From John Burton's Workers' Compensation Resources

Workers' Compensation Policy Review

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In This Issue:

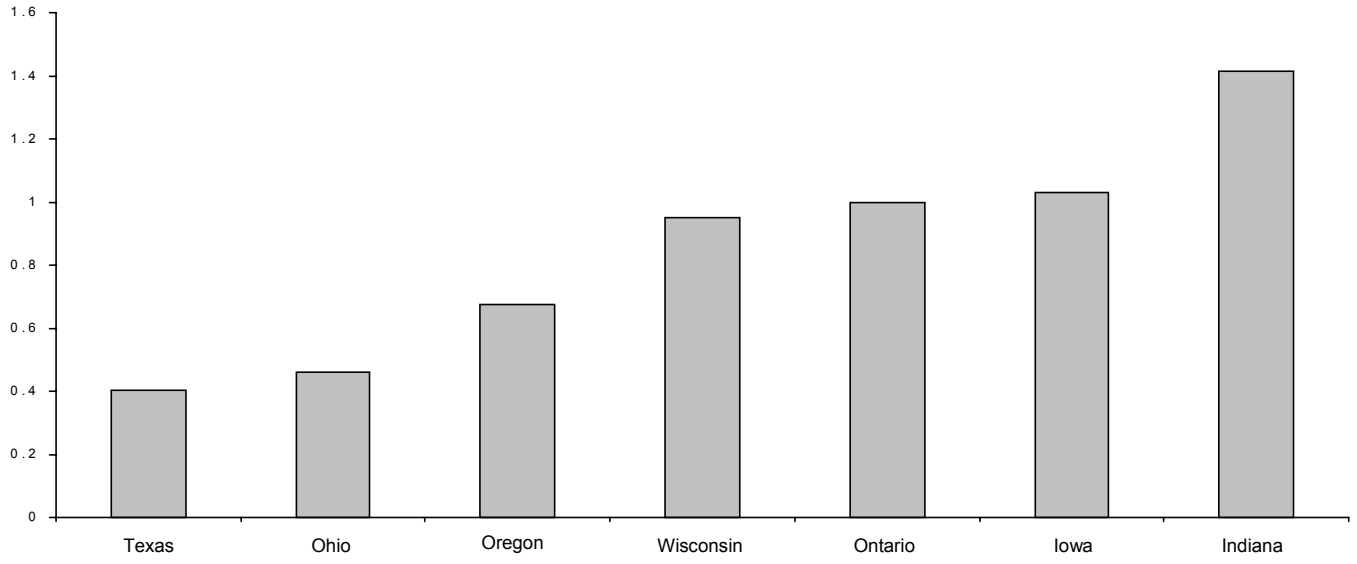
Featured Topics

Summary of the Contents

The employers' costs of workers' compensation insurance for comparable types of employers vary considerably among the states in the U.S. and the provinces in Canada. Most of the cost differences can be explained by interjurisdictional variations in factors such as statutory level of cash benefits, payments for medical care, and injury rates, as well as by the efficiency of the workers' compensation program delivery system. A state can be described as having a relatively efficient delivery system if, for example, the jurisdiction has high levels of cash and medical benefits and a high frequency of injuries coupled with low insurance rates. Conversely, a state with high insurance rates, but low cash and medical benefits and relatively few injuries, can be characterized as having a relatively inefficient delivery system. Thomason and Burton provide measures of the relative efficiency of the delivery systems of 50 North American jurisdictions for 1975 to 1995. The relative efficiencies for the various jurisdictions are compared to Ontario (which has a value of 1.0), ranging from Texas (the least efficient state, with a value of 0.4) to Indiana (the most efficient state, with a value of 1.4).

The huge costs for American workers and businesses caused by work-related musculoskeletal pain are examined by Melhorn, Kennedy, and Wilkinson. The $50 billion per year costs resulting from ergonomics problems are likely to increase in the future with the aging of the workforce and the increasing number of women entering jobs prone to musculoskeletal disorders (MSDs). The Ergonomics Standard issued in 2000 by the Occupational Safety and Health Administration under the Clinton Administration was subsequently nullified by Congress and President Bush in 2001, a move that has largely eliminated the threat of federal sanctions for firms whose practices result in MSDs. The authors nonetheless argue that the costs are still there and that practical solutions are available to employers to reduce these costs in an efficient and effective manner.

Relative Efficiency of Workers' Compensation Delivery Systems, 1975-1995



Source: Figure E of Thomason and Burton article in this issue.

TERRY THOMASON

Terry Thomason died on Saturday, April 20, 2002 at his home in Newport, Rhode Island after a long struggle with cancer. He was born in Inglewood, California on November 18, 1950 and was 51 at the time of his death.

Terry was Director of the Schmidt Labor Research Center and a professor at the University of Rhode Island since 1999. He was on the faculty of McGill University from 1988 until 1999. Terry held undergraduate and master's degrees from the University of Alabama and received a Ph.D. in Industrial and Labor Relations from Cornell University in 1989.

Terry's research interests included workers' compensation, workplace safety and health, and public sector collective bargaining. His recent publications include *Workers' Compensation: Benefits, Costs, and Safety under Alternative Insurance Arrangements* (Upjohn Institute 2001) with Timothy Schmidle and John Burton. He and Silvana Pozzebon wrote "Determinants of Firm Workplace Health and Safety and Claims Management Practices," which appeared in the January 2002 issue of the *Industrial and Labor Relations Review*. Terry authored or co-authored over forty journal articles, book chapters, or other publications.

Terry was active in the Industrial Relations Research Association. Terry contributed chapters to several of the IRRA annual research volumes; he co-edited (with Douglas Hyatt and John Burton) the 1998 IRRA research volume on *New Approaches to Disability in the Workplace*; and Terry and John Burton are co-authors of a chapter that will appear in the 2003 IRRA research volume on public sector bargaining. Terry was also a member of the IRRA Editorial Committee.

Terry was a member of the National Academy of Social Insurance, and served on the Academy's Steering Committee on Workers' Compensation. He was also a member of the Steering Committee of the Workers' Compensation Research Group. He served as an expert witness, a consultant to several organizations (including the Ontario Workplace Safety and Insurance Board), and as a referee for several professional journals.

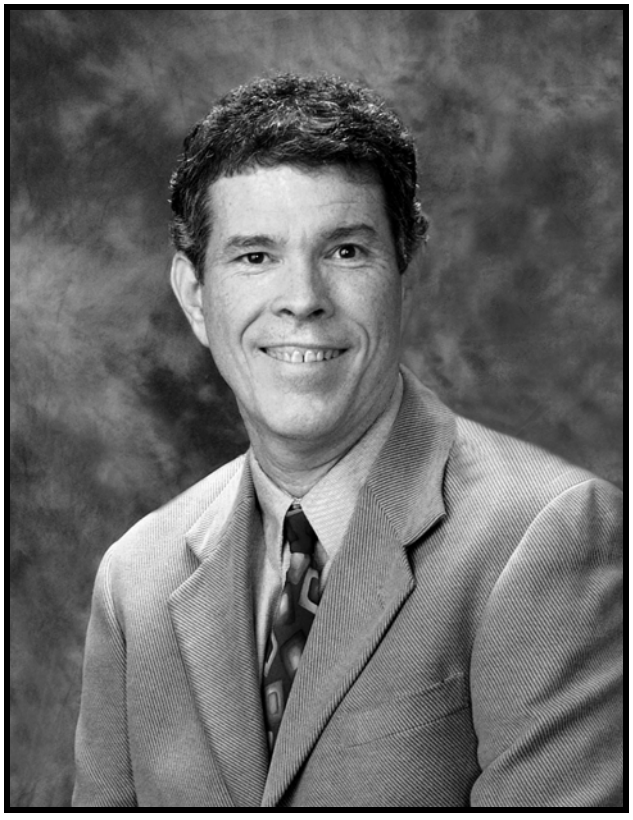
Terry is survived by his wife, Julie Grand-Landau, his mother, Betty (Oates) Thomason, and his brother, Kevin Thomason of Portland, Oregon. Sympathy cards can be sent to Julie at 28 East Street, Newport, Rhode Island, 02840 or to Betty at 2917 Cloverland Court, Mobile, Alabama 36609.

A memorial service for Terry was held at 11 A.M. on Saturday, May 11 at St. Paul's United Methodist Church, 12 Marlborough, Newport, Rhode Island.

The family suggests three possible ways to honor Terry's life. Books can be donated to a university library in Terry's name. Contributions can be made to hospice in his memory. Contributions can be made to the Industrial Relations Research Association to support the research activities of the IRRA. (The address for the IRRA is Room 119, 504 East Armory Avenue, Champaign, Illinois 61820.)

Matt Bodah, Terry's colleague at the University of Rhode Island, wrote that "Most of all, Terry was a great man and a gentle spirit." Tim Schmidle and John Burton were Terry's friends since his years at Cornell, and their admiration and affection for Terry and Julie have grown over the years. They, along with Terry' s family and his numerous other friends, grieve in his loss and savor the memories of his wonderful accomplishments during his life.

Additional information about the service or other matters can be obtained from Tim Schmidle (schmidlet@hotmail.com) or John Burton (jfburtonjr@aol.com).



The Employers' Costs of Workers' Compensation Insurance in Ontario and Other Canadian and U.S. Jurisdictions

by Terry Thomason and John F. Burton, Jr.

This article provides a concise overview of *The Employers' Costs of Workers' Compensation Insurance in Ontario and Selected Other Canadian and U.S. Jurisdictions*, which is a *Report* submitted to the Workplace Safety and Insurance Board (WSIB).[1] The contents of the *Report* have been reorganized for this article as responses to a series of questions. References are provided in endnotes to the extended discussions in the *Report* of topics briefly covered in this article.

Our *Report* examines the costs of workers' compensation insurance in Ontario over 25 years relative to the costs in other North American jurisdictions, specifically 47 U.S. states, the District of Columbia, and the province of British Columbia. We find that Ontario has a "low-cost" workers' compensation program relative to the programs in these other jurisdictions and that this is due, in part, to the relatively efficient delivery system of the Ontario program. That is, the administrative costs of delivering benefits to injured workers in Ontario are relatively low compared to similar costs incurred by the workers' compensation programs in an overwhelming majority of jurisdictions in North America.

I. How Are the Employers' Costs of Workers' Compensation Insurance Measured in Ontario and Other Jurisdictions?

The measurement of workers' compensation costs is neither a simple nor a straightforward matter.[2] The costs for each individual employer are dependent on a number of factors that are unique to the employer, including the nature of the employer's business, the employer's accident record, and the size of the employer. For these reasons, it is impossible to accurately compare the cost of workers' compensation in one jurisdiction with costs in another jurisdiction by taking a simple average of those costs across employers, since the characteristics of the employers may differ substantially from one employer to the next. For example, a province that has a large proportion of employment engaged in inherently dangerous industries – such as logging, construction, or fishing – will necessarily pay higher compensation costs, on average, than a province that is dominated by relatively safe industries – such as finance or wholesale and retail trade.

In addition, there are substantial differences among jurisdictions, particularly between U.S. states and Canadian provinces, in the rate setting process, which further complicate the measurement problem. For example, an employer's workers' compensation premiums in the United States are determined by multiplying the appropriate assessment rate by the employer's total payroll, while Canadian provinces use only that portion of payroll that is below a certain threshold, called the maximum assessable wage.

In our study we address these measurement problems, controlling for most of the differences among jurisdictions that affect an accurate comparison of workers' compensation costs between Ontario and other North American jurisdictions. For example, to control for differences in industrial composition (which could affect the underlying risk of injury) among jurisdictions, we relied on a standardized set of 71 insurance classes used in U.S. jurisdictions where private insurance carriers offer workers' compensation insurance to employers. We match those 71 classes to the corresponding classes in Ontario and other jurisdictions without private carriers. We calculate an average for those 71 classes (or the equivalent classes) using the same weights for these classes in all jurisdictions in order to control for differences in industry mix among jurisdictions.[3]

We start with the base assessment rates (or manual rates) for these 71 insurance classifications and calculate base rates per $100 of payroll. We adjust these base rates for modifying factors that affect the insurance premiums actually paid by employers. In

About the Authors

Terry Thomason was appointed as Director of the Charles T. Schmidt, Jr. Labor Research Center and as a professor at the University of Rhode Island in 1999. His untimely death in April 2002 is noted in a Remembrance included in this issue. John Burton is Editor of the *Workers' Compensation Policy Review* and is Professor in the School of Management and Labor Relations at Rutgers University.

