experienced. The employer is also required to provide the average employment for the year and the total number of hours worked, so that the number of full-time employee equivalents can be estimated.

The Survey of the 1986 calendar year experience in Michigan was completed in the first 7 months of 1987. The Bureau of Safety and Regulation sampled 13,031 of the ~180,000 Michigan establishments, mailed original and follow-up questionnaires to 11,774 establishments, and received 11,439 usable responses. The Survey yielded an estimate of 2,200,700 lost work days resulting from nonfatal occupational injuries and illnesses, of which 1,877,400 were missed work days (85.3%) and the balance were restricted work days. The total for 1986 showed a 6.54% increase over the preceding year, while the Michigan work force increased 3.93%, so there is no reason to believe that the 1986 Survey results are particularly unrepresentative.

In contrast, the 1986 Michigan Comprehensive Compensable Occupational Injury and Illness Database (Michigan Database) uses duration of workers' compensa-

tion as the measure of missed work days. The objective of the present study was to compare the estimate of missed work time obtained from the Survey methodology, a mail questionnaire completed sometime in the first 7 months of 1987, with the estimate obtained by the methodology of the Michigan Database, which employs follow-up data through March 1, 1990. The comparison indicates that the Survey estimate of missed work days underestimates the magnitude of the problem by a factor of no less than four. In addition, if workers' compensation insurance company disbursements and reserves are factored into the analysis, the underestimate could be on the order of magnitude of 8.58 times. Because estimating bias is inherent in the BLS methodology, and because of the importance of accurate statistics in setting national priorities, we report our findings.

MATERIALS AND METHODS

The Michigan Database was created to permit an "open case," or historical (retrospective) [Checkoway et al., 1989], cohort study of workers' compensation, in contrast to the traditional "closed case" compensation studies [Barth and Hunt, 1980]. In "closed case" studies, cases for which payments are stopped during the calendar period are regarded as closed and the amounts paid through closing are analyzed. Under compensation law (see below), some closed cases can be reopened, and payments resumed, if there is a recurrence of the disability due to a subsequent incident. In the Michigan Database, described below, the worker with a compensable injury had anywhere from one to 19 separate disability episodes (average 1.14) voluntarily compensated by the employer, from the date of injury in 1986 to March 1, 1990. Thus closed case data are clearly incomplete.

While incomplete follow-up information alone would not invalidate such studies, "closed case" studies suffer from two additional near-fatal flaws. Neither the population of workers at risk for occupational injury and illness, for which injury risk estimates could be calculated from the "closed case" injuries, nor the population of injured workers with specific injuries, to which the "closed case" disability payments would apply, are ever identified. These difficulties arise because the distribution of the year of injury for cases closed in any single calendar year is skewed toward the year of closure, but with a long tail extending toward the past [Hunt, 1988]. Thus, for any demographic or injury characteristic, the cohort of "closed" cases contains individuals from different annual injury cohorts. Without comparing the characteristics of cases from a particular annual injury cohort that are closed in a particular year with cases from the same cohort closed earlier or later, it is inappropriate either to characterize risk or to generalize disability experience from such populations. Such comparisons have never been undertaken, to our knowledge.

In contrast, the term "open case" refers to any member of the annual cohort of workers with compensable injuries or illnesses with a date of injury in 1986 who were reported to the compensation system before March 1, 1990. The Michigan Database thus relies on the traditional epidemiologic notion of a cohort where entry to the cohort occurs during a defined calendar period, and entry is independent of any particular outcome, and this reliance permits some generalizability of results. The Michigan Database probably seriously underenumerates compensable occupational diseases, as do all compensation-based systems [Barth and Hunt, 1980]. Subsequent

references to occupational injuries include the much smaller group of occupational diseases.

The 1986 Michigan Database was created by linking the compensation history from the Bureau of Workers' Disability Compensation (BWDC) data file with the Bureau of Safety and Regulation (BSR) Supplementary Data System injury characteristic data file, using the Social Security number and date of the worker's injury to match information. The BWDC data file provides demographic and outcome information, the latter in the form of detailed compensation payment histories. The term "compensation" in the present report refers only to the replacement of lost wages provided by the compensation insurance programs, since medical benefits are not routinely recorded in the BWDC data file. The BSR data file is based on the First Report of Injury forms (F100) submitted to BWDC. This form triggered the opening of a case file at BWDC and was then forwarded to BSR, where it served as the source for the BSR datafile. The BSR staff added additional demographic information and coded injury characteristics from the F100 (nature of injury, part of body affected, source of injury, and type of accident), worker occupation, and industry [MIOSHA, 1988b]. Injury characteristics in the BSR data file are coded according to the American National Standards Institute Standard Z16.2 (1962, R-1969) (ANSI) [ANSI, 1963] as modified for the SDS project [BLS, 1986; MIOSHA, undated].

In Michigan, state law specifies that a worker is eligible for workers' compensation if the worker is disabled for more than 7 days from the date of a work injury, excluding the day of injury or Sunday; is killed on the job (benefits are paid to the dependent[s]); or suffers a specific anatomic loss [West, 1985] or loss of industrial use [Pipe v. Lane, 1981] of the appendages or sensory organs on the job (so-called schedule or specific losses because the statute provides a schedule of total disability periods for each specific loss). The disability that initially qualifies an injured worker for compensation payments must be "total"; i.e., the worker must be absent from work for the minimum period indicated. Subsequently, payments are made for additional missed work time, regardless of whether the disability is total or partial. Partial disability occurs when the worker can still do part-time work or less demanding work at a lower wage [West, 1991a].

Payments continue for as long as the injured worker is unable to work as a result of the compensable injury or illness. Even if a worker has suffered a specific loss, compensation payments can be continued beyond the period specified in the statute, as long as the worker remains unable to work [Van Dorpel vs. Haven-Busch Co., 1957]. Thus, aside from the specific losses, Michigan compensates only when missed work time occurs.

In the present report, the duration of compensation paid voluntarily by the employer or as a result of an administrative/court decision provides a direct measure of the number of missed work days due to occupational injuries. More than 94% of the cumulative missed work time in these two payment categories was for missed work days associated with nonfatal occupational injuries, not listed as a specific loss in the statute. The balance of the cumulative missed work time through follow-up in these two payment categories was paid to three groups of injured workers: to dependents of workers killed on the job (<2.0%), to workers with specific losses (<2.0%), or to workers with partial disability (<1.5%). Compensation for partial disability was converted to missed work day equivalents, as described below.

When weekly payments were made either voluntarily by the employer or as a

result of an administrative or court decision (62,154 cases), missed work time was calculated by dividing the amount paid in each payment episode by the compensation rate for that episode. Then the episode results were summed to obtain the cumulative missed work time for an individual through follow-up to March 1, 1990. Durations for voluntary payments were also accumulated through two dates relevant to the conduct of the BLS Survey: April 30, 1987, the approximate date on which responses to second survey request mailings were complete, and July 31, 1987, the approximate date on which the collection of survey data was closed.

