HRRI Working Paper 07-03

Disabling and Fatal Occupational Accidents Rates, Risks and Costs in the Oregon Construction Industry 1990-1997

Irwin B. Horwitz, Ph.D.

University of Texas School of Public Health at Houston

Brian P. McCall, Ph.D.

University of Minnesota Industrial Relations Center

Corresponding Author: **Irwin B. Horwitz**
Assistant Professor
University of Texas
School of Public Health – Houston
Suite W310
Houston, TX 77089
(713) 500-9194
ihorwitz@sph.uth.tmc.edu

Abstract

Occupational research has demonstrated construction to be among the most dangerous of all occupational industries. This study examines 20,680 accepted workers' compensation claims filed by Oregon construction workers over the period of 1990-1997. Injury rate estimates for occupations were calculated using Oregon employment data from the Current Population Survey. The estimated annual rate of lost-time claims was 3.5 per 100 workers annually (95% CI = 2.8 - 4.2) with insulators having the highest rate and supervisors the lowest. The majority of claims, 3,940, were filed by laborers. Over 52% of all claims were filed by workers under 35 years of age, and over half the claimants had less than 1 year of tenure at the time of injury. There were 52 fatalities reported, representing a rate of 8.5 per 100,000 workers (95% CI = 8.1-8.9), of which 32.7% resulted from falls. The most frequently recorded nature of non-fatal injury was listed as a "sprain," and the most common body part injured was the back. The total costs of all claims was $208,537,120, averaging $10,084 per claim, and the average indemnity time per injury was 57.3 days, with female claimants having longer indemnity periods than males. The highest percentage of claims on weekdays occurred on Mondays (21.5%), and subsequent analysis showed the highest odds ratio for time of accident, relative to the first hour on the job, occurred on the third hour of work (OR = 2.456, 95% CI = 2.452-2.460).

Key Words: Construction; Workers' Compensation; Occupational Safety; Fatalities; Injuries; Musculoskeletal Disorders; Surveillance

Introduction

The construction industry is one of the most dangerous industries for workers. For example, the U.S Bureau of Labor Statistics reported that in 2002 the construction industry had the greatest number of occupational fatalities of all major U.S. industries, and the third highest rate following mining and agriculture.[1] Other studies have also estimated the mortality rate associated with construction to be among the highest of all industries.[2-4] Reasons for the higher fatality rate of workers in the construction industry relative to workers in other industries include frequent exposure to toxic agents, dealing with high-voltage industrial wiring and appliances, working on places where serious falls are more likely, and involvement in duties which increase the risk of fatal encounters with motor vehicles.[1,5-14] Investigations have also reported high rates of non-fatal injuries for construction industry workers, including musculoskeletal disorders, hearing damage, burns, eye injuries, and emotional disorders.[15-22]

Occupational safety investigators are interested in whether certain demographic factors of construction workers are associated with increased accident risk. Research has found that female construction workers have a higher overall rate of fatalities than male construction workers, although males have higher fatality rates for some specific tasks or causes like electrocutions. [13,23-24,10] Gender differences in patterns of non-fatal injuries have also been reported.[25] Other studies have found age differences in construction injuries. Some investigations have found that older construction workers have higher rates of both physical and mental problems and all cause mortality than younger construction workers [22, 26-27] A French case-control study found that construction workers under the age of 30 had a greater risk of accidents than those 30 years and older. [28]Age has also been linked to differences in hearing and sleep disorders as well as injury disability periods.[29] In addition, a study on teenage construction workers found higher rates of eye and feet injuries for teenagers than for older workers, while on average injuries of teenage construction workers resulted in less disability time and lower costs than injuries of older workers.[30]

Workers' compensation data has been previously used to study the risk of injury for construction workers. Because in many cases workers' compensation data contains reports on both fatal and non-fatal accidents and information on employee demographics, injury costs, disability length, and worker occupation, it allows for the assessment of multi-dimensional risk factors associated with construction work among large employee populations over time. Studies which have previously used workers' compensation data to study work injuries include studies that the examined musculoskeletal disorders of union carpenters and laborers in the state of Washington, overexertion and bodily reaction events among Oregon construction workers, injuries among homebuilder construction workers as well as the specific segment of teenage workers in North Carolina, assessing non-fatal fall injuries among West Virginia construction workers, and low-back injury claims of construction workers in Virginia.[31-37] Workers' compensation data collected at specific worksites, such as those collected for construction workers at the Denver International Airport, has also been used in construction safety research.[38-40]

This study contributes to the literature on workplace injuries by using administrative workers' compensation claim data from Oregon to examine factors related to the incidence and severity of injuries among workers in the construction industry. Oregon's workers' compensation data is particularly useful for such an analysis because it contains a wealth of information such as claimant demographic, job tenure, shift of work, occupation, indemnity, and cost information. To calculate injury rates and odds ratios this study also uses data from the United States Bureau of Census' Current Population Surveys. Because the Oregon claim data also records information on the time, day and month of injury, these factors were also examined for possible associations with the work-related injuries sustained by construction workers.

Methods

This study used workers' compensation claim data that were provided by the Oregon Department of Consumer and Business Information and Management Division for the period 1990 – 1997. Records were kept for all claims that were disabling or potentially disabling (i.e. those that involved either potential or actual lost work time), although the records were available for some claims that did not actually result in disability. For this study only claims from individuals working in the construction industry (1990 U.S. Census Industry Code 60) were analyzed.

The data set included information on claimant occupation and industry, individual demographics (e.g. age, gender), work schedules, nature of reported injury, body part affected, compensated days of lost work and costs associated with indemnity and injury. Claim costs were tracked through 1999 and the cost data reflect accumulated claim costs through this time. By the end of the observation period 95.6% of all accepted injury claims of construction workers were closed and for these claims the cost data was complete.

Data from the U.S. Bureau of the Census' Current Population Survey (CPS) was used to estimate Oregon employment levels for different demographic categories and time periods. The CPS is a monthly survey of approximately 50,000 households that is used by the United States government to assess, among other things, monthly unemployment rates. The CPS is a rotating survey with households first surveyed for four months, not surveyed for the next eight months, and then surveyed for an additional four months before permanently leaving the survey. Most of our employment estimates are based on the monthly outgoing rotation group (CPS-MORG) files for 1990 through 1997. These files contain data for all individuals participating in their fourth or eighth monthly survey.