The article is based on a research project we conducted for the Workplace Safety and Insurance Board (WSIB) of Ontario that was submitted in December 2001. We received considerable assistant from the officers and staff of the WSIB during several trips we made to Toronto and in extensive correspondence. We particularly want to express our appreciation to Linda Jolly, Vice-President for Policy and Research, and Richard Allingham, Director of the Research and Evaluation Branch. We accept responsibility for all the analysis and data contained in this article, including (perish the thought) all errors and oversights.

Ontario (as well as all other jurisdictions) we account for the effects of experience rating, which is a process that modifies a particular employer's premiums based on prior benefits paid to employees of that employer.[4] We also consider other factors that influence the insurance rates paid by employers in the U.S., including premium discounts and dividends.[5]

Ontario insurance rates need to be further adjusted in order to be comparable to rates in U.S. jurisdictions because – as noted above -- in Canadian jurisdictions only a portion of payroll is assessed to calculate premiums, while in the U.S. the total payroll is used to calculate premiums. In order to generate the same amount of premiums, a jurisdiction that excludes some payroll from assessments needs to charge a higher insurance rate per $100 of covered payroll than the rate that would be used if the entire payroll were subject to assessments. We used information on the ratio of assessed payroll to total payroll for Ontario rate groups to reduce the Ontario rates per $100 of payroll to make these rates comparable to rates in the U.S.[6]

Ontario insurance rates must also be adjusted to account for payments toward the unfunded liability of the Ontario workers' compensation program. Since 1983, the insurance rates paid by Ontario employers have included a charge to amortize that debt. We calculate five variations of insurance rates for Ontario that differ in their treatment of payments for unfunded liability and retroactive benefit increases.[7]

Figure A presents three measures of the employers' costs of workers' compensation insurance in Ontario between 1975 and 1999.[9] Rate I is the "new claims costs" rate, which is what employers would have paid since 1983 if they had not been assessed to pay for the unfunded liability of the Ontario program. Rate II is the "target" rate, which is Rate I plus the assessments that would have been made if the program had adhered to a 30-year amortization schedule. Rate III is the "actual" rate, which is Rate II minus a transition amount that limits the size of the increases in the assessments used to amortize the debt. As can be seen, the new claims cost rate (Rate I) has been consistently below the other rates, and was approximately $1.00 per $100 of payroll in 1999. However, because employers have been required to pay assessments since 1983 to amortize the

Figure A
Ontario Rate Estimates Using Different Adjustments for the Unfunded Liability, 1975-99

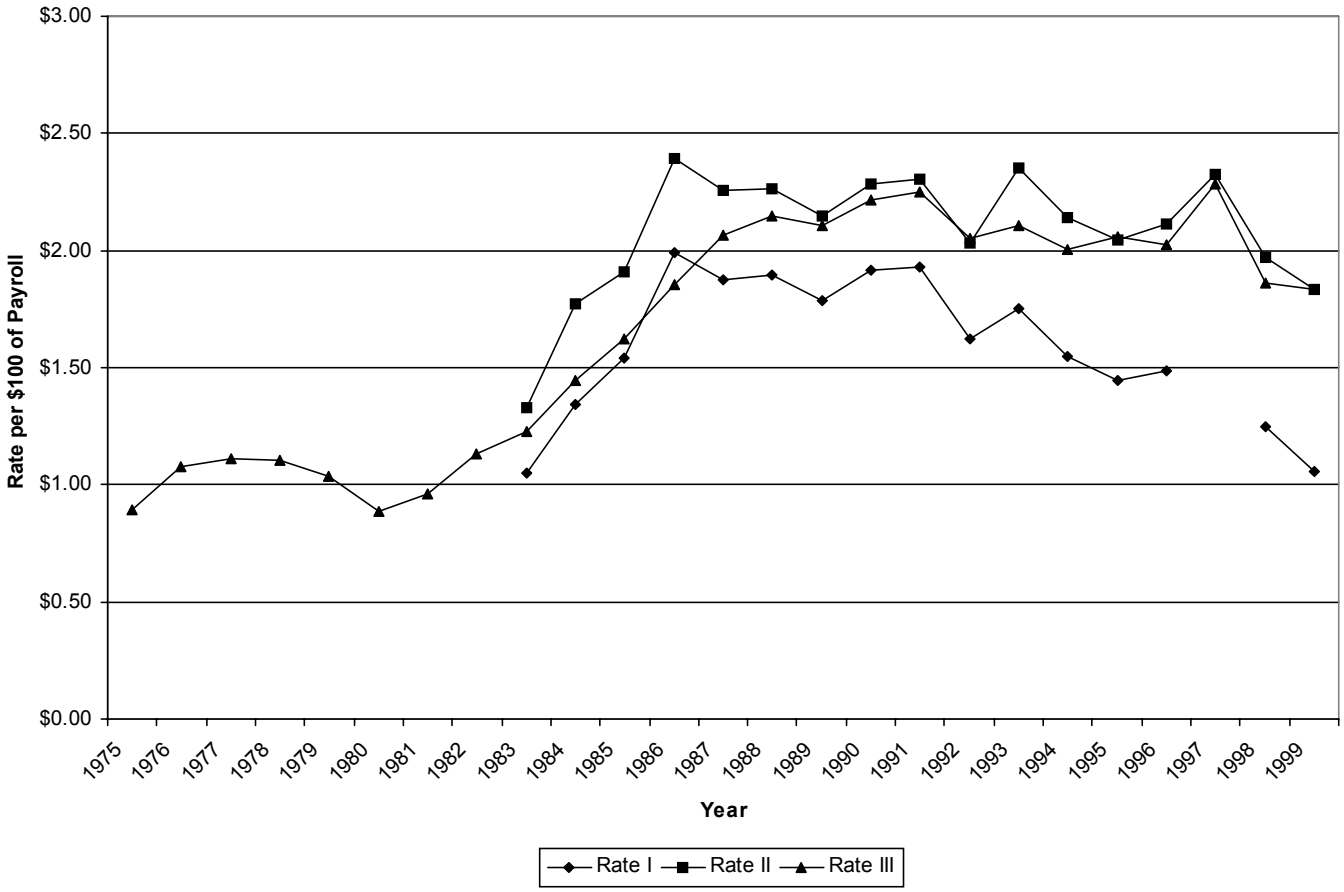
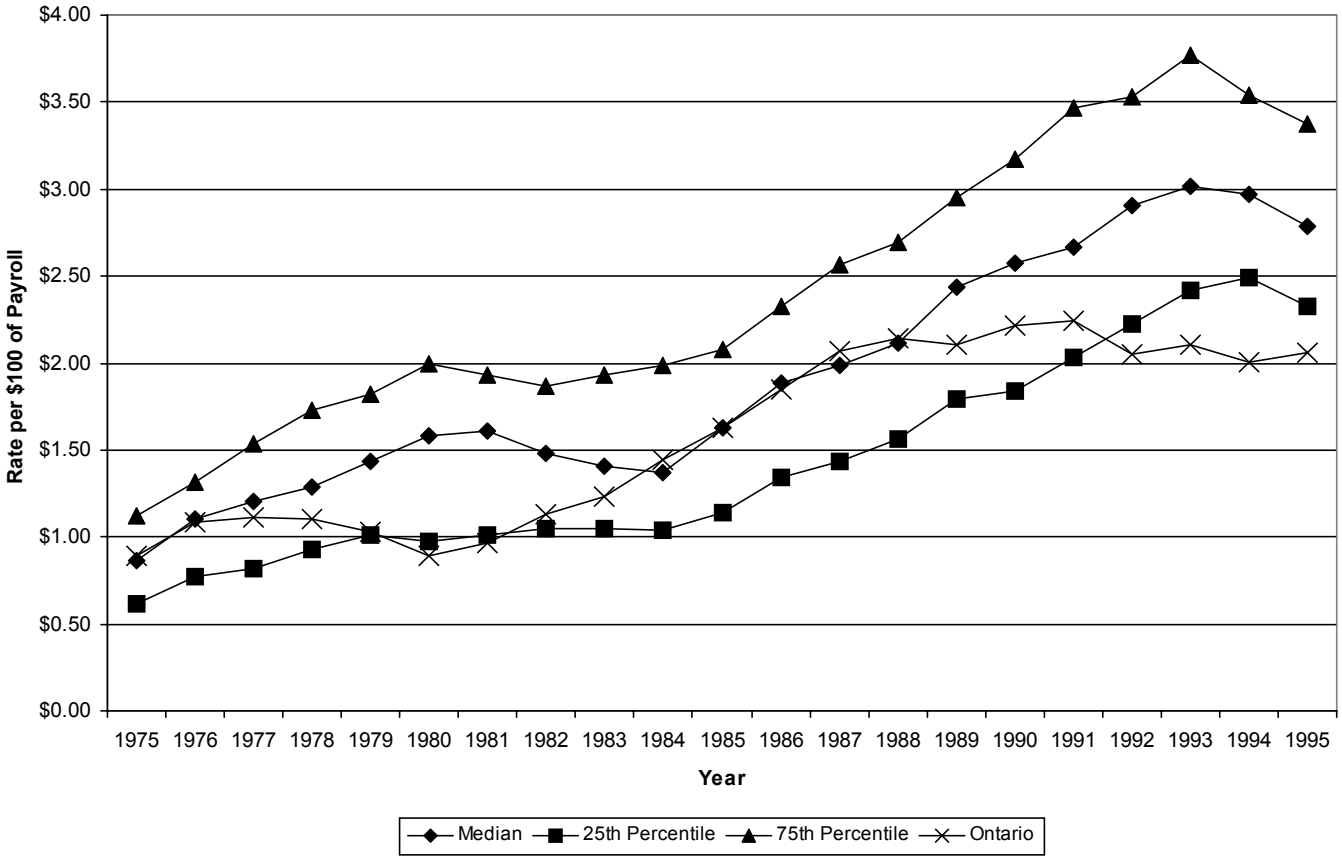


Figure B
"Actual" Rate Estimates, Ontario and Summary Rates forRemaining Jurisdictions, 1975-1995



unfunded liability of the Ontario workers' compensation program, the target rate (Rate II) and the actual rate (Rate III) have exceeded the new claims cost rates. In 1999, for example, Rate II and Rate III were approximately $1.80 per $100 of payroll. Because Rate III represents the workers' compensation rates actually paid by Ontario employers, it is the rate comparable to the insurance rates from other jurisdictions and is the measure used for the balance of this article.

II. How Do the Employers' Costs of Workers' Compensation Insurance in Ontario Compare to the Costs of Insurance in Other Jurisdictions?

The employers' costs of workers' compensation for Ontario employers are shown in Figure B for 1975-1995, which is the period during which rates for other jurisdictions are available.[9] The Ontario rates are the actual rates (Rate III) paid by Ontario employers, including the assessments to amortize the debt. The Ontario rates began at approximately $1.00 per $100 of payroll in 1975 and stayed at about this level until 1980, when rates began to increase until reaching a peak of about $2.10 in 1991. Ontario rates then declined to about $2.00 per $100 payroll for 1992 to 1995.

Figure B also contains Ontario actual rates plus the summary rates from 1975 to 1995 for the other 49 jurisdictions in the study, which are 47 states (all but Montana, Nevada, and Wyoming), the District of Columbia, and British Columbia. The median jurisdiction (the jurisdiction that has costs lower than half of the other 49 jurisdictions) had workers' compensation rates as a percent of payroll that were higher than Ontario's rates except for 1984 to 1988, when Ontario's rates were about the same as the median jurisdiction's rates. During the 1990s, Ontario's workers' compensation rates were consistently below the rates in the median state. Indeed, since 1992 the Ontario insurance rates have been lower than the insurance rates in the 25th percentile jurisdiction (the jurisdiction that had costs lower than all but 25 percent of the other 49 jurisdictions).

