

More Evidence of the Need for an Ergonomic Standard

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Background In 1999, the Occupational Safety and Health Administration (OSHA) proposed regulations designed to reduce work related injuries by limiting worker exposure to “ergonomic risk factors.” Congress subsequently overturned the regulations. We provide additional evidence on earnings losses attributable to musculoskeletal disorders (MSDs), and thus on the need for an ergonomic standard.

Methods Regression techniques are used to analyze data from a survey of injured workers that has been matched to employer-reported earnings data covering pre- and post-injury periods, and to workers’ compensation claims records.

Results MSDs lead to large and persistent earnings losses. Cost estimates used by OSHA to justify the 1999 EPS are corroborated. Losses are greatest among workers who file workers compensation claims, but nonclaimants also have losses.

Conclusions Earnings losses and lost productivity associated with work-related MSDs are substantial and an ergonomic standard could be cost effective. *Am. J. Ind. Med.* 45:329–337, 2004. © 2004 Wiley-Liss, Inc.

KEY WORDS: ergonomics; workers’ compensation; earnings losses; ergonomic standard; musculoskeletal disorder

“Work related musculoskeletal disorders (MSDs) currently account for one third of all occupational injuries and illnesses reported to the BLS (Bureau of Labor Statistics) each year. . . (E)mployers are annually paying more than \$15 billion in workers’ compensation costs for these disorders, and other expenses associated with work-related MSDs, such as the cost of training new workers, may increase this total to \$45 billion a year. Workers with severe MSDs often face

permanent disability that prevents them from returning to their jobs or handling simple, everyday tasks like combing hair, picking up a baby, or pushing a shopping cart”

[US Department of Labor, 2000, p 68263].

INTRODUCTION

In November of 1999, the Occupational Safety and Health Administration (OSHA) issued a final version of its Ergonomics Program Standard (EPS), a set of regulations designed to significantly reduce the number of work-related injuries by limiting worker exposure to “ergonomic risk factors.” These regulations were designed in particular to prevent musculoskeletal disorders (MSDs), also referred to as repetitive stress injuries, cumulative trauma disorders, and soft tissue injuries. This class of injuries includes most prominently sprains and strains of the back and carpal tunnel syndrome. In March of 2001, Congress overturned the regulations [Marcinkoski, 2001]. However, the problems

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created by repetitive strain industries persist, and in December 2002, the Department of Labor created the National Advisory Committee on Ergonomics to develop new preventative guidelines [US Department of Labor, 2002].

The EPS was several years in the making and generated controversy at almost every step along the way. By OSHA's estimate, the EPS would have affected over 6 million employers and 100 million workers at a cost of \$4.5 billion to employers. Not surprisingly, employers argued that the regulations would have been intrusive, costly, and ineffective [e.g., US Department of Labor, 2000]. However, as quoted in the passage above, OSHA believed that the benefits of eliminating even a fraction of the MSDs that occur each year outweigh the costs to employers of the standard. Indeed, in its economic analysis of the potential benefits of the regulation, OSHA estimated that the EPS would save \$9.1 billion per year.

A key component of OSHA's estimate of the benefits of the EPS is its conclusion that the average work-related MSD costs the economy \$22,546, about half of which is represented by the earnings losses of victims of MSDs. The earnings loss component of the estimate is based on figures from two previous studies: an estimate of the average amount of workers' compensation wage replacement benefits paid to claimants with MSDs based on data from an insurance carrier [Webster and Snook, 1994], and an estimate of the percentage of lost earnings typically replaced by workers' compensation benefits, based on Berkowitz and Burton's [1987] analysis of data from three states.

We present new evidence on MSD-related earnings losses, derived from an alternative dataset using a method very different from that used by OSHA. Our dataset includes information on Michigan manufacturing workers who were reported by physicians as having work-related MSDs. The methods used in this study differ from those previously used in two important ways. First, where OSHA's approach to estimating lost earnings involved inflating workers' compensation payments using an estimated workers' compensation replacement rate, our data permit earnings loss inferences from direct observations of worker earnings both before and after injury.