For periods of partial disability, missed work day equivalents were estimated. This was done by dividing the total amount paid for the partial disability episode by the compensation rate for the last total disability episode preceding the partial disability episode. The partial disability compensation rate could not be used, because that would have given only the duration of the payment episodes in these cases and not the missed work time durations. The Michigan Database does not contain any estimate for restricted work time that does not lead to lost wages, as reflected in compensation for partial disability.

To confirm that the duration of missed work time was equivalent to the duration of compensation, an analysis was undertaken of the reasons for terminating compensation in a subgroup of 3,953 cases in which all payments were made voluntarily by the employer. There were 6,261 stop payment forms filed for these cases, indicating that these workers had an average of 1.6 missed work time episodes during follow-up. In 80.3% of the stop payment forms, return to work was given as the reason for stopping payment; in 6.1%, the form indicated that the worker had recovered but did not indicate whether she or he had returned to work; in 13.2%, "other" was given as the reason. This last code was also used if the form was blank for this item. For the 1,079 stop payment forms terminating voluntary payment episodes in one of the two groups who ultimately redeemed their claims (see below), 73.1% indicated that the worker had returned to work or had recovered. Once again, the remaining 286 stop payment forms contained many with no response for this item. Thus these analyses indicate that the cessation of compensation payments and return to work or recovery were contemporaneous.

A third algorithm was used to estimate missed work time for the 4,488 cases where the employee ultimately redeemed, or settled, their claim; 85.7% of cases in this group also had voluntary payment periods preceding the final redemption payment and these were handled in the manner just described. In Michigan, a redemption or a lump-sum final settlement, also referred to as a "redemption of liability," occurs when the injured worker and the employer agree that the worker will give up all her or his future rights to workers' compensation benefits for the injury or illness in return for a single lump-sum payment [West, 1991b]. In this report, the amounts redeemed, listed separately from medical benefits redeemed, are regarded as representing mutually bargained for periods of missed work time, although it may be argued whether the parties involved have the same negotiating strength. To obtain an estimate equivalent to missed work time, the redeemed amount was divided by the last total disability compensation rate given in the file for a voluntary payment period. For the third group of 5,415 cases (including an additional 4,977 redemption cases) without individual duration information, a rough estimate of duration is provided, but the result is not included in the final study estimate. The methodology is described further in the Appendix.

The severity of the injuries in the group of cases that were ultimately redeemed was compared with those in the group of cases who were paid entirely on a voluntary basis or as a result of an administrative decision in order to decide whether the missed work time durations for both groups could be combined to yield a single estimate for the entire cohort. The comparison was undertaken because of the possibility that the redemption negotiation process itself might distort the duration estimates as a result of additional monies that might be paid to induce the redemption agreement.

To perform the comparison, the cumulative missed work times for the 4,488 redemption cases with duration data were tabulated separately from the cumulative missed work times for voluntary/decision payment cases. Then the durations for the redeemed cases were further subdivided into those durations obtained directly from voluntary/decision payment periods preceding the redemptions (85.7% of cases had such payments) and those estimated from redemption components. The redemption negotiation process would not be expected to affect significantly the voluntary payment component of the case that preceded the redemption agreement. Finally, the mean and quantile values for cumulative missed work times resulting from voluntary/decision payments were compared for the two payment groups for all injuries combined. For all injuries combined, as well as for categories of individual injury characteristics, the group of cases with the greater mean and quantile values were considered, on average, to be more seriously disabled than the group with lesser durations.

The preceding comparison of missed work times for voluntary/decision payment cases and redemption cases for all injuries combined was then replicated for individual categories for three ANSI injury characteristics, nature of injury, part of body affected, and type of accident. For each injury characteristic, the category with a combination of the greatest number of cases and the highest fraction of redemptions is tabulated in the present report. The criteria for evaluating the severity of the resulting disabilities, noted in the preceding paragraph, were employed.

Injury characteristic data are available for 56,206 of the 72,057 study cases in the Michigan Database with compensation data. Matching the BWDC and BSR data files by Social Security number and date of injury produced a match for 57,927 (94.2%) of the 61,491 cases with injury characteristic information that constitute the BSR data file. Of these 57,927 cases, 56,206 had both injury characteristic and missed work time information.

From the perspective of the BWDC data file, the 56,206 cases with both injury characteristics and missed work time information represent 78.0% of the 72,057 cases in the BWDC data file with missed work time information. Analyses indicate that the distributions by age, gender, nature of injury, and part of body injured in the group of 56,206 matched cases are comparable to those distributions in the group of all cases with an injury report (tables available from the authors). The cases with an injury report constitute more than 91% of the cases with missed work time information. Therefore, the missed work time experience of the 56,206 matched cases with both missed work time and injury characteristic information is used to represent the experience of the entire cohort with missed work time information.

RESULTS

Table I gives the cumulative missed work time through March 1, 1990, for Michigan workers injured at work during 1986. Cumulative missed work time is

TABLE II. Cumulative Missed Work Time to March 1, 1990, for Occupational Injuries, Michigan, 1986: Summary Statistics for Subsets of Cases Defined by the Injury Characteristic and Method of Payment

Population subgroup	Sample summary		Aggregate effect		Statistics summarizing the distribution of cumulative missed work time in weeks					
	N	Percent	Person years	Percent	Mean	Sample quantities				
						.05	.15	.50	.95	
Nature of injury	25,759	45.83	11,512.1	49.74	23.2	1.3	1.7	4.2	27.0	164.3
Sprains, strains	24,052	42.79	6,714.2	29.01	14.5	1.3	1.7	3.8	16.8	67.8
Causes paid voluntarily	1,707	3.04	4,797.9	20.73	146.2	15.2	31.3	121.3	271.7	358.1
Redemption cases	1,616	2.88	1,558.5	6.73	50.1	2.2	6.3	32.8	106.1	149.7
Voluntary component only	1,704	3.03	3,241.4	14.00	98.9	4.9	16.5	82.3	186.9	239.4
Redemption component only										
Part of body affected	13,477	23.98	7,180.7	31.03	27.7	1.3	1.7	4.2	37.4	182.5
Back	12,327	21.93	3,876.9	16.75	16.4	1.3	1.7	3.7	18.6	94.7
Causes paid voluntarily	1,150	2.05	3,303.8	14.27	149.4	14.0	31.7	124.8	277.9	468.7
Redemption cases	1,082	1.93	1,066.2	4.61	51.2	2.6	6.6	35.0	106.6	148.0
Voluntary component only	1,149	2.04	2,237.6	9.67	101.3	5.1	16.6	85.4	191.7	258.7
Redemption component only										
Type of accident	6,133	10.91	2,801.2	12.10	23.8	1.4	2.0	5.9	27.6	157.1
Fall on same level	5,662	10.07	1,594.7	6.89	14.6	1.3	1.8	5.2	18.0	56.2
Causes paid voluntarily	471	.84	1,206.4	5.21	133.2	13.9	25.3	96.1	260.0	370.6
Redemption cases	450	.80	397.8	1.72	46.0	2.2	6.0	25.5	102.0	152.1
Voluntary component only	469	.83	809.5	3.50	89.8	3.2	13.4	64.0	177.3	258.7
Redemption component only										
Total	56,206	100.00	23,143.2	100.00	21.4	1.3	1.8	4.8	23.5	143.8

given by method of payment. Overall, cumulative missed work time estimates were obtained for 72,057 of 73,609 eligible cases with compensation payment information (97.9%).