For individuals in CPS-MORG, additional questions pertaining to an individual's employment are asked. We restricted the sample to individuals who reported residing in Oregon and being employed in the construction industry at the time of the interview. We further excluded self-employed construction workers since they are not recorded in Oregon's workers' compensation claim reports.

The injury rates for specific categories of construction worker were calculated by dividing the reported number of injuries from construction accidents by the number of employed construction workers for each particular category. Data for the numerator was obtained from the Oregon workers' compensation administrative data while the denominator is estimated using CPS sample data for Oregon construction workers. The construction worker accident injury rates were converted to injuries per 100 construction workers by multiplying the rate by 100. Since estimates were employed in calculating injury rates, 95% confidence interval estimates were derived.

In some cases injury rates are reported in relation to a baseline employment category. Odds ratios were computed by forming a ratio of the injury rate of the particular employment category and the injury rate of the baseline employment category. A ratio greater than one indicates that the particular employment category has a higher injury rate than the baseline category. Since both the numerator and denominator of the ratio were based on estimates 95% confidence intervals, they were calculated using the delta method. Analysis of variance (ANOVA) analysis was performed to investigate cost and lost workdays differences by shift, occupation, nature of injury and cause of injury. Analysis of variance (ANOVA) analysis was also performed to investigate total claim costs differences by shift, month of injury, year of injury, day of week of injury, gender, tenure, wage, occupation, nature of injury, cause of injury and part of body injured. All calculations reported in this paper were made using Stata (release 7) software (Stata Corp., College Station TX).

To estimate the fraction of Oregon workers employed in the construction industry that work at particular times of day and days of week, we used data from the May 1991 and May 1997 CPS Work Schedule Supplement Surveys (CPS-WSS). These surveys contain supplemental questions pertaining to individuals' work schedules in addition to the usual monthly survey questions. Only individuals in these work schedule supplements who reported working in the construction industry were included in the analysis. Since only 42 of the 4836 of these construction workers reported residing in Oregon, in order to increase the precision of our estimates, we used the entire sample of construction workers when estimating shift work, time of day, and day of week employment fractions. Through further analysis, we found no statistically significant differences between Oregon and the rest of the U.S. in the fraction of construction workers 40 years of age and older and the fraction of female construction workers, which lends some support to using the entire sample for deriving estimates.

Results

Oregon employees in the construction industry filed a total of 22,936 workers' compensation claims between 1990-1997, of which 20,680 (90.2%) were accepted and deemed compensable. The average number of accepted claims per year was 2,585, and ranged between a high of 2,835 claims in 1990 and a low of 2,388 in 1992. Using the CPS-MORG data to estimate average annual employment of construction workers in Oregon for the years examined, the average annual rate of accepted injury claims for the 8-year period was estimated to be 3.5 per 100 workers (95% CI = 2.8 – 4.2), with the highest estimated rate found for 1990 of 5.0 claims per 100 (95% CI = 3.9- 6.1) and the lowest rate for 1997 of 2.6 claims per 100 (95% CI = 2.1- 3.1). During this time, 19,780 (96.1%) claims were filed by males and 810 (3.9%) by females. Employment in the construction industry in Oregon between 1990-1997 was 12.2% female.

The majority of claims (52.5%) were filed by workers aged 35 and younger, with workers aged 25 and younger having filed 3,728 (18.0%) of total accepted claims and workers aged 26-35 years old having filed 7,128 (34.5%). Of the remaining claims, construction workers aged 36-45 accounted for 5,953 (28.8%), workers aged 46-55 accounted for 2,785 (13.5%), workers aged 56-65 accounted for 1,019 (4.9%), and workers over 65 years old accounted for 67 (0.3%). In Oregon during the years 1990-1997, 16.7 percent of construction workers were aged 25 and younger, 31.3% were aged 26-35, 30.4% were aged 36-45, 16.1% were aged 46-55, 3.3% were aged 56-65 and 1.3% were over 65 years of age. Thus, injury claims were disproportionately filed by workers aged 35 and younger and by workers aged 56-65.

Among all claims by construction workers, 10,992 (53.2%) of the workers' had less than or equal to 1 year of tenure at the time of injury. Employees having between 1-5 years of tenure also constituted a substantial portion of the total claimant population, having filed 5,028 (24.3%) of claims. For construction workers with 5 or more years of job tenure, those with between 5-10 years of tenure filed 1,409 (6.8%) claims, those with between 10-15 years of tenure filed 525 (2.5%) claims, those with between 15-20 years of tenure filed 282 (1.4%) claims, and those with over 20 years of tenure filed 2,444 (11.8%) claims.

There were 52 fatalities reported during the 8-year period examined, of which 51 were males and 1 was a female. Using the CPS for calculating Oregon construction worker employment estimates, a death rate of 8.5 per 100,000 workers was calculated (95% CI = 8.1-8.9). The highest number of claims 17 (32.7%) cited "fall or jump" as event leading to death, followed by "traffic accident" with 16 (30.8%), "struck, caught or rub" with 12 (23.1%), and in the case of 7 (13.5%) no specific event was recorded. Injuries to multiple body parts and body systems were the most common body part listed as injured among the fatality claims with 25 (48.1%), injuries to the face/head the second most common with 19 (36.5%) claims. Injuries to the chest accounted for 3 (5.8%) of the fatality claims, while injuries to the trunk and to internal organs each accounted for 2 (3.9%) of the claims, and injury to the neck was listed for 1 (1.9%) claim. The ages of claimants in fatal accidents ranged from below 25 to 65 years, with 5 (9.6%) claimants aged 25 years or younger, 20 (38.5%) aged 26-35 years, 12 (23.1%) aged between 36-45 years, 11 (21.2%) aged between 46-55 years and 4 (7.7%) aged between 56-65 years. Half of the fatalities, 26 (50%), occurred among employees with 1 year or less of job tenure. Another

17 (32.7%) were among employees with 1-5 years of time at their job. Of the remaining fatal claimants, 3 (5.8%) each had between 5-10 years and 11-15 years of tenure, 1 (1.9%) had between 16-20 years of tenure, and 2 (3.9%) had more than 20 years of tenure.