Second, almost all analyses of earnings losses associated with work-related health problems, including those cited by OSHA and more recent studies [e.g., Biddle, 1998; Boden and Galizzi, 1999; Reville, 1999] use data consisting of workers' compensation claimants, usually only those claimants who received wage replacement benefits. Most workers' compensation claimants, however, receive no wage replacement benefits, but are reimbursed only for medical expenses. Further, recent research indicates that many victims of work-related injuries do not file for workers' compensation benefits at all [Biddle et al., 1998; Glazner et al., 1998]. Different studies of the earnings losses due to work-related injuries make different assumptions about the

losses of workers who miss little or no work time, or whose injuries go unreported. OSHA assumed that the cost to society of the average unreported MSD is about 25% of the cost of the average reported MSD [US Department of Labor, 2000]. Our dataset includes workers who did not file for and/or did not receive wage replacement benefits, allowing us to compare the earnings losses of those who received such benefits to the losses of those who did not. Further, our dataset includes information that allows us to construct measures of injury severity. The measures of severity permit the third contribution of this study, which is to estimate savings in earnings losses if a less stringent standard were imposed.

Our results indicate that the earnings losses associated with a work-related MSD are substantial and persistent. Losses are greatest among those who file workers' compensation claims for wage replacement benefits, but we also find statistically significant losses for workers who do not file workers' compensation claims. The savings expected from the 1999 EPS depended on effectively eliminating ergonomically created injuries. Our data indicate that if even a partial standard were generated that reduced the severity of the injury for the most serious 40% of the cases, the average earnings loss associated with an MSD would be reduced by nearly one-third.

MATERIALS AND METHODS

Data from a survey of Michigan workers suffering from work-related MSDs, administrative data from Michigan's Bureau of Workers' Disability Compensation (BWDC) and earnings data from Michigan's Employment Security Commission (MESCC) was combined.

Data Sources

The data are drawn from a set of reports required by Michigan law of physicians who treat individuals with work-related illnesses. These "Known or Suspected Occupational Disease" reports must be filed with the state's Department of Consumer and Industry Services and include name, social security number, some demographic information, employer identifiers, diagnosis, and date of diagnosis. They are to be filed upon the health care provider's first contact with the patient. MSDs are among the illnesses required to be reported. The reporting requirement is independent of the state's workers' compensation laws and is administered by a different agency. Because of this, cases reported include incidents that do not eventuate in workers' compensation claims or trigger injury reports to the BLS. Thus, these occupational disease reports provided us with a sampling frame of individuals that does not depend on self-report, on the filing of a workers' compensation report, or being included in an OSHA log.

Selecting a sample from these reports has a drawback beyond those that typically plague governmental attempts to count occupational illnesses [van Charante and Mulder, 1998] in that compliance with the reporting law is not very widespread: for the most part only company doctors comply with the law. As a result, the sample is composed almost entirely of employees of large manufacturing firms, mainly highly paid hourly workers. The average wage in the sample is \$17.73 in 1996 and the unionization rate is 94%.

Using this sampling frame, a slice-in-time sampling strategy was employed: beginning in April, 1996, any worker identified on an occupational disease report filed with the Department of Consumer and Industry Services with a condition involving the shoulder, back, wrist or hand was selected as a potential sample member. Attempts were made to contact 2,705 workers, and interviews were completed with 1,598 of them, for a response rate of 59%. The median length of time between the date of the reported injury and the date of survey was 57 days. Earnings and workers' compensation claims data were obtained both for both respondents and nonrespondents, and there was no statistically significant difference between proportion of the respondents filing a wage loss claim during 1995 and 1996 and the proportion of nonrespondents doing so. The quarterly earnings of the nonrespondents were about 10% higher, however, which may be because those not employed in the post-injury quarters are more likely to have been available to respond to the telephone survey. The survey also collected information on the worker's general health, the severity of the reported condition, earnings prior to the date of report, work history and workers' compensation claim information. Missing values for some of these variables reduced the usable sample size to 1,437 workers, but there was no evidence that the sample members removed because of a missing variable were different from those used in the analysis with respect to key observable characteristics.