The workers' compensation insurance rates for manufacturing firms in Ontario and the other 49 jurisdictions are presented in Figure C for the

years from 1975 to 1995.[10] Ontario manufacturing employers paid workers' compensation premiums per $100 of payroll that were below the median jurisdiction for almost all years (1984 to 1989 are exceptions). During the 1990s, the rates in Ontario declined, and from 1993 to 1995 the Ontario insurance rates for manufacturing employers were lower than the insurance rates in the 25th percentile jurisdiction. The workers' compensation insurance rates in the manufacturing sector are particularly important to assessing the competitive environment since manufacturing firms are more likely to engage in competition across provincial or state borders than are construction or service firms.[11]

The workers' compensation insurance rates for all Ontario employers are compared to the workers' compensation rates in the nine states that border the Great Lakes in Figure D.[12] Since the number of states is small, we only show the insurance rate in the median Great Lake state. The pattern is similar to the previous comparisons involving all North American jurisdictions. Ontario employers paid workers' compensation insurance rates that were below the rates in the median Great Lakes state for most years between 1975 to 1995, with the exception of 1983 to 1988, when the Ontario rates were similar to the rates in the median Great Lakes state.[13] Because of their geographical proximity, these states are likely to be particularly important competitors of Ontario employers. Comparisons with this group of states reinforce the general conclusion that Ontario workers' compensation rates have generally been at or below the rates in the North American jurisdictions that are appropriate for comparisons, and that Ontario insurance rates have been particularly low during the most recent years in the comparisons.

III. What Are the Possible Limits on the Comparability of the Costs of Workers' Compensation in Ontario with the Costs in Other Jurisdictions?

As indicated, we were able to account successfully for most of the differences among jurisdictions that could affect accurate comparisons of workers' compensation costs. However, some factors that potentially could affect the comparability of the workers' compensation insurance were less quantifiable. We did exam-

Figure C
Actual Adjusted Rates for Manufacturing,
Ontario and Other North American Jurisdictions, 1975-95

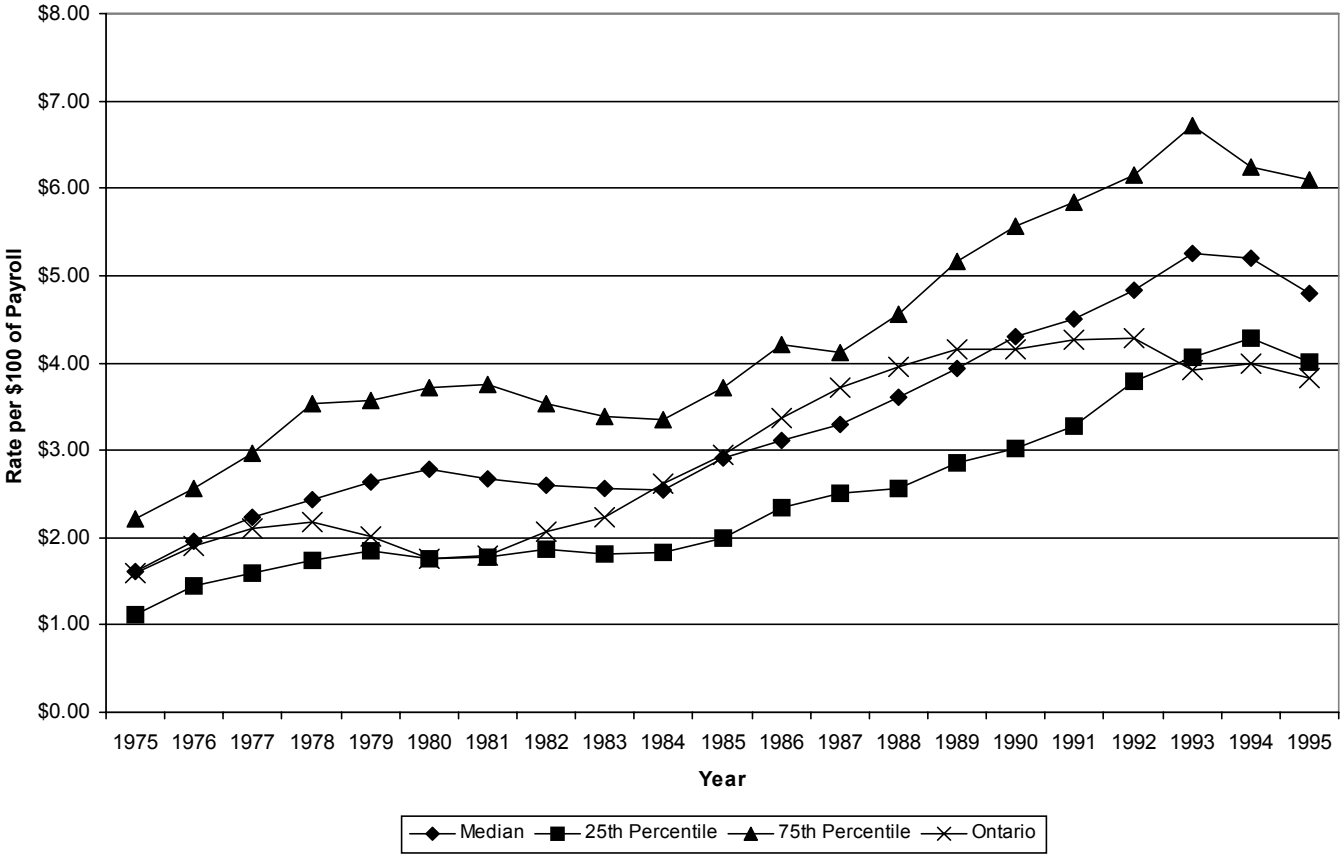
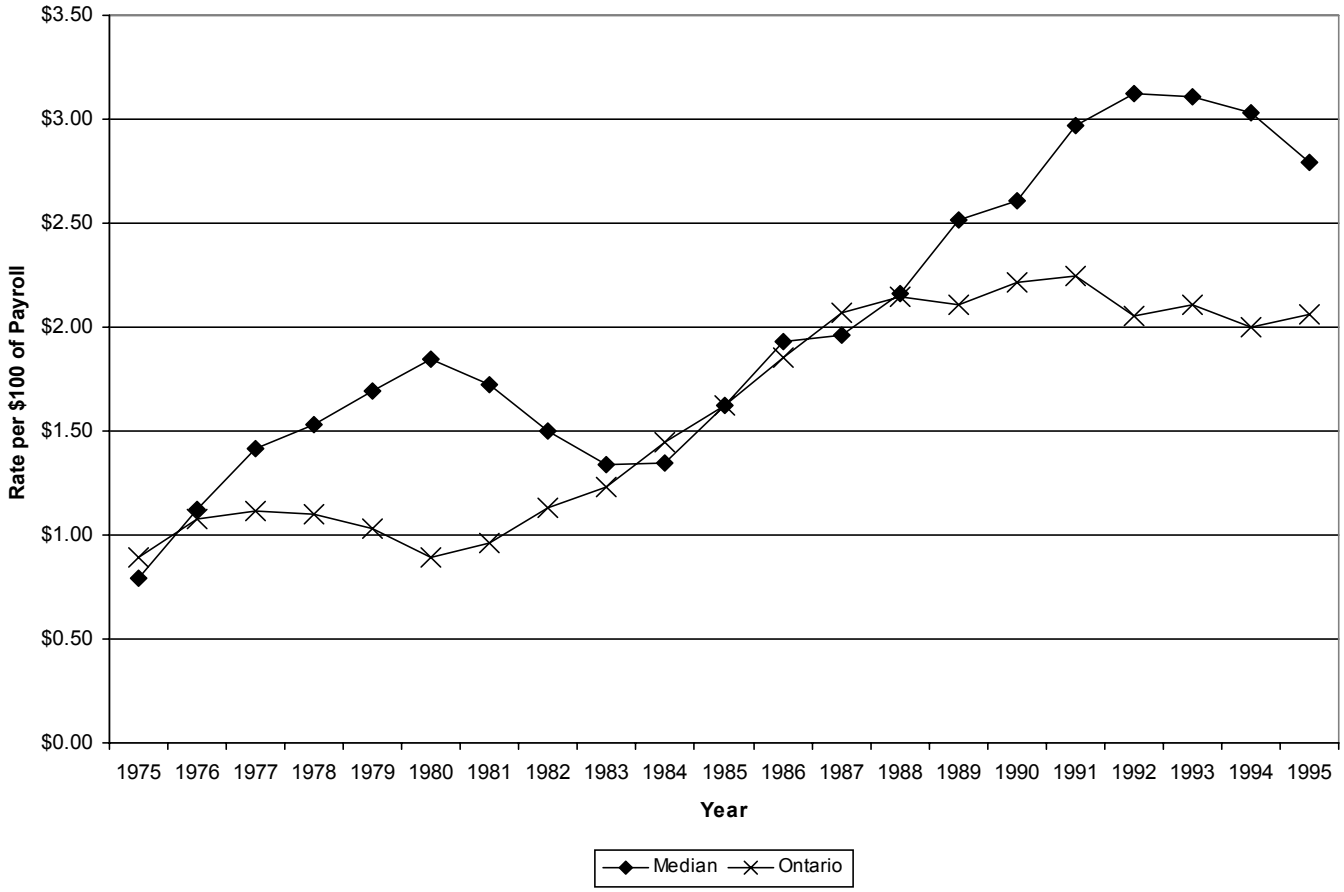


Figure D
Actual Ontario and Median Rate of Great Lake States, 1975-1995



ine each of these factors and were able to qualitatively assess the extent to which they might bias our comparisons.

One factor is the possibility that some of the medical costs have been shifted between the workers' compensation program and the general health care system. In Ontario, the concern is that the Ontario Health Insurance Program (OHIP) is paying for health care for some work-related injuries and diseases, which would mean that the workers' compensation insurance rates for the province are artificially low. We learned that an extensive audit of OHIP and workers' compensation medical expenditures has been conducted that should solve this potential problem. In the U.S., the concern is that the workers' compensation program is paying for health care for some non-work-related injuries and diseases, which would mean that the U.S. workers' compensation rates are artificially high. The limited evidence suggests that the extent of cost shifting of medical care in the U.S. is not extensive. Thus cost-shifting of medical costs should not adversely affect our comparisons.[14]

Another factor we examine that could affect the comparability of the workers' compensation insurance rates in Ontario and the U.S. pertains to costs that are included in the insurance rates in one country that are not included in the costs in the other country. In Ontario, the workers' compensation rates include charges for mandated programs, such as the Occupational Health and Safety Administration, which are not included in the workers' compensation rates in the U.S. The costs of these mandates should be removed from the Ontario rates in order to make them comparable to U.S. insurance rates. In the U.S., most of the workers' compensation insurance is provided by private carriers, who are subject to corporate taxes that are reflected in insurance premiums, which are charges not included in the workers' compensation rates in Ontario. The costs of these taxes should be removed from the U.S. rates in order to make them comparable to Ontario insurance rates. Fortuitously, the data indicate that the costs of the mandates in Ontario are about the same as the costs of the taxes in the U.S. – about five percent of premiums – and so the adjustments

Table A
Independent Variables and Relationships to Employers' Costs of Workers' Compensation

Variable	Expected Relationship	Actual Relationship
Cash Benefits	+	+
Medical Benefits	+	+
Injury Rates	+	+
Union Density	+	0
Long-term Disability Claims as Share of All Claims	+	+
Self-Insurers Benefit as Share of All Benefits	+	+

Source: Table 11 of *Report*.

for these factors should not affect the relative costs of workers' compensation insurance in the jurisdictions in the study.[15]

IV. What Factors Determine the Employers' Costs of Workers' Compensation in Ontario and Other Jurisdictions?

As indicated, our comparisons revealed that the costs of workers' compensation are lower in Ontario than in most other North American jurisdictions, particularly in recent years. However, it is also important to determine why Ontario is a relatively "low-cost" jurisdiction. Costs could be less for a variety of reasons: for example, because Ontario pays benefits that are less than those paid elsewhere or because the injury rate is lower in Ontario. We were particularly interested in whether costs were lower because Ontario has a more efficient delivery system than other jurisdictions. That is, are the administrative costs associated with delivering benefits in Ontario less than they are elsewhere in North America?