Construction worker claims were further analyzed by worker occupation. Laborers filed 3,940 (19.1%) claims, carpenters filed 3,897 (18.8%) claims, electricians filed 1,150 (5.6%) claims and plumbers filed 1,001 (4.8%) claims. For 4,810 (23.3%) claims, claimant occupation was not reported. The CPS-MORG was used to derive employment levels in each occupation for Oregon, which were subsequently used to estimate the rate of claims by occupation. Insulation workers were found to have the highest claim rate among all occupations at 8.3 per 100 workers (95% CI = 0.7 – 15.9) and supervisors the lowest rate at 1.4 per 100 workers (95% CI = 1.0 - 1.8). Claims rate estimates for all occupations in the construction industry with their corresponding 95% confidence intervals are presented in Table 1.

The total cost of all construction worker claims for the year 1990-1997 was $208,537,120, with a mean annual cost of $26,067,140. The average amount of compensated lost work days by injured construction workers was 57.3 days, and the average associated per claim cost was $10,084, of which $3,690 was for temporary total disability (TTD) payments, $4,057 was for medical costs, $1,994 was for permanent partial disability (PPD) payments, and $342 was for vocational rehabilitation costs. Female claimants lost an average of 68.1 days per injury as compared to an average of 56.8 days by male claimants, although the average total amount paid on claims were approximately equal at $10,142 and $10,082 for females and males respectively. Workers aged 25 years and younger lost the least amount of days of work when injured, averaging 37.8 days per injury claim, while employees aged between 46-55 lost the most days of work, averaging 70.0 days per claim.

Employees with less than or equal to 1 year of tenure on the job at the time of the injury lost the most days of work averaging 62.5 days, while those with between 15-20 years of tenure lost time least days of work averaging 40.7 days. Nevertheless, the latter group incurred the highest average cost per claim at $13,105. Workers with between 1 and 5 years of tenure at the time of the injury had the lowest average cost per claim at $9,760.

We examined whether average lost work days and costs were associated with specific construction occupations. It was found that injuries sustained by drywall installers resulted in the most lost work days, averaging 78.7 days per claim, while those classified in construction trades n.e.c. and electricians had the least lost work days with 46.5 and 48.1 average days, respectively. The most expensive claims were filed by structural metal workers with an average total claim amount of $16,472, while the least expensive were file by heating, air conditioning, and refrigeration mechanics with an average claim amount of $7,820. The most expensive costs associated with medical treatment received for injuries were filed by structural metal workers and averaged $8,283 per claim, while the least expensive were made by insulation workers and averaged $2,923 per claim. Average total cost and lost work days information for construction worker occupations are provided in Table 2.

A multivariate ANOVA analysis was conducted on total costs and revealed that total costs was significantly impacted by the part of body injured, nature of injury experienced, age of worker, amount of job tenure, weekly wage, year of injury and the event causing injury. However, the effects of gender, job shift, day of week, and month of injury were not statistically significant at the 5% significance level.

The most frequently recorded nature of injury was “sprain” with 9,602 (43.4%), and was cited as most often occurring among laborers, followed by 2,502 claims of fractures in which construction occupations listed as “other” and carpenters each accounted for over 500 claims. The least frequent nature of disabling injury reported was “stress” with 12 (0.06%) claims as cited by a variety of construction worker occupations. In the case of 145 claims (0.7%) the nature of injury was unreported. A tabulation of injury claims by nature of disabling injury and construction worker occupation is presented in Table 3.

The most commonly reported body part injured was the back which constituted 5,362 (25.9%) of all claims. The next most frequent body part was hands with 2,539 (12.3%) claims, knees with 2,032 (9.83%), multiple body parts and body systems with 1,873 (9.1%). Claims reporting injuries to multiple body parts and body systems had the highest average days of lost work, 92.6 days, while claims reporting an injury to both the eyes and ears had the lowest average days of lost work, 14.4 days. The frequency distribution for body parts injured is presented in Figure 1, while the frequency distribution of average lost work days by body part injured is displayed in Figure 2.

The timing of injury was examined with respect to shift, day of week and month of year. In doing so, it was found that most injuries filed by construction workers were by those on the day shift and represented 20,002 (96.7%) of all claims. In contrast, evening shift workers constituted 495 (2.4%) claims and night shift workers 183 (0.9%) claims. However, data from the CPS-WSS show that 96.7%, 2.7%, and 0.6% of construction workers report working the day, evening and night shift, respectively. Thus, there was no apparent relation between shift of work and injury rate.

The highest percentage of claims by weekday occurred on Mondays (21.5%), and declined steadily through Friday (17.0%), and the number of accidents reported on the weekends dropped substantially with those occurring on Saturdays and Sundays comprising a combined total of 5.3% of the claims. Using the CPS-WSS to calculate the relative fraction of construction employment by day of the week, the estimated odds ratio of a Monday injury relative to Tuesday was 1.099 (95% CI 1.095-1.103). The estimated odds ratio of Wednesday, Thursday and Friday injuries relative to Tuesday, on the other hand, were all significantly less than 1. The estimated odds ratios of Saturday and Sunday injuries relative to Tuesday was 1.376 and 3.129, respectively, with both being significantly greater than 1.

Injury rates varied from a high of 0.47 injuries per 100 workers in July (95% CI 0.33-0.61) to a low of 0.24 injuries per 100 workers in March (95% CI 0.19-0.29). Accidents leading to injury were also examined by hours since work began. It was found that the highest number of accidents occurred during the third hour on the job, with 2,342 (14.2%) claims made for this period. Using data from the CPS-WSS to adjust for differences in the number of hours worked, odds ratios of accidents by hour of work relative to the first hour of work and their corresponding confidence intervals were calculated and are shown in Table 4.