In 1998, we gave the BWDC and the MESC the social security numbers of all workers originally chosen for potential inclusion the sample. The BWDC provided all records of past and currently open wage loss claims associated with those social security numbers as of July of 1998, and the MESC provided the quarterly earnings reports filed by employers for those social security numbers from the third quarter of 1996 to the second quarter of 1998. The MESC data included six quarters of earnings information for each sample member, but because the period covered by the MESC data does not contain all of the period during which the sample members were injured, different post-injury periods were observed for different sample members. Earnings observations exist for the quarter of injury for 462 workers, the first quarter after injury for 1,169, the second quarter through sixth quarter after injury for 1,437, the seventh quarter after injury for 1,179, the eighth quarter after injury for 975, and the ninth quarter after injury for 268.

DATA ANALYSIS

Defining Injury Start Dates

Because MSDs are often the result of repetitive trauma, there is rarely a specific injury "event." Workers became eligible for our sample because they experienced symptoms that led them to visit a physician, who in turn believed those symptoms to be caused by a work-related MSD. To estimate the earnings loss associated with the MSD symptoms that led to the report, we treat the appearance of symptoms that prompted the physician visit as an event that occurred over a relatively short period of time, and refer to it as "the injury." The quarter in which the worker first visited the physician is treated as the quarter of injury.

Estimating Earnings Loss

Injury related earnings loss for an individual is defined as the difference between what that worker actually earned after the appearance of the MSD symptoms and what that worker would have earned had the "injury" not occurred (counterfactual earnings).

Creating a control group

The ideal method of estimating counterfactual earnings would be to examine a control group of uninjured workers with characteristics identical to our sample. Our dataset, however, consists only of injured workers, so we divide the sample into injury severity categories and then assume that the earnings of workers in the lowest severity category are only trivially affected by the injury. Thus the workers in our sample with the least severe injuries serve as the basis for creating counterfactual earnings. This method is similar to that used in Boden and Gallizi [1999] and Biddle [1998]. To the extent that injuries in the lowest severity category do affect earnings, our estimates of earnings loss will be lower bound estimates.

Injury severity measures

Workers were placed in categories on the basis of their responses to survey questions about the extent of the pain and disability associated with their MSD. The questions depended on the type of MSD the respondent reported and asked specifically about the impact of the reported MSD. Severity of hand/wrist injury was measured using a scale developed by Levine et al. [1993] to measure pain severity. The scale involves nine items answered on a five point scale, such as "How severe is the hand or wrist pain that you have at night?" The measure of severity of shoulder injury was derived from the self-administered shoulder pain and disability index (SPADI) [Williams et al., 1995], and is

composed of 13 items measuring pain severity and extent of disability. Respondents rated pain or difficulty with tasks on a 1–10 scale, e.g., “Using a scale from 0–10 where 0 = No difficulty and 10 = So difficult it required help, how much difficulty do you have washing your hair?” The back injury severity measure was derived from a scale created by Roland and Morris [1983], and is composed of 24 yes/no questions concerning the extent of limitations on movement and daily living activities. A sample item is “Because of my back, I use a handrail to get upstairs.” If a worker’s severity score for his type of MSD was in the lowest quintile of the sample distribution of scores for all workers with that type of MSD, he was placed in the lowest injury severity category; if his score was in the second quintile he was placed in the second severity category, and so on.