In order to determine the source of the lower workers' compensation costs in Ontario, we developed and tested a model of the factors that determine the interjurisdictional differences in the employers' costs of workers' compensation.[16] This model controls for most, if not all, of the variables affecting workers' compensation costs. Table A summarizes the hypothesized relationships between the workers' compensation insurance rates and most of the independent variables used in our study.[17] The hypothesized relationships are based on economic theory and/or previous research results. Table A also summarizes the results of our statistical examination of those hypothesized relations using regression analysis.

We developed a measure of the adequacy of cash benefits prescribed by each jurisdiction's workers' compensation statute. We expected higher cash benefits to be associated with higher costs of workers' compensation insurance and find statistically significant evidence to support the hypotheses. We also measured the actual medical benefits per claim in each jurisdiction. Again we expected that higher medical benefits will be associated with higher insurance costs, and the evidence supports this hypothesis.

We constructed a measure of each jurisdiction's injury rate controlling for industry mix. We expected higher injury rates to be associated with higher insurance costs and the evidence supports the hypothesis. We also expected that jurisdictions with higher union densities (proportion of workers who are organized) would have higher workers' compensation costs. Previous studies generally have found such a positive relationship, presumably because unions assist injured workers to submit claims or protect workers who submit claims from employer retaliation. Contrary to our expectations, we did not find any statistically significant evidence that greater unionization is associated with higher workers' compensation costs.

We also measured long-term disability claims as a proportion of all workers' compensation claims in each jurisdiction. Previous research has generally found a positive association between this variable and the costs of workers' compensation insurance, presumably reflecting interjurisdictional differences in the administration of workers' compensation programs. Since these long-term disability claims are usually more expensive than short-term claims, states with a high proportion of long-term claims should have higher costs. This hypothesis is supported by our empirical results.

The final variable included in Table A measures the percentage of the benefits in a jurisdiction that are accounted for by self-insuring employers, as opposed to benefits that are provided by public or private insurance carriers. Self-insurance accounted for about 20 percent of all workers' compensation benefit payments in the U.S. during 1975 to 1995, and there are considerable variations among jurisdictions in the importance of self-insuring employers. The hypothesis is that a higher share of self-

insuring employers in a jurisdiction will be associated with higher workers' compensation insurance rates.[18] The statistical evidence supports the hypothesis.

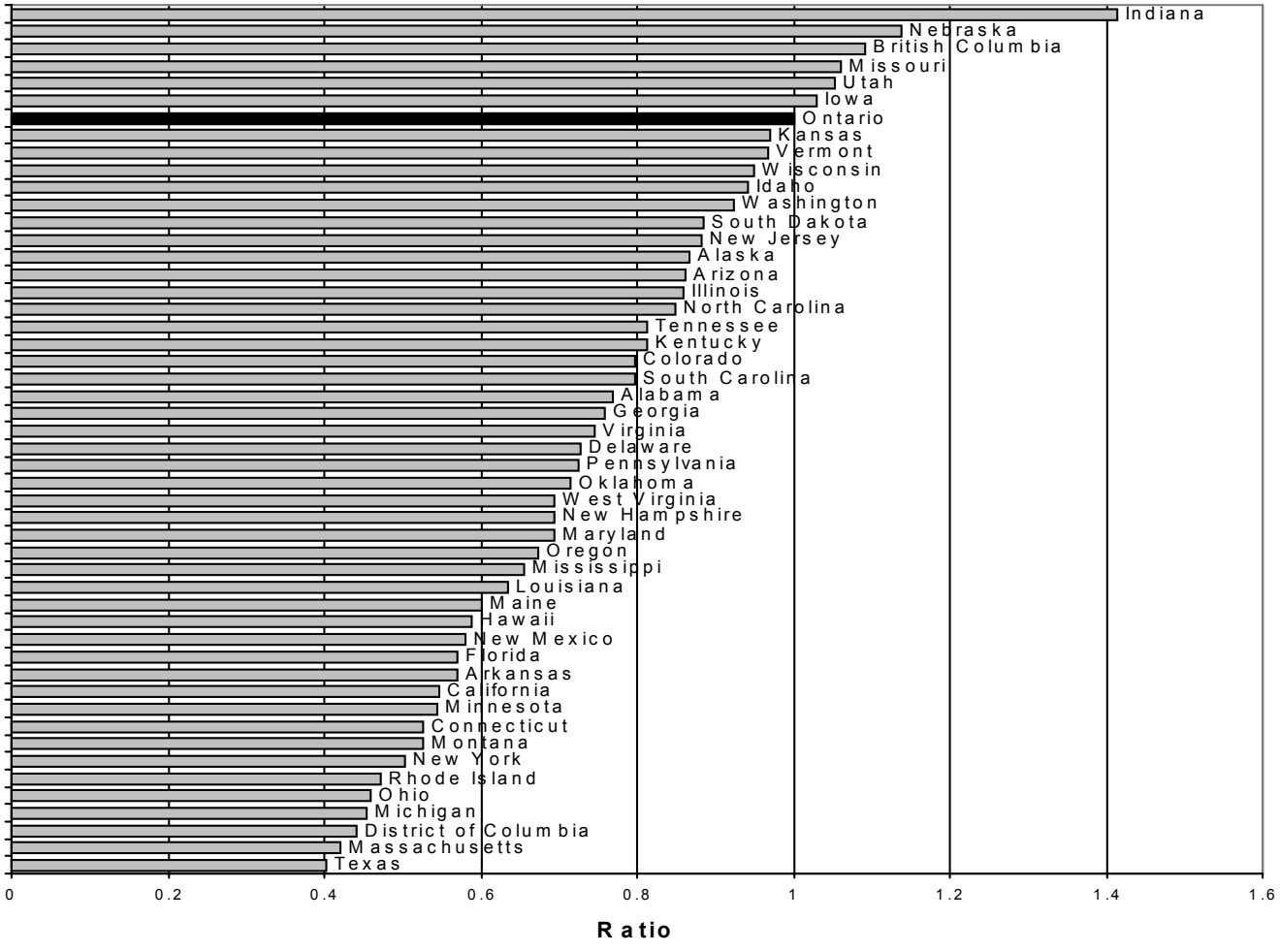
We tested the model using data from 48 U.S. jurisdictions and two provinces (Ontario and British Columbia) for the years 1975 to 1995. We made special efforts to increase the comparability of data from the two countries since there are important differences in the institutional arrangements and in the data between Canada and the U.S.[19] The statistical results included in the *Report* indicate that we have successfully explained a high proportion of the variations among jurisdictions in the costs of workers' compensation insurance.

V. How Efficient Are the Workers' Compensation Delivery Systems for Benefits in Ontario and Other Jurisdictions?

We used the information from our model about the normal relationships between workers' compensation insurance costs and the explanatory variables, such as the level of cash benefits. By controlling for other factors affecting workers' compensation costs, we were able to derive measures of the relative efficiency of the workers' compensation delivery system in each jurisdiction. If, for example, a jurisdiction had values on most of the independent variables that are normally associated with higher workers' compensation costs, but the actual costs of workers' compensation in the jurisdiction were lower than the costs in most other jurisdictions, we concluded that the jurisdiction had demonstrated delivery system efficiency.

Our best effort to replicate the proper approach to measuring delivery system efficiency for the jurisdictions in our study is shown in Figure E.[20] We rank jurisdictions in terms of the relative efficiency of their delivery systems. Indiana has the best delivery system

Figure E
Relative Efficiency of Delivery System, Controlling for Self-Insurance Option, 3SLS Regression, 1975-95, Total Market



efficiency in this analysis, and Texas the worst. Of particular relevance to this study, Ontario ranks seventh in the relative efficiency of the delivery system among the 50 North American jurisdictions included in our study.

The relative efficiency results in Figure E are interesting because the only two Canadian jurisdictions in the study – British Columbia and Ontario – are both among the seven most efficient jurisdictions. One possible explanation is that monopolistic government funds (known in the U.S. as exclusive state funds) are more efficient than private insurance carriers. However, the three monopolistic funds in the U.S. included in our study show no consistent pattern of efficiency: of the 50 jurisdictions, Washington is 12th; West Virginia is 29th; and Ohio is 46th. Perhaps the explanation is that Canadian jurisdictions are more efficient for reasons other than reliance on monopolistic government funds, although we are unwilling to avidly support that conclusion based on data from only two provinces. In any case, the results in Figure E for the five jurisdictions with monopolistic workers' compensation funds lends credence to an argument that government funds are not inherently more – or less – efficient than private insurance carriers.[21]

VI. What Are the Essential Conclusions of this Study?

The costs of workers' compensation insurance for Ontario employers are lower that the costs for comparable employers in most North American jurisdictions. Ontario employers' costs are lower for employers in the manufacturing sector as well as for employers in other sectors of the economy.

The lower costs of workers' compensation insurance in Ontario are due in part to the relatively high efficiency of the workers' compensation delivery system in the province. This greater efficiency does not appear to be caused by greater efficiency of government insurance funds because states with similar insurance arrangements are not consistently efficient.

VII. What are the Limitations and Possible Extensions of this Study?

The study includes data on the employers' costs of workers' compensation in Ontario through 1999. The costs in other North American jurisdictions are only available through 1995 because of the considerable effort needed to update these data. We expended considerable effort in the current report to improve the comparability between the insurance rates in the U.S. and Ontario for the period ending in 1995. However, because workers' compensation insurance rates in the U.S. apparently declined after 1995, the relative costs of Ontario and U.S. jurisdictions may have changed in recent years.

We also devoted considerable energy to refining the variables used in this study in order to improve comparability between insurance rates in the U.S. and Ontario. We have resolved to our satisfaction most of these issues. However, consistent with our agreement with the WSIB, we have not totally resolved some of these issues. In particular, we have refined but not totally resolved the issue of possible shifting of the costs of medical care between the workers' compensation program and the general health care programs. We recommend that a subsequent examination of this issue be undertaken.

ENDNOTES

1. The full report can be downloaded from www.workerscompresources.com.

2 . An extended discussion of the methodology used to measure workers' compensation costs is included in Chapter 3 and Appendix C of Terry Thomason, Timothy P. Schmidle, and John F. Burton, Jr. 2001. *Workers' Compensation: Benefits, Costs, and Safety under Alternative Insurance Arrangements*. Kalamazoo, MI: W. E. Upjohn Institute for Employment Research.

3. The matching of Ontario insurance classes to those in other jurisdictions is discussed in Sections I.A. and I.B. of the *Report*.

4. Experience rating is discussed in Section I.C. of the *Report*.

5. The adjustments in the U.S. for dividends, premium discounts, and other factors that affect employers' premiums are discussed in Section I.D. of the *Report*.

6. The payroll adjustment for Ontario insurance rates is discussed in Section I.E.1. of the *Report*.

7. The adjustments for the unfunded liability of the Ontario workers' compensation program are discussed in Section I.E.2. of the *Report*.

8. Figure A corresponds to Figure 1 in the *Report*.

9. Figure B corresponds to Figure 7 in the *Report*.

10. Figure C corresponds to Figure 12 in the *Report*.

11. Figures 13 and 14 of the *Report* provide actual adjusted rates for construction and for other industries for Ontario and the other North American jurisdictions.

12. Figure D corresponds to Figure 16 in the *Report*.

13. Figures 17, 18, and 19 of the *Report* provide actual adjusted rates for manufacturing, construction, and other industries for Ontario and the Great Lakes states. The pattern is similar to the data shown in Figure D for all industries.

14. The hypotheses and evidence concerning medical costs are discussed in Section III.A. of the *Report*.

15. The mandates included in the Ontario insurance rates and the taxes included in the U. S. insurance rates are discussed in Section III.B. of the *Report*.