The 62,154 cases who have been paid either voluntarily by their employers (95.8% of compensation in this category) or as the result of a decision producing an award, stipulation, or voluntary payment in a disputed case (4.2%) constitute 86.3% of the 72,057 workers injured in 1986 for whom there is cumulative missed work time information. This group of injured workers had a total of 17,318.6 person-years of missed work time through March 1, 1990, which represents a total of 4,502,836 missed work days based on a 5 day work week and a 52 week work year. At the end of follow-up, 3.48% of this group were receiving weekly compensation payments. The quantile values for the distribution of cumulative missed work time, in work weeks, indicate that 15% of workers with compensable injuries (those workers with durations at, or beyond, the 85th quantile) missed work for almost one-third of a year (≥ 17.0 weeks) between the injury and the close of follow-up. Five percent of the injured population had more than 1 year of cumulative missed work time (≥ 61.8 weeks) in the average follow-up period of a little more than 3.5 years, i.e., from an average midyear date of injury of July 1, 1986, to the follow-up date of March 1, 1990. Duration information was excluded, in part, for 0.6% of cases in this group.

Among 4,488 cases with a redemption (lump-sum settlement) agreement, voluntary payments preceded or accompanied the redemption agreement in 3,846 cases. The phrases "pre-redemption voluntary payments" in the text or "redemption case-voluntary component" in the tables refer to the cumulative missed work time experience of members of this group up to the time when the redemption occurred. These phrases distinguish the voluntary payment experience for members of the redemption group from that of workers who received only the voluntary form of payment during the follow-up period. The cumulative person-years of missed work time for the pre-redemption voluntary payments total 3,678.2 years, or 956,332 missed work days. Of these missed work days, only 0.02% represent the completion of ongoing voluntary payment episodes mandated by the redemption agreement and may have been affected by the negotiation process itself.

The mean and all quantile values for cumulative missed work time calculated from the pre-redemption voluntary payments are substantially greater than the comparable durations for workers paid entirely on a voluntary basis. For example, the mean value for cumulative missed work time for the pre-redemption voluntary component of payment, 49.7 weeks, is more than three times the value of 14.5 weeks for workers paid entirely on a voluntary basis (the median values are 31.6 and 4.5 weeks, respectively). Thus, by the time of the redemption agreement, and without regard to the cumulative missed work time added by the redemption payment, workers in the redemption group had already experienced far greater periods of cumulative missed work time than did those paid only voluntarily during the follow-up period. Consistent with our earlier hypothesis, the workers who redeemed their compensation claims appear to have suffered more disabling injuries.

The redemption component in these cases provides the equivalent of 7,921.6 person-years (2,059,616 days) of missed work time. The mean redemption equivalent, i.e., the mean prepaid total disability period jointly agreed upon by the employer and the injured employee, is 1.75 years (92.1 weeks). The quantile values for dura-

tion equivalents also indicate prolonged periods of missed work time. The median value exceeds 1.25 years of compensation (68.7 weeks), the 85th quantile approximates 3.5 years of additional compensation (180.1 weeks), and the 95th quantile approximates 4.75 years of additional compensation (244.3 weeks).

Through April 30, 1987 (the cut-off date for responses to the second Survey request for data), the cumulative duration of missed work time of 2,996,500 missed work days amounts to 39.9% of the total of 7,518,784 missed work days through follow-up. The comparable figure through July 31, 1987 (the cut-off date for all Survey data), is 44.8%, or 3,369,900 missed work days. The redemption payments themselves, in contrast to the pre-redemption voluntary payments, contributed less than 100 person-year equivalents through the latter date.

For 5,415 cases, the source tapes yielded only the amount of wage replacement, but no compensation rate. The indirect estimate of 3243.6 person-year equivalents (843,336 missed work days) in Table I is based on the 4,977 redemption cases contained in this group (Appendix), while no estimate of duration is available for the remaining 438 cases in this group. These 5,415 cases are not analyzed further.

Table II gives the cumulative missed work times for voluntary payment and redemption cases, for one category within each injury characteristic. The category selected for presentation was chosen because it comprised the greatest number of cases overall *and* had the highest fraction of redemptions, although the redemption fraction was <10% in all three categories shown. The first two categories listed represent, by far, the largest single category in each of their respective injury characteristic classifications. Thus, sprains/strains account for 45.83% and 49.74% of all injuries and total cumulative missed work time, respectively, when injuries are classified by nature of injury, while back injuries are also the most frequent anatomic area injured (23.98%) and account for the largest fraction of cumulative missed work time (31.03%). Falls on the same elevation are the third most frequent type of accident (10.91%) and produce the second greatest amount of cumulative missed work time (12.10%).

The pattern of longer pre-redemption voluntary payment periods than voluntary only payment periods is seen consistently in each category. For example, in the sprains/strains category, the mean cumulative duration of missed work time for the pre-redemption voluntary component is 3.5 times that for cases paid voluntarily only (50.1 vs. 14.5 weeks, respectively). In addition, all the quantile values for the pre-redemption voluntary component are substantially greater than those observed in the voluntary payment only group. The differences are particularly striking for the 50th, 85th, and 95th quantile values. The redemption agreement then adds substantial additional mutually agreed-upon missed work time equivalents. Given the missed work time experience of those injured workers who are paid only voluntarily throughout the entire follow-up period, it is difficult to imagine that they will "catch up" with the missed work time experience of workers who redeem their case.

In addition, this pattern is observed consistently in three additional categories for each of the three injury characteristics analyzed. Together with the particular category tabulated in Table II, the four categories analyzed for each of the three injury characteristics account for 73.09% of all injuries by injury type, 47.42% of injuries by part of the body injured, and 39.42% of injuries by accident type, respectively. Similarly, they account for 73.70% of the person-years of cumulative duration of missed work time by injury type, 52.12% of missed work time by anatomic area

injured, and 37.34% of missed work time by accident type. (These additional analyses are available from the authors.) Clearly, however, it is true that workers who redeem their cases have experienced more disabling injuries than workers who do not redeem their cases, both for all injuries combined and when injuries are classified by category within a particular injury characteristic.

DISCUSSION

Missed Work Time Estimates

The discrepancy between the estimate of missed work time reported by the Survey and that reported by the Michigan Database cannot be explained by differences in the scope of coverage for employers and employees in the two data sets [MIOSHA, 1988a,c]. Both data sets exclude Federal Government employees and, in addition, the Survey does not cover farms with fewer than 11 employees, private households, or self-employed individuals. With these exclusions, the Michigan Survey estimates that it covered 3,065,900 workers in the private sector and 536,500 workers in state and local government. The Michigan Database does not cover maritime employments, merchant seafarers, and railroad employees who are covered by Federal workers' compensation or employers' liability laws. In addition, compensation coverage is voluntary for household workers (if employed <35 hr/wk), certain corporate officers, sole proprietors and partners, employers with fewer than three employees (unless one employee works 13, or more, weeks in the preceding 52 weeks) and public safety employees. Our estimate of the total population at risk for Michigan Database injuries or illnesses in Michigan in 1986 is 3,696,000 [Bureau of the Census, 1989] and excludes 232,000 self-employed individuals. This figure is known to be a slight overestimate because some of the industry subcategories included in this total, such as the 47,000 private household workers, could not be subdivided further with available data into those with, and without, compensation coverage.