Estimating Lost Earnings

Counterfactual earnings were estimated using standard econometric techniques. Regressions were estimated in which the dependent variable was the sum of all earnings reported by employers to the MESC for each worker in each quarter, converted to 1996 dollars using the CPI-U. When a worker had no earnings reports for a particular quarter, earnings were set to zero for that quarter. In the context of investigating the labor market impact of MSDs, lack of an MESC earnings report in a post-injury quarter may be a significant occurrence: the condition may have led to labor force withdrawal. But there are other reasons why a worker might have a zero earnings observation in a quarter. The worker may have left the state, withdrawn from the labor force due to retirement or a non-work related disability, or gone into self-employment. In theory, all workers in the sample should have MESC earnings observations for the quarters in which their injury was reported, for they had to be working in order to be reported by a company physician. As one moves beyond the quarter of injury, the percentage of workers with earnings reports declines through the ordinary process of migration and labor force withdrawal, even if MSDs have no labor market impact. The assumption that workers in the lowest injury severity category are only trivially affected by their MSD implies that post-injury growth in the percentage of these workers with zero earnings observations reflects the ordinary processes of labor market attrition and out-migration that would occur even in the absence of injury. If higher percentages of workers in the more severe injury categories have zero earnings observations at some post-injury point, our specification attributes that excess to the effect of the MSD.

It is possible that those with low severity MSDs are more likely than the average healthy worker to withdraw from the labor force due to non-work-related disabilities. If so, the use of these workers as a control group will understate earnings losses due to MSDs. This is not likely to be a serious

problem in our sample, as it consists of workers with fairly stable employment histories, and zero earnings observations are relatively infrequent in the low severity group—less than 2% in the first year after injury, and less than 5% during the second year after injury. By comparison, Peterson et al. [1998], fig 5.7 report that approximately 8% of all uninjured California workers with an earnings observation in an unemployment insurance data base in a particular quarter have no earnings observation in the data base five quarters later.

The predictor variables in the regression include weekly pre-injury earnings rate, (constructed from the survey data); measures of race, age, educational level, and tenure with employer; dummy variables measuring quintile of injury severity; dummy variables for number of quarters since the injury; interactions between severity and quarter since injury; and variables indicating calendar quarter to control for secular economic conditions. The lowest severity category was the excluded category.

Counterfactual or potential earnings is defined as the predicted value from this regression when the severity-related measures are set to zero. Total discounted post-injury earnings are calculated by summing post-injury quarterly earnings values using a 2.3% annual discount rate. A similar method is used to construct total discounted potential earnings. Total discounted earnings loss is then total discounted potential earnings minus total discounted actual earnings.

Assigning Workers’ Compensation Claim Status

The data from the BWDC contains information on lost-time claims filed by workers in our sample from the quarter of their injury to July of 1998. Twenty-three percent of the workers in our sample filed claims for wage replacement benefits during this period. For 19% of these claims the worker had received no wage replacement payments for the claim as of July of 1998, and we classify those claims as denied claims. The claims from this data source are for wage replacement benefits only and exclude medical-only claims.

Unfortunately, the data do not allow us to definitively identify which claims in the BWDC data are related to the reported MSD and which are not. Thus, a claimant is defined as one who filed a wage replacement claim for any reason between the quarter of injury and July of 1998.

To measure the relationship between claiming and post-injury earnings we add the following variables to the regression described earlier: a dummy indicating whether a worker filed a claim in the subsequent quarter (this controls for the possibility of claims filed in response to falling earnings); an indicator of whether the worker filed a claim in the current quarter; dummies indicating that a claim was filed one quarter earlier and two quarters earlier (to capture continuing earnings loss); and a linear trend counting quarters

from the third quarter after the claim to the end of the observed period, allowing for a smooth trend in earnings recovery.

RESULTS

Average Post-Injury Earnings Over Time

Figure 1 shows the earnings predicted by the regression for the quarter of injury and the nine quarters beyond in the five injury severity categories, assuming sample mean values for all of the predictor variables in the regression for each category. The figure supports the use of the self-reported severity scales as a measure of the severity of the injury as it relates to post-survey labor market performance. The predicted earnings of the lowest severity group, which serve as an estimate of counterfactual or potential earnings, are the highest in every quarter except the quarter of injury, in which they are \$40 below those of the second group. In five of the ten quarters, predicted earnings decrease as one moves through the injury severity categories, and in three of the remaining five, the deviations from this pattern are small.