16. The model and empirical testing of the determinants of the interjurisdictional differences in the costs of workers' compensation insurance are discussed in Sections IV.A. and IV. B. of the *Report*.

17. Table A is based on some of the results in Table 11 of the *Report*.

18. Since self-insurers tend to be larger firms with lower injury rates, as the self-insurers' share of benefits increase, the average injury rate of the firms that continue to purchase insurance increases. Because we are measuring workers' compensation costs for employers who purchase insurance, those costs tend to increase as self-insurance becomes more prevalent.

19. An example of the differences in the data between the countries is that in the U.S. the injury rates are derived from a federal survey conducted by the Bureau of Labor Statistics while much of the workers' compensation data are from the private insurance industry, while in Canada there are no federal data and all provincial data are from public funds.

20. Figure E corresponds to Figure 31 in the *Report*.

21. The conclusion that monopolistic government funds are not inherently more or less efficient than private funds is reinforced by the more extensive analysis of U.S. jurisdictions in Thomason, Schmidle, and Burton (2001) (see full reference in endnote 2), which concluded "there is no clear difference in costs between exclusive state fund jurisdictions and private carrier states."

Solving the "Ergonomics Injury" Enigma: A Reasonable Approach for Employers

by J. Mark Melhorn, M.D., Eric M. Kennedy, M.S., C.P.E., and Larry Wilkinson, M.D.

Introduction

American businesses incur huge costs for work-related musculoskeletal pain (WRMP). The National Academy of Sciences (NAS) report confirms the scope of the financial problem previously estimated by the Occupational Safety and Health Administration (OSHA),[1] but cites an even larger number of workers losing time.[2] The NAS report estimates that 1 million people lose time from work each year due to these disabling injuries compared with OSHA's more conservative estimate of 600,000. The NAS report also substantiates OSHA's estimate that ergonomic problems cost the economy around $50 billion each year. In 1996, total corporate health and safety costs were more than $418 billion with indirect costs estimated at more than $837 billion for a total cost of $1.25 trillion,[3] and so the cost of WRMP represents a significant portion of these costs. Additionally, a National Research Council report warns that musculoskeletal disorders (MSDs) are expected to increase in the future due to the changing nature of work, the aging of the workforce and rising numbers of women entering material handling and computer jobs.[4]

Historical Perspective of MSDs

Studies of work-related musculoskeletal pain are not new or unique to the United States. Early works by Ellenbon in 1473 devoted to goldsmiths, by Paracelsus in 1567[5] related to diseases of miners, and by Ramazzini[6] in 1700 on laborers describe the historical problems of pain in the workplace.[7] Historically, manifestations of pain in the workplace related to innovation and technology changes have an interesting counterpoint in government decisions and the subsequent waxing and waning of these disorders as public concerns. For example, in 1830, Sir Charles Bell described writer's cramp, which differs from repetitive strain injury only in the high incidence of hand spasm.[8] In 1833, he determined that writer's cramp occurred bilaterally 50 percent of the time even though individuals write with only the dominant hand. He pointed out that the majority of individuals with writer's cramp frequently suffered from "a distinctively nervous temperament, irritable, sensitive, bearing overwork and anxiety badly," and that it "was a disease easily imagined by those who have witnessed the disorder." In 1882, Robinson described the similarity of telegraphist's cramp to writer's cramp.[9] In 1888, Gowers mentioned other similar occupational neuroses of the time: pianoforte player's cramp, violin player's cramp, seamstress cramp, and telegraphist's cramp.[10] In 1908, telegraphist's cramp was added to the schedule of diseases covered by the British Workman's Compensation Act; its incidence steadily increased to affect 60 percent of operators. In 1910, the Great Britain and Ireland Post Office Departmental Committee of Inquiry removed telegraphist's cramp from the list after concluding that telegraphist's cramp was a "nervous breakdown due to nervous instability and repeated fatigue."[11] Interestingly, telegraphist's cramp developed about the time of introduction of the Morse code used in telegraphy, while the above authors suggested that the increased incidence of writer's cramp was accompanied by a change from the feather quill to the more productive steel nib.

During the second half of the Twentieth Century, musculoskeletal pain in workplace was represented by a variety of names and had international exposure. For example, the term occupational cervicobrachial disorder was first established by the Japan Association of Industrial Health in 1972. In the years between 1960 and 1980, an epidemic of occupational cervicobrachial disorders was reported in Japan.[12] The initial reports of cervicobrachial problems were noted among punch card perforators in 1958; subsequently, the disorder was found to affect typists, telephone operators, office keyboard operators, calculator operators, cash register operators, packing machine operators, assembly line workers and process workers. The frequency of problems varied with 81 percent reporting shoulder stiffness, 49 percent only right shoulder pain, 31 percent neck pain, 13 percent wrist symptoms, 19 percent with hand symptoms, 13 percent finger symptoms, 82 percent general fatigue, 59 percent headaches, 27 percent insomnia, and 42 percent low back pain. The term occupational cervicobrachial disorder was used to describe a somewhat vague syndrome of pain about the posterior parascapular shoulder musculature, the glenohumeral musculotendinous structure, and pain radiating in the upper arm. In other words, it was not a pathologic or clinical diagnosis, but a symptom-based diagnosis. In 1964, the problem became so widespread that the Japanese Ministry of Labor set ergonomic guidelines for keyboard operators, limiting their workday to 5 hours and ordering 10-minute rest breaks each hour. Unfortunately, these rigid guides did not decrease the number of new cases reported.

Cervicobrachial disorders have been discussed in medical journals in Scandinavia,[13] Switzerland and Sweden as tension neck,[14] in Finland as occupational disorder, and in West Germany as occupational complaint number 2101.[15] Some investigators suggest that high levels of stress and subsequent muscle tension predispose workers to occupational cervicobrachial disorder. Although light physical work seemed to be associated

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The research group would like to offer all employers the opportunity to use the CtdMAP Intervention Program for one year at no cost. The goal is to increase our understanding and develop effective intervention programs with many different employers. Interested employers should contact us at melhorn@CtdMAP.com for further details.

with occupational cervicobrachial disorder symptoms, heavy physical work was not. A cross sectional study performed in Sweden actually found a negative correlation between heavy work and neck and shoulder problems.[16] This finding should not be taken as an indication that heavy lifting prevents neck and shoulder problems, but it does support the fact that occupational cervicobrachial disorder is more prevalent among sedentary and light assembly workers. The study also found that people with complaints from the neck and shoulder area had more sick leave for illnesses of all types than job-matched controls. In a study of various staff members at the University of Hong Kong, back and neck problems were found to be more prevalent in the 31 to 40 age category and to have an increased incidence in females.[17]

In the 1980s, the United Kingdom experienced an epidemic of upper limb pain. The pain was often nonspecific and did not conform to the pattern of various well-recognized rheumatologic entities. The syndrome was known by a number of terms, some of which implied an etiologic link to workplace activities unsubstantiated by hard evidence. The syndrome was considered largely psychosocial and analogous to the chronic fatigue syndrome.[18] Studies based on a random sample of more than 1,000 working age people in the north of England revealed that, at any point in time, 9 percent of men and 12 percent of women had arm or neck pain sufficiently severe enough to consult their physician.[19] Other studies have drawn attention to the prevalence of neck and arm pain in the normal activities of daily living.[20]

The Australian repetitive strain injury experience differs only in its epidemic spread and high incidence when compared to occupational cervicobrachial disorder. The epidemic of repetitive strain injury spread to involve a wide spectrum of occupations, including data processors, process workers, typists, clerks, cashiers, bank tellers, musicians, packers, and textile industry machinists whose manual tasks and productivity had not changed significantly for decades. It then spread to workers who were not engaged in repetitive movements, such as retail sales assistants. In 1985, 34 percent of the national telephone company's operators complained of this phenomenon.[21] Repetitious use was suggested as the cause for repetitive strain injury, but medical studies could not demonstrate a

common denominator for motion of the upper limb and repetitive strain injury. In one study of Telecom (the government-run national telephone company), the highest incidence of repetitive strain injury occurred in the following groups: 34 percent in telephonists who had the lowest keystroke rate, followed by 28 percent in clerks, and 3.4 percent in keyboard operators, who had the most repetitious tasks and highest keystroke rate.[22] Other studies showed the frequency of occurrence was different for repetitive strain injury with keypunch operators at 16 percent to 28 percent, cash register operators at 11 percent to 16 percent, typists at 13 percent, calculator operators at 10 percent, and light assembly line workers at 16 percent. A 1981 Australian survey of 122 data process workers showed that 78 percent had symptoms of repetitive strain injury. Most symptoms, however, were mild, and only 26 percent of the entire group had obtained medical treatment. No specific work-related explanation was found.[23]

The American experience has been similar to and influenced by the Australian and United Kingdom experience. In 1970, the Occupational Safety and Health Act (OSHAct) signed by President Nixon provided authority to the Occupational Safety and Health Administration (OSHA) to establish regulations and to enforce compliance by employers.[24] In 1984, Hadler coined the term "regional musculoskeletal disorder" for musculoskeletal pain that lacked association with physical activities in the workplace.[25] The debate regarding causation of "cumulative trauma disorders" (to be defined later) was in full swing in the lay media and medical literature.[26] In November 1990, OSHA started work on Ergonomics Standards and by August 1992, OSHA published an Advance Notice of Rulemaking on Ergonomics. On November 23, 1999, OSHA published a proposed Ergonomics Program Standard, which resulted in 9 weeks of public hearings and in 18,337 pages of testimony from 714 witnesses. This hearing was followed by 11,000 pages of comments and briefs, which resulted in an additional 50,000 pages that were entered into the docket of the ergonomics rulemaking. On November 14, 2000, OSHA issued its final ergonomics standards.[27] After President Clinton signed an administrative decree with a 90-day discussion period the OSHA ergonomics rules became effective January 16, 2001, with an overall program evaluation required at the end of three years and the implementation of permanent ergonomic controls required by January 18, 2005. On March 8, 2001, Congress passed a Joint Resolution of Disapproval of OSHA's ergonomics standard that was signed by President Bush on March 20, 2001, which nullified the ergonomics standard.

Meanwhile, at the state level, California had already taken a leadership role when its OSHA Standards Board, with approval by the Office of Administrative Law Section, passed the California Code of Regulations on July 3, 1997, Title 8, Section 5110 pertaining to Repetitive Motion Injuries (RMIs), which was followed on October 16, 1997 by a peremptory writ of mandate, followed by an appeal September 27, 1999, followed by an October 29, 1999, court reversal which was followed by an April 28, 2000, approval of the court-ordered revision. Compared to the recently rejected OSHA ergonomic rule, the California Standard is a model of simplicity. It takes up less than a page in the California Code of Regulations. If an employer has more than one "repetitive motion injury" in any consecutive 12-month period as the result of work from identical work activities, then the employer must establish and implement a program designed to minimize repetitive motion injuries. The program must include: worksite evaluation, control of exposures that have caused the repetitive motion injury, and training of employees. The California approach is more employer and employee friendly, encouraging employer involvement while waiting for additional science to support interventions that are more specific.

In May of 2000, the State of Washington adopted an Ergonomics Rule WAC 296-62-051 with 14 pages and eight key elements: 1) the rule applies only to employers with "caution zone jobs," 2) the employer must provide ergonomics awareness education, 3) the rule requires employer to develop a method and criteria for identifying and reducing work-related musculoskeletal disorders (WMSDs) hazards, 4) the rule applies only for jobs with WMSDs hazards, 5) the employer must reduce exposures below hazardous levels or to the extent technologically and economically feasible, 6) the employer must provide for and encourage employee participation, 7) the implementation schedule can be extended over time with employer developing guides and models that identify industry best practices, establish inspection policies and procedures, and conduct demonstration projects, and 8) a grandfather clause is available for effective programs already in place. Following the state model, this year Alaska and Minnesota have introduced but not passed similar legislation.

Clarifying the Question

In response to concerns by labor about the demise of the OSHA ergonomics standard, Labor Secretary Elaine L. Chao scheduled three national public forums on the issue of ergonomics safety in the workplace in July 2001: Washington, DC, at George Mason University; Chicago, IL, at the University of Chicago; and Stanford, CA, at Stanford University, which resulted in 4,882 additional pages contained in 177 exhibits provided by over 1,000 organizations.