Nor is the discrepancy explained by the fact that the two data sets define an occupational illness or injury differently. The OSHA log [OSHA, 1989b], Form 200, which is used in the Survey, defines an occupational injury or illness as "an occupational fatality; every nonfatal occupational illness; and those nonfatal occupational injuries which involve one or more of the following: loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment (other than first aid)." The definition of a compensable injury in the Michigan Database includes an occupational fatality, a specific anatomic loss, or disability (absence) from work for more than 7 days. Thus, the definition of an occupational injury or illness in the Survey is broader than that for the Michigan Database, so that the estimate of lost work days should be greater in the Survey if there were no other differences in the two data sets.

However, the data sets differ in two important respects. First, the Michigan Database includes missed work days for workers who were injured or became ill in 1986 but who did not have any compensable missed work time until a later calendar period. This compensable missed work time would not have been picked up by the Survey unless it occurred by the time the employer received the Survey questionnaire. However, this difference between the two data sets, by itself, would explain only a small fraction of the documented discrepancy. Fewer than 5% of the 66,000 cases

who received any voluntary payments subsequent to the injury or illness in 1986 received their first voluntary compensable disability payment after 1986.

The second difference, and the major reason for the discrepancy in the results from the two data sets, is that they measure the amount of missed work time at different periods in the natural history of the event. The Survey in Michigan was carried out in the 7 month period following the injury year of interest [BLS, 1989]. The data for individual payment episodes in our Michigan Database, which were combined to obtain cumulative missed work time for each case, document that many workers experience recurrent episodes of disability and missed work time over long periods of time following an injury, for example, a back strain. More than one-half of the cumulative missed work time through follow-up in our study occurred after the close of the BLS Survey. The Survey makes no provision for estimating such subsequent episodes of disability, except for workers who had not returned to work at the time of the Survey, nor do later Surveys make any effort to update the data from earlier calendar periods.

Moreover, the Survey even appears to underestimate seriously the disability through the time of the survey, as we demonstrated by comparing the Survey estimates with estimates from the Michigan Database at the same points in time. The Survey procedure has several serious flaws. First, while the employer is asked to verify that their Survey report numbers are correct [OSHA, 1989c], the instructions for maintaining the log itself specifically exclude any duty to update either component of the lost work day figure entered originally, if the worker is back at work at the time of the survey [OSHA, 1989d]. Thus, to ensure the accuracy of the lost time components reported, the employer would have to compare the figure in the OSHA 200 log with the personnel record, but the survey form does not suggest this procedure. Lacking such a comparison, the Survey cannot evaluate the potential for bias in its estimate caused by the ambiguous directions. Our data indicate that the BLS survey identified only 62.7% of the cumulative missed work time for which compensation was paid voluntarily through April 30, 1987 (55.7% through July 31, 1987).

Second, for workers whose work day loss is continuing at the time of the Survey, the employer is asked to add an estimate for future lost work time [OSHA, 1989c]. Presumably, this estimate would be based on a physician's estimate, but the survey instructions do not specify the source of the estimate, and it is unclear how current such an estimate need be or how reliable such estimates actually are.

Which estimate of missed work time from the Michigan Database should be adopted? The most conservative analytic approach would be to disregard all but the cumulative missed work time calculated from all the voluntary payment episodes, regardless of whether such episodes originate from cases in which all payments are made voluntarily or represent pre-redemption voluntary components for cases that later redeem their claim. This would ignore the missed work time equivalents attributable to the redemption (lump-sum settlement) payment because of the possibility that the redemption negotiation process itself may artificially inflate any resulting estimate by offering additional missed work time equivalents to induce the agreement. If the most conservative analytic approach is adopted, then the Michigan Database estimate is 2.91 times greater than the Survey estimate of 1,877,400 missed work days.

However, we believe that the most conservative approach would be too conservative. We believe that the missed work time equivalents derived from the re-

ols.
4811

1989

deemed amounts in the redemption agreements should be counted as missed work days in deciding the extent to which the Survey underestimates missed work time. The median and quantile values for the missed work time for the pre-redemption voluntary payments are consistent with the hypothesis that these redeemed cases represent seriously disabling injuries. The long periods of voluntary payments by the employer preceding the redemption agreement certainly suggest that they view the injuries as seriously disabling. The redemption equivalents themselves, which are the consequence of a voluntary agreement between the employer and employee that provides a prepaid period of disability, are also consistent with this hypothesis, e.g., producing median missed work time equivalents in excess of 1 year. These findings remain consistent when missed work times for voluntarily paid and redeemed cases are compared on a variety of injury characteristics.

All evidence to date indicates that injured workers who redeem their cases suffer, on average, from more disabling injuries than those who do not redeem their cases. No evidence suggests that they do not. Moreover, data from the early part of this century, the only such data extant, indicate that agreements, including redemptions, actually led to undercompensation of lost work time in injured New York workers [Larson, 1991]. New York banned such agreements following the study report. If undercompensation with redemptions is widespread, then our duration estimates in the present analysis for redeemed cases should be viewed as underestimates, rather than overestimates, and would further support our decision to include them in the total of missed work days.

At this time, we are prepared to lay aside, as too speculative, our indirect estimate of 843,336 missed work days for the 4,977 redemption cases for which we could not calculate missed work time equivalents directly. However, it is worth pointing out that, with further study, many of the duration equivalents in this group may be validated and so would supplement the total for the other groups.

Therefore, at this time, we suggest that a reasonable compromise on the question of including the missed work time equivalents from redemptions is to include those equivalents that can be calculated directly from amounts redeemed and compensation rates given in the records. We would exclude the estimates we give for cases without a compensation rate in the file. If, as outlined in Appendix Table, part 1, the missed work time equivalents calculated directly from the redeemed amounts are added to those paid voluntarily, the Michigan Database "best" estimate is 4.00 times the estimate given in the Survey.

Financial data from the Data Collection Agency of the Compensation Advisory Organization of Michigan (CAOM), the analytic center for commercial workers' compensation insurance carriers in Michigan, and the National Council on Compensation Insurance (NCCI), the commercial insurers national resource for actuarial information on workers' compensation claims, indicate that our analytic algorithms have captured a large fraction of the compensation data in the system. For all compensable injuries and illnesses, our Michigan Database indicates that \$381,660,000 was paid in compensation through March 1, 1990. This can be partitioned into 58.6% paid by commercial workers' compensation insurers and 41.4% paid by self-insured employers with data from cases closed in 1986 and 1987 (M. Madden, personal communication). We estimate that \$223,652,760 was paid out through March 1, 1990, by commercial insurers. This amount represents 84.3% of the amount reported by these two organizations as disbursed through December 31, 1989, as compensa-

tion for all their cases (W. Miller, personal communication). If our data are corrected to account for the omission of 15.7% of wage replacement disbursed, then the Michigan Database would give an estimate of missed work days that is 4.75 times the estimate from the Survey, using our "best" estimate value calculated directly from the compensation records (Appendix Table part 1).

