EPIDEMIOLOGY OF OCCUPATIONAL INJURIES IN A LARGE MANUFACTURING EMPLOYER, 2002-2006

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Eileen Nosko Lukes

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As members of the Dissertation Committee, we certify that we have read the dissertation prepared by Eileen Nosko Lukes
entitled Epidemiology of Occupational Injuries in a Large Manufacturing Employer, 2002-2006
and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy

_______________________________ Date: 7/28/08
Mary Kay O'Rourke

_______________________________ Date: 7/28/08
Jeff Burgess

_______________________________ Date: 7/28/08
Denise Roe

_______________________________ Date: 7/28/08
Jane Mohler

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College. I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

_______________________________ Date: 7/28/08
Dissertation Director: Mary Kay O'Rourke

STATEMENT BY AUTHOR

Signed: Eileen Nosko Lukes

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DEDICATION

This dissertation is dedicated to my parents, who insisted that I go to college even when I didn’t see the value in it. I am forever grateful.

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ABSTRACT

Approximately 4.2 million workers were injured in the United States in 2005, costing employers over $171 billion, a figure under-estimating the true cost. This retrospective descriptive occupational injury study analyzed existing health and safety data from 2002 through 2006 at a large US manufacturing employer. All work-related injuries from six geographic locations were included in the study. A total of 36,611 injuries involving 20,738 employees were analyzed using descriptive statistics to characterize the injuries, and general estimating equations (GEE) and multivariate logistic regression analyses to identify risk factors affecting the severity of occupational injuries.

Nearly two-thirds of injuries reported were recorded on the OSHA log. Forty percent of occupational injuries resulted in restricted days, and 21% resulted in lost days. Three-quarters of the occupational injuries occurred among Production and Maintenance employees. Various injury characteristics and personal/work characteristics influenced recordability of occupational injury, restricted activity and lost days following occupational injury. Repetitive motion and over-exertion injuries were most commonly associated with recordable injuries and injuries with restricted or lost days. Employees with injuries due to repetitive motion in shop operations were more than twice as likely to experience lost days following injury as workers with most other types of injuries. Men were six times as likely to sustain a repetitive motion injury in shop operations. Union affiliation increased the likelihood of having an injury being recorded on the OSHA log or incurring restricted or lost days; however, significant interaction terms that included

union status and other variables, suggest that the results should be viewed cautiously. Production & Maintenance workers were at greatest risk for incurring multiple injuries.

Results of this study can be used to enhance prevention programs already in place in this company. Targeting future repetitive motion and over-exertion injuries and ensuring proper treatment and prevention interventions may reduce the severity and recurrence of injuries.

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Introduction

Approximately 4.2 million non-fatal work-related injuries occurred in the United States in 2005 (USDL 06-1816, 2006), in spite of numerous policies to limit them. Congress passed the Occupational Safety and Health Act in 1970, creating the Occupational Health and Safety Administration (OSHA) and the National Institute of Occupational Safety and Health (NIOSH) to protect worker safety. NIOSH, situated in the Department of Health and Human Services, has responsibility for recommending health and safety standards in the work place and for educating health and safety professionals. NIOSH determines research priorities and funds occupational health and safety research. OSHA, a part of the Department of Labor, is responsible for establishing and enforcing workplace health and safety standards (US DHHS, 1981; Rogers, 1994).

OSHA requires employers in certain industries with at least 15 employees, to keep records of occupational injuries and illnesses (29 CFR 1904). This is referred to as the OSHA 300 Log, or OSHA Log. OSHA defines a work-related injury and specifies injury documentation. Although the government requires employers to track injuries, not all employers must submit injury reports to the government. Instead, the Bureau of Labor Statistics (BLS, another branch of the Department of Labor) uses a probability sample to estimate occupational injuries and illnesses for the entire working population (USDL 06-1816, 2006; USDL 06-1982, 2006).

BLS divides private-sector employers into two broad categories: those producing goods and those providing services. Within the product sector are: agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing. Twenty-one types of manufacturing are included in this category, with the largest (in number of employees) being transportation and equipment manufacturing (USDL 06-1816, 2006).

One of the largest companies in the transportation and equipment-manufacturing sector was selected as the focus of this research study because of its size and progressive health and safety program. With approximately 150,000 employees around the world, this large company employs about 20% of the US workforce in the aerospace and defense industry (Aerospace Industries Association, 2006). It is the third largest transportation and equipment manufacturing company on Fortune's 500 list (2006), following General Motors and Ford.

Purpose

Although BLS provides incidence rates and numbers of occupational injuries and illnesses by selected industries every year, no comprehensive epidemiological analysis of a transportation and equipment manufacturing (or aerospace and defense) company was found in the literature. This study provides an epidemiological analysis of occupational injuries and illnesses at a large manufacturing company during a five-year period, 2002-2006. The analysis identified factors associated with injury severity. The specific aims of the study were to describe occupational injuries among employees in a large manufacturing firm over a five-year period; identify influential factors that impact occupational injury severity in a large manufacturing company; and determine whether variables identified in the literature, by company safety professionals, and by my professional experience play a significant role in injury severity in a US manufacturing environment. In addition to identifying factors associated with injuries, the study identified characteristics of employees and the workplace associated with multiple injuries, factors associated with common types of injury, and factors associated with selected job titles.

Occupational injury and illness defined

For this study, injury is defined as bodily damage that results from an unforeseen or unplanned incident or series of incidents in the work place. Cumulative trauma is technically considered an illness, not an injury, because repeated incidents over time, rather than a single event, result in damage to a body part (29 CFR 1910, OSHA Ergonomics Program). For this study injuries and illnesses are treated as injuries, with no attempt to differentiate the two conditions.

OSHA considers the severity of a work-related injury or illness along a continuum (Table 1). Not all injuries occurring at work are considered work-related. For instance, people who work at a movie theater might be at the theater on their day off, as a member of the public, when they slip and fall. Or workers may eat lunch at work and become ill because they improperly stored the lunch they brought from home. Workers may trip and hurt themselves during a company open house accompanied by their family. These are examples of incidents that are unrelated to work. OSHA also defines when an employee is "at work" when on business travel. Other types of injuries or illnesses occur at work during work, but are classified as "first aid" by OSHA and are not recordable on the

OSHA 300 log, the official recording document required by OSHA. OSHA defines 14 situations that would specify an injury as first aid, and anything outside of that list is considered to be medical treatment (US DOL, 29 CFR 1904).

Table 1.1. OSHA recordability continuum.

Severity ↓	Not work related	Not recordable
	Work related, first aid only	Not recordable
	Work related, medical treatment	Recordable
	Work related, restricted days or job transfer	Recordable
	Work related, lost days	Recordable
	Work related, fatality	Recordable

The least severe, recordable incident is an injury or illness requiring medical attention (beyond first aid) (29 CFR 1904). The type of care defines the severity, rather than the licensure or academic credentials of the care provider. If a prescription medication is prescribed, the injury is recordable (with the exception of a tetanus booster). If a fracture occurs, even without treatment, the case is recordable (as may be the case of a fractured little toe). If ongoing treatment (e.g., physical therapy) is required, the case is recordable. Any use of sutures to close wounds, and wraps or splints meant to immobilize joints, would make an injury recordable. Each incident is recorded once, regardless of the number of body parts, surgeries, treatments, or the time involved (29 CFR 1904).

“Cases with job transfer or restriction” involve employees unable to perform any aspect of their essential job functions because of the injury, beyond the date of the injury. These cases include the number of days of restriction, beginning with the day following the injury (29 CFR 1904). The next most severe category would be injuries with days away from work. This category requires the employer to indicate how many days the employee was absent from work due to the injury or illness. The most severe level of work-related injury is a fatality, which must also be documented on the OSHA 300 log.

OSHA (29 CFR 1904) requires the employer to mark the most severe category on the OSHA log. If an injury was initially recorded as one that required restricted days, but later the employee required surgery and days away from work, the OSHA log would be revised/updated at the time that the employee needed to be in an off-work status to reflect the greater severity level. OSHA allows the employer to "cap" the total restricted or lost days on the OSHA log at 180, so there is no differentiation between a person off work for six months and one who is permanently disabled. If the employee leaves the company while still on a restricted-duty or lost-time, OSHA allows the employer to *estimate* how long the employee would have been in that status.

National statistics

The Bureau of Labor Statistics (BLS) calculates injury rates using a formula of 2000 hours for one full-time equivalent employee (FTE) (USDL 06-1982, 2006). When employers submit data to the BLS, all employees in the company are included in the FTE rate determination. Thus, office employees (with presumably lower risk) are treated the same as production employees, and employers with large populations in non-production work, will likely have lower injury rates than employers with a higher ratio of production-to-office workers.

Between 1998 and 2003, the overall number and rate of occupational injuries/illnesses requiring hospital treatment in the United States remained stable at 2.5 injuries per 100 FTE (MMWR, 2006). According to the BLS (USDL 06-1816, 2006), in

2005, the rate of non-fatal work-related injuries and illnesses in the United States declined to 4.6 cases per 100 FTEs, from 4.8 the previous year. Among manufacturing employers, the 2005 non-fatal occupational injury rate was much higher at 6.3 cases per 100 FTE, and among transportation equipment manufacturing employers, the rate was 6.8 cases per 100 FTE. Among all service and product industry sectors, the largest share (38.8%) of all non-fatal occupational injuries and illnesses occurred in manufacturing (6.3 per 100 FTE), although manufacturing represents about 11 percent of all employment (USDL IAG, 2006).

In 2005, approximately 1.2 million injuries in the United States required employees to miss work (USDL 06-1982, 2006). The median time away from work was 7 days per case in 2005, which was the same as 2004. Among manufacturing sector employers, over 206,000 injuries required days away from work, with nearly 131,000 of these lost-time injuries occurring among workers in production occupations. Trunk (including shoulder and back) and upper extremity injuries accounted for over 65 percent of the occupational injuries involving days away from work in the manufacturing sector (9.6 cases per 1000 workers). More than 35 percent of all non-fatal manufacturing injuries were classified as strain/sprain injuries in 2005. Between 2004 and 2005 the manufacturing sector experienced an 8 percent decline in the number of sprain/strain injuries. Whether this decline was real/actual or merely a decline in reporting was not a point of speculation by the BLS (USDL 06-1982, 2006).

In most industry sectors, there is a higher incidence rate of cases requiring days away from work, compared to days of restricted duty (USDL 06-1816, 2006). However, in the manufacturing sector the opposite is true. BLS gives no reasons for this phenomenon, but based on professional experience, I am willing to speculate that there are less severe injuries in manufacturing, or a greater ability or commitment to accommodate workers with restrictions.

Overall, occupational injury/illness rates show a “declining trend,” although severity of injury is increasing (Biddle and Blanciforti, 1999). These researchers claim that an “imprecise match” of numerator and denominator data used to calculate rates causes inaccuracies and confusion. The BLS calculates injury rates based on the company’s total hours worked, rather than hours worked by the population truly at risk.

Musculoskeletal disorders (MSDs) are defined by the Department of Labor as “an injury or disorder of the muscles, nerves, tendons, joints, cartilage, or spinal discs” (USDL 06-1982, 2006, p. 7). Typically the “event” causing the injury or illness is bodily reaction/bending, crawling, climbing, reaching, twisting, or repetition (but not a fall, trip, motor vehicle crash, or struck-by injury). Back pain, carpal tunnel syndrome, and tendonitis are examples of injuries or illnesses are often referred to as “cumulative trauma disorders” because they occur as the result of repetitive motion, and a specific causal “event” may be difficult to identify (29 CFR 1910). In the manufacturing sector, the incidence rate for repetitive motion cases (10.7 cases per 100 FTEs) was greatest of any industry sector in 2005. In an analysis of 1996 BLS data of injuries involving lost work days, MSDs accounted for 30 percent of the occupational injuries requiring days away from work (Courtney and Webster, 2001).

Cost of occupational injuries

Cost estimates for occupational injuries in the United States come from several sources, including BLS, workers' compensation, and studies of hospital emergency department records. Some researchers contend that injuries and associated costs are generally underestimated. For instance, Stanbury, Reilly and Rosenman (2003) identify a 64 percent undercount of the true number of amputation cases in Michigan in 1997. Leigh, Marcin and Miller (2004) estimate that overall the BLS survey misses 33 percent to 69 percent of all injuries due to underreporting and the exclusion of government workers and those self-employed. Reville, Bhattacharya and Weinstein (2001) indicate insufficient data exist to adequately estimate the consequences of workplace injuries, and that research on costs associated with occupational injuries is limited. Danish researchers' review of the literature suggests "large variations" in definitions and theoretical framework in research of costs related to occupational injuries (Rikhardsson and Impgaard, 2004). A Canadian cross-sectional study finds that 40 percent of 2500 survey respondents said that they failed to file workers' compensation claims for a workplace injury in the previous year (Shannon and Lowe, 2002), representing an undercount of the government's numbers. According to Weil (2001), although annual cost estimates range from $128 billion to $171 billion, true economic costs tend to be understated in analyses of occupational injuries, especially when considering fatalities and disabilities. Employer costs of work-related injuries are generally modest, and fail to include costs associated with hiring and retraining, bringing in temporary workers, overstaffing in anticipation of lost days, worker morale, and deterioration in labor relations (Boden, Biddle and Spieler, 2001).