Labor Secretary Chao opened the first of the forums with the comments: "We can choose to do one of two things starting today. We can play politics or we can protect workers. We can engage in sideshows or we can pursue safety, but the goal is to answer the following three ques-

tions: 1. What is an ergonomics injury? 2. How can the Occupational Safety and Health Administration, employers and employees determine whether an ergonomics injury was caused by work-related activities or non-work-related activities; and, if the ergonomics injury was caused by a combination of the two, what is the appropriate response? 3. What are the most useful and cost-effective types of government involvement to address workplace ergonomics injuries?"

The questions demonstrate a fundamental misconception about ergonomics. There is no such thing as an "ergonomics injury." Ergonomics is an applied, design-oriented science that can assist companies in reducing the occurrence of what OSHA has termed "musculoskeletal disorders" (MSDs). Applying ergonomics principles is a method through which MSDs and their direct and indirect costs can be controlled. Ergonomics can also be applied to increase productivity and efficiency, reduce errors, improve quality, reduce waste, increase employee retention and satisfaction, and ultimately improve work, products, and a company's bottom-line.

So, to rephrase the question for accuracy, "What is an ergonomics injury?" should be rephrased as "What is an MSD?" MSDs are illnesses or disorders of the muscles, nerves, tendons, ligaments, joints, cartilage and spinal discs. Although commonly called injuries, OSHA has defined an injury as occurring from a single event while illness occurs over time. MSDs can be directly and indirectly related to risk factors associated with activities and the environment in the workplace and in the nonworkplace. Examples of risk factors include forceful exertions, awkward postures, repetitive exertions, and exposure to environmental factors such as extreme heat, cold, or vibration. It is often a combination of these risk factors that, over time, lead to pain, injury, illness, and disability.

This physiological model is based on an event such as lifting, pushing, or pulling, which may stress body tissues, yet the exposure may be too low for traumatic injury, and the tissues recover. Some individuals have greater capacity to tolerate physical activity (individual risk). Repeated exposure to this stress, on the other hand, may interfere with the normal recovery process and produce disproportionate responses and eventually an MSD event. Traumatic injuries may occur due to cumulative effects that manifest themselves suddenly at the time of a specific event, or they may occur because the event exposes the body to risk factors that exceed the person's individual capabilities. A sudden back or shoulder injury tied to a specific task is an example.

There is no such thing as an "ergonomics injury." Ergonomics is an applied, design-oriented science that can assist companies in reducing the occurrence of what OSHA has termed "musculoskeletal disorders" (MSDs).

When an MSD is associated with work, it is usually referred to as a Work-Related Musculoskeletal Disorder (WRMSD or WMSD). Other terms, such as cumulative trauma disorders (CTDs), repetitive stress injuries (RSIs) and repetitive motion injuries (RMIs), mean roughly the same thing as MSDs. However, RSIs and RMIs are arguably inaccurate because these terms imply that repetition is the primary risk factor, which may or may not be the case. Further, MSDs is not a medical diagnosis but a descriptive term for musculoskeletal pain.

Intrinsic and Extrinsic Risks for Work-related Musculoskeletal Pain

"I hurt" and "I hurt because of the workplace" is a description of pain with or without a proposed cause--not a medical diagnosis.[28] However, under current OSHA definition, OSHA 300 log "F" injuries are defined as RMIs, commonly described as CTDs or MSDs.[29] Many authors have taken issue with this approach, a including Hadler,[30] Louis,[31] Kasdan,[32] and Vender.[33] Other authors agree with the work-related injury construct (the job is the cause), including Armstrong,[34] Silverstein,[35] Fine,[36] and Bernard.[37]

A reasonable approach for employers and legislatures is a middle ground. That is, physical activities (workplace and nonworkplace) have inherent extrinsic risk factors for the development of musculoskeletal pain that interact with the intrinsic risk factors of the individual. This approach is supported by reports from the National Academy of Sciences[38] and the National Research Council[39] on work-related MSDs. It is important to remember that not all musculoskeletal pain is caused by physical activities.

Finding the Balance

MSD/CTD occurrences require two elements: an individual and an activity. The activity can occur at work or at home. Many healthcare providers believe that the etiology of MSDs is multifactorial, but they choose to focus on the things that they can evaluate and change (medical conditions) rather than focusing on things that they cannot change (age, gender, inherited genetics) or things that they often do not treat (workplace conditions). Therefore, some healthcare providers believe that it is the individual's medical history that largely determines if he or she will develop MSDs. Their proof is that employees can and do perform identical jobs, but only some develop MSDs while others never experience a symptom.[40] From an epidemiological point of view, this approach is not supported by the science. Healthcare providers can easily relate to the clinically defined disorders in which the criteria for the epidemiologist's case definition are similar to the physician's diagnostic criteria. Nonetheless, while epidemiological evidence

may be helpful for population-based treatment and prevention, the evidence is of little help to the medical provider treating an individual by seeking to optimize healing by reducing pain and inflammation, increasing strength and flexibility, and immobilizing the affected area when appropriate. Therefore, healthcare providers treat the individual's MSDs with anti-inflammatory medication, specific therapeutic exercises, splinting, injections, and, when appropriate, surgery. Most healthcare providers do not have time to go to their patients' work site and look at their workstations.

Assessing individual risk and job risk will not answer all of the questions concerning the causes of work-related musculoskeletal pain. A complete understanding involves multiple biosocial factors: personality traits, psychological dysfunction (depression), coping ability, attitude toward life, and attitude toward one's own health. Specific factors associated with an increased likelihood of WRMP include overall poor health, lower socioeconomic status, lower intelligence, marital problems, living alone, financial problems, child rearing problems, interpersonal conflicts, job dissatisfaction, and economical concerns.[41]

For most clinicians, the term "biosocial issues" or "psychosocial elements" are ill defined and difficult to grasp. Currently, there is considerable confusion and misunderstanding regarding their contribution to the development of MSDs. Biosocial issues do explain why two individuals may react differently to the same workplace experience.[42] A model developed by Hurrell *et al.*[43] may provide some insight into the complexity with which these factors interact. This model includes: individual factors, job stressors, nonwork factors, buffers, acute reactions, and illness. Three mechanisms have been suggested to account for associations between biosocial issues and musculoskeletal disorders:[44]

1. Psychosocial demands may overwhelm the individual's coping mechanism and produce a stress response. This stress response may increase muscle tension or static loading of muscles.[45]

2. Psychosocial demands may affect MSDs awareness and reporting, or increase its attribution to the work environment.[46]

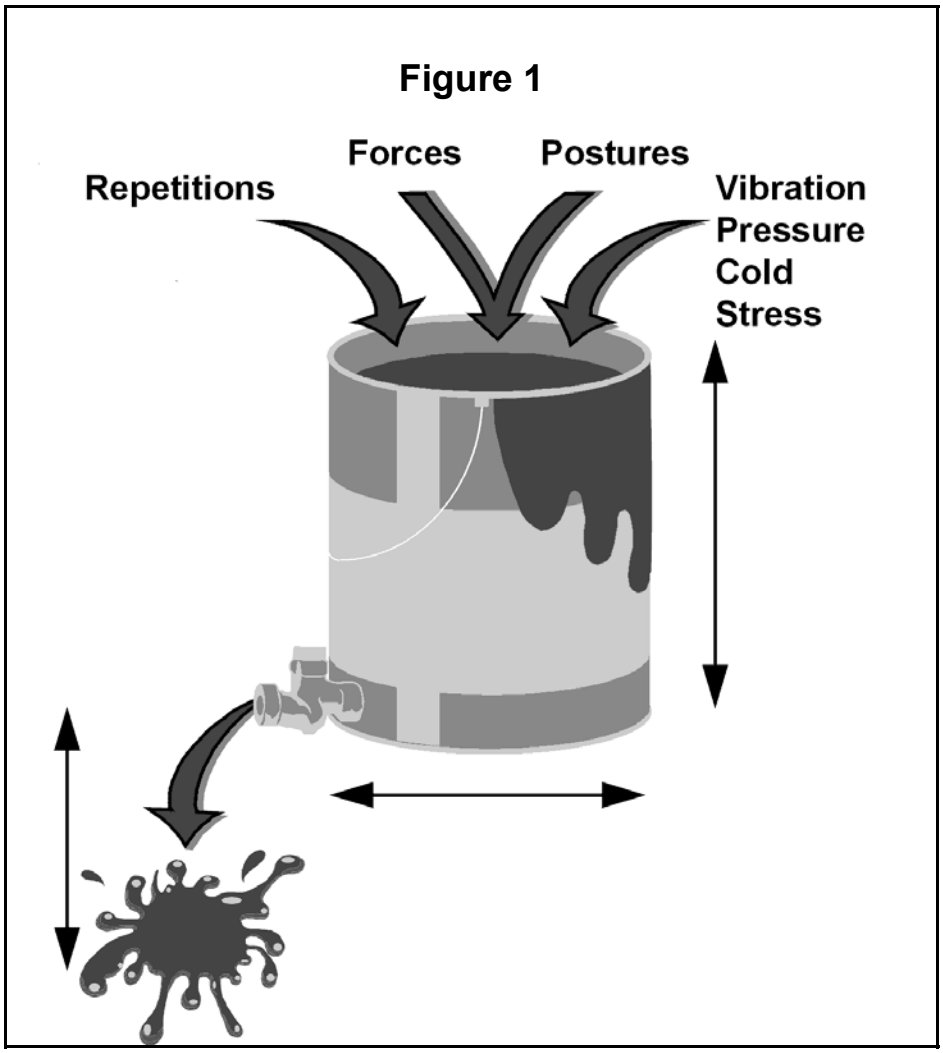
3. In some work situations, psychosocial demands may be highly correlated with increased physical demands. Therefore, any association between psychosocial factors and MSDs may actually reflect an association but not a cause between physical factors and MSDs.[47]

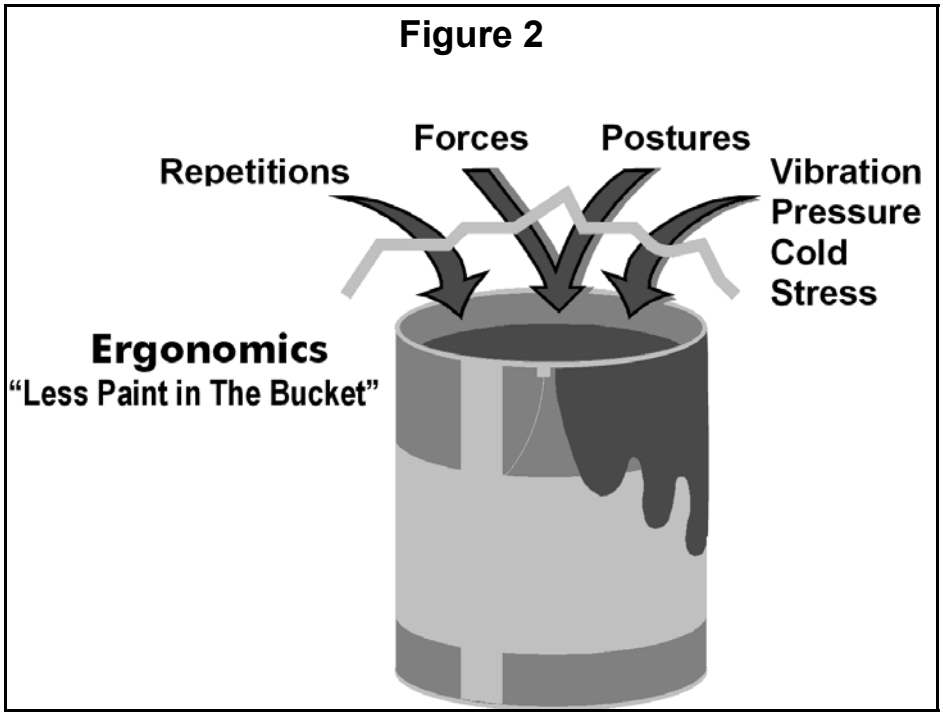
Table 1

Individual Risk Factors	Biosocial Issues
Age	Personality traits
Gender	Psychological dysfunction
Genetics	Coping
Biosocial issues	Social & Family
Nonworkplace activities	Economic concerns