The CAOM and NCCI data also include estimates of the reserves required to pay for future episodes of disability in both the known cases and the cases incurred but not yet reported to the insurance carrier (IBNR) [CAOM, 1991]. This estimate can be used to obtain an upper boundary for the estimate of cumulative missed work days attributable to an annual cohort of occupational injuries in Michigan. Their figure for indemnity (wage replacement) losses includes both the compensation paid out through December 31, 1989, an estimate of future compensation payments for known cases, and an estimate of the wage replacement that will be needed for the IBNR cases (W. Miller, personal communication). This combined figure is 1.57 times the amount paid out through December 31, 1989. In addition, their data include an additional factor derived from analysis of their historical experience of actual expenditures vs. estimated reserves. This "factor to develop indemnity losses to an ultimate report" is 1.15. When these two factors are combined, the result indicates that the commercial insurance carriers estimate that total compensation payments for missed work days will be ~1.81 times the amount paid out through December 31, 1989.

If the CAOM and NCCI data are combined with our "best" estimate results, corrected for undercounting, they indicate that the Survey estimate could be inaccurate by a factor of 8.58 (Appendix Table part 1). This larger ratio would apply if the estimates of future liability for the commercial carriers were correct, if they applied as well to the self-insured employers in Michigan, and if the amounts to be disbursed translate to missed work times in the same way as the compensation amounts already paid out. This would mean that the number of missed work days ultimately attributable to compensable occupational injuries or illnesses suffered by the 1986 cohort of injured Michigan workers could reach as high as 16,103,398 days, a figure close to an order of magnitude greater than the 1,877,400 missed work days reported by the Survey. Moreover, even our maximum estimate underestimates the missed work time due to occupational injuries, since, as the recent Rand report shows, sick leave and disability insurance provide compensation for additional missed work days due to such occupational injuries [Hensler et al., 1991].

A recent *New York Times* investigative report [Kerr, 1991a,b] claims that, at least in some states, fraud produces an inflation in the number of claims filed and the amount of missed work time compensated, but estimates of the magnitude of this problem indicate that it could explain, at most, only a small fraction of the difference we observe between the Database and Survey estimates in Michigan. It is difficult to evaluate the estimates of fraud, by state, since the nature and source of the data underlying such estimates are not provided. Generally, the estimates of fraud appear to come from investigative units, which are more likely to deal with a *nonrepresentative sample of cases at higher risk of fraud than is found in the reference population*. Hence these estimates would overestimate the true magnitude of the problem. In the states of California and Massachusetts, the article claims, fraud inflates the number of claims or costs in the range of 13% to "more than 20%," but officials in New York and Illinois assert that it contributes only a small fraction to overall costs.

In Michigan, the data suggest that the employer and the insurance carrier exercise reasonably diligent oversight regarding the legitimacy of claims filed, so that only a small fraction of costs is possibly attributable to fraud. This oversight occurs through the use of a Form 107, Notice of Dispute. This form is filed when the employer claims that the injury is not work-related, that the medical treatment is not related to the injury, that further investigation or information is needed before the claim will be paid, or if there is a dispute involving the need for vocational rehabilitation. The filing of the form stays any penalties for failure to make timely compensation payments on the claim.

Employers filed 18,890 Form 107s disputing claims for compensable injuries occurring in 1986. Employers disputed 60.5% of the 8,022 claims that received no compensation payments during the follow-up period. This group of cases is not included in the Michigan Database. Employers also disputed 19.3% of the 66,642 cases in the Michigan Database for which we have been able to estimate directly cumulative duration of missed work time. In the subgroup of 6,663 workers who have cumulated the most missed work time since their injury (90th–100th percentiles, accounting for 70% of the total cumulative missed work time), employers disputed 51% of the claims. However, both disputed and nondisputed cases in this subgroup were ultimately paid compensation, for the most part voluntarily (>96% in each category), for an average of 156 cumulative missed work weeks. Given the large sums of monies paid out, it is difficult to believe that many employers would make such payments, absent an administrative order, if there were substantial residual doubts regarding the claim's validity.

The Michigan Database can also be used to estimate the potential for error in the 1986 national estimate of missed work days for the private sector provided by the national Survey, as shown in Appendix Table parts 2 and 3. To produce our estimate, we multiplied 7,210,060, which is the number of missed work days given by our "best" estimate for the private sector through the follow-up date, by the ratio of the 1986 average annual employment in the private sector in the United States to the comparable figure for Michigan (27.17) [BLS, 1988b; MIOSHA, 1988d]. This yields an estimate of 195,897,330 missed work days, compared to the figure of 46,725,400 missed work days reported by the national Survey. If, instead, we had used the estimate of 15,442,187 days, which includes the actual missed work days through follow-up, the correction for the 15.7% undercount of missed work days produced by our algorithms and an estimate of the future missed work days, then the difference between the Michigan Database figure and the Survey result would have been 372,838,696 days. The estimate is not affected materially by using the ratio of full-time employees nationally to those in Michigan (24.45) [BLS, 1988c; MIOSHA, 1988e], since the two ratios are very close.

The enormous difference between the national Survey estimate and the Michigan Database extrapolation is not explained by substantial differences between Michigan and the nation in the lost work day rates. The direct standardized rate for Michigan, the result of applying Michigan rates by industry to the national work force, is 7.7 lost work day cases per 100 full-time workers compared to the U.S. rate of 7.9 [MIOSHA, 1988f]. This finding suggests that the lost work day rates by industry for the State and the country are similar and direct comparison of rates by industry division confirms this conclusion [BLS, 1987; MIOSHA, 1988e]. Second, the nonstandardized rate for the private sector in Michigan is 8.2 per 100 full-time

employees, compared to the direct standardized rate of 7.7, suggesting a difference in the work force distribution by industry. Comparison of the percentage distributions of the work forces by industry division indicates that only the manufacturing industry, among the divisions with higher Michigan than U.S. rates, is overrepresented in the Michigan work force. However, the increase, from 23.6% to 33.5% of the work force [MIOSHA, 1988g], can hardly explain the greater than eightfold increase in the number of missed work days derived from the Michigan Database.

The only other national estimate of time lost due to occupational injuries is one provided by the National Safety Council (NSC). The NSC estimated that 35,000,000 days were lost in 1986 as a result of injuries that occurred during that year and that 100,000,000 days would be lost in the years beyond 1986 because of the on-the-job deaths and disabling injuries that occurred in 1986 [NSC, 1987]. In the total of 135,000,000 lost work days, occupational fatalities contribute almost one-half, the ratio of permanent disabilities to occupational fatalities is set at 6:1 in calculating the contribution of permanent disabilities, and the NSC uses the average duration of lost work time from the Survey for temporary disabilities (S. Landes, personal communication). The NSC estimate is most appropriately compared to our estimate of 419,564,096 missed work days, which combines the figure for actual missed work days with an estimate of future time loss. The NSC figure is 32% of our estimate. Moreover, the NSC estimate is of limited utility in planning because it is not further subdivided by demographic factors, injury characteristics, occupation, or industry.