Tests of statistical significance of various groups of coefficients in the regression reveal that the hypothesis that all parameters associated with a particular severity category are jointly equal to zero cannot be rejected for severity category 2, but can be rejected at the 10% level for category 3 and the 1% level for categories 4 and 5. At the fourth post-injury quarter, earnings for severity categories 4 and 5 are significantly below earnings for the lowest severity category; at the fifth quarter after the quarter of injury earnings for severity categories 2, 4, and 5 are significantly below earnings for the lowest severity category. At the eighth

post-injury quarter, earnings for severity categories 3, 4, and 5 are still significantly below earnings for the lowest severity category.

Total Lost Earnings

Table I presents various measures of earnings loss over the quarter of injury and the nine following quarters. In column A are estimates of “average absolute discounted earnings loss” for each injury category, calculated as described earlier. Column B shows the percentage loss of income relative to counterfactual or potential earnings. Column C reports a measure of earnings loss relative to pre-injury earnings. In this measure, the numerator is column A’s absolute loss measure, but the denominator is the average value for the severity category of 52 times the pre-injury weekly earnings variable.

Losses in the observed period increase with the severity of the injury. In the second severity category, absolute losses are \$7,304, which is 6.1% of potential earnings for that period and 16.5% of annual pre-injury earnings. Those in the highest severity category lose 17% of potential earnings over the period and almost half of annual pre-injury earnings. If one assumes that the workers in the comparison group had no losses and averages over all five groups, average absolute discounted earnings loss for the entire sample equals \$9,418.

Table I allows us to conduct a fairly simple simulation of the effect of an ergonomic standard that would reduce the severity of the worst 40% of MSDs to the current median level for MSD severity. Based on Table I column A, suppose that all people in the severity 4 and 5 categories experienced the wage loss estimated for severity 3 category. Then, the average loss for the whole group would be \$6,513, which is a 31% reduction from the current average loss figure of \$9,418.

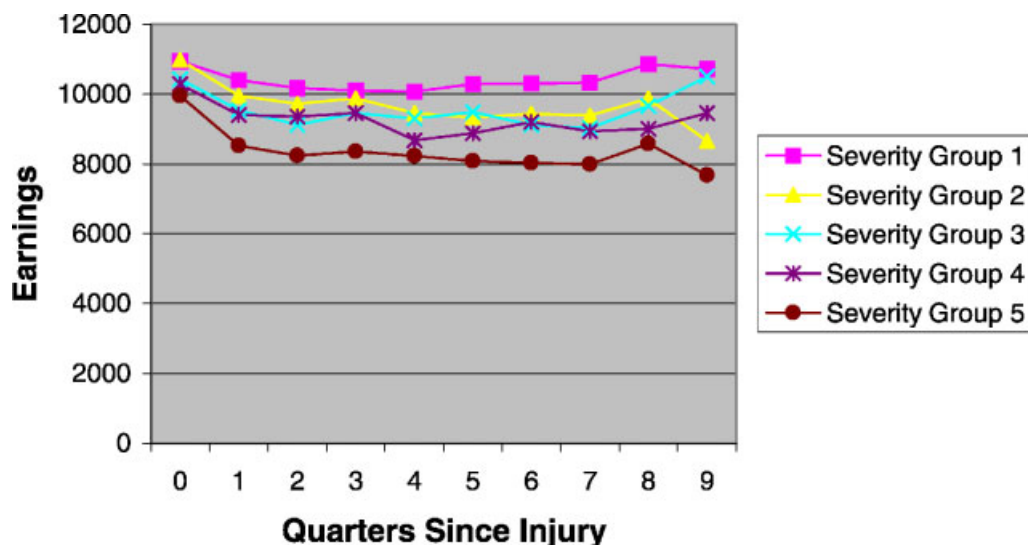


FIGURE 1. Post-injury earnings of Michigan manufacturing workers, by severity of MSD.