Human and economic impact of occupational injuries is “inadequately studied and understood,” according to Boden, Biddle and Spieler (2001). While lost earnings average more than $10,000 per injury, they find little research to measure the non-economic impact, including family relationships, self-confidence, self-esteem, and the worker’s ability to fulfill social roles.

Workplace safety programs and efforts to return employees to work quickly after an injury improve productivity, according to Zaloshnja, Miller and Waehrer (2006). Their financial analysis of a 38 percent injury rate reduction between 1993 and 2002, across all US industries, shows a 9 percent increase in the gross domestic product during the same period, potentially attributable to the decline in occupational injuries. They indicate that the unemployment rate in 2002 would have been 6.16 percent instead of 5.78 percent if occupational injury rates had remained static.

According to research conducted by Boone and van Ours (2006), in economic recessions the rate of occupational injuries decreases (unemployment increase → injuries decrease). They contend that fluctuations in occupational injury rate are related to reporting behavior of workers, rather than changes in workplace safety. They theorize that workers fear reporting injuries, since reporting may make them vulnerable to being fired. Smitha, Kirk, Oestenstad, Brown and Lee (2001) identified an opposite, inverse relationship between unemployment and injury rates at the state level. Miller, Kim and Vincent (2004) found a potential for increased reporting of injury during a manufacturing plant closure, which could provide financial protection through the workers' compensation system for workers who would otherwise be laid off.

At the individual level, employees who are injured on the job can experience a financial impact when they are unable to remain fully employed. Workers' compensation, a no-fault insurance available to employees in every state, provides financial benefits that vary from state to state. When workers accept compensation through this system, they forgo the right to sue their employer for unsafe working conditions. Likewise, employers must provide care or compensation even when the employee was working in an unsafe manner. The amount of compensation varies by state, but is capped in some manner. Injured workers accepting workers' compensation lose wages when their regular earnings exceed the maximum compensation allowed by law, or when they are unable to work customary over-time or shift work with paid differential. Some employers supplement workers' compensation wages, but such benefits are not required (Rogers, 1994).

Risk factors to be evaluated in a large manufacturing employer

Research studies focusing on occupational injuries in the manufacturing sector are scarce. In the past 10 years, few studies specifically evaluate occupational injury at large manufacturing employers in the United States. Bunn, Pikelny, Slavin and Paralkar (2001) evaluated the impact of an integrated health/wellness, safety, disability, and workers' compensation program on the cost of health care, absenteeism, short-term disability, long-term disability, and workers' compensation. Collins, Smith, Baker and Warner (1999) evaluated occupational injuries and fatalities associated with powered industrial vehicles (forklifts, manlifts, etc.). Cooper and Phillips (2004) examined the impact of a safety program on safety climate in a packaging production plant, and Bell and MacDonald (2003) investigated laceration injuries at a washing machine assembly plant. Occupational injuries in the health care industry (hospitals, nursing homes) (Carrivick, Lee & Yau, 2002; Carrivick, Lee & Yau, 2001; Haney, 2003; Clarke, Rockett, Sloane & Aiken, 2002; Badii, Keen, Yu & Yassi, 2006; Saleh, Fuortes, Vaughn and Bauer, 2001), agriculture (Choi et al., 2005; Lyman, McGwin Jr., Enochs, & Roseman, 1999), transportation (Wallace, Popp, & Mondore, 2006), and emergency response (fire and police) (Liao, Arvey, Butler & Nutting, 2001) were more frequently evaluated. Although risks in other industries may be different from manufacturing, some physical demands and workplace hazards are similar to those seen in manufacturing. Therefore, the broader occupational injury literature was reviewed to identify potential risk factors expected in manufacturing environments.

Gender. In the United States, Canada, and Europe, researchers identify men as having greater risk than women for occupational injury, although none of the studies adjusted for type of job (Bhattacherjee et al., 2003; LaFlamme and Eilert-Petersson, 2001; Layne and Pollack, 2004; Liao, Avery, Butler and Nutting, 2001). In Israel, Kirschenbaum, Oigenblick and Goldberg (2000) find that gender is not a significant risk factor (when several other socioeconomic variables were included in the model), but without knowing much about work and culture in Israel, it is difficult to draw any conclusions about this finding. Saleh, Fuortes, Vaughn and Bauer (2001) find that women had a higher claim rate than men in a study of injuries in a large US teaching hospital. This study did not adjust for job type, and because men tend to work in high-risk jobs, job type must be adjusted to identify real gender-specific risk. Smith, Huang, Ho and Chen (2006) emphasize the need to control for industry-specific hazards to avoid reaching false “risk factor” conclusions.

Park (2002) concludes that age, gender, seniority, or prior injury may be confounders or effect modifiers of unknown exposures. Causative risk factors remain unknown, and existing data collection systems provide insufficient insight. A population-based prospective study of men in Iceland and Sweden indicates snoring and excessive daytime sleepiness are predictors of occupational accidents in the subsequent 10 years (Lindberg, Carter, Gislason and Janson, 2001).

Age. The literature paints a contradictory picture of the effect of age on injuries. Younger workers have greater injury rates, and older workers are more likely to have a more severe or fatal injury (Salminen, 2004; MMWR, 2006; Breslin, Koehoorn, Smith and Manno, 2003; Layne and Pollack, 2004; Grandjean et al., 2006; Alamgir, Koehoorn, Ostry, Tompa and Demers, 2006). Compared with younger workers (<45 years), older workers have greater rates of reported slips, trips and falls (Kemmlert and Lundholm, 2001). Injuries in a large teaching hospital suggest young employees (16-25 years) have a reduced injury rate, and middle-aged employees (36-45 years) have a greater injury rate (Saleh, Fuortes, Vaughn and Bauer, 2001). Bhattagherjee et al. (2003) find that age is not a significant risk factor in a study of occupational injuries in France. Breslin and Smith (2005) conclude that job type, not age of young workers is related to their high-risk status for injuries.

Shift work and work duration. Some research suggests a link between occupational injury and working rotating shifts, shifts other than day-time work, and over-time work (Frank, 2000; Swaen, van Amelsvoort, Bultmann, Slangen and Kant, 2004). Lilley, Feyer, Kirk and Gander (2002) contend longer work hours and shorter recovery time may allow less sleep time. A Finnish steel mill tried to help morning workers minimize fatigue by starting the morning shift one hour later (Rosa, Harma, Pulli, Mulder and Nasman, 1996). Although the change reduces fatigue and sleepiness, and improves performance for day-shift workers, it undermines workers on evening and night shifts. Police officers in the UK changing to a different method of rotating shifts, experience few changes on subjective fatigue and sleepiness, but improve objective sleepiness (Smith and Mason, 2001).

Changing work-shifts and the consequential disruption of the circadian cycle is detrimental to restful sleep, and affects more than 23 million workers in the US (Connor et al., 2002; Coburn and Sirois, 1999; Akerstedt, Fredlund, Gillberg and Jansson, 2002; Garbarino et al., 2001). Shift workers experience more motor vehicle incidents on the job and while driving home, reduced productivity, and greater absenteeism and turn-over compared to employees who remain on fixed shifts (Coburn and Sirois, 1999; Rogers, Holmes and Spencer, 2001). According to a study of Italian policemen, shift work significantly influences the sleep disorder score, and work hours interfere with quantity and quality of sleep (Garbarino et al., 2001). Researchers in Israel conclude that medical residents' complaints of sleep and daytime functioning are similar to those of shift workers (Epstein, Tsischinsky, Herer and Lavie, 2001).

Since round-the-clock work is common to many jobs and industries, shift work remains a risk factor. Additionally, working longer hours on a compressed schedule (e.g., three 12-hour shifts or four 10-hour shifts) allows large blocks of time for vacation and holidays away from work. In a two-week pay period, an employee can work a compressed schedule at the beginning and end of the pay period, and have an extended period off in between, all without using any vacation time or working overtime. A Swedish study of mill workers examines the health effects of an 84-hour workweek, which enables workers to have extensive time away from work during their “off” time. It takes employees on average three days to recover from the extended hours (Nordin and Knutsson, 2001). The researchers recommend keeping working hours at less than 48 per week. Swedish construction workers working 15.5 hours per day and resting 8.5 hours between workdays are insufficiently rested for complete recovery (Kecklund, Ekstedt, Akerstedt, DaHearing lossgren and Samuelson, 2001). However, Beckers et al. (2004) find that working overtime is unrelated to fatigue. Dembe et al. (2005) conclude that working jobs with over-time is associated with a 61 percent increased risk of occupational injury, and working a 12-hour day is associated with a 37 percent increased risk. They demonstrate that working 60 hours or more per week is associated with a 23 percent increased risk for occupational injury. Folkard and Lombardi (2006) find that night shift and 12-hour shifts are associated with increased risk of injury, and that an increased length of time between breaks is also associated with increased risk.

The National Institute for Occupational Safety and Health (NIOSH) (2006) provides suggestions to reduce shift-work fatigue, including educating workers on the need for sleep and establishing routines to ensure adequate sleep. The Department of Transportation (2005) established regulations prohibiting commercial drivers from driving more than 11 consecutive hours; working more than 14 hours in a shift; and driving more than 60 hours in a seven-day period or 70 hours in an eight-day period. In addition, commercial drivers must rest at least 10 hours between shifts. The Occupational Safety and Health Administration has no similar work limitations on workers in other industries.

Hearing Loss. Noise-induced hearing loss (NIHL) can be differentiated from other hearing losses by its characteristic pattern. Hearing losses are either conductive or sensorineural. NIHL is considered a sensorineural hearing loss, affecting the hair cells in the inner ear (Dobie, 1993; ACOM, 2002). Dobie (1993) describes the “noise notch” that occurs at 4000 Hz, but shows improvement at 8000 Hz. The American College of Occupational Medicine (1989) indicates damage from noise is first seen in losses at 3000, 4000, and 6000 Hz, with little damage at 500, 1000, and 8000 Hz. McBride and Williams (2001) indicate that the notch can be observed at 6000 Hz when people are exposed to impulse noise, and at 3000 Hz when they are exposed to low frequency noise. Sulkowski et al. (1999) find NIHL more frequently at 6000 Hz in forge-drop operators with impulse exposures of 135 dB. However, a “noise notch” at 6000 Hz is also found in subjects with no known noise exposure (Borchgrevink, 2003).

Although the 4000 Hz notch is one of the first indications of noise-induced damage to hearing, NIHL progresses to a deeper and wider notch, affecting more frequencies with greater loss in perception (Dobie, 1993; Rabinowitz, 2004; R. Jensen, personal communication, June 12, 2005). NIHL is a condition without pain, and since it occurs gradually, workers adjust to the loss of hearing by reading lips, asking to have comments repeated, or ignoring verbally transmitted information when they are unable to understand speech. NIHL is typically irreversible, and by the time someone recognizes a problem through environmental and communication clues, significant damage has occurred.

With NIHL, many sounds can be heard, but clarity of spoken communication diminishes, especially in noisy environments. Voiceless consonants (TH, S, F, T, K) are high-frequency sounds; thus when high-frequency hearing is damaged, those sounds disappear (Danielson, 2004). Employees working in a noisy environment must focus carefully on conversations, and may rely heavily on lip-reading or evaluating context to understand the speech of others. Hicks and Tharpe (2002) find that children with hearing loss expended more effort in listening than children with normal hearing. Does the effort to understand conversations result in fatigue among employees with hearing loss?

Dual-task experiments indicate that two concurrent competing activities are more demanding (Kimchi, 1982). When intent listening is required, employees with hearing loss may be more fatigued. If fatigued employees have more occupational accidents than non-fatigued employees, then employees with hearing loss may have more accidents than employees with normal hearing. Additionally, hearing-impaired employees may miss warning sounds (voice, alarm), which can result in injury (Moll van Charante and Mulder, 1990).