Discussion:

This study analyzed 20,680 accepted workers' compensation injury claims filed by Oregon workers in the construction industry during the years 1990-1997. Using the CPS data to determine construction industry employment populations in Oregon, we estimate that construction industry workers file 3.5 claims per 100 employees annually, hence buttressing the serious concerns over safety expressed by past occupational researchers regarding construction work. In comparison to a rate estimate of over 9 non-fatal workplace injury and illnesses per 100 construction workers reported by the BLS for 1997, [41] our claim rate estimate appears significantly lower. However, because Oregon provides workers' compensation only for injuries in which 3 or more days of indemnification are required, while the BLS rate estimate includes minor injuries in where little or no lost work time occurred, our rate is understandably less, and is closer to the rate of 4.9 per 100 full-time worker lost work time days estimated by the BLS in 1995. [42] Our estimated fatality rate of 8.5 per 100,000 workers was also lower than those reported by previous works estimating on-the-job construction mortality rates [1,3], but not remarkably so, and still demonstrates a rate of over double that of the average for all U.S. occupations.

It should also be noted that within the construction injury literature, researchers calculate injury rates differently. While some researchers use employee population to calculate risk others instead use full time equivalents (FTE) to approximate on-the-job exposure. [32-33,35] While both are valuable methods for providing a measure of injury risk, comparing the findings across studies becomes difficult. Additionally, in the past, some criticism has been expressed that using the CPS to develop a baseline for the purpose of establishing employment rates for construction workers leads to an underestimation bias, as the CPS generally includes all workers while many in the construction industry are self-employed and thus not covered by workers' compensation. However, this study adjusted for the number of self-employed individuals by not including them in the denominator in our injury rate calculations.

In our opinion, the results showing that over half of all the workers injured had 1 year of job tenure or less, and over 75% had less than 5 years of job tenure, suggests that previous experience may be a very substantial factor influencing injuries in construction. This hypothesis is consistent with previous reporting of disproportionate injuries among young and low company-specific tenured employees in West Virginia.[36] The finding that workers under 25, while filing the second highest number of claims required the least amount of indemnity for their injuries, supports the hypothesis advanced by investigators that the injuries of younger workers may be less serious than other workers possibly due to less exposure to extreme hazards when beginning in construction work.[30] Furthermore, the higher overall accident rate among construction workers under the age of 35 may be indicative of higher attitudes of safety and adoption of stricter adherence to safety protocols with increased job experience as hypothesized in prior literature examining these attitudes and behaviors.[44] While further research is warranted, the results strongly point to the need for increased training interventions and more intensive supervision of new employees at construction sites as a means of decreasing serious workplace injury and bolstering attitudes of engaging in safe work practices.

The tenure proportions for fatalities was quite similar to those of non-fatal injuries with half occurring to workers with under 1 year of tenure and over 80% were those with

5 year less of job experience. The events which led to employee deaths were reported as caused by “fall or jump,” “motor vehicles,” or “struck, caught or rub” and relatively consistent with some of the leading causes of construction worker fatalities reported in previous investigations. [9,35] However, no electrocutions were reported for the 8-year period which is surprising considering past data on the relative prevalence of this as a fatal event among construction workers,[9-10] although it is possible that some electrocutions were among those where specific event went unreported in the data.

Our analysis also revealed that laborers had the highest number of injury claims, followed by carpenters, which is similar to other investigations finding that both groups had significantly high rates of on-the-job injury within construction trades.[38-39,43,33] When examined by rate using employment data from the CPS, it was found that insulation workers had the highest rate among the construction worker claimants, which is fairly consistent with previous findings that insulators tend to be among the highest occupational groups experiencing falls during the course of their work, as well as being at high risk of being struck by objects during the course of their job duties.[35] However, we would caveat this particular finding with the fact that very few CPS observations were taken on insulators, which is evident in the large confidence interval of the estimate, and thus would leave it to future research to determine if workers in this particular construction trade are at significantly higher risk relative to workers in other construction trades; because of the high number of injuries occurring among many various work occupations within the construction industry, it is also likely that there will inherently be a great deal of variability between studies with respect to conclusively identifying a specific occupation as the “riskiest” among all trades.

The cost of workers' compensation expenses alone cost the state of Oregon over $200 million dollars over the 8-year period examined. This amount does not include other expenses associated with the employee injuries that go unrecorded in the state data, such as decreased work productivity and accommodation costs. Thus the overall monetary burden from construction work injury is understated by the data in this report. Measures of TTD disability benefits indicate that injuries sustained by drywall installers and structural metal workers were among the most serious, with the average claim amount of structural metal workers also being the highest among all construction worker occupations. It may be beneficial for future research endeavors to focus specifically on the specific functions of these construction jobs to identify particular risks and develop specific interventions to address the unique hazards that make these occupations particularly dangerous.

In our opinion, the finding of the highest odds ratios for the third and fourth hours of work relative to the first hour, and being higher than any other hours, is also an important finding. While from the data itself there is no specific causal link that can definitively explain the reason behind this increased risk, we feel this may be due to a lack of warm-up period, whereby employees may be more stiff and less attentive toward the beginning of their work periods. Supporting this hypothesis, we note that while the other hours have higher relative risks compared to the first hour, they are less, in spite of fatigue effects which could be expected to occur as the workday progresses (with the exception of lunch break, where we do find a drop in relative injury rate compared to all but the first hour of work). For example, studies have shown that health promotion, exercise, flexibility interventions, and regular stretching can be particularly valuable in overall risk reduction, preventing musculoskeletal injury, improving cognitive functioning, and even reduce falls by older employees by enhancing and maintaining coordination. [45-50] Additionally, we believe that the finding that Mondays have the highest rate of injury of all weekdays, further support our contention that the lack of a warm-up period may contribute to higher accident risk. Because of different scheduling patterns typically used on weekends, we find it more difficult to apply our theory as an explanation for the higher relative risks found for those two days. Nevertheless, we feel this discovery important enough to warrant future assessment, and perhaps the regular inclusion of warm-up periods by construction employees as an important preventative injury intervention prior to beginning their daily routines.