Policy Implications and Recommendations

The findings in this report raise important policy questions. First, should the federal Occupational Safety and Health Administration, as successor to the federal Bureau of Labor Statistics in mandating the content of the annual Survey of occupational injuries and illnesses, continue the longstanding effort to measure the incidence and severity of occupational injuries and illnesses in the same survey? Currently, the redesigned occupational safety and health (ROSH) information system, the replacement for both the annual Survey and the Supplementary Data System, will continue the effort to collect both types of statistics in the same survey [BLS, 1990]. Our data indicate that the proximity of the Survey to the injury event, while it may increase the accuracy of incidence estimates, works against the accuracy of data on the severity of the injury as measured by subsequent missed work days.

Accordingly, and based on our experience in constructing the Michigan Database, we suggest that estimates of injury severity be obtained from payment records contained in state workers' compensation systems. This will, of course, require a feasibility study to determine whether the payment data in the compensation system of other states can be converted directly to missed work time estimates by a series of computer algorithms. For example, some states do not separate the wage indemnification and medical expenses components on a redemption form, so that missed work time equivalents cannot be calculated for this form of payment (L. Boden, personal communication). If estimates of cumulative missed work time can be obtained from compensation data in representative states, they would provide, in our opinion, the most appropriate measure of work time missed due to occupational injury available today, short of individual medical follow-up. Such estimates would be preferable, by far, to those provided by Survey methodology.

This proposed approach ignores the relatively small contribution to total cumu-

lative missed work time from workers whose noncompensable occupational injuries are reported to the Survey. In Michigan, where the criterion of compensability requires, *inter alia*, eight or more days of total disability following an occupational injury, the cumulative total disability associated with missed work days for noncompensable injuries represents only ~2% of the number of missed work days for compensable injuries. This fraction is obtained by subtracting the 56,206 compensable injuries with injury characteristics, which we know were identified by mid-1987, from the number of lost work day cases, 117,700, reported in the Survey at about the same time and assuming that the remaining (noncompensable) cases had 0.5 weeks of missed work days, on average [MIOSHA, 1988e].

The scheme proposed would require, as in the Michigan Database, that injury reports and workers' compensation payment records be linked. Practically, however, it would be prohibitively expensive to attempt such linkages in every state and territory, if a pilot study indicated that such linkage was feasible. Substantial time and money are required to convert payment records into missed work day counts, because the programming must reflect the variability both in recording workers' compensation payments and in the statutory compensation schemes. We propose, instead, that national estimates of occupational injury severity be obtained from prolonged follow-up of cases in a sample of states chosen to reflect current state variations in distribution by industry, occupation, injury characteristics, demographic factors, and workers' compensation rules.

It is possible that the proposed injury severity monitoring scheme could be built into the new ROSH system. This would be feasible if the sample of occupational injuries in each state that will provide data for the ROSH incidence figures could also serve as the source for the proposed injury severity monitoring scheme in selected states. Under this approach, the sample of cases would first be used to estimate the incidence of occupational injuries and illnesses and then would be used to monitor the accumulation of missed work days through the workers' compensation system for those cases meeting the criteria for compensability. This approach would minimize the burden on participating employers.

However, since ROSH will not yield long-term follow-up data until the mid to late 1990s following its implementation in 1993 (for the 1992 experience) (W. Eisenberg, personal communication), a need remains to obtain national estimates of injury severity in the near term. Replicating the analytic approach in this study in a sample of representative states could produce such estimates in 2-3 years and thus provide a head start in reviewing current prevention and rehabilitation strategies.

The second major policy issue raised by our findings is whether the current major focus by the National Institute for Occupational Safety and Health on occupational fatalities [Bell et al., 1990], to the exclusion of a comparable major effort focused on estimating the disabling effect of severe injuries, is advisable. The data from Michigan indicate that there were fewer than 200 fatalities at work reported to the workers' compensation system in 1986 and that the families of 138 such workers obtained some compensation. This figure almost surely excludes a large number of fatalities due to occupational diseases [Barth and Hunt, 1980]. It is unlikely, however, that the true number of occupational fatalities would greatly exceed the number of Michigan workers who are seriously disabled by injuries each year. Over 3,000 Michigan workers experienced 3 or more years of cumulative missed work time following occupational injury in 1986 alone. A more balanced approach to both

occupational fatalities and the severe disabilities produced by some occupational injuries is suggested by the data.

In summary, the present study documents that the current federal/state Survey yields estimates of occupational injury severity that seriously underestimate the magnitude of the problem. An alternative approach for measuring injury severity is suggested that would extend our Michigan Database approach of linking injury reports with payment records to additional state workers' compensation systems.

CONCLUSIONS

Data from the Michigan Database, created by linking Michigan's injury characteristic and compensation reporting systems, indicates that workers who had compensable work-related injuries or illness in 1986 have missed 7,518,784 work days through follow-up to March 1, 1990. Corrections for the capture rate for missed work time by the Michigan Database and future loss estimates, both obtained from commercial insurance companies, indicate that the final cumulative number of missed work days for the 1986 cohort of injured workers may reach 16,103,398 missed work days. The Michigan Database results indicate that the current federal/state Survey estimate of the severity of occupational injuries and illnesses underestimates the extent of the problem by almost an order of magnitude in this state and, by extrapolation, nationally. The present Survey reliance on a single instrument to measure both the incidence and the severity of occupational injuries and illnesses should be reconsidered. If a pilot study indicates the feasibility of extending the present methodology to additional, and representative, states, then the proposed ROSH replacement for the Survey should be revised to incorporate the use of compensation data to estimate severity.

ACKNOWLEDGMENTS

We are grateful to Eula Bingham, PhD, and Leslie I. Boden, PhD, for their careful reading of earlier versions of the manuscript and for helpful comments. This study was supported in part under contract PO 90-20023 from the Department of Labor, State of Michigan.