TABLE I. Measures of Earnings Loss due to MSDs Suffered by Michigan Manufacturing Workers

	A: Average absolute discounted earnings loss	B: Discounted earnings loss relative to potential earnings (%)	C: Discounted earnings loss relative to annual pre-injury earnings (%)
Severity group 2	\$7,307 (3,004)	6.1	16.5
Severity group 3	\$8,419 (3,030)	7.1	19.1
Severity group 4	\$11,278 (3,076)	9.6	26.1
Severity group 5	\$20,101 (3,295)	17.1	47.1
Average for entire sample (assuming zero losses in severity group 1)	\$9,418	8.0	21.7

1,437 workers, 11,496 observations. Standard errors in parentheses beside estimates in column A calculated with formulas robust to heteroskedasticity and serial correlation. Estimates based on regression that holds constant pre-injury earnings, race, sex, education, age, age squared, tenure, tenure squared, severity of reported MSD, quarter relative to quarter of reported MSD, and calendar quarter.

Earnings Loss by Workers' Compensation Claim Status

Figure 2 shows the earnings loss associated with filing a workers' compensation claim, displaying the predicted earnings of three hypothetical workers with sample mean values for the predictor variables and an MSD placing them in the fourth injury severity category. The figure indicates that workers who file wage replacement claims, whether accepted or rejected, earn less than those who do not. Earnings of denied claimants begin to fall in the quarter before the claim is filed, while those of accepted claimants do not fall until the quarter that the claim is filed. Earnings of both types of claimants recover towards the level of the earnings of nonclaimants after several quarters.

Both accepted and denied claimants earn significantly less than non-claimants during the quarter of injury and the following three quarters. The difference between denied claimants and non-claimants in the quarter prior to the claim shown in Figure 2 is statistically significant, although by seven quarters after the claim the earnings of denied claimants are converging to the earnings of the nonclaimants.

Figure 2 suggests that there are considerable earnings losses associated with claims for wage replacement benefits. Table II shows that nonclaimants suffer losses as well. Column A reports results based on parameter estimates from the same regression that underlies Figure 2. Since this regression controls for whether a wage replacement claim is filed, setting all claim-related variables equal to zero allows one to project the average earnings of groups of workers who did not file a wage replacement claim in the period of observation. These projections are then used to calculate average absolute discounted earnings loss in the manner used to create column A of Table I. Column B of Table II is produced by estimating the regression using only the workers who did not have claims records in the BWDC data during the observation period. This shrinks the sample and lowers the precision of the estimates, but avoids any biases that might result from the rather restrictive way in which we parameterized the impact of claims on earnings.

Both columns of the table present a consistent message. There are significant earnings losses even among those who do not file wage replacement claims. The losses of the non-claimants in the second severity category are about the same