This idea is supported by a study of farmers in Iowa (Choi et al., 2005), which finds hearing loss in the better ear, hearing asymmetry, and self-report of poor/fair hearing were all associated with increased risk for agricultural injury. Occasional use of hearing protection (as opposed to always) is associated with increased risk for injury, leading the authors to suggest that reducing hearing loss through hearing protection may be useful in preventing occupational injuries.

Other risk factors. Occupational injuries are associated with various risk factors, but insufficient evidence is available to determine causality. For instance, when asked whether they think their medications impact safety on the job, employees with diagnoses of depression and anxiety admit that they anticipate an increased risk of work-related injuries due to symptoms or the medications taken (Haslam, Atkinson, Brown and Haslam, 2005). Gauchard, Chau, Mur and Perrin (2001) suggest physical status, attention/vigilance, and fatigue are associated with falls. Employees with a history of seizures are at greater risk of occupational injury, although seizures fail to provoke the injury incident (Cornaggia, Beghi, Moltrasio and Beghi, 2006). Personal emotional factors increase the risk of work-related injuries (Kirschenbaum, Oigenblick and Goldberg, 2000), and this may be a precursor to "cognitive failure" or mental error. Cognitive failure can result in an error in execution and is more likely when tasks are automated. Wallace and Vodanovich (2003) conclude that cognitive failure leads to occupational injuries. High body-mass index (BMI) and obesity are associated with occupational injury (Hou, Hsu, Lin and Liang, 2007); others suggest they are confounding or effect-modifying variables (Nakata et al., 2006; Schulte et al., 2007).

The relationship between length of time on the job and workplace injury is stronger for males, older workers, and manual operations in a Canadian study (Breslin and Smith, 2006). Workers in their first month on the job have a relative risk for injury of 4.23 compared with workers in their job for more than a year. Oh and Shin (2003) find education and experience are associated with fewer work-related injuries. Collins, Smith, Baker and Warner (1999) reviewed BLS data and suggest a relationship exists between experience on the job and risk of work-related motor vehicle injury: 50 percent of workers involved in a 2-vehicle collision were injured in their first month on the job, and 20 percent experiencing a motor vehicle injury worked less than one year. These findings suggest training is a protective factor for occupational injuries. Another possible explanation for lower injury rates in employees with greater tenure may be under-reporting injuries. Long-term employees have accumulated sufficient vacation and sick time and they may avoid submitting claims for work-related injuries. Rather, they may have their injury treated by a personal healthcare provider and may not identify the injury as being work-related. For musculoskeletal injuries involving repetitive motion or "bodily reaction," avoiding the workers' compensation system would be easy without witnesses.

Union membership is associated with occupational injuries in a study of workers in the manufacturing sector (Smitha, Kirk, Oestenstad, Brown and Lee, 2001). At the individual level, union membership had no effect on work *disability* (Krause, Frank, Kasinger, Sullivan and Sinclair, 2001). Although injury incidence is unrelated to disability, the contrasting findings are interesting and may indicate a lack of adequate study control.

I described the general purpose and specific aims of this investigation. Examination of the literature helped me formulate specific research questions and develop testable hypotheses. These follow.

Research Question 1: *What are the characteristics of injuries that occurred at several key locations of a large manufacturing employer?*

Research Question 2*: What are the characteristics of employees who were injured while working for a large manufacturing employer?*

Research Question 3: *What factors influence occupational injury severity in a large manufacturing company?*

Null Hypothesis 1*: There are no differences in influential factors affecting recordability of occupational injuries among employees in a large manufacturing company, after adjusting for pay code, union location, and number of injuries.*

Null Hypothesis 2*: There are no differences in influential factors affecting restricted days following occupational injuries among employees in a large manufacturing company, after adjusting for pay code, union location, and number of injuries.*

Null Hypothesis 3*: There are no differences in influential factors affecting lost days following occupational injuries among employees in a large manufacturing company, after adjusting for pay code, union location, and number of injuries.*

Null Hypothesis 4*: There are no differences in risk factors among employees with multiple injuries versus single injuries in a large manufacturing company, after adjusting for pay code and union location.*

Null Hypothesis 5*: There are no differences in risk factors for different types of injuries in a large manufacturing employer.*

Theoretical framework

Based on information in the literature and on professional experience, both personal factors and organizational/ job factors can influence injury risk. How much each variable contributes to the risk of injury severity (if at all) is unknown. A retrospective study that uses existing data can measure few of these factors. Future data collection efforts, in the form of post-injury investigations, however, may be able to include some of the variables currently not measurable. The theoretical framework I developed is illustrated in Figure 1.1.

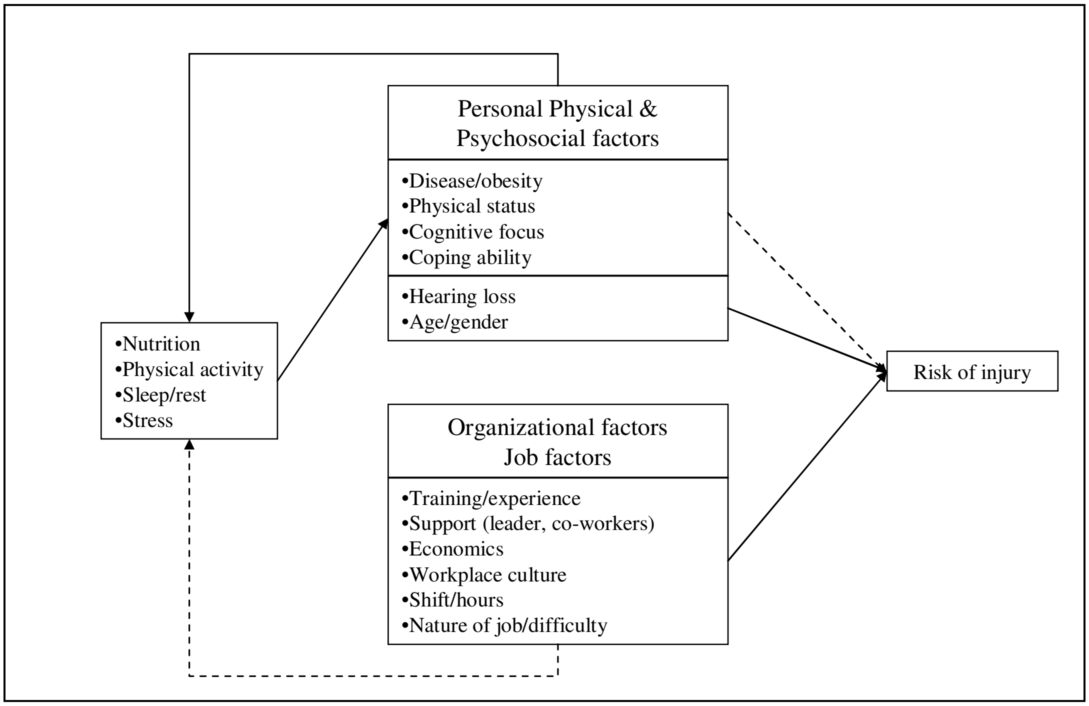

Figure 1.1. Theoretical framework of variables' influence on risk of injury.

As the literature review has shown, the risk of injury to an individual is influenced by individual factors and organizational/job factors. Individual factors can be physical or psychosocial, stemming from one's ability to cope or focus, or from one's physical state or disease status. Some factors can be controlled, while others, such as age and gender, cannot be controlled by the individual and have also been shown to influence risk of injury. While research has shown the influence of nutrition, sleep, physical activity, and stress on health status, lack of available data restricted evaluation of these potential/likely confounders in this study. Personal health factors can affect risk of injury, but they can also affect lifestyle and behavioral choices, that in turn affect health status. For instance, an individual may be obese and have diabetes, which affects his energy level and desire/ability to be physically active, and consequently leads to greater obesity and more of a problem controlling diabetes.

Organizational and job factors, such as workplace culture of safety, the difficulty or hazards of the job and the training (or lack thereof) provided, and support of others, also influence injury risk. The shift worked and number of hours worked (perhaps with overtime) may impede sleep/rest, which in turn affects physical and psychosocial health. With the exception of shift, none of the other organizational and job factors listed in the theoretical model were evaluated in the present study.

This study looked at personal factors (age, gender, hearing loss, and proxies for fatigue), organizational/work characteristics (type of job, tenure, work shift, work location, union status, and pay code), and injury characteristics (type of injury, hazardous conditions, body part injured, nature of injury, and unsafe acts) on the risk of occupational injury severity.

Knowing what risks exist is the basis for prevention. If lack of training increases the risk of injury-causing incident, then prevention efforts would include providing training. If the nature of the job leads to injury, can the job be modified to reduce the likelihood of injury? If stretching or strength training is useful for improving physical status among employees, then targeted physical activity may lead to decreased injuries.

In most workplaces, injuries are investigated to determine what happened, how they occurred, what environmental conditions contributed to the incident, and what might have prevented the injury. Specific data are collected and coded and periodically analyzed by safety and health professionals. When trends are identified, plans are designed and implemented to prevent future incidents. This study used existing safety and health data to identify factors associated with occupational injuries over a five-year period. Standard safety investigations do not collect and code many of the factors identified by the literature to be influential in occupational injuries. Although the company knows what shift the employee worked, the company does not know how many hours of sleep the employee had in the 24 hours before the occupational injury occurred. The company may know how heavy a riveting gun is, but standard safety investigations do not assess an employee's grip strength.

Companies want to limit injury and associated cost. They are not research institutes and undertake "studies" only when they can be shown unreasonable injury/cost occurs. The first step of investigating injury in a company is the examination of existing data and identification of problem areas. Although there are limitations to using existing data retrospectively, the fact that they are "real" and not derived in a laboratory setting is a strength of this method.

CHAPTER 2

METHODS

Target population and setting

The participating company is a large aerospace and defense company, with major manufacturing centers in several states. The work force is diverse, with 150,000 employees working in 48 states and 70 countries. Unions represent hourly production workers in most US locations. Manufacturing sites are located in ten geographic locations in the United States. Locations serving as plant sites for this large manufacturing company have typical workers' compensation case rates (neither the five most- nor the five least-expensive) (Waehrer, Leigh, Cassady and Miller, 2004). Therefore, workers' compensation is unlikely to be a confounding factor in occupational injuries throughout the company.

Henceforth this large aerospace manufacturing company will be referred to as "the company." Evaluations of single or multiple locations will be referred to as "the location" or "the site(s)." Sites may be accompanied by a regional descriptor.

In accordance with the limited dataset agreement that the company and I signed, health and safety data were provided for injuries from six diverse geographic locations; however, limited demographic data about the employee populations were accessible to me. In an effort to describe the communities where the manufacturing centers are located, US Census data are presented (Table 2.1). One location is on the east coast, one in the Midwest, two in the Southwest, and two in the Northwest. The host/home communities differ in size (0.5 million to over 3 million residents), in ethnic/racial make-up, with white persons (not Hispanic) ranging from 33.5 percent to 72.8 percent, and percent of high school graduates ranging from 71.2 percent to 90.3 percent. The poverty rates of these communities vary as well, ranging from 8.6 to 20.1 percent below poverty, and home-ownership rates ranging from 55.8 percent to 74.1 percent. Geographically, the locations are different, with population concentrations ranging from 333 to almost 10,000 people per square mile.

Table 2.1. Census comparisons by county‡ of work locations used in this study.

People QuickFacts (employee population)	**Location 1** (4593)	**Location 2** (14225)	**Location 3** (1785)	**Location 4** (4158)	**Location 5** (1140)	**Location 6** (40650)
Population	1,517,550	1,016,315	1,392,931	3,072,149	529,121	1,737,034
Population, percent change, April 1, 2000 to July 1, 2005	-3.6%	-1.1%	9.0%	18.3%	1.8%	3.3%
Persons 18-65 years old, percent	61.50%	62.60%	61.80%	61.50%	67.30%	68.20%
Female persons, percent	53.4%	52.4%	51.2%	49.7%	50.6%	50.1%
White persons, percent	47.4%	74.3%	88.2%	89.0%	77.9%	76.2%
Black persons, percent	45.4%	21.3%	7.4%	4.3%	6.6%	5.9%
Asian persons, percent	5.2%	2.9%	1.9%	2.7%	6.3%	12.9%
Persons of Hispanic or Latino origin, percent	10.2%	1.7%	56.8%	29.0%	4.1%	6.7%
All other persons, percent	1.9%	1.4%	2.6%	4.0%	5.0%	5.0%
Foreign born persons, percent	9.0%	4.2%	10.9%	14.4%	13.0%	15.4%
Language other than English spoken at home, pct age 5+	17.7%	6.4%	43.2%	24.1%	16.9%	18.4%
High school graduates, percent of persons age 25+	71.2%	88.0%	76.9%	82.5%	85.7%	90.3%
Bachelor's degree or higher, pct of persons age 25+	17.9%	35.4%	22.7%	25.9%	32.6%	40.0%
Mean travel time to work (minutes), workers age 16+	32.0	24.0	24.0	26.1	23.1	26.5
Homeownership rate	59.3%	74.1%	61.2%	67.5%	55.8%	59.8%
Median household income	$30,414	$51,359	$38,521	$46,322	$40,146	$53,414
Per capita money income	$16,509	$27,595	$18,363	$22,251	$22,643	$29,521
Persons below poverty, percent	20.1%	8.6%	17.6%	12.8%	13.1%	9.4%
Business QuickFacts						
Private non-farm establishments	26,524	29,951	30,690	79,345	N/A*	60,825
Private non-farm employment	578,955	570,526	582,905	1,411,802	N/A*	984,046
Total number of firms	67,006	81,372	100,999	239,517	52,862	165,089
Geography QuickFacts						
Land area (square miles)	135	507	1,246	9,203	134	2,126
Persons per square mile	9,999.9	2,000.6	1,117.0	333.8	3,939.2	817.0

*N/A = not available from census
‡City or region presented when metro areas are comprised of more than one county.