REFERENCES

- ANSI (1963): American National Standards Institute. Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries. ANSI Z16.2-1962 (R1969). ANSI: New York.
- Barth PS, Hunt HA (1980): "Workers' Compensation and Work-Related Illnesses and Diseases." Cambridge, MA: The MIT Press.
- Bell CA, Stout NA, Bender TR, Conroy CS, Crouse WE, Myers JR (1990): Fatal occupational injuries in the United States, 1980 through 1985. *JAMA* 263:3047-3050.
- BLS (1986): U.S. Department of Labor, Bureau of Labor Statistics, Office of Survey Processing. Supplementary Data System: SDS Operating Manual and Notes to Assist in Classifying Cases.
- BLS (1988a): U.S. Department of Labor, Bureau of Labor Statistics. Occupational Injuries and Illnesses in the United States by Industry, 1986. Bulletin 2308. Washington, DC: Government Printing Office, May 1988.
- BLS (1988b): U.S. Department of Labor, Bureau of Labor Statistics. Table 1: Occupational injury and illness incidence rates by industry, 1985 and 1986. Occupational Injuries and Illnesses in the United States by Industry, 1986. Bulletin 2308. Washington, DC: Government Printing Office.
- BLS (1988c): U.S. Department of Labor, Bureau of Labor Statistics. Text Table 1: Occupational injury

- and illness incidence rates per 100 full-time workers, 1972-1986: Unnumbered table, p. 7: Number of lost worktime cases. *Occupational Injuries and Illnesses in the United States by Industry, 1986*. Bulletin 2308. Washington, DC: Government Printing Office.
- BLS (1989): U.S. Department of Labor, Bureau of Labor Statistics. *OSH Survey Operating Manual* 12.89.
- BLS (1990): U.S. Department of Labor, Bureau of Labor Statistics. *Occupational Safety and Health Statistics Program Redesign: Regional Commissioners Handbook*. Washington, DC: Government Printing Office.
- BLS (1991): BLS transfers to OSHA responsibility for tracking workplace injuries, illnesses [article]. *Occupational Safety & Health Reporter* 1991; 20(336):1269-1270. Washington, DC: Bureau of National Affairs.
- Bureau of the Census (1989): Bureau of the Census, U.S. Department of Commerce. *State Population and Household Estimates with Age, Sex, and Components of Change: 1981-88*. Series P-25, No. 1024. Washington, DC: Government Printing Office.
- CAOM (1991): Compensation Advisory Organization of Michigan. Appendix C-I-Section C. Michigan Accident Year Experience Valued as of December 31, 1989. The Data Collection Agency Workers' Compensation Pure Premium Publication. Effective January 1, 1991. Livonia, MI: CAOM.
- Checkoway H, Pearce N, Crawford-Brown D (1989): "Research Methods in Occupational Epidemiology." New York: Oxford University Press.
- Hensler DR, Marquis MS, Abrahamse AF, Berry SH, Ebener PA, Lewis EG, Lind EA, MacCoun RJ, Manning WG, Rogowski JA, Vaiana ME (1991): Compensation for Accidental Injuries in the United States. Report R-3999-HHS/ICJ of The Institute for Civil Justice. Santa Monica, CA: RAND.
- Hunt HA (1988): Figure 1: Workers' Compensation Injury Data Distribution. In: "The Incidence of Workers' Compensation Claims in Michigan: Final Report to Michigan Department of Labor." Kalamazoo, MI: The W.E. Upjohn Institute for Employment Research.
- Kerr P (1991a): Vast amount of fraud discovered in workers' compensation system. *New York Times*. Dec. 29, Sect. 1, Col. 1, p. 10.
- Kerr P (1991b): Profitably policing workers' comp. *New York Times*. Dec. 30, Sect. C, Col. 2, p. 2.
- Larson A (1991): "Workmens' Compensation (Desk Ed)." New York: Mathew Bender (Times Mirror Books) Section 82.20.
- Mich Dept Labor (1986): "1986 Weekly Benefit Tables." Michigan Department of Labor, Bureau of Workers' Disability Compensation. Lansing, MI, MDL.
- MIOSHA (1988a): MIOSHA Information Division, Michigan Department of Labor. "Annual Occupational Injuries and Illnesses Survey Michigan, 1986." Ref. 184068. Lansing, MI: MIOSHA.
- MIOSHA (1988b): MIOSHA Information Division, Michigan Department of Labor. "Compensable Occupational Injuries and Illness Report Michigan, 1986." Ref. 184067. Lansing, MI: MIOSHA.
- MIOSHA (1988c): MIOSHA Information Division, Michigan Department of Labor. Appendix A: Supplementary Data System Occupational Injury and Illness Data, Michigan, 1986. Compensable Occupational Injuries and Illness Report Michigan, 1986. Ref. 184067. Lansing, MI: MIOSHA.
- MIOSHA (1988d): MIOSHA Information Division, Michigan Department of Labor. Table 8: Comparison of Change of Employment and Change in Total Cases by Industry Division, Michigan 1986 and 1985. "Annual Occupational Injuries and Illnesses Survey Michigan, 1986." Ref. #184068. Lansing, MI: MIOSHA.
- MIOSHA (1988e): MIOSHA Information Division, Michigan Department of Labor. Table 1: Occupational Injuries and Illnesses Incidence Rates by Industry Division Michigan, 1986 and 1985; Table 5: Number of Occupational Injuries and Illnesses by Industry Division Michigan, 1986 and 1985. "Annual Occupational Injuries and Illnesses Survey Michigan, 1986." Ref. 184068. Lansing, MI: MIOSHA.
- MIOSHA (1988f): MIOSHA Information Division, Michigan Department of Labor. Chart 5: Occupational Injuries and Illnesses Standardized Incidence Rates, Michigan and the United States Private Sector, 1976-1986. "Annual Occupational Injuries and Illnesses Survey Michigan, 1986." Ref. 184068. Lansing, MI: MIOSHA.
- MIOSHA (1988g): MIOSHA Information Division, Michigan Department of Labor. Table 12: Comparison of Employment Proportions by Private Sector Industry Divisions Michigan and U.S. 1986. "Annual Occupational Injuries and Illnesses Survey Michigan, 1986." Ref. 184068. Lansing, MI: MIOSHA.

- MIOSHA (undated): MIOSHA Information Division, Michigan Department of Labor. "Rules for Selection, Supplementary Data System." Lansing, MI: MIOSHA.
- NSC (1987): National Safety Council. "Accident Facts, 1987." Chicago, IL: National Safety Council. Table on p. 31: Total Time Lost in 1986.
- OSHA (1989a): Code of Federal Regulations: Title 29, Part 1094.20. Occupational Safety and Health Administration. See also, Bureau of National Affairs, S-239: Instructions for Completing OSHA Form No. 200-S, 27:1261-1264. Washington, DC: OSHA.
- OSHA (1989b): Code of Federal Regulations: Title 29, Part 1094.2, 1094.5. Occupational Safety and Health Administration. See also, Bureau of National Affairs, S-239: Instructions for Completing OSHA Form No. 200, 27:1251-1254. Washington, DC: OSHA.
- OSHA (1989c): Bureau of National Affairs, S-239: U.S. Department of Labor, OSHA Form No. 200-S, 27:1262. Washington, DC: OSHA.
- OSHA (1989d): Bureau of National Affairs, S-239. U.S. Department of Labor: Instructions for Columns 4 and 11, OSHA Form No. 200, 27:1253. Washington, DC: OSHA.
- Pipe v. Lane (1981): Pipe v. Lane Tool & Die Co., 410 Mich 510, 302NW2d 526 (1981).
- Van Dorpel v. Haven-Busch (1957): Van Dorpel v. Haven-Busch Company, 350 Mich 135, 85 N.W.2d 97.
- West Pub. Co. (1985): Mich. Comp. Laws Ann. §§418.311 (Disability or Death), 418.361(2)(3) (Scheduled Injuries) (West 1985, Supp. 1991).
- West Pub. Co. (1991a): Mich. Comp. Laws Ann. §418.361(1) (West, Supp. 1991).
- West Pub. Co. (1991b): Mich. Comp. Laws Ann. §418.836-.837 (West, Supp. 1991).