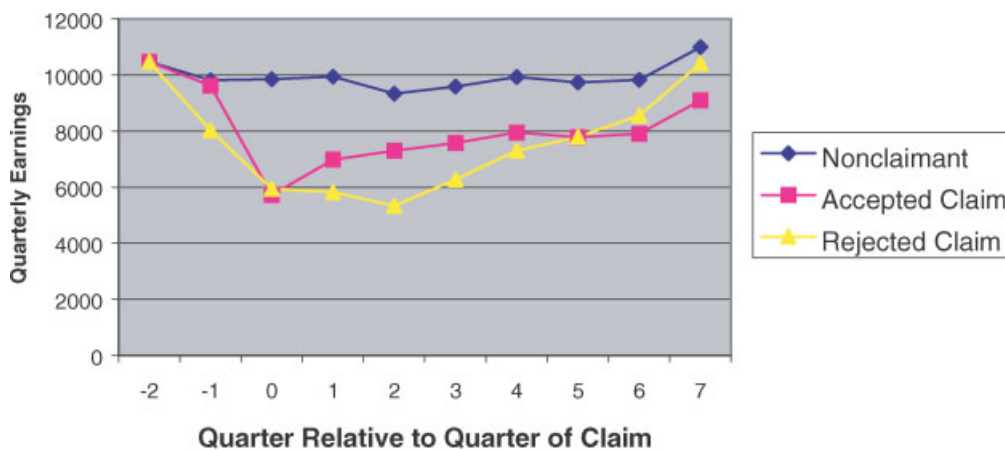


FIGURE 2. Impact on earnings of claim two quarters after MSD report, fourth severity quintile.

TABLE II. Average Absolute Discounted Earnings Loss for MSD Sufferers who do not File Wage Loss Claims: Michigan Manufacturing Workers

	A: Full sample, controlling for claimant status	B: Sample of nonclaimants only (1,110 workers, 8,669 observations)
Severity group 2	\$7,577 (3,003)	\$8,015 (3,230)
Severity group 3	\$6,506 (2,964)	\$5,562 (3,247)
Severity group 4	\$8,591 (3,000)	\$6,891 (3,364)
Severity group 5	\$15,412 (3,288)	\$13,132 (3,884)
Average for entire sample (assuming zero losses in severity group 1)	\$7,617	\$6,620

Standard errors in parentheses beside estimates calculated with formulas robust to heteroskedasticity and serial correlation.

as the losses reported in Table I for all workers in the second category, but in the remaining severity categories, losses of the nonclaimants are lower than the corresponding losses for the entire sample reported in Table I. Weighted averages of the discounted earnings loss estimates for the five severity categories produce full sample estimates of \$7,617 and \$6,620, compared to the figure of \$9,418 from Table I.

DISCUSSION

The first objective of this study was to estimate earnings losses due to MSDs and compare our estimates to those used to justify the EPS promulgated by OSHA in 1999 and overturned in 2001. The results show an estimate of average earnings losses comparable to those used by OSHA using different data and methods. OSHA's estimate of the before tax earnings loss due to a typical MSD is \$10,640, which is \$12,600 in 1996 dollars. Although neither our estimates nor OSHA's are based on nationally representative samples of MSD sufferers, the evidence of Table I suggests that OSHA's estimate is of the right order of magnitude and not a serious exaggeration. The results here also show earnings losses that increase with the severity of the injury and persist for at least 2 years for the most severely injured.

Although of the same magnitude, our estimates are lower than OSHA's. There are several possible explanations. First, the estimates assume that workers in the lowest severity category experience no losses at all, which may lead them to understate lost earnings. Second, our estimates include both workers' compensation claimants and nonclaimants. As our results indicate, workers' compensation claimants experience greater earnings loss than nonclaimants, even after controlling for severity. OSHA's earnings loss estimates were based on data from workers' compensation claimants only, and so would be expected to be higher than those presented here. Third, our estimates cover only nine quarters of post-injury earnings loss. Figure 1 indicates that those in the third through fifth severity quintiles do not experience an earnings

recovery comparable to those in the first two quintiles by the ninth quarter. This suggests that for the more severe cases, earnings losses may persist beyond nine quarters, so that our estimates understate total losses. Finally, this sample was mainly comprised of employees of large manufacturing firms. Such employers tend to have better than average return to work programs, which would mitigate the earnings losses of our sample members. On the other hand, the workers in our sample are high wage unionized workers. This would tend to increase the losses of our workers relative to average, since absolute earnings losses of injured workers rise with earnings [Biddle, 1998; Reville, 1999].

Another objective of this study was to examine earnings loss by workers' compensation claimant status. The results show that after controlling for severity, workers who receive workers' compensation wage replacement benefits experience greater earnings losses. One well documented feature of workers' compensation and other disability-related income replacement programs is that increases in benefit levels result in longer absences from work [Doherty, 1979; Stern, 1989; Meyer et al., 1995], or what can be termed a labor supply effect. Our results showing a greater earnings loss for workers' compensation benefits recipients may in part reflect this labor supply effect.