All work-related injuries reported by employees at six locations of the company between January 1, 2002 and December 31, 2006 were eligible for inclusion in this study. Although the company has other manufacturing centers in the US, injury data for those locations were unavailable for this study. Existing data were extracted from the company's safety, health, and human resources databases. Although the company has one corporate safety department, uniform safety practices were not consistently established in all locations by 2002, when data were first generated for this study (S. Boone, personal communications, 11/20/07). Likewise, all health services were not operating under one set of corporate standards in 2002, so injured employees may have been treated differently from one site to another.

The six locations used for this study all have engineering, manufacturing, and support functions, but their products are different. The work product in Location 3 is primarily re-manufacturing. That is, products are refurbished for reuse. Employees in Location 3 may do more grinding and buffing than employees in other sites. Some refurbishing work occurs in Location 4, but not to the same degree as Location 3. Most locations create the company's products from scratch, or import parts and assemble the products. In addition to making large transportation devices, Location 4 is the company's Center of Excellence for producing electronic wire assemblies for use in many of the company's other products. Wire assembly does not involve heavy lifting or use of heavy tools, but crimping and stripping wires can result in repetitive motion injuries of the upper extremities. These six locations would be considered representative of the company's manufacturing sites. Locations not included in this study also have engineering, manufacturing, and support functions, and may produce complete products or components of products used elsewhere in the company.

Much of the production and maintenance work at all company locations involves heavy tools, repetitive motion, and awkward working positions. Employees may have to crawl into small spaces or hold a rivet gun overhead or above shoulder level for extended periods of time. The company's emphasis on ergonomic solutions to ease or prevent musculoskeletal problems has improved working conditions in physically-demanding jobs. I was unable to obtain specific demographic data for the general employee population by location and job title, so analyses are limited in that regard.

Human Subjects protection

Both the company and the University of Arizona have Human Subjects Protection Programs to review research proposals. The company is not a covered entity under the Healthcare and Insurance Portability and Accountability Act (HIPAA). However, the company treats health records *as if they were* protected by HIPAA. Additionally, the company has strict policies governing company information that is shared with the public. Any presentation or publication must obtain approval from a department executive, the communications department, and the legal department.

This research proposal was reviewed and approved by the Human Subjects Review Board of the company. Since zip code and birth date are considered by HIPAA to be part of identifiable personal information, I signed a Limited Data Agreement prior to receiving any data. After the University's Human Subjects Review Committee approved the research proposal, the company released data to me. Bogus identifiers replaced employee identification numbers before the information technology staff gave me the data. Copies of the company and university approval letters are included in Appendix A.

Methods

This retrospective descriptive occupational injury study was conducted using existing occupational health and safety data, stored in an electronic database. The requested information is listed in Appendix B. When injuries occur, specific information is captured by safety professionals immediately after the incident is reported. As a method of ensuring employee confidentiality and anonymity, while being able to know when employees had more than one injury, the company generated alternate employee identification numbers before providing the data.

Variables

The variables requested from the company are listed in Appendix B and the variables provided by the company are listed in Table 2.2. Pay code provided information about production/non-production work status. I defined Union status as Production and Maintenance (P&M) workers who worked in Locations 1, 2, 5, and 6. Exempt and non-exempt employees meet the definitions in the Fair Labor Standards Act, which generally equates to salaried and hourly workers, who are not in one of the other categories (M. Gonzalez, personal communication, 6/7/07). "Other" employees include executives, contingent (contract) labor, and employees on leaves of absence. Work location, combined with home zip code, was used to calculate commuting distance and average commute times, which were used as a proxy for additional personal stress and fatigue. Commuting distance and time were calculated using MapQuest® driving directions, which are "a combination of speed (miles-per-hour or kilometers-per-hour) and distance calculations that vary according to the type of road being used and the speed limit on that road type. These attributes do not consider traffic congestion, construction lasting less than one year, weather related delays or accidents" (personal communication, MapQuest® technical support, 8/15/07). Commutes from home zip code to work zip code that were greater than four hours or longer than 200 miles were coded "999" to exclude them from analyses, because I assumed those employees were actually on business travel to a location different from their usual work location.

Tenure was calculated using the last hire date to date of injury, and is used as a continuous variable in the analyses. Information about previous employment (or contractor status) with the company was unavailable. Female is the reference group to which male gender is compared. Age at injury date was calculated in Excel® prior to removing the data from company premises, and is used as a continuous variable in the analyses.

Delay in reporting injury was calculated using the date of the report of injury minus the date that the injury occurred. In some cases, injury date was an estimate because the nature of the injury (e.g., repetitive motion) caused difficulty in determining a precise injury date.

Employees in the hearing conservation program had hearing test results available because OSHA mandates annual hearing tests for employees who are exposed to high noise levels at work (DOL, 1910.95). The hearing test prior to the date of injury was used to determine hearing status of injured employees. Of the frequencies tested during annual hearing tests, loud sounds are most likely to damage hearing at frequencies of 3000, 4000, and 6000 Hz. When noise damages hearing, failure to hear high frequencies sounds will be more common than hearing loss at lower frequencies. Any hearing loss at or above 25 dB at those frequencies was considered positive for hearing loss.

Five injury characteristics were included in analyses, and they are listed in Appendix C. The codes selected for inclusion were the most frequently-used codes in the dataset. The comparison groups for each characteristic are “all others” not included in the list.

Table 2.2. Variable list

Independent Variables	Dependent Variables
Work characteristics	Injury severity (recordable/not recordable)
Work location	Injuries with restricted days
Job title	Injuries with lost days
Pay code	Type of injury
Work shift	Multiple injuries
Employee characteristics	
Age	
Gender	
Delay in reporting injury (days)	
Distance to work (zipcode)	
Hearing loss	
Tenure/hire date	
Number of injuries	
Injury characteristics	
Type of injury	
Body part injured	
Reason for injury (unsafe act)	
Nature of injury	
Date of injury	

Data analysis

Descriptions of injury frequency used two approaches to model the data. Outcomes of injury severity and number of injuries were handled differently in the analyses. Occurrence of injury was modeled using injury characteristics as well as employee and work characteristics. In looking at the differences among employees, injury characteristics were excluded.

StataMP10 (Statacorp, 2007) was used for data analysis. Data were analyzed first using descriptive statistics. Since Stata recognizes numerically-coded variables as continuous, "dummy variables" were created for body part injured, type of injury, unsafe act, nature of injury, job title, pay code, hazardous condition, and work shift. Age was limited to employees 17-74 years.

Descriptive statistical approaches were used to examine the raw data. Results were assembled into tables describing the injuries and the injured employees. Following this preliminary analysis, data were modeled using two approaches with different ends. First, *injuries* were evaluated to determine which factors influence severity of occupational injuries. Second, *employee* variables were examined to identify personal and workplace characteristics that were influential in the severity of occupational injuries. Whereas all injuries were included in the analyses of injury characteristics, analysis of employee characteristics was limited to the employee's first injury in the dataset.

General Estimating Equations (GEE) were used for analyses of injury severity (recordable injury, restricted days, lost days) because this approach "accurately recovers the common…'risk difference' within each cluster" of employees who had multiple injuries (Hanley, Negassa, deB.Edwardes, and Forrester, 2003, p 375). GEE is useful for analyzing correlated data, which was seen in this study where over 20,000 employees experienced more than 36,000 injuries. Records were clustered on employee. Stepwise backward elimination was used to achieve a preliminary model using all significant factors except injury characteristics (nature of injury, type of injury, unsafe act, body part, workplace hazard). Once significant variables were identified, injury characteristics were added to the analysis, and backward elimination was used again to determine a final model. The same approach was repeated for each outcome under consideration (recordable injury, restricted-days injury, lost-days injury) first including location and pay code, and then including union status, which by definition limited the analysis to only Production and Maintenance (P&M) workers in Locations 1, 2, 5, and 6 (and compared them to P&M workers in Locations 3 and 4). GEE was also used to analyze the most common types of injuries that impact severity, using all other types of injury as the reference group. Repetitive motion (not elsewhere classified) and repetitive motion in shop operations were combined for one analysis, and overexertion and repetitive motion in shop operations were analyzed separately. Significance was established at $p<.05$ for all analyses.

Logistic regression analyses were used to identify influential employee/work factors, without regard to the injury characteristics. Multiple logistic regression is a technique used when the outcome variable is dichotomous and several categorical or continuous confounding variables may exist (Rosner, 2000; Pagano and Gauvreau, 2000). The Stata *xi* command was used to identify and test possible interaction terms. Significance was established at $p<.05$ for all analyses, but generally, due to the large number of significant variables identified, only those variables that reached a significance level of $p<0.001$ are highlighted in results and discussion in this paper. Goodness of fit was assessed using the Hosmer-Lemeshow test, and area under the ROC curve was calculated for each model developed using logistic regression.

CHAPTER 3

RESULTS

Descriptive results of injuries

The data were evaluated using two approaches with different ends. First, *injuries* were considered. Occupational injuries (n=36,611) over a five-year period (2002-2006), from six work locations were evaluated. The mean and median age of employees with injuries was 48 at the time of injury, though women were slightly older than men (Table 3.1). The mean and median length of service with the company was 17 years at the time of injury. Injured women worked at the company about one year less than injured men at the time of injury. Only 7654 injuries (21%) resulted in lost days (>0 days), with a mean 54.3 (median = 19.5) days lost per injury. More injuries (n=14,684, 40%) resulted in restricted days, with a mean 35.2 (median = 20.4) restricted days per injury.

The company expects injuries to be reported immediately, but that expectation is not always met. More than 44 percent (n=16,239) of all injuries resulted in a delay of one or more days in reporting the injury (Table 3.1). The mean delay was 20.4 days per injury, with a median delay of 4 days. Among women, the mean delay was 24.5 days (median = 4), and among men the mean delay was 19.1 days (median = 3). Although cumulative trauma injuries/illnesses could be naturally delayed because employees may not fully realize that they've been injured, fewer than 13 percent of the injuries were categorized as "repetitive motion" injuries.

Table 3.1. Demographic breakdown of all injuries, 2002-2006.

	Female			Male			All injuries		
	n	Mean	Median	n	Mean	Median	n	Mean	Median
Age at injury	8609	48.9	49.5	27967	47.9	47.8	36576	48.1	48.2
Tenure at injury	8411	16.3	16.6	27528	17.9	17.4	35939	17.5	17.2
Restricted days*	3612	38.1	22.0	11072	34.3	19.0	14684	35.2	20.0
Lost days*	1929	62.4	22.0	5725	51.5	19.0	7654	54.3	19.5
Reporting delay*	3853	24.5	4.0	12386	19.1	3.0	16239	20.4	4.0

*when days >0

Males suffered more than three-quarters of the injuries (n=27,982, 76%), and male production and maintenance (P&M) workers in Location 6 accounted for nearly half of all injuries among workers in this 5-year period (n = 17,714, 48%) (Table 3.2). Among P&M employees and engineers, fewer than one quarter of the injuries were among female workers (n=6107 & 186, 20%); however, among exempt employees (professional, salaried employees), more than half of the injuries were among females (n=1130, 54%).

Of the 36,374 injuries that were categorized, 64 percent (n=23,326) were recordable (Table 3.2). The crossed-out injuries are not included in the table because their numbers were small. The pattern of recordable versus non-recordable injuries differed by work location (Table 3.2). Location 3 had the highest percentage of recordable injuries (78%, n=730), and Location 4 had the lowest percentage of recordable injuries (27%, n=754). In spite of a three-fold difference in employee populations, Locations 3 and 4 had a comparable number of recordable injuries, but in the 5-year period, Location 4 had ten times the number of non-recordable injuries (187 vs. 1,885). Figure 3.1 illustrates the year-to-year percent recordable injuries by location.