There are several limitations to this study. First, while we were able to adjust our injury rate estimate by excluding that portion of the CPS which includes self-employed individuals, the actual number of injuries experienced by construction workers throughout the state for the period examined may be underestimated because in some cases specific worksite records may not be aggregated in state or national data bases.[40] Moreover, minor medical injuries, in which less than three days of indemnity were not taken are not included in the Oregon records. Second, some injuries and fatalities due to long-term exposure to chemicals and toxic substances/inhalants that have been reported and measured by other studies employing specific methodologies, are not typically recorded in workers compensation data because of the difficulty of establishing a causal relationship to work to satisfy administrative requirements, and hence, such injuries are also underestimated. Last, the full costs associated with claims are also likely to be understated as measures such as lost productivity are not recorded by the state or readily estimated by the data used in this study. Nevertheless, areas of future research have been articulated within this work that should be addressed in future investigations, particularly with respect to assessing age and tenure effects, occupations in need of particular safety precautions, and the development and integration of interventions that should be applied prior to the start of new working shifts.

References:

1. United States Department of Labor, Bureau of Labor Statistics, USDL-03-488, National Census of Fatal Occupational Injuries in 2002. Washington, D.C. September 17, 2003.

2. Tuscano G., Windau J. The changing character of fatal work injuries: Fatal workplace injuries in 1993: A collection of data and analysis. U.S. Department of Labor, Bureau of Labor Statistics. Washington D.C. 1995.

3. Wang E, Dement JM, Lipscomb H. Mortality among North Carolina construction workers, 1988-1994. Appl Occup Environ Hygiene,1999;14(1):45-58.

4. Dong W, Vaughhan P, Sullivan K, Fletcher T. Mortality study of construction workers in the UK. Int J Epidemiol, 1995;24:750-757.

5. Dorevich S, Forst L, Conroy L, Levy P. Toxic inhalation fatalities of U.S Construction workers, 1990-1999. J Occup Environ Med, 2002;44 (7):657-662.

6. Woskie SR, Kalil A, Bello D, Virji MA. Exposures to quartz, diesel, dust, and welding fumes during heavy and highway construction. AIHA J;2002;63(4)447-57.

7. Bakke B, Stewart P, Eduard W. Determinants of dust exposure in tunnel construction work. Appl Occup Environ Hygiene 2002;17(11):783-796

8. Triebig G, Nasterlack M, Hacke W, Frank KH, Schmitter H. Neuropsychiatric symptoms in active construction painters with chronic solvent exposure. Neurotoxicology, 2000;21(5):791-794.

9. Chen GX, Johnston JJ, Alterman T, Burnett C, Steenland K, Stern F, Halperin W. Expanded analysis of injury mortality among unionized construction workers. Am J Ind Med 2000;37:364-373.

10. Ore T, Casini V. Electrical fatalities among U.S. construction workers. J Occup Environ Med, 1996;38(6):587-592.

11. McCann M, Hunting KL, Murawski J, Chowdhury R, Welch L. Causes of electrical deaths and injuries among construction workers. Am J Ind Med, 2003;43(4)398-406.

12. Cattledge GH, Hendricks S, Stancvich R. Fatal occupational falls in the U.S. construction industry, 1980-1989. Accid Anal Prev, 1996;28(5):647-654.

13. Kines P. Construction workers' falls through roofs: fatal versus serious injuries. J Safety Research, 2002; 33(2)195-208.

14. Ore T, Fosbroke DE. Motor vehicle fatalities in the United States construction industry. Accid Anal Prev, 1997;29(5):613-626.

15. Schneider SP. Musculoskeletal injuries in construction: a review of the literature. Appl Occup Environ Hygiene 2001;16(11):1056-1064.

16. Holmstrom E, Moritz U, Engholm G. Musculoskeletal disorders in construction workers. Occup Med: State of the Art Reviews, 1995:10(2):295-312.

17. Latza U, Karmaus W, Sturmer M, Neth A, Rehder U. Cohort study of occupational risk factors of low back pain in construction workers. Occup Environ Med, 2000;57(1):28-34.

18. Strumer T, Luessenhoop S, Neth A, Soyka M, Karmaus W, Toussaint R, Liebs TR, Rehder U. Construction work and low back disorder. Preliminary findings of the Hamburg Construction Worker Study. Spine, 1997;22(21):2558-2563.

19. Hessel PA. Hearing loss among construction workers in Edmonton, Alberta, Canada. J Occup Environ Med, 2000; 42(1):57-63.

20. Zwerling C, Miller ER, Lynch CF, Torner J. Injuries among construction workers in rural Iowa: emergency department surveillance. J Occup Environ Med, 1996;38(7):698-704.

21. Welsh LS, Hunting KL, Mawudeku A. Injury surveillance in construction: eye injuries. Appl Occup Environ Hygiene, 2001; 16(7):755-762.

22. Peterson JS, Zwerling, C. Comparison of health outcomes among older construction and blue-collar employees in the United States. Am J Ind Med, 1998;34(3):280-287.

23. Ore T. Women in the U.S. construction industry: an analysis of fatal occupational injury experience, 1980-1992. Am J Ind Med, 1998;33(3):256-262.

24. Ore T, Stout NA. Risk differences in fatal occupational injuries among construction laborers in the United States, 1980-1992. J Occup Environ Med, 1997;39(9):832-843.

25. Welsh LS, Goldenhar LM, Hunting KL. Women in construction: occupational health and working conditions. J Am Med Womans Assn, 2000; 55(2):89-92.

26. de Zwart BC, Frings-Dresen MH, van Duivenbooden JC. Senior workers in the Dutch construction industry: a search for age-related work and health issues. Experimental Aging Research, 1999;25(4):385-391.

27. Arndt V, Rothenbacher D, Brenner H, Fraisse E, Zschenderlein B, Daniel U, Schuberth S, Fliedner TM. Older workers in the construction industry: results of a routine health examination and a five year follow up. Occup Environ Med, 1996;53(10): 686-691.

28. Chau N, Mur JM, Benamghar L, Siegfried C, Dangelzer JL, Francais M, Jacquin R, Sourdot A. Relationships between some individual characteristics and occupational accidents in the construction industry: a case control study on 880 victims of accidents occurred during a two-year period. J Occup Health, 2002;44:131-139.