Understanding how the individual's multiple risk factors such as those identified in Table 1 affect the development of MSDs is crucial to the concept of return to work and prevention. Studies have supported a direct relationship for increased risk for the development of CTS with increasing age.[48] Population studies have shown a higher incidence in women than men.[49] Inherited genetic characteristics, which include a variety of anatomical anomalies and general systemic medical conditions such as rheumatoid arthritis, thyroid imbalance, acromegaly, multiple myeloma, amyloidosis, diabetes mellitus, local trauma to the wrist, alcoholism, hemophilia, local tumor, hormonal changes associated with menopause, pregnancy, pleonosteosis, and gout, can increase an individual's risk level.[50]

On the other end of the risk spectrum are the ergonomists who are fully aware of the multifactorial nature of MSDs, but choose to focus on the things that they can evaluate and change (workplace conditions) rather than focusing on things that they cannot change (age, gender, inherited genetics) or things that they cannot treat (medical conditions). Therefore, the workplace becomes their primary focus for understanding the causation of MSDs. Too many repetitions, high forces, awkward positions, direct pressure, vibration, cold temperature, contact stress, and unaccustomed work activities are the causative factors. The basis for this approach is supported by epidemiological studies that industries with higher occupational risk factors such as meatpacking and textiles routinely have the highest rates.[51] The ergonomists therefore would attempt to reduce repetition and force, avoid awkward postures, isolate vibration, modify temperature, and eliminate direct pressure to eliminate or reduce the risk. Where possible, the ergonomists would consider prevention programs for employees, wellness tips, biomechanics training, and tool and workstation redesign.





Tipping the Scales

What makes MSDs different between the workplace and the nonworkplace depends on social, cultural, and governmental rules. When social, cultural, and government rules change, the incidence, location, and type of workplace pain also changes.[52] From a comprehensive perspective, workplace risk factors include any part of the production process (the manufacturing of a product). The production process usually includes Input (raw materials), the Production (methods, materials, machines, environment, physical stressors), and the Output (the finished product).[53] As discussed before, the individual risk factors become contributors, moderators, and buffers as to how the workplace may affect the individual for the development of MSDs. Workplace or employer risk factors can be placed into three broad categories that include job or task demands, organizational structure, and the physical work environment.

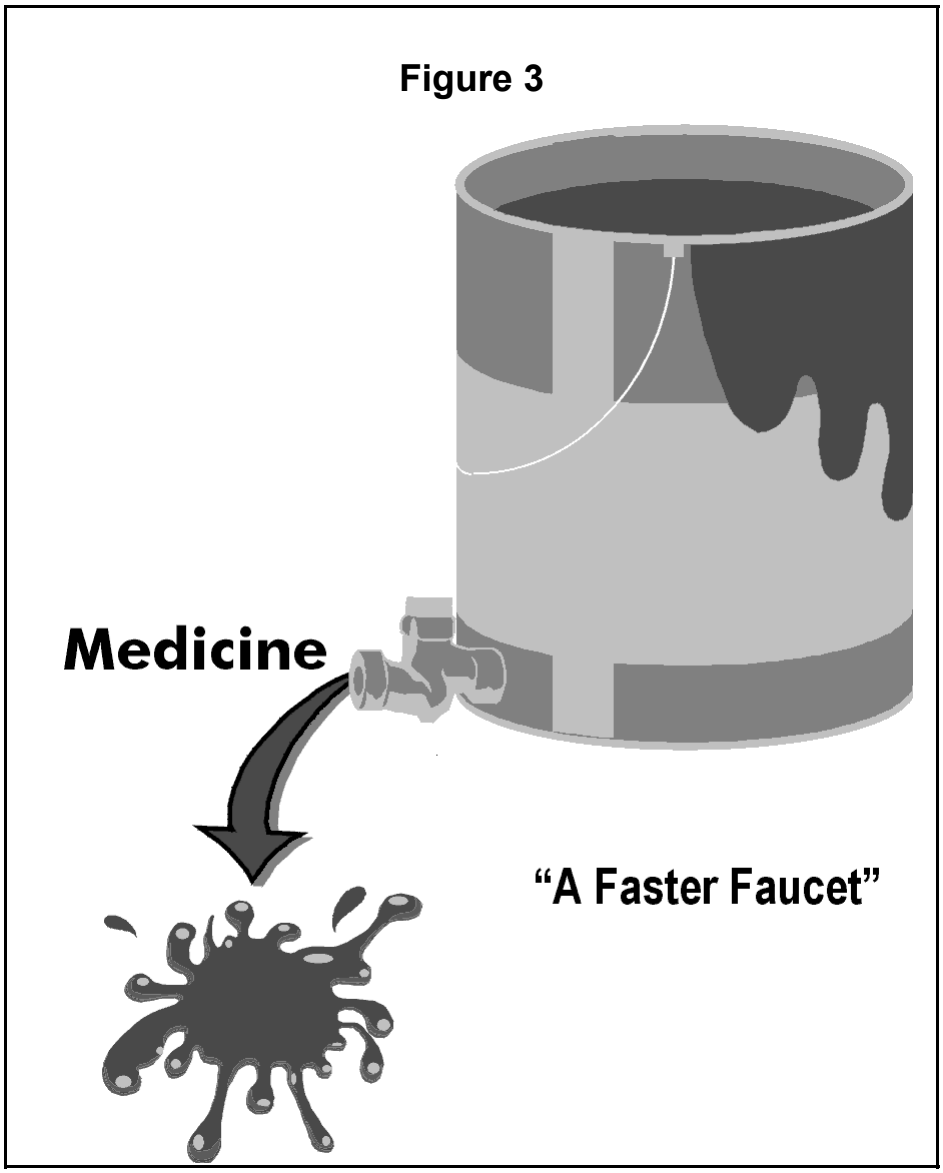
The Paint Bucket Analogy

The paint bucket analogy can be helpful in providing an overview as to how these risks interact. Consider the individual body as a bucket with a faucet, as shown in Figure 1. Activities at work and home are like paint. As the activities increase, the amount of paint in the bucket increases. The capacity of the faucet is controlled by the individual's inherited genetic characteristics and learned behaviors. If too much paint is in the bucket, or if the faucet is too small, the paint will spill over and the individual will have an MSD/CTD. The paint (workplace stressors such as repetitions, force, postures, vibration, contract stress, and cold) can be modified or decreased by changes in the job, job activities, and management style. Changing the capacity of the faucet can be more challenging. Changing one's genetics is very difficult, but to change one's

physical capacity is realistic. The body can be conditioned for the workplace just as for sports. This conditioning can result in improved performance and decreased injuries.

Figure 2 suggests the impact from ergonomic intervention, while Figure 3 illustrates the impact from medicine. The best approach is achieved by combining the benefits obtained by ergonomics (the job) and medicine (the individual).

The development and implementation of an ergonomics program requires a team effort. The implementation of a successful ergonomics program can benefit the employer and employee by: 1) reducing the number and severity of work-related injuries and illnesses; 2) reducing employee turnover; 3) increasing productivity; 4) increasing product quality; and, 5) increasing employee morale. These benefits result in lower costs due to fewer MSDs, decreased absenteeism, reduced workers' compensation premiums, increased productivity and higher product quality.[54] The Appendix to this article details several studies in which such benefits were realized. Achieving these benefits will require the physician to be knowledgeable about MSD risks and to understand the related workplace issues.



Summary

Solving the "ergonomics injury" requires an understanding of multiple workplace issues and the developing science related to MSDs. Confusion reigns because of the complex interaction between the individual and job and the subsequent development of job-related musculoskeletal pain. Not every individual performing a specific job develops job-related musculoskeletal pain. Even when individuals perform similar jobs and develop work-related musculoskeletal pain, their clinical symptoms and signs can vary greatly. Poorer outcomes for job-related musculoskeletal pain than for non job-related musculoskeletal pain despite similar treatment plans are common. Successful management of occupational musculoskeletal problems goes beyond the traditional medical dimension. Despite the continuing debate on causation, current medical and epidemiological literature supports a causal relationship between activities and musculoskeletal pain. Reasonable management decisions can be made based on individual and job risk provided by assessment instruments.[55] The benefit-to- cost ratio of interventions can be over 300 for MSDs programs.[56] It is clear that financial and legislative initiatives will mandate prevention from a public health perspective.[57] To protect their human and financial resources, employers should not wait for these mandates. Prevention by risk assessment currently provides an opportunity for reduction of the incidence and severity of work-related MSDs by allowing engineering controls to be applied in a prioritized approach, resulting in real solutions for the problems facing the American worker and employer.

APPENDIX

The Science of Risk Assessment

Although the concept of MSD prevention is appealing, the limiting element has been the lack of an appropriate individual risk assessment instrument.[58] For the individual risk assessment instrument to be effective, it must meet certain required criteria which include: reproducibility (test-retest reliability or reproducibility); internal consistency (the ability of a scale to measure a single coherent concept); validity (the instrument actually measures what it is purported to measure); and sensitivity or responsiveness to change (the instrument's ability to detect changes in clinical status).[59] Additionally, research has shown that disease-specific instruments are usually more accurate and sensitive than general outcome instruments for measuring specific injuries or illnesses.[60]

The CtdMAP™ has been used successfully to assess risk for the job and the individual by using an individual symptoms survey and a job activities form. CtdMAP™ Risk Scores© range from a low of 1 to a high of 7. The average risk score for both the job and the individual is 4. The individual and job risk scores can be combined to provide a combined risk score. The combined risk score is the best measure of overall risk. MSD/CTD risk is calculated using the probit model in Figure A1. This MSD/CTD model is used to assess risk for the individual and has a 95% accuracy curve with a variation of 2.5% above and below for each risk score as seen in Figure A2.

The General Accounting Office and NIOSH list six critical elements necessary for successful ergonomics in the workplace: management commitment; employee involvement; risk assessment of individual and job; analysis of data and development of controls; training and education; and traditional health care management.[89, 104] A reasonable, manageable, and cost effective ergonomics intervention program was developed for employers using the CtdMAP™ risk assessment instrument. The following examples suggest opportunities for other employers.

Figure A1

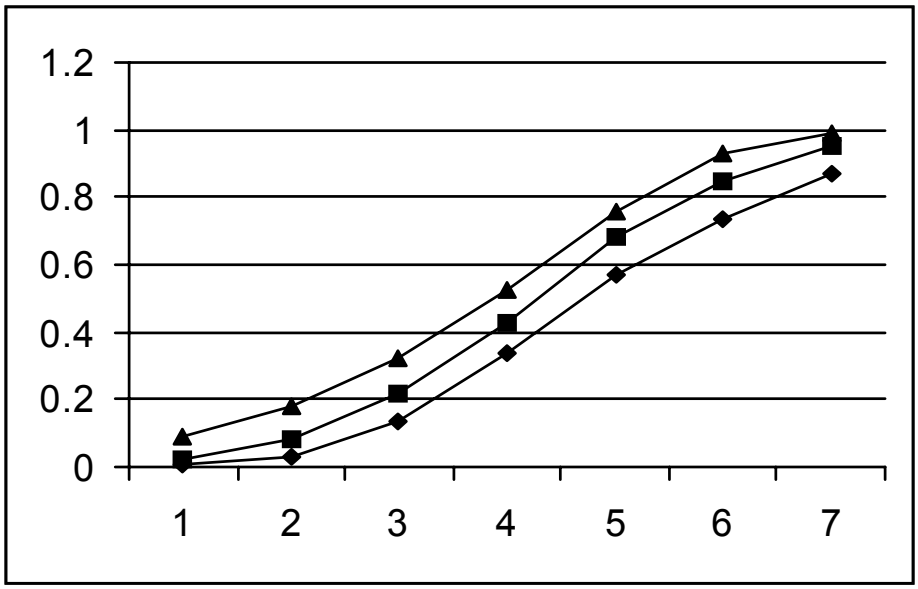
$$P(CTD|Risk\ Level) = \int_{-\infty}^{\alpha+\beta(Risk)} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = \Phi(\alpha+\beta(Risk))$$

Probit Model (above) is used to assess individual risk.