To calculate injury rates, the BLS uses 2,000 hours per 1 Full-Time Equivalent employee [FTE]). Location 4 had the lowest rate of recordable injuries (3.6 per 100

FTE), but Location 2 had the lowest overall injury rate (8.0 per 100 FTE) (Table 3.2). The rates of recordable injuries were fairly consistent from year to year in Location 1, but generally declined over time in most locations (Figure 3.2). Location 2 went from a high of 10.8 injuries per 100 FTE in 2002 to a low of 6.1 over the 5-year period. Location 3 started with fewer than 1 injury per FTE per year in 2002, increased to 17.6 injuries per 100 FTE by 2004, and reduced to 10.7 injuries per 100 FTE by 2006, a pattern largely attributable to changes in injury reporting practices.

Table 3.2. Severity of injuries by location and year.

All Injuries	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	8801		7532		6530		6466		7045		36374	
recordable	5975	*68%*	4960	*66%*	4115	*63%*	3856	*60%*	4420	*63%*	23326	*64%*
non-recordable	2439	*28%*	2185	*29%*	2091	*32%*	2214	*34%*	2310	*33%*	11239	*31%*
Injuries with restricted days*	3917	*45%*	3036	*40%*	2583	*40%*	2396	*37%*	2752	*39%*	14684	*40%*
Injuries with lost days*	2221	*25%*	1645	*22%*	1281	*20%*	1156	*18%*	1351	*19%*	7654	*21%*
FTE	66969		65623		65412		69166		75610		68556	
Recordable injuries/100 FTE/year	*8.9*		*7.6*		*6.3*		*5.6*		*5.8*		*6.8*	
Injuries/100 FTE/year	*13.1*		*11.5*		*10.0*		*9.3*		*9.3*		*10.6*	
Ratio recordable: non-recordable	2.4		2.3		2.0		1.7		1.9		2.1	

Location 1	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	631		532		610		568		476		2817	
Recordable	297	*47%*	247	*46%*	308	*50%*	284	*50%*	248	*52%*	1384	*49%*
Non-recordable	262	*42%*	216	*41%*	233	*38%*	214	*38%*	184	*39%*	1109	*39%*
Injuries with restricted days*	163	*26%*	120	*23%*	175	*29%*	134	*24%*	134	*28%*	726	*26%*
Injuries with lost days*	64	*10%*	52	*10%*	73	*12%*	39	*7%*	52	*11%*	280	*10%*
FTE	5067		4295		4391		4571		4642		4593	
Recordable injuries/100 FTE/year	*5.9*		*5.8*		*7.0*		*6.2*		*5.3*		*6.0*	
Injuries/100 FTE/year	*12.5*		*12.4*		*13.9*		*12.4*		*10.3*		*12.3*	
Ratio recordable: non-recordable	1.1		1.1		1.3		1.3		1.3		1.2	

Table 3.2, cont. Severity of injuries by location and year.

Location 2	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	1360		1349		1068		1036		896		5709	
Recordable	738	*54%*	730	*54%*	567	*53%*	600	*58%*	527	*59%*	3162	*55%*
Non-recordable	567	*42%*	549	*41%*	439	*41%*	350	*34%*	292	*33%*	2197	*38%*
Injuries with restricted days*	294	*22%*	310	*23%*	258	*24%*	291	*28%*	239	*27%*	1392	*24%*
Injuries with lost days*	135	*10%*	126	*9%*	115	*11%*	149	*14%*	123	*14%*	648	*11%*
FTE	12644		13820		14794		15103		14765		14225	
Recordable injuries/100 FTE/year	*5.8*		*5.3*		*3.8*		*4.0*		*3.6*		*4.4*	
Injuries/100 FTE/year	*10.8*		*9.8*		*7.2*		*6.9*		*6.1*		*8.0*	
Ratio recordable: non-recordable	1.3		1.3		1.3		1.7		1.8		1.4	
Location 3	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	14		327		273		156		167		937	
Recordable	14	*100%*	265	*81%*	236	*86%*	101	*65%*	114	*68%*	730	*78%*
Non-recordable	0	*0%*	57	*17%*	36	*13%*	43	*28%*	51	*31%*	187	*20%*
Injuries with restricted days*	8	*57%*	176	*54%*	142	*52%*	69	*44%*	64	*38%*	459	*49%*
Injuries with lost days*	3	*21%*	47	*14%*	46	*17%*	20	*13%*	23	*14%*	139	*15%*
FTE	2250		2031		1552		1530		1563		1785	
Recordable injuries/100 FTE/year	*0.6*		*13.0*		*15.2*		*6.6*		*7.3*		*8.2*	
Injuries/100 FTE/year	*0.6*		*16.1*		*17.6*		*10.2*		*10.7*		*10.5*	
Ratio recordable: non-recordable	14:0		4.6		6.6		2.3		2.2		3.9	

Table 3.2, cont. Severity of injuries by location and year.

Location 4	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	570		535		549		587		502		2743	
Recordable	210	*37%*	178	*33%*	139	*25%*	116	*20%*	111	*22%*	754	*27%*
Non-recordable	337	*59%*	333	*62%*	394	*72%*	450	*77%*	371	*74%*	1885	*69%*
Injuries with restricted days*	43	*8%*	54	*10%*	34	*6%*	49	*8%*	38	*8%*	218	*8%*
Injuries with lost days*	17	*3%*	24	*4%*	10	*2%*	11	*2%*	12	*2%*	74	*3%*
FTE	3845		3982		4090		4555		4318		4158	
Recordable injuries/100 FTE/year	*5.5*		*4.5*		*3.4*		*2.5*		*2.6*		*3.6*	
Injuries/100 FTE/year	*14.8*		*13.4*		*13.4*		*12.9*		*11.6*		*13.2*	
Ratio recordable: non-recordable	0.6		0.5		0.4		0.3		0.3		0.4	

Location 5	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	145		124		79		118		131		597	
recordable	75	*52%*	85	*69%*	53	*67%*	67	*57%*	57	*44%*	337	*56%*
non-recordable	66	*46%*	38	*31%*	23	*29%*	50	*42%*	71	*54%*	248	*42%*
Injuries with restricted days*	43	*30%*	54	*44%*	34	*43%*	49	*42%*	38	*29%*	218	*37%*
Injuries with lost days*	17	*12%*	24	*19%*	10	*13%*	11	*9%*	12	*9%*	74	*12%*
FTE	1185		1028		1018		1115		1353		1140	
Recordable injuries/100 FTE/year	*6.3*		*8.3*		*5.2*		*6.0*		*4.2*		*5.9*	
Injuries/100 FTE/year	*12.2*		*12.1*		*7.8*		*10.6*		*9.7*		*10.5*	
Ratio recordable: non-recordable	1.1		2.2		2.3		1.3		0.8		1.4	

Table 3.2, cont. Severity of injuries by location and year.

Location 6	**2002**		**2003**		**2004**		**2005**		**2006**		**Total**	
	n	%	n	%	n	%	n	%	n	%	n	%
Total injuries‡	6081		4663		3950		3998		4865		23557	
recordable	4641	*76%*	3453	*74%*	2812	*71%*	2685	*67%*	3356	*69%*	16947	*72%*
non-recordable	1207	*20%*	992	*21%*	965	*24%*	1107	*28%*	1340	*28%*	5611	*24%*
Injuries with restricted days*	3356	*55%*	2342	*50%*	1927	*49%*	1798	*45%*	2232	*46%*	11655	*49%*
Injuries with lost days*	1963	*32%*	1378	*30%*	1023	*26%*	919	*23%*	1123	*23%*	6406	*27%*
FTE	39976		38463		37563		40287		46963		40650	
Recordable injuries/100 FTE/year	*11.6*		*9.0*		*7.5*		*6.7*		*7.1*		*8.3*	
Injuries/100 FTE/year	*15.2*		*12.1*		*10.5*		*9.9*		*10.4*		*11.6*	
Ratio recordable: non-recordable	3.8		3.5		2.9		2.4		2.5		3.0	

*Some cases may have had both restricted and lost days.
‡Total injuries = recordable, non-recordable, crossed-out.

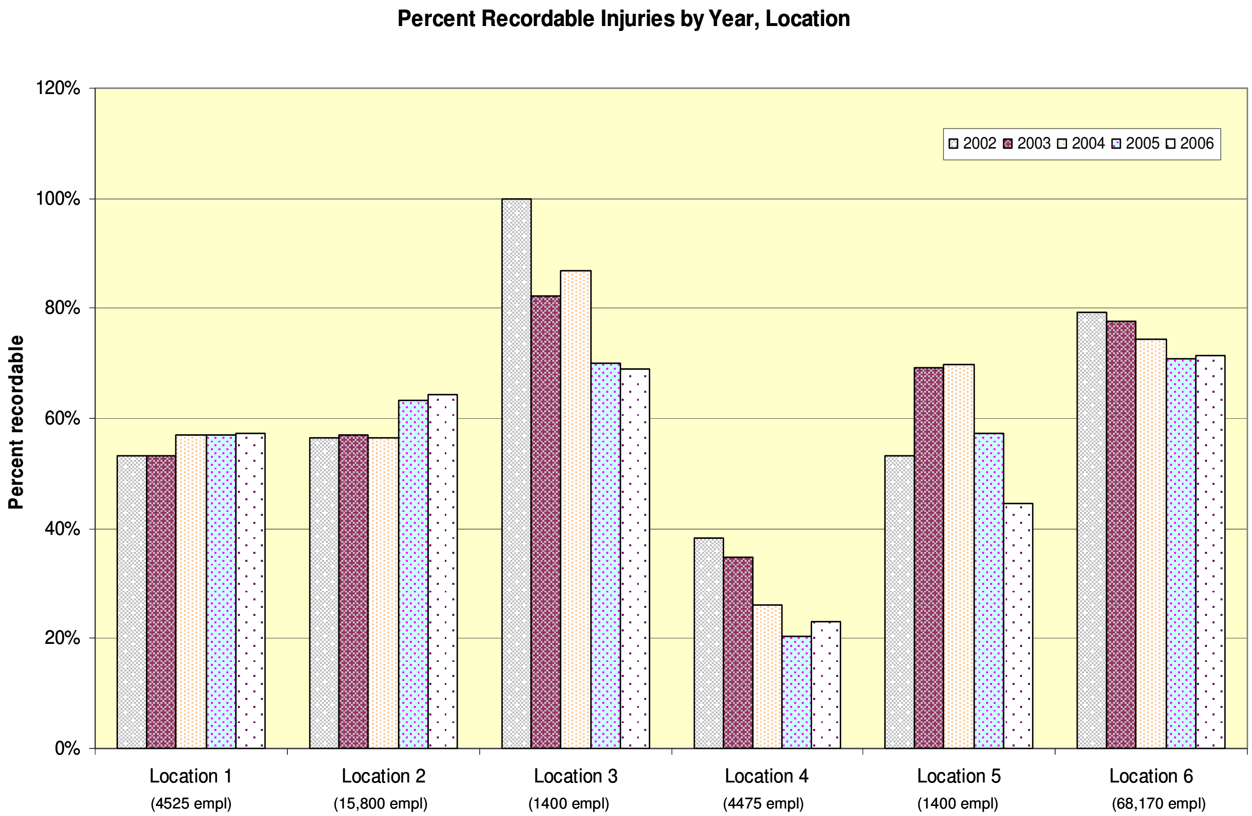

Figure 3.1. Percent recordable injuries by location and year.