29. Chau N, Gauchard GC, Siegfried C, Benamghar L, Dangelzer JL, Francais M, Jacquin R, Sourdot A, Perrin PP, Mur JM. Relationships of job, age, and life conditions

with the causes and severity of occupational injuries in construction workers. Int Arch Occup Environ Health, 2003**.**

30. Lipscomb LJ, Li L. Injuries among teens employed in the homebuilding industry in North Carolina. Injury Prevention, 2001;7(3):205-209.

31. Culver, C, Marshall M, Connolly C. Construction accidents—The workers' compensation data base 1985-1988. U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), Cincinnati, OH, 1992.

32. Washington State Department of Labor and Industries: Work-related musculoskeletal disorders, Washington State summary 1992-1994. Washington Department of Labor and Industries, Olympia, WA 1996.

33. Lipscomb HJ, Dement JM, Loomis DP, Silverstein B, Kalat J. Surveillance of work-related musculoskeletal injuries among union carpenters. Am J. Ind Med 1997;32:629-640.

34. The Center to Protect Workers' Rights: Analysis of workers' compensation data from members of the Laborers' Union in Washington State 1990-1991. Center to Protect Workers' Rights, Washington D.C. 1995.

35. Dement JM, Lipscomb H. Workers' compensation experience of North Carolina residential construction workers, 1986-1994. Appl Occup Environ Hygiene, 1999;14:97-106.

36. Cattledge GH, Schneiderman A, Stanevich R, Hendricks S, Greenwood J. Nonfatal occupational fall injuries in the West Virginia construction industry. Accid Anal Prev, 1996;28(5):655-663.

37. Enders LJ, Walker WC. Work-related low back injuries: an analysis of workers' compensation claims in Virginia. Arch Phys Med Rehabil, 2003;84(9):E16.

38. Lowery JT, Glazner J, Borgerding JA, Bondy J, Lezotte DC, Kreiss K. Analysis of construction injury burden by type of work. Am J Ind Med, 2000;37:390-399.

39. Lowery JT, Borgerding J, Glazner J, Bondy J, Zhen B, Kreiss K. Risk factors for injury among construction workers at Denver International Airport. Am J Ind Med, 1998;34:113-120.

40. Glazner JE, Borgerding JA, Lowery JT, Bondy J, Mueller KL, Kreiss K. Construction injury rates may exceed national estimates: evidence from the construction of Denver International Airport. Am J Ind Med, 1998;34:105-112.

41. United States Department of Labor, Bureau of Labor Statistics: Workplace Injuries and Illnesses in 2001, USDL 02-687, Washington DC (2002).

42. United States Department of Labor, Bureau of Labor Statistics: Workplace Injuries and Illnesses in 1993, USDL Pub No. USDL-95-142, Washington, DC (April 26, 1995).

43. Welch LS, Hunting KL, Anderson JT. Injury surveillance in construction: injuries to laborers. J Occup Environ Med ,2000;42(9):898-905.

44. Siu O, Phillips DR, Leung T. Age differences in safety attitudes and safety performance in Hong Kong construction workers. J Safety Research 2002;34:199-205.

45. Johnson KA, Ruppe J. A job safety program for construction workers designed to reduce the potential for occupational injury using tool box training sessions and computer-assisted biofeedback stress management techniques. International J Occup Safety Ergonomics 2002;8(3):321-329.

46. Musich S, McDonald T, Hirschland D, Edington DW. Examination of risk status transitions among active employees in a comprehensive worksite health promotion program. J Occup Environ Med 2003;45(4):393-399.

47. Karas BE, Conrad KM. back injury prevention in the workplace: an integrative review. AAOHN J 1996;44(4):189-196.

48. Amako M., Oda T, Masuoka K, Yokoi H, Campisi P. Effect of static stretching on prevention of injuries for military recruits. Military Med 2003;168(6):442-446.

49. Brisswalter J, Collardeau M, Rene A. Effects of acute physical exercise characteristics on cognitive performance. Sports Med 2002;32(9):555-566.

50. Carter ND, Kannus P, Khan KM. Exercise in the prevention of falls in older people: a systematic literature review examining the rationale and the evidence. Sports Med 2001;31(6):427-438.

Table 1:

Estimated Claim Rate by Construction Industry Occupation

Occupation	Estimated Claim Rate per 100 Workers	95% C.I.
Carpenters	4.6	3.8 – 5.4
Drywall Installers	7.0	2.4 – 11.6
Electricians	3.2	2.2 – 4.2
Painters	2.3	1.4 – 3.2
Roofers	6.4	2.9 – 9.9
Plumbers	3.1	2.1 - 4.1
Laborers	5.6	4.5 – 6.7
Truck Drivers	3.3	2.0 – 4.6
Construction Trades n.e.c.	5.2	2.9 – 7.5
Heating/Air/Refrig Mech.	2.8	1.6 – 4.0
Welders and Cutters	3.4	1.3 – 5.5
Concrete/Terrazzo Finishers	6.3	1.1 – 11.5
Structural Metal Workers	8.3	0.7 – 15.9
Supervisors Construction	1.4	1.0 – 1.8
Other	2.1	1.9 – 2.3

Table 2:

Average Indemnity and Costs for Construction Workers by Occupation

Occupation	TTD (Days)	TTD Cost	Medical Cost	PPD Cost	Voc. Rehab. Cost	Total Cost
Carpenters	58.3	$3,770.27	$3,592.29	$2,050.87	$378.92	$9,792.35
Drywall Installers	78.7	$5,107.78	$3,595.22	$1,916.76	$788.53	$11,408.29
Electricians	48.1	$3,712.75	$4,720.17	$1,798.16	$173.66	$10,404.74
Painters	63.4	$3,597.41	$4,441.92	$2,182.57	$561.52	$10,783.42
Roofers	60.1	$3,164.31	$3,930.81	$2,151.59	$331.84	$9,578.55
Plumbers	53.5	$4,155.68	$3,814.81	$2,021.84	$378.29	$10,370.62
Laborers	60.8	$3,672.55	$3,847.50	$1,947.25	$308.78	$9,776.08
Truck Drivers	61.3	$3,772.46	$4,134.17	$2,265.19	$322.42	$10,494.25
Construction Trades n.e.c.	46.5	$2,949.69	$3,322.55	$1,849.54	$234.09	$8,355.88
Heating/Air/Refrig Mech.	49.8	$2,858.35	$3,304.20	$1,357.59	$300.03	$7,820.17
Welders and Cutters	57.1	$3,778.60	$3,377.60	$1,636.52	$309.49	$9,101.65
Concrete/Terrazzo Finishers	52.5	$3,619.20	$3,389.93	$1,449.71	$372.05	$8,830.90
Insulation Workers	57.1	$3,437.92	$2,922.57	$1,713.96	$405.73	$8,480.18
Structural Metal Workers	72.1	$5,621.99	$8,282.72	$2,002.79	$563.17	$16,471.68
Supervisors Construction	62.4	$4,622.13	$5,551.22	$3,185.30	$548.15	$13,906.80
Sheet Metal Duct Installers	67.6	$4,472.57	$4,647.51	$2,107.95	$470.39	$11,698.42
Other	53.5	$3,422.24	$4,407.75	$1,987.31	$276.83	$10,094.13