Impact of workplace screening

The Study: A prospective study of the impact of workplace screening was undertaken in 1997 by a financial institution with 82 employees assigned to six branch offices. Data was collected for age, gender, job, branch local and study group (control or screened). The control group was made up of individual employees who received no information regarding the study or MSDs in the workplace. The study group was introduced to MSDs in the workplace by an office memo, employee management meetings, edu-

Figure A2



In the Accuracy Curve (above), the y axis measures the probability of an MSD/CTD event, and the x axis measures the CtdMAP risk score. The square represents the best estimate of the relationship between the variables measured on the x and y axes, while the triangle shows the 2.5% variation above the best estimate and the diamond shows the 2.5% variation below the best estimate.

cational materials and a question and answer session over a four-week period followed by 40 of the employees being screened using a risk assessment instrument (screened group).[62] The screened group was further randomly divided into a group of 20 individuals who were informed of their risk assessment score and 20 who were not informed. Individuals were notified or informed of their individual risk level by letter and a follow-up interview. Education was provided to the informed group but no specific health interventions, workplace modification, or ergonomic programs were provided. Retrospective data was collected for the 5 years before the start of this study. During the study period, the employer experienced the usual first aid events and workplace injuries, but recorded no OSHA 200 "F" injuries (MSDs).

Conclusions: Employers may be concerned with workplace screening; however, this study suggests that the impact of screening on the recordable rate may be minimal.

Observations: Each employer is unique. It is possible that there could be an initial increase in the recordable rate but often there is a reduction in the lost time severity index, which is more closely linked to the actual costs associated with workers' compensation.

Tools and ergonomic program design

The Study: In a prospective study, 212 workers were randomly sampled out of an 8,000-member workforce for musculoskeletal disorders or activity-induced pain in the workplace.[63] Employees were randomly assigned to one of four primary groups: vibration-dampened rivet guns, standard rivet guns (control group), ergonomic training, and exercise training.[64] Individual risk assessment was performed at the start of the study and at 7 and 15 months.

A statistical model was developed that included the following controlled variables: (job, rivet gun, posture, time and exercises) and uncontrolled variables (task-specific measures such as number of rivets driven, number of rivets bucked, number of holes drilled). Ergonomics training included awareness of early warning signs of musculoskeletal disorders, methods for controlling risk factors, techniques to apply forces with less stress or strain, and correct posture to improve balance and absorb forces. Exercise training included muscle relaxation and gentle stretching of muscles and tendons. Tool options included vibration dampening rivet (recoilless) gun, standard rivet gun, conventional bucking bars, and training for specific tool use.

Analysis demonstrated benefits for the individual, which included fewer musculoskeletal pain events, a reduction in severity, and a reduction in number of days with pain. Employer benefits included fewer OSHA 200 log events, a reduction in lost work time, a reduction in restricted workdays, and a reduction in workers' compensation costs. Ergonomics training had a statistically significant impact on the preceding benefits and resulted in a reduction of individual risk as measured by the risk assessment instrument. Additional reduction of risk occurred with ergonomic training and the covariates of dominant hand, time spent in an awkward position and number of standard rivets bucked. Exercise training demonstrated a risk reduction benefit for the covariates of dominant hand, number of parts routed, and number of parts ground. Vibration dampening riveting provided risk reduction for new employees, but increased risk for current employees.

Conclusions: Employees benefited from ergonomic and exercise training with a reduction in MSDs. The employer-estimated savings were $4 million based on the unnecessary potential cost of purchasing vibration dampening rivet guns for all employees. For every dollar spent on prevention, the employer saved $285 (a benefit to cost ratio of 285) for direct workers' compensation costs.

Observations: The increased risk for current employees using the new tool (vibration dampening rivet gun) appears to be due to a change in the tactile feedback of the rivet gun. After using a specific rivet tool for years, each employee had developed a feel for when to stop riveting, but with the new tool, the feel was lost and a subsequent increase in the time, frequency, and duration of riveting occurred. New employees having no previous experience with the feedback were able to learn the correct feel using the new tool.

Workplace Intervention Program

The Study: In a prospective study, a plastic product manufacturer wanted to improve its safety program by identifying individuals and jobs at risk.[65] All jobs were analyzed for workplace risk factors (methods, materials, machines, environment, and physical stressors) and were prioritized for interventions based on job and individual risk. The ergonomics team (which consisted of an employee representative, supervisor, ergonomists, safety engineer, health nurse, and physician) reviewed higher risk jobs.[66] Job modifications included administrative controls, work practice modification, personal protective equipment, retrofit engineering, and informed purchasing. When new product lines were developed, workplace design was part of the initial consideration based on the benefits of previous job modifications and job risk reduction, as measured by the risk assessment instrument. Individual intervention included education, exercise, and job training.

Quarterly analysis showed a reduction in the OSHA 200 incidence rate, lost time workday severity index, and workers' compensation costs, while production increased and rework decreased. Over 24 months, the combined composite risk score from the instrument for the company moved from 4.79 to 3.95.

Conclusions: A risk assessment instrument can be used to identify job

risk, to prioritize job modification by an ergonomic team, and to identify individual risk for development of personalized intervention programs based on education, exercise, and job training. This combined approach provided the employer with reduced costs of $234,000 for year one and $953,000 for year two when compared to the previous two years. The benefit to cost ratio was 185 for the intervention program without consideration of the increased production.

Observations: Individual and job-risk assessments resulted in effective distribution of limited funds that were available for this prevention program.

MSDs Prevention for New Hires

The Study: A prospective study with historical data for comparison was completed for an aircraft manufacturer using a risk assessment instrument.[67] During a two-year period, 1,010 new employees were hired. The company elected to risk-assess individuals for the high-risk job of sheet metal mechanic (n=754) and not to risk assess individuals for the low-risk job of administrative staff (n=256) which served as the control group. After a conditional job offer, each individual was seen by the company physician for functional capacity assessment, which included a traditional employment examination and laboratory testing. Risk assessment was provided for the high-risk job group only. The individual risk assessment scores were used to help the physician develop individual specific education and exercise programs. Education included review of ergonomics in the workplace, proper lifting, body mechanics, and early reporting of MSDs symptoms and signs. Exercises included strengthening and flexibility programs to develop endurance. Job matching was not a part of this study; all individuals were hired for a specific job. No intervention was provided for the control group.

Analysis of outcome measures showed a reduction in lost work hours from 3,000 to 1,000 and 1,000 to 650 in years one and two compared to 780 to 782 and 782 to 791 in the control group. Over the two-year study period, the number of surgeries in the study group was reduced from 14 per 754 (1.9 percent) to 1 per 754 (0.1 percent) compared to the control group with 3 per 256 (1.1 percent) to 2 per 256 (0.78 percent).

Conclusions: Although individuals bring a unique risk for the development of MSDs to the workplace and the job may act as a trigger event for MSDs, successful interventions will require an approach that also takes into account the individual risks. Two interesting observations are that individuals who are now performing the "high-risk job" have a lower rate of surgery, 0.1 percent versus 0.78 percent, and they have lower lost work hours to employee ratio, 0.8 ratio versus 3.1. When considering the reduction in lost work hours and the direct costs of workers' compensation, the employer estimated savings were $1.8 million for the two-year period with a benefit-to-cost ratio of over 257 for the program. The data suggest that additional benefits could be obtained by adding job risk to the new hire placement process.

Observations: Although employers may consider some jobs a higher risk, MSDs can occur in lower risk jobs also because of the strong impact of individual factors on the development of MSDs.

MSDs Prevention in New Hires Modified by Job Requirements

The Study: In January of 1995, an aircraft company established a prospective MSDs risk management program for new hires. The MSDs intervention program was designed to integrate a traditional occupational medicine clinic (physician on site) and a risk assessment instrument for assigning risk and implementing intervention.[68] The MSDs intervention program was designed to prospectively evaluate each new employee for his or her individual risk of developing MSDs in the workplace and assist the physician in matching the employee to the most appropriate available job. The concept of "best fit" (the goal of ergonomics) was being placed into practical application. Since these employees were being hired for many different jobs, each job was risk assessed and an essential functions description was developed. The physician used an algorithm based on the individual's risk score and provided transitional work options, long-term work guides, education, and exercise programs. Before job placement, individuals at higher risk were assigned to a period of transitional work.

Analyses of six outcome measures were reviewed (recordable case incidence rate, lost time case incidence rate, lost time day severity incidence rate, airplane production, costs of the intervention program, and estimated workers' compensation costs). All rates were converted to 200,000 hours worked per year to allow comparison with other publications. There was no significant change in recordable case incidence, a significant reduction in lost time and lost time day severity incidence rate, and no change in airplane production. Risk intervention costs over 4 years were: $122,928 for 3,152 assessments, $29,697 for 761 repeat assessments, $142,500 for transitional work (production loss), $2,028 for education, and $7,485 for administration with a total of $304,470 or $76,118 per year, which represented less than 0.06 percent of the employer's annual salary costs. Workers' compensation cost decreases per year were: 16 percent, 3 percent, 24 percent, and 12 percent, while work hours increased 56 percent. Employer-estimated savings in direct workers' compensation costs per year were $469,990, $678,337, $1,936,105, and $1,995,759 during a time when the total hours worked

doubled with a benefit-to-cost ratio of over 390 percent for the program.

Conclusions: Management of newly hired workers can be improved by including the risk associated with the future job activities. After a period of transitional work, most employees will not require permanent work guides. Risk-reduction strategies will become increasingly important as the national workforce ages and more individuals with disabilities are employed.

Observation: Only 11 of the 34 (29 percent) with risk scores of 7 required permanent restrictions as follows: vibratory or power tool was limited to 6 of 8 hours in time blocks of 1½ hours per 2 hours and repetitive motion tasks were limited to 6 of 8 hours in time blocks of 50 to 55 minutes per hour. This group represents less than 1 percent of the original high-risk group (risk scores 5 to 7, n = 761) and only 0.4 percent of the entire study group.

Medical Management of Current Employees

The Study: In 1998, an aircraft company modified its medical intervention protocol to include the use of an individual risk assessment instrument to assist in the decision of medical referral after retrospectively reviewing the previous two years workers' compensation records. A decision was made to address medical management of MSDs seen by health services. A prospective study was developed with a specific decision tree for all employees who reported to health services with a recordable OSHA 200 MSDs event. The company physician evaluated each employee using traditional healthcare techniques and the risk assessment instrument. After completing the history and physical examination, the physician would review the current and previous individual risk score. If either individual risk score was above average (>4), the employee was referred to a specialist for additional treatment. If the individual's risk score was below average or average (≤4), in-house medical care was provided.

Analysis of ten outcome measures was reviewed (recordable case incidence rate, lost time case incidence rate, lost time day severity incidence rate, airplane production, costs of intervention program, estimated workers' compensation costs, number of operations, medical treatment, and job activities or new tasks). Improvements in incidence rates and production occurred with reduction in costs, surgery, and treatment. New tasks and onset of symptoms were reviewed. Over 70 percent of low-risk individuals and none of the high-risk individuals had experienced a job change or new task in the previous six weeks before onset of symptoms.

Conclusions: Traditional medical management of MSDs can be enhanced by using a risk-assessment instrument. Employer-estimated savings in direct workers' compensation costs were $2.42 million and estimated indirect savings were more than $13.5 million during the study with a benefit-to-cost ratio (of direct costs only) of over 398 percent for the program.

Observations: Individual risk scores of 6 and 7 did not require a change in job or a new task to trigger a MSDs event. As the individual risk score decreases, the job requirements or task change increases. The data suggests a ratio of individual-to-job risk of 65 to 35 for predicting the likelihood of any one individual for developing a MSDs. This ratio is being further evaluated in current studies to assist in better allocation of intervention funds in an effort to reduce risk and incidence.

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