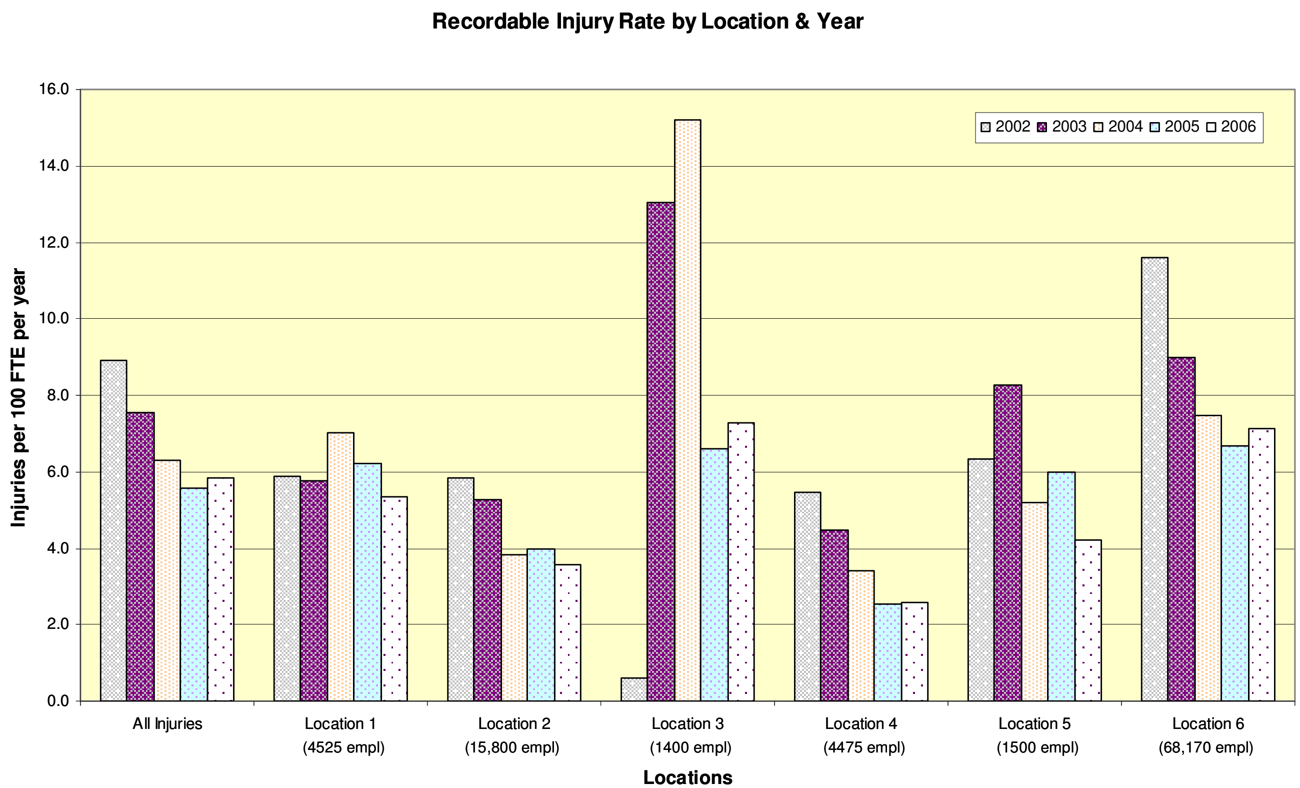

Figure 3.2. Recordable injury rate by location and year.

The ratio of recordable-to-non-recordable injuries may be an indicator of how hazardous the work is at each location, or it may signal the site's compliance with the expectation that each injury – regardless the severity – be reported promptly. Location 4 had the lowest ratios, ranging from 0.6 in 2002 to 0.3 in 2005 and 2006. At Location 3 in 2002, only 14 injuries were reported (which is uncharacteristically low), and all 14 were considered recordable on the OSHA log. In subsequent years, the ratio of recordable-to-non-recordable injuries at Location 3 was as high as 6.6 and as low as 2.2 recordable injuries per each non-recordable injury.

The percentage of recordable and non-recordable injury remained fairly consistent from year to year at most sites, but generally decreased over time for most locations and for the company as a whole (Table 3.2). However, the ratio at Location 1 gradually increased (from 47% to 52%) in the percentage of recordable injuries over the first 4 years. Ratios at Location 3 changed from 100 percent injuries being recordable in 2002 to 68 percent recordable in 2006.

Location 4 had fewer than 10 percent of all injuries resulting in restricted days or lost days every year. These low numbers contrasted sharply with injuries at other locations that resulted in restricted and/or lost days. For instance, at Location 6 nearly half of the injuries (n=11,655, 49%) resulted in restricted days, and more than a quarter of the injuries (n=6,406, 27%) resulted in lost days. Likewise, at Location 3, nearly half of the injuries (n=459) resulted in restricted days, but only 15 percent (n=139) led to lost days. Overall, 40 percent of the injuries from these 6 locations resulted in restricted days (n=14,684), and 21 percent (n=7,654) resulted in lost days.

Fifty-three specific body parts were identified for 36,169 injuries. Injuries to 6 body parts accounted for more than 55 percent of those injuries (n=20,212). The body parts most often injured were back (n=4885, 13.4%), fingers (n=4609, 12.7%), shoulders (n=2901, 8.0%), knees (n=2812, 7.8%), wrists (n=2720, 7.5%), and elbows (n=2292, 6.3%) (Table 3.3). Injuries to women accounted for 24 percent of all injuries, and represented about one-fifth to one-quarter of injuries to these body parts. However, women suffered 38 percent (n=1020) of all wrist injuries.

Table 3.3. Injured body part by gender.

	All Injuries with body part specified		Percent of injured body part	
Body Parts	n	% all injuries	female	male
Back	4882	13.5%	20.9%	79.1%
Elbow	2291	6.3%	26.8%	73.2%
Finger	4607	12.7%	19.7%	80.3%
Knee	2811	7.8%	21.6%	78.4%
Shoulder	2901	8.0%	25.6%	74.4%
Wrist	2720	7.5%	37.5%	62.5%
All others	15943	44.1%	22.6%	77.4%
Total injuries	36169			

Twenty-eight injury dispositions ("nature of injury") were specified in 34,219 injuries. The nature of injury most often cited included sprains, strains (n=9973, 29.1%); cut, laceration, puncture (n=5897, 17.2%); pain, unspecified cause (n=4502, 13.2%); and inflamed joints, tendons, muscles (n=3787, 11.1%), accounting for over 65 percent of all injuries (Table 3.4). Although men experienced three-quarters of all injuries, they suffered 85 percent (n=5029) of the cut/laceration/puncture injuries.

Table 3.4. Nature of injury by gender.

	All Injuries with nature specified		Percent of injury dispositions	
	n	% all injuries	female	male
Cut, laceration, puncture	5897	17.2%	15%	85%
Inflamed joints, tendons, muscles	3787	11.1%	29%	71%
Sprains, strains	9973	29.1%	23%	77%
Pain, unspecified cause	4502	13.2%	28%	72%
All other injury dispositions	11214	32.8%	24%	76%
Total injuries (with nature specified)	34219			

Seventy-seven types of injuries were identified in 36,611 injuries. Eight incident types were seen in half of the occupational injuries (n=18,172). The types of incidents that most frequently resulted in occupational injuries were overexertion in lifting objects (n=1563, 7.7%); repetitive motion or tasks [not elsewhere classified] (n=2442, 6.7%); repetitive motion in shop operations (n=2191, 6.0%); unclassified, insufficient data (n=2141, 5.8%); striking a stationary object (n=2045, 5.6%); rub, cut, abraded, or punctured by objects being handled (n=1760, 4.8%); fall to the walkway or working surface (n=1693, 4.6%); overexertion in pushing or pulling objects (n=1563, 4.3%); and rubbed, abraded, cut, or punctured [not elsewhere classified] (n=1505, 4.1%) (Table 3.5). For most types of injuries, women sustained fewer than one quarter of those injuries, but they are few in the workplace. However, 42 percent (n=716) of falls occurred among women, and 35 percent (n=850) of repetitive motion (not elsewhere classified) injuries were sustained by females. Unfortunately, without additional information about the gender make-up of the work force, inferences about these results cannot be made.

Table 3.5. Type of injury by gender.

	All Injuries with type specified		Percent of type of injury	
	n	% all injuries	female	male
Struck against object	2045	5.6%	18%	82%
Fall to walkway/work surface	1693	4.6%	42%	58%
Rubbed, abraded, cut, puncture by object	1760	4.8%	21%	79%
Rubbed, abraded, cut, puncture NEC	1505	4.1%	12%	88%
Overexertion in lifting	2832	7.7%	22%	78%
Overexertion in pushing/pulling	1563	4.3%	24%	76%
Repetitive motion in shop operations	2191	6.0%	16%	84%
Repetitive motion NEC	2442	6.7%	35%	65%
Unclassified, insufficient data	2141	5.8%	24%	76%
Total injuries	36611			

Nearly three quarters of the job hazards (n=8,846) involved in occupational injuries were classified as "no hazardous condition." Over 200 records had a hazard code of 999, but that code is not officially used by the company and was not listed in the table of hazard codes. In describing the unsafe acts that were considered the cause of occupational injury, the most often-cited code was 990, "No unsafe act" (34.1%). Of the remaining unsafe acts identified, 4813 injuries resulted from four unsafe acts: inattention to footings and surroundings (19.7%); failure to use handling aids or obtain help (9.2%); failure to use adequate/proper personal protective equipment (6.3%); and failure to use available personal protective equipment (5.4%). Documentation regarding unsafe acts and hazardous conditions was not available for two-thirds of the injuries.

The Pay Code variable appropriately divided workers into broad labor categories. Within each pay code were numerous job titles differentiating the type of work actually performed, the experience of the worker, and (to some extent) the education and responsibilities of the worker. More than one-third of the injuries (n=12,101) were experienced by employees working in 18 job titles (Table 3.6). Sheet Metal Assemblers & Riveters had the greatest frequency of injuries (n=2174, 5.94%). Compared to employees classified as Sheet Metal Assemblers & Riveters, employees with other job titles had reduced risk of recordable injury, restricted days, and lost days (AC/ORD Assembly Tech, Assembler – Sheetmetal A, Composite Fabricator, Electrical Technician). Employees in most job titles had increased or decreased risk consistently for recordable injury, restricted days, and lost days, except for Structural Mechanics who were at increased risk for recordable injuries and injuries with restricted days, but had decreased risk for lost days. Employees who worked as Installer Internal Assembly B had more than twice the risk of recordable injury, restricted days, and lost days compared to those whose job title was Sheet Metal Assembler & Riveter.

Table 3.6. Odds ratios for risk of recordable injury, restricted days, and lost days.

	Freq.	% of Total	Recordable Injury		Restricted Days		Lost Days	
			OR	p	OR	p	OR	p
SHEET METAL ASSEMBLER & RIVETER	2174	5.94	1.000		1.000		1.000	
AC/ORD ASSEMBLY TECH	308	0.84	**0.145**	**0.000**	**0.154**	**0.000**	**0.179**	**0.000**
AIRCRAFT TEST TECH A	312	0.85	**1.489**	**0.003**	**1.662**	**0.000**	**1.565**	**0.000**
ASSEMBLER - SHEETMETAL A	644	1.76	**0.566**	**0.000**	**0.440**	**0.000**	**0.384**	**0.000**
ASSEMBLER INSTALLER ELECTRICAL SYSTEMS B	599	1.64	**1.677**	**0.000**	**2.082**	**0.000**	**1.654**	**0.000**
ASSEMBLER INSTALLER GENERAL B	1160	3.17	**1.480**	**0.000**	**1.734**	**0.000**	**1.841**	**0.000**
ASSEMBLER INSTALLER STRUCTURES B	1310	3.58	**1.474**	**0.000**	**1.600**	**0.000**	**2.019**	**0.000**
ASSEMBLER INSTALLER WING STRUCTURES B	787	2.15	**1.992**	**0.000**	**2.194**	**0.000**	**1.463**	**0.000**
ASSEMBLER WIRE GROUP B	758	2.07	**1.419**	**0.000**	**1.987**	**0.000**	**1.472**	**0.000**
COMPOSITE FABRICATOR	345	0.94	**0.711**	**0.004**	**0.548**	**0.000**	**0.480**	**0.000**
ELECTRICAL TECHNICIAN	678	1.85	**0.182**	**0.000**	**0.098**	**0.000**	**0.078**	**0.000**
INSTALLER INTERNAL ASSEMBLY B	357	0.98	**2.369**	**0.000**	**2.227**	**0.000**	**2.809**	**0.000**
INTEGRAL FUEL CELL ASSEMBLY B	507	1.38	**1.398**	**0.003**	**1.323**	**0.003**	**1.574**	**0.000**
MACHINE REPAIR MECHANIC A	387	1.06	**1.422**	**0.001**	**1.608**	**0.000**	1.049	0.660
MATERIALS PROCUREMENT/REQUISITION FACILITATOR B	829	2.26	0.955	0.680	1.042	0.693	0.849	0.214
MECHANIC GENERAL	417	1.14	**1.409**	**0.000**	**1.580**	**0.000**	**1.395**	**0.000**
MECHANIC STRUCTURAL	300	0.82	**1.411**	**0.000**	**1.265**	**0.002**	**0.711**	**0.001**
TOOL MAKER C	311	0.85	**1.463**	**0.004**	**1.290**	**0.026**	**1.404**	**0.008**
ALL NON-SHEET METAL ASSEMBLER & RIVETER	34433	94.06	**1.399**	**0.000**	**1.974**	**0.000**	**1.774**	**0.000**

Analysis of all injuries by job title would have been onerous; therefore, five job titles with the greatest injury rates, which were all in the Production & Maintenance pay code and accounted for 16.9 percent of all injuries, were selected (Table 3.7). Sheet metal assemblers and riveters were both the oldest group and the group with the greatest tenure, while assembler/installer wing structures B workers were the youngest and newest to the company (of these 5 job titles). Repetitive motion injuries among sheet metal assemblers & riveters (n=579) accounted for 26 percent of all repetitive motion injuries in the company, more than any other job title. Sheet metal assemblers & riveters also sustained more injuries per employee (mean=3.3) than any of the five job titles analyzed. Injuries to female workers were most concentrated in jobs assembling electrical wire harnesses (Assembler Wire Group B); six percent of all injured female workers had this job title. Structures installer assemblers (Assembler Installer Structures B) had more than 12 percent of the repetitive motion injuries during the five-year period examined. Nearly 15 percent of all injuries to the back were among workers with two job titles: Assembler Installer General B and Assembler Installer Structures B.