The labor supply effect, however, does not explain why denied claimants experience losses comparable to those of accepted claimants at least for the first five quarters after injury. That earnings in the quarter prior to the injury are statistically different and lower for denied claimants relative to both non-claimants and accepted claimants suggests that denied claimants are a different group along some unmeasured dimension. That accepted claimants experience greater losses than denied claimants after the fifth quarter could, however, be seen as support for the labor supply effect.

This study also examined potential reductions in lost earnings if an ergonomic standard were imposed that partially reduced the severity of the injuries. Our calculations suggest that if a standard were applied that reduced the

severity of the cases in the two most severe quintiles to equality with the severity of the cases in the third quintile, lost earnings could be reduced by nearly one-third.

Conceptual models of ergonomic dynamics identify various biomechanical factors associated with injury such as the degree of force, repetitiveness, and awkwardness of posture [Alder et al., 1997]. In addition, evidence exists that psychosocial work factors such as pace of work and control over tasks can affect lost work time due to MSDs. Numerous interventions have been implemented in various workplaces to reduce the incidence of MSDs, including work station redesign, equipment redesign, job rotation, and physical therapy [Buckle and Devereux, 2002]. The proposed OSHA standard included these and specified a three part process that included management leadership, employee participation, and hazard information and reporting to employees. Employers with one recordable MSD would be required to comply with the EPS and in many cases be expected to engage in a full analysis of the ergonomic hazards in their workplace and attempt to eliminate those hazards [Gallagher and Watchman, 2000].

Much of the resistance to OSHA's EPS was based on the belief that it would be very costly to employers. Among the multiple costs associated with injury, however, is lost productivity. The earnings losses examined in this analysis are not necessarily a measure of uncompensated losses; that is, they do not take possible disability benefits into account. However, under the standard assumption of economic theory that workers' earnings tend to equal the value that they produce for their employers, the loss estimates do provide a good indicator of the loss of economic productivity resulting from MSDs. The results presented here suggest that society experiences a productivity loss of approximately \$9,418 per MSD injury. Our simulation suggests that the average earnings loss can be reduced significantly if a standard that reduces injury severity is imposed. Based on that simulation, a standard with a cost to employers plus an enforcement cost of slightly under \$3,000 would in effect pay for itself from a societal point of view.

However, cost to society of an MSD will not be the same as the cost to an individual employer [Meltzer, 2001]. An injury does lead the injured worker to produce less for the employer, due to missed work or partial disability, but the employer also pays the worker less, freeing up money that can be used in hiring another worker to replace the output the injured worker was formerly producing. The only costs to the employer of the injury are the costs of locating and training a replacement, and the costs of any partial compensation paid to the injured employee (e.g., increased workers' compensation costs). These employer costs may well fall short of the value society loses as a result of the workers' injury. Evaluations of programs implemented by individual employers that use parts of the OSHA standard have shown positive results with regards to reducing MSD injuries and their

effects [Buckle and Devereux, 2002], and it is argued on this basis that an ergonomic standard in might make economic sense to employers. However, if the cost of an MSD to an employer are below the cost of an MSD to society, employers cannot be expected to implement all measures that are economically beneficial from a social point of view without legal incentives and government enforcement. [Alder et al., 1997].

In conclusion, the most important result of this study is the finding that earnings losses resulting from MSDs are substantial and that when using a different methodology and dataset, the estimated lost earnings are comparable to those used by OSHA. We also find that those earnings losses persist over time. By distinguishing between those who receive workers' compensation benefits and those who do not, this study is able to provide some support for a labor supply effect. Increasing benefit levels is likely to induce longer absences from work and exacerbate the productivity losses associated with these sorts of injuries. However, denied claimants experience greater losses than nonclaimants, suggesting that the dynamics of claiming need further examination.

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