Table 3:

Nature of Injury by Construction Worker Occupation: Number of Claims

	Dislocation	Fracture	Sprain	Bruise	Carpal Tunnel	Stress	Hearing Loss	Multiple Trauma	Cuts & Lacerations	Rheumatism	Hernia	Burns	Other	Unknown	**Total**
Carpenter	124	525	1,663	252	74	0	3	114	574	67	79	12	379	31	**3,897**
Drywall Installer	21	58	278	37	14	0	1	16	37	12	10	3	44	2	**533**
Electrician	51	126	522	49	47	0	4	30	111	22	38	31	112	7	**1,150**
Painters	23	72	229	27	14	0	1	14	33	13	12	7	66	3	**514**
Roofers	21	97	314	35	7	0	0	15	70	7	16	47	67	3	**699**
Plumbers	51	98	509	58	24	1	2	16	58	18	42	17	100	7	**1,001**
Laborers	110	467	1,841	296	86	2	3	101	383	50	94	61	429	17	**3,940**
Truck Drivers	26	84	334	29	4	0	0	31	37	4	12	6	56	2	**625**
Construction n.e.c.	38	91	453	62	19	1	3	20	55	10	17	11	87	9	**876**
Heat/Air/Refrig Mech.	17	53	262	22	16	0	0	9	73	9	13	12	53	0	**539**
Welders & Cutters	13	43	103	21	14	0	1	7	23	1	13	13	34	2	**288**
Concrete & Terrazzo	15	23	161	13	12	0	0	5	18	7	8	8	30	3	**303**
Insulation Workers	13	28	191	31	6	0	0	9	40	2	7	2	32	9	**370**
Struct Metal Workers	11	48	163	16	5	0	0	13	23	8	5	3	32	3	**330**
Supervisors	38	91	255	32	11	0	0	23	32	11	12	12	56	4	**577**
Sheet Metal Installers	10	27	104	11	3	0	0	6	41	2	2	1	19	2	**228**
Other	212	571	2,220	291	117	8	8	129	429	93	153	65	473	41	**4,810**
Total	**794**	**2,502**	**9,602**	**1,282**	**473**	**12**	**26**	**558**	**2,037**	**336**	**533**	**311**	**2,069**	**145**	**20,680**