In the jobs with the greatest number of injuries, a highest percentage of injuries occurred among employees lacking tenure (Table 3.8). For both assembler Installer Structures B and Assembler Installer Wing Structures B, younger males with less tenure were responsible for more than half of all repetitive motion, rubbed/abraded/cut/puncture, and overexertion injuries associated with their job titles.

Female workers in the assembler wire group B job suffered more than half of the overexertion injuries, repetitive motion injuries, and cut/abrasion/puncture injuries in that job title (Figures 3.2 - 3.4). Women with this job title sustained more injury than women with any other job title. However, without information about the number of males and females working within specific job titles, further interpretation is not possible.

Table 3.7. Characteristics of injured employees and injuries by job title.

	ASSEMBLER INSTALLER GENERAL B		ASSEMBLER INSTALLER STRUCTURES B		ASSEMBLER INSTALLER WING STRUCTURES B		ASSEMBLE R WIRE GROUP B		SHEET METAL ASSEMBLER & RIVETER		All employees
Employees by gender	freq	% of all inj	freq	% of all inj	freq	% of all inj	freq	% of all inj	freq	% of all inj	
Female	54	1.1%	24	0.5%	35	0.7%	305	6.0%	121	2.4%	5120
Male	535	3.4%	623	4.0%	391	2.5%	152	1.0%	529	3.4%	15618
Mean number of injuries per injured person with this job title	2.1		2.1		1.9		1.7		3.3		1.8

	ASSEMBLER INSTALLER GENERAL B		ASSEMBLER INSTALLER STRUCTURES B		ASSEMBLER INSTALLER WING STRUCTURES B		ASSEMBLE R WIRE GROUP B		SHEET METAL ASSEMBLER & RIVETER		All injuries
Number of injuries	1160		1310		787		758		2174		36607
Mean age at time of injury	47.3		45.1		44.7		48.7		49.7		48.1
Mean tenure at time of injury	16.4		14.0		13.7		14.0		22.4		17.5
Type of injury	freq	% of all inj	freq	% of all inj	freq	% of all inj	freq	% of all inj	freq	% of all inj	
Struck against stationary object	80	3.9%	131	6.4%	41	2.0%	30	1.5%	17	0.8%	2045
Fall to walkway or working surface	25	1.5%	28	1.7%	16	0.9%	44	2.6%	14	0.8%	1693
Rubbed, abraded, cut or punctured by objects being handled	46	2.6%	70	4.0%	29	1.6%	20	1.1%	118	6.7%	1760
Rubbed, abraded, cut or punctured (NEC)	43	2.8%	44	2.9%	45	3.0%	3	0.2%	246	16.2%	1514
Overexertion in lifting objects	93	3.3%	46	1.6%	41	1.4%	50	1.8%	69	2.4%	2832
Overexertion in pushing/pulling objects	47	3.0%	26	1.7%	32	2.0%	53	3.4%	65	4.2%	1563
Repetitive motion or tasks in shop operations	85	3.9%	232	10.6%	155	7.1%	39	1.8%	482	22.0%	2191
Repetitive motion or tasks (NEC)	60	2.5%	38	1.6%	28	1.1%	111	4.5%	97	4.0%	2442
Unclassified, insufficient data	63	2.9%	89	4.1%	30	1.4%	25	1.2%	81	3.8%	2150
Body part injured											
Elbow	65	2.8%	75	3.3%	63	2.7%	67	2.9%	218	9.5%	2292
Wrist	47	1.7%	81	3.0%	53	1.9%	107	3.9%	208	7.6%	2720
Fingers	94	2.0%	140	3.0%	86	1.9%	61	1.3%	522	11.3%	4609
Back	217	7.5%	203	7.0%	125	4.3%	86	3.0%	127	4.4%	2885
Shoulder	105	3.6%	118	4.1%	69	2.4%	104	3.6%	205	7.1%	2901
Knee	154	5.5%	123	4.4%	68	2.4%	22	0.8%	102	3.6%	2812

Table 3.8. Injuries by selected job titles.

ASSEMBLER INSTALLER GENERAL B																
	Female								Male							
	≤48 y/o				>48 y/o				≤48 y/o				>48 y/o			
	≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure	
Repetitive motion or tasks (all)	5	3%	2	1%	4	3%	2	1%	47	32%	28	19%	28	19%	29	20%
Rubbed, abraded, cut, puncture (all)	4	5%	1	1%	1	1%	1	1%	36	40%	10	11%	12	14%	24	27%
Overexertion (lifting, pushing/pulling)	7	5%	0	0%	2	1%	2	1%	44	31%	32	23%	22	16%	31	22%

ASSEMBLER INSTALLER STRUCTURES B																
	Female								Male							
	≤48 y/o				>48 y/o				≤48 y/o				>48 y/o			
	≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure	
Repetitive motion or tasks (all)	6	2%	1	0%	0	0%	0	0%	152	56%	32	12%	52	19%	27	10%
Rubbed, abraded, cut, puncture (all)	2	2%	1	1%	0	0%	0	0%	68	60%	12	11%	21	18%	10	9%
Overexertion (lifting, pushing/pulling)	5	7%	0	0%	1	1%	1	1%	38	53%	8	11%	11	15%	8	11%

Table 3.8, cont. Injuries by selected job titles.

	ASSEMBLER INSTALLER WING STRUCTURE B															
	Female								Male							
	≤48 y/o				>48 y/o				≤48 y/o				>48 y/o			
	≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure	
Repetitive motion or tasks (all)	10	5%	0	0%	2	1%	1	1%	102	56%	23	13%	34	19%	9	5%
Rubbed, abraded, cut, puncture (all)	2	2%	0	0%	0	0%	0	0%	38	51%	11	15%	18	24%	5	7%
Overexertion (lifting, pushing/pulling)	2	2%	0	0%	0	0%	1	1%	43	59%	10	14%	11	15%	6	8%

	ASSEMBLER WIRE GROUP B															
	Female								Male							
	≤48 y/o				>48 y/o				≤48 y/o				>48 y/o			
	≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure	
Repetitive motion or tasks (all)	30	20%	12	8%	37	25%	24	16%	28	19%	5	3%	10	7%	4	3%
Rubbed, abraded, cut, puncture (all)	8	35%	0	0%	4	17%	4	17%	5	22%	1	4%	1	4%	0	0%
Overexertion (lifting, pushing/pulling)	15	15%	6	6%	30	29%	17	17%	13	13%	4	4%	13	13%	5	5%

	SHEET METAL ASSEMBLER & RIVETER															
	Female								Male							
	≤48 y/o				>48 y/o				≤48 y/o				>48 y/o			
	≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure		≤17 years tenure		>17 years tenure	
Repetitive motion or tasks (all)	7	1%	24	4%	16	3%	116	20%	100	17%	142	25%	27	5%	147	25%
Rubbed, abraded, cut, puncture (all)	5	1%	9	3%	5	1%	58	16%	66	18%	74	20%	24	7%	123	34%
Overexertion (lifting, pushing/pulling)	3	2%	5	4%	2	2%	3	2%	29	22%	43	32%	10	8%	39	29%

Descriptive results of employees

The second evaluation looked at employees. The 36,611 injuries were experienced by 20,738 employees (mean 1.77 injuries per employee). Nearly two-thirds of the injuries (n=23,784) were among employees with more than one injury in the five-year period. Among employees with more than one injury in this five-year period, the mean number of injuries was 3, with a range of 2 to 28 injuries.

Employees were distributed into 6 pay codes (Table 3.9). The broad pay code of Production & Manufacturing (P&M) accounted for three-quarters of employees with injuries (n=15,923), though they accounted for less than one-quarter of the work force (n=34,000). The P&M 5-year injury rate per 100 employees was fairly similar for employees with one injury (25.5) and more than one injury (21.3), but was substantially greater than all other pay codes. Conversely, all pay codes except P&M had higher injury rates among employees with one injury compared to employees with more than one injury.

Location 6 employed about 61 percent of the workers during this 5-year period, but their injury rates were not substantially greater than most other sites (Table 3.9). Locations 1 and 2 were fairly balanced in the rate of employees with one injury (16.0, 9.8) and more than one injury (13.4, 8.1). All other locations had far greater rates of employees with one injury (22.2-25.9) versus employees with more than one injury (10.6-14.5).

Table 3.9. Distribution of injured employees by pay code and location at 6 sites.

	Employees with 1 injury		**Employees with >1 injury**		**All injured employees**		**Company Population (2006)**	
	Freq.	***Inj/100 empl.****	**Freq.**	***Inj/100 empl.****	**Freq.**	***Inj/100 empl.****	**n**	***%***
Engineer	770	*2.2*	83	*0.2*	853	*2.4*	35,300	*23.5%*
P&M	8677	*25.5*	7246	*21.3*	15923	*46.8*	34,000	*22.7%*
Manager	358	*2.4*	29	*0.2*	387	*2.6*	15,000	*10.0%*
Non-exempt	1394	*8.6*	343	*2.0*	1737	*10.7*	16,300	*10.9%*
Other	17	*0.2*	1	*0.0*	18	*0.2*	10,800	*7.2%*
Exempt	1612	*4.2*	208	*0.5*	1820	*4.7*	38,600	*25.7%*
Total	12828	*8.6*	7910	*5.3*	20738	*13.8*	150,000	*100.0%*

*2006 population

	Employees with 1 injury		**Employees with >1 injury**		**All injured employees**		**Mean FTE** 2002-2006	
	Freq.	***Inj/100 FTE***	**Freq.**	***Inj/100 FTE***	**Freq.**	***Inj/100 FTE***	**n**	***%***
Location 1	733	*15.7*	614	*13.4*	1347	*29.3*	4593	*6.9%*
Location 2	1398	*9.8*	1150	*8.1*	2548	*17.9*	14225	*21.4%*
Location 3	426	*23.9*	209	*11.7*	635	*35.6*	1785	*2.7%*
Location 4	922	*22.2*	604	*14.5*	1526	*36.7*	4158	*6.2%*
Location 5	295	*25.9*	121	*10.6*	416	*36.5*	1140	*1.7%*
Location 6	9041	*22.2*	5212	*12.8*	14253	*35.1*	40650	*61.1%*
Total	12815	*19.3*	7910	*11.9*	20725	*31.1*	66551	*100.0%*

A slightly greater percentage of men were in the group with more than one injury (n=6168, 78%), compared to the group with one injury (n=9438, 74%) (Table 3.10). Differences in percent of male and female workers with one or more than one injury were not extreme in most pay codes and locations. However, female workers at Locations 4 and 6 sustained 30 and 29 percent, respectively, of the injuries among workers with just one injury (n=274, 2590). Thirty-five percent (n=209) of injured female employees at Location 4 suffered more than one injury.

Employees with one and more than one injury showed similar patterns in males and females at most work locations. Among employees with more than one injury, more than three-quarters were men in all locations except Location 4, where one third were women (Table 3.10). Among employees with just one injury, more than one-quarter were women in Locations 4 and 6.

Table 3.10. Demographics of injured employees.