APPENDIX

When weekly payments were made either voluntarily by the employer or as a result of an administrative or court decision (62,154 cases), the cumulative missed work times represented by the compensation payments were estimated from the payment information in the BWDC database using specially developed algorithms. Missed work time was calculated by dividing the amount paid in each payment episode by the compensation rate for that episode, and the episode results were summed to obtain the cumulative missed work time for an individual. Detailed analysis of a sample of 3,953 cases in which all the payments were made voluntarily indicated that compensation rate and amount paid were available for ~98% of all payment episodes. If either the amount paid or the compensation rate was not given, the duration was calculated directly from the beginning and end-payment dates given in the file. If the calendar period of payment was unavailable, a third subroutine calculated duration based on the amount paid and a compensation rate taken from the last form which reported the start of a payment episode.

A different approach was used to calculate the missed work time for periods of partial disability. This algorithm selected the compensation rate for the last total disability episode preceding the partial disability episode. Dividing the total disability compensation rate into the amount paid for the partial disability episode yielded an estimate of missed work day equivalents.

Still another algorithm was used to estimate missed work times for the 4,488 cases where the injured employee and employer entered into a redemption agreement. A redemption occurs when there is payment of a mutually agreed lump sum to the employee, in exchange for which the employee surrenders any right to further payments under the compensation scheme [West, 1991b]. Since many of the cases terminating with a redemption agreement had prior voluntary payment episodes, missed work time for the voluntary component of the case was calculated in the manner described above.

For the monies provided by the redemption agreement, the portion designated as the redeemed amount is intended to represent the compensation for lost wages. To obtain an estimate of missed work time equivalent to those for the other payment scenarios, the redeemed amount was divided by the last total disability compensation rate given in the file for a voluntary payment period. If no compensation rate was given, a compensation rate was estimated from the combined weekly wage found in the original report of injury. To estimate the compensation rate from the combined weekly wage, we assumed that the injured worker was a single head of household with two dependents. The compensation rate varies only 5-6% under widely disparate assumptions regarding marital status or number of dependents [Mich. Dept. Labor, 1986].

The estimate of missed work time obtained by this method for redemption payments should be considered as equivalent to the missed work time that would have resulted from the employer's voluntary payment for the time period required to reach the agreed redemption sum. In effect, the redemption amount provides an agreed period of total disability. The results are referred to as missed work days equivalents, rather than as missed work days, to distinguish them from estimates obtained in the case of voluntary payments or payments after decision. The estimate of missed work day equivalents should be regarded as a minimum estimate because no attempt was made to correct the estimates based on the actuarial concept of "present value."

A third group of 5,415 case files contained 4,977 cases with only a redemption agreement and no information regarding either the compensation rate or combined weekly wages. An indirect estimate of missed work time was obtained by taking the ratio of the average amount of compensation paid to workers redeeming their claims, but without a missed work time estimate, to the average amount of compensation paid to workers redeeming their claims, with a missed work time estimate. This ratio was multiplied by the average weeks of compensation paid the latter group and the result multiplied by the number of workers in the former group. This indirect estimate is tabulated separately in the report.

The estimate of missed work time for this first group of 62,154 cases excludes missed work time information for a subset of 366 cases from a subgroup of cases with a final open payment episode. The data for the open payment episode for 279 cases were excluded when the injured worker had been compensated for partial disability at any time before the final open payment episode. Since the basis for payments, i.e., partial or total disability, is indicated only in the forms that close a payment episode, whether some, or all, of the final open payment period should be treated as a partial disability interval could not be determined. Data for the final open payment episode for the remaining 87 cases were excluded because of a logic error in combining the individual payment episode data.

All data were excluded for an additional 1,552 cases. For 487 cases, the file indicated that the compensation claim was disputed, but no payments had been made through the date of follow-up. Data were excluded for the remaining 1,065 cases for a variety of reasons. These include the following: cases were excluded if the algorithms used to compute duration indicated that there was a final open payment episode, but a redemption or award form indicated that the case should be closed (~600 cases); most of the remainder were excluded because of a probable logic error in the algorithm for the group of cases involving a formal dispute outcome, i.e., an award, stipulation or voluntary payment after contest.

TABLE. Comparisons Between Database and Annual Survey

	Line	This database (D)	Mich. or U.S. survey (S)	Ratio D-S
1. Michigan experience				
Missed workdays private and public [28918.4 p-yrs - 260 days] (Table I)	(A)	7,518,784	1,877,400	4.00
Fraction of commercial insurance payouts captured by database algorithms	(B)	0.843		
Adjusted missed work days (A)/(B)		8,919,079	1,877,400	4.75
Future experience factors from commercial insurers:				
Known cases + incurred but not yet reported (IBNR)	(C)	1.57		
"Factor to develop to an ultimate report"	(D)	1.15		
Combined factors (C) × (D)/(B)	(E)	2.141756		
Readjust missed work days to consider future experience: (A) × (E)		16,103,398	1,877,400	8.58
2. Michigan data for extrapolation				
Missed work days private and public sectors		7,518,784		
less missed work days public sector		308,724		
Missed work days private sector	(F)	7,210,060		
Adjust private by combined factors: (F) × (E)	(G)	15,442,187		
3. Extrapolation to U.S. private sector				
Ratio of private sector employment, U.S. to Michigan	(H)	27.17		
Extrapolate missed work days to U.S.: (F) × (H)		195,897,330	46,725,400	4.19
Adjusted with combined factors and Extrapolate Michigan private to U.S.: (G) × (H)		419,564,096	46,725,400	8.98
Less Survey value for private missed work days		46,725,400		
Private missed work days not accounted for		372,838,696		

TABLE 1. Cumulative Missed Work Time to March 1, 1990, for Occupational Injuries, Michigan, 1986: Summary Statistics for Subsets of Cases Defined by the Method of Payment

Population subgroup	Sample summary		Cumulative person years	Statistics summarizing the distribution of cumulative missed work time in weeks						
	N	Percent		Sample quantiles						
				Mean	S.D.	.05	.15	.50	.85	.95
Cases paid voluntarily or by decision	62,154	93.27	17,318.6	14.5	33.7	1.3	1.8	4.5	17.0	61.8
Redemption cases	4,488	6.73	11,599.8	134.4	115.0	10.6	24.5	102.6	261.5	353.3
Redemption cases, voluntary component only	3,846		3,678.2	49.7	48.6	2.2	6.0	31.6	106.6	148.8
Redemption cases, redemption component only	4,471		7,921.6	92.1	85.3	4.1	12.9	68.7	180.1	244.3
Subtotal of cases with cumulative missed work time data	66,642	100.00	28,918.4	22.6	53.4	1.3	1.8	5.0	26.0	154.0
Cases with wage replacement data but no cumulative missed work time data	5,415		(3,243.6)*							
Subtotal of cumulative missed work time	72,057		32,192.6							
Cases with no cumulative missed work time or wage replacement data	8,598									
Cases excluded	1,065									
Total	81,720									

*Indirectly estimated value. See Materials and Methods.