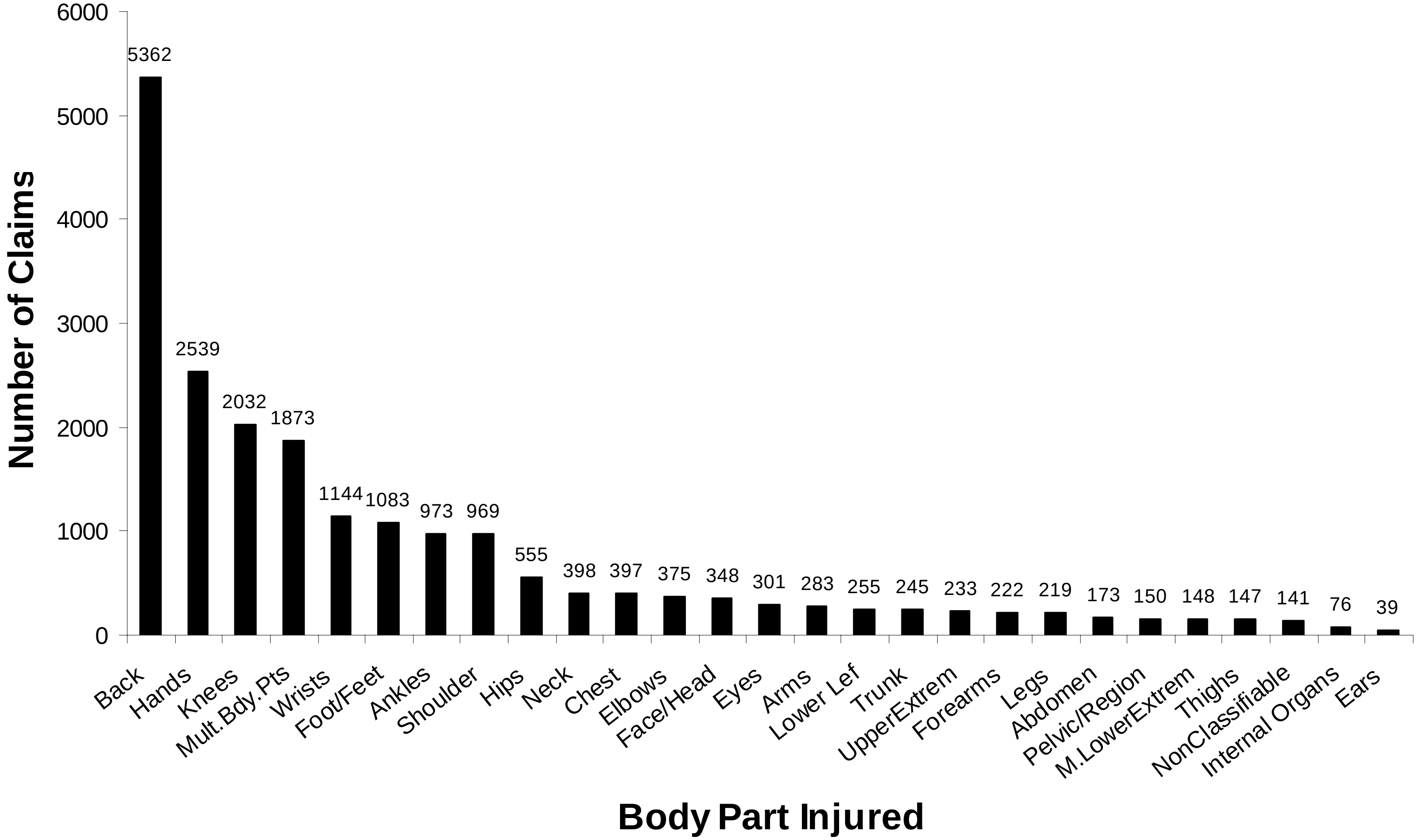
Table 4

Odds Ratios of Construction Worker Accidents by Hour Worked

Hour of Work	Odds Ratio	95% CI
1	1.000	---
2	1.862	1.860 - 1.864
3	2.456	2.452 – 2.460
4	2.392	2.386 – 2.398
5	1.830	1.824 – 1.836
6	1.195	1.189 – 1.201
7	1.864	1.854 – 1.874
8	2.028	2.003 – 2.053
9	1.934	1.909 - 1.959
10	1.551	1.535 – 1.567
11	1.309	1.299 – 1.319
12	0.861	0.855 – 0.867

Figure 1

Number of Claims by Body Part Injured



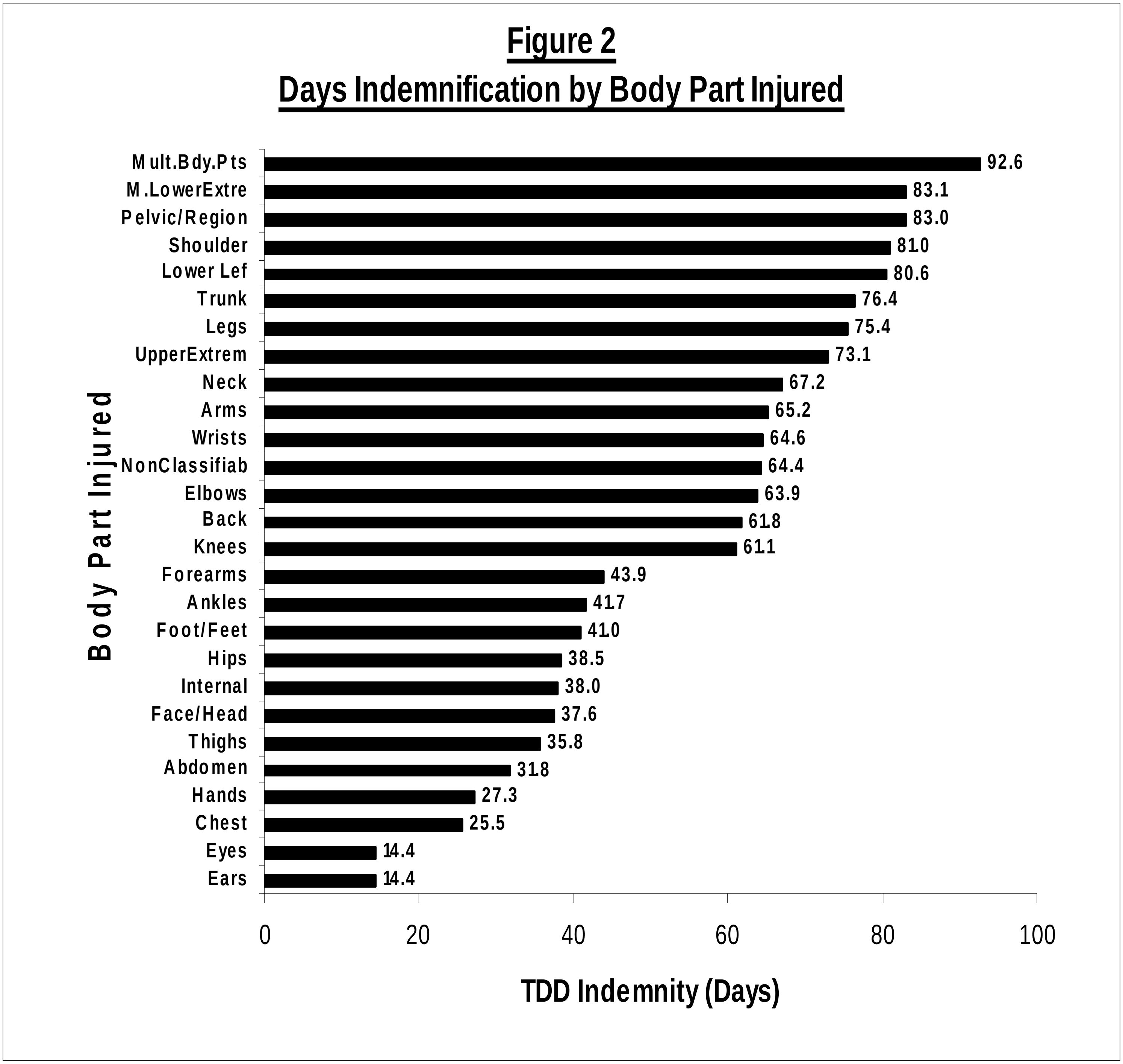


Figure 2
Days Indemnification by Body Part Injured
Mult.Bdy.Pts 92.6
M.LowerExtre 83.1
Pelvic/Region 83.0
Shoulder 81.0
Lower Lef 80.6
Trunk 76.4
Legs 75.4
UpperExtrem 73.1
Neck 67.2
Arms 65.2
Wrists 64.6
NonClassifiab 64.4
Elbows 63.9
Back 61.8
Knees 61.1
Forearms 43.9
Ankles 41.7
Foot/Feet 41.0
Hips 38.5
Internal 38.0
Face/Head 37.6
Thighs 35.8
Abdomen 31.8
Hands 27.3
Chest 25.5
Eyes 14.4
Ears 14.4
Body Part Injured
0
20
40
60
80
100
TDD Indemnity (Days)