	All injured employees n=20727				**Employees with 1 Injury** n=12817				**Employees with >1 Injury** n=7910			
	female		male		female		male		female		male	
	n	%	n	%	n	%	n	%	n	%	n	%
Engineer	164	19%	689	81%	142	18%	628	82%	22	27%	61	73%
P&M	3057	19%	12866	81%	1613	19%	7064	81%	1444	20%	5802	80%
Manager	97	25%	290	75%	89	25%	269	75%	8	28%	21	72%
Non-exempt	814	47%	923	53%	666	48%	728	52%	148	43%	195	57%
Other	5	28%	13	72%	5	29%	12	71%	0	0%	1	100%
Exempt	983	54%	837	46%	863	54%	749	46%	120	58%	88	42%
	female		male		female		male		female		male	
	n	%	n	%	n	%	n	%	n	%	n	%
Location 1	206	*15%*	1141	*85%*	123	*17%*	610	*83%*	83	*14%*	531	*86%*
Location 2	509	*20%*	2039	*80%*	305	*22%*	1093	*78%*	204	*18%*	946	*82%*
Location 3	68	*11%*	567	*89%*	46	*11%*	380	*89%*	22	*11%*	187	*89%*
Location 4	483	*32%*	1043	*68%*	274	*30%*	648	*70%*	209	*35%*	395	*65%*
Location 5	53	*13%*	363	*87%*	39	*13%*	256	*87%*	14	*12%*	107	*88%*
Location 6	3800	*27%*	10453	*73%*	2590	*29%*	6451	*71%*	1210	*23%*	4002	*77%*
Total	5119	*25%*	15606	*75%*	3377	*26%*	9438	*74%*	1742	*22%*	6168	*78%*
1st shift	4104	*26%*	11522	*74%*	2790	*29%*	6953	*71%*	1314	*22%*	4569	*78%*
2nd shift	925	*21%*	3548	*79%*	532	*20%*	2133	*80%*	393	*22%*	1415	*78%*
3rd shift	88	*14%*	540	*86%*	53	*13%*	356	*87%*	35	*16%*	184	*84%*
Hearing loss	1613	*14%*	9800	*86%*	866	*14%*	5445	*86%*	747	*15%*	4355	*85%*
	female		male		female		male		female		male	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Age	48.4	49.1	47.9	47.6	48	48.6	47.6	47.8	49.4	49.9	48.2	48.0
Tenure	15.7	16.1	17.5	17.2	15.3	15.6	17	16.8	16.6	16.9	18.4	17.8
Commute (mi)	17.6	14.2	20.0	15.7	17.6	14.3	20.0	15.8	17.5	13.8	20.1	15.4
Commute time (min)	25.2	21.0	27.9	23.0	25.3	22.0	27.8	23	25.1	21	28.0	23
Report delay*	24.8	4.0	21.1	4.0	26.5	5.0	21.4	4.0	21.5	4.0	20.6	3.0
Restricted days*	38.7	22.0	33.6	18.0	38.5	22.0	32.9	18.0	39.0	21.0	34.6	17.0
Lost days*	63.0	22.0	53.9	18.0	61.2	21.0	56.6	18.0	66.4	24.0	50.1	18.0

*when days >0

Approximately three-quarters of all injured employees with one and more than one injury worked first shift (Table 3.10); however, further comparison of injured employees by gender and shift could not be made because employee population information about these variables was unavailable.

Hearing test results were available for 19,582 injured employees. Although men represented three-quarters of the injuries, 85 percent of injured employees with hearing losses were male (Table 3.10). Men and women who had more than one injury were slightly older and had longer tenure than those who had just one injury. In both groups males were slightly younger than their female counterparts.

There was no difference in the median commuting time (less than 30 minutes) for men and women with one and more than one injury (Table 3.10). The median commuting distance was slightly less for women than for men, though less than about 20 miles for both groups.

Men who sustained lost days following an occupational injury had fewer lost days, on average, than women, among workers with one injury and more than one injury (Table 3.10). Men who had more than one injury lost a mean 50.1 days, but men with just one injury lost a mean 56.6 days. Women, on the other hand, lost more days when they had more than one injury (mean=66.4), compared to those with just one injury (mean=61.2). Restricted days followed a similar pattern, although the differences were not as stark.

Multivariate results

The previous section described the data. The next section will proceed with the multivariate analysis to address the research questions I posed. First, *what factors influence occupational injury severity in a large manufacturing company?*

Null Hypothesis 1*: There are no differences in risk factors affecting recordability of occupational injuries among employees in a large manufacturing company, after adjusting for pay code, union location, and number of injuries.*

Descriptive statistics from most work sites were fairly consistent from year to year, with the exception of Location 3. The safety program for that site was not well-established before 2004. In order to determine whether site differences really existed, data were analyzed twice: 2002 through 2006, and 2004 through 2006. While substantial over-lap existed, the results were different for the two time periods.

This null hypothesis was rejected. A number of variables were found to be significant risk factors for recordable injuries in both the three-year and five-year analyses (Table 3.11). Repetitive motion in shop operations put employees at double the risk for having their injury recorded on the OSHA log. Injuries to wrist and shoulder also doubled the risk of recordable injury. Inflamed joints, tendons, muscles, and sprain/strain injuries were more than twice as likely to be recordable. Compared to workers in non-union locations, working in a union location placed workers at a 12-fold increased risk of having an injury recorded on the OSHA log (in the five-year analysis). However, the increased risk was less than three-fold in the three-year analysis, and raises questions about the quality of the data from 2002 and 2003.

Table 3.11. Factors influencing recordability of occupational injury.

Outcome: recordable injury	2002-2006						2004-2006					
	Location, pay code			Union/P&M			Location, pay code			Union/P&M		
	Number of records: 11306			Number of records: 11306			Number of records: 5706			Number of records: 5708		
	Number of employees: 6355			Number of employees: 6355			Number of employees: 3660			Number of employees: 3662		
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Type of injury												
All other types of injury	1.000			1.000			1.000			1.000		
Struck against object	**0.736**	**0.000**	**0.662, 0.817**	0.871	0.104	0.738, 1.029	**0.685**	**0.000**	**0.597, 0.787**	**0.718**	**0.000**	**0.628, 0.822**
Fall to walkway/work surface	1.008	0.903	0.892, 1.139	0.936	0.496	0.774, 1.132	1.015	0.857	0.866, 1.189	0.966	0.661	0.828, 1.127
Rubbed, abraded, cut, puncture by object	**0.752**	**0.000**	**0.664, 0.864**	**0.711**	**0.009**	**0.550, 0.919**	**0.755**	**0.001**	**0.639, 0.893**	**0.788**	**0.004**	**0.668, 0.928**
Rubbed, abraded, cut, puncture NEC*	**0.584**	**0.000**	**0.510, 0.669**	**0.591**	**0.000**	**0.460, 0.760**	**0.596**	**0.000**	**0.491, 0.723**	**0.611**	**0.000**	**0.506, 0.738**
Overexertion in lifting	**1.588**	**0.000**	**1.398, 1.805**	**1.606**	**0.000**	**1.359, 1.897**	**1.628**	**0.000**	**1.375, 1.927**	**1.614**	**0.000**	**1.368, 1.904**
Overexertion in pushing/pulling	**1.455**	**0.000**	**1.248, 1.698**	**1.692**	**0.000**	**1.375, 2.083**	**1.384**	**0.002**	**1.130, 1.695**	**1.491**	**0.000**	**1.221, 1.819**
Repetitive motion in shop operations	**2.091**	**0.000**	**1.797, 2.433**	**1.968**	**0.000**	**1.516, 2.554**	**1.940**	**0.000**	**1.578, 2.385**	**2.063**	**0.000**	**1.686, 2.524**
Repetitive motion NEC*	**1.792**	**0.000**	**1.574, 2.041**	**1.929**	**0.000**	**1.596, 2.332**	**1.632**	**0.000**	**1.379, 1.933**	**1.592**	**0.000**	**1.351, 1.876**
Unclassified, insufficient data	**0.383**	**0.000**	**0.330, 0.444**	**0.483**	**0.000**	**0.390, 0.598**	**0.581**	**0.000**	**0.462, 0.730**	**0.553**	**0.000**	**0.442, 0.691**
Body part injured												
All other body parts	1.000			1.000			1.000			1.000		
Elbow	**1.425**	**0.000**	**1.248, 1.625**	**1.303**	**0.008**	**1.071, 1.586**	**1.496**	**0.000**	**1.260, 1.776**	**1.419**	**0.000**	**1.199, 1.679**
Wrist	**1.958**	**0.000**	**1.743, 2.199**	**1.499**	**0.000**	**1.261, 1.781**	**2.106**	**0.000**	**1.805, 2.457**	**1.911**	**0.000**	**1.645, 2.220**
Fingers	**1.119**	**0.013**	**1.024, 1.222**	0.970	0.699	0.830, 1.133	**1.171**	**0.008**	**1.042, 1.316**	1.117	0.058	0.996, 1.253
Back	**1.776**	**0.000**	**1.604, 1.966**	**2.015**	**0.000**	**1.749, 2.321**	**1.750**	**0.000**	**1.532, 1.999**	**1.794**	**0.000**	**1.574, 2.045**
Shoulders	**2.032**	**0.000**	**1.786, 2.311**	**1.972**	**0.000**	**1.653, 2.354**	**2.268**	**0.000**	**1.916, 2.683**	**2.238**	**0.000**	**1.896, 2.640**
Knee	**1.636**	**0.000**	**1.470, 1.821**	**1.747**	**0.000**	**1.507, 2.026**	**1.606**	**0.000**	**1.400, 1.841**	**1.672**	**0.000**	**1.461, 1.913**
Unsafe act												
All other unsafe acts	1.000			1.000			1.000			1.000		
Fail to use available PPE**	0.838	0.066	0.695, 1.012	0.877	0.372	0.657, 1.170	0.771	0.057	0.590, 1.007	**0.734**	**0.022**	**0.564, 0.957**
Fail to use adequate/proper PPE**	**1.406**	**0.001**	**1.154, 1.712**	**2.035**	**0.000**	**1.394, 2.971**	**1.765**	**0.000**	**1.337, 2.331**	**1.688**	**0.000**	**1.281, 2.224**
Fail to use material handling aids/get help	1.212	0.057	0.995, 1.478	1.249	0.103	0.956, 1.632	1.071	0.617	0.818, 1.402	1.085	0.553	0.829, 1.418
Inattention to footings, surroundings	0.993	0.903	0.881, 1.118	0.967	0.723	0.801, 1.166	0.999	0.994	0.849, 1.177	1.001	0.988	0.851, 1.178
No unsafe act	**0.793**	**0.000**	**0.712, 0.883**	**0.742**	**0.000**	**0.627, 0.877**	**0.857**	**0.044**	**0.737, 0.996**	**0.848**	**0.027**	**0.733, 0.981**
Nature of injury												
All other injury dispositions	1.000			1.000			1.000			1.000		
Cut, laceration, puncture	**0.784**	**0.000**	**0.716, 0.859**	**0.775**	**0.005**	**0.649, 0.926**	**0.842**	**0.004**	**0.748, 0.947**	**0.778**	**0.000**	**0.693, 0.874**
Inflamed joints, tendons, muscles	**2.988**	**0.000**	**2.632, 3.391**	**2.529**	**0.000**	**2.109, 3.034**	**2.868**	**0.000**	**2.432, 3.383**	**2.858**	**0.000**	**2.432, 3.359**
Sprains, strains	**2.219**	**0.000**	**2.026, 2.376**	**1.746**	**0.000**	**1.559, 1.955**	**2.234**	**0.000**	**2.013, 2.478**	**2.102**	**0.000**	**1.899, 2.327**
Pain, unspecified cause	**1.531**	**0.000**	**1.394, 1.683**	**1.399**	**0.000**	**1.221, 1.604**	**1.446**	**0.000**	**1.273, 1.642**	**1.460**	**0.000**	**1.288, 1.654**

Table 3.11, cont. Factors influencing recordability of occupational injury.

Outcome: recordable injury	2002-2006						2004-2006					
	location, pay code			union			location, pay code			union		
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Hazardous condition												
All other hazardous conditions	1.000			1.000			1.000			1.000		
Slippery	0.997	0.986	0.754, 1.320	1.136	0.593	0.712, 1.813	1.017	0.932	0.690, 1.500	0.833	0.338	0.573, 1.211
Worn, cracked, frayed, broken	1.068	0.696	0.766, 1.489	1.355	0.319	0.746, 2.462	1.186	0.444	0.767, 1.834	1.047	0.834	0.681, 1.608
Excessive noise	**2.055**	**0.000**	**1.445, 2.923**	**0.274**	**0.003**	**0.116, 0.644**	**2.233**	**0.002**	**1.341, 3.718**	**1.891**	**0.013**	**1.141, 3.133**
Lack of safe access	1.060	0.750	0.739, 1.521	1.120	0.658	0.678, 1.851	1.530	0.484	0.464, 5.046	1.145	0.822	0.351, 3.735
Hazardous method, procedure	1.039	0.805	0.768, 1.406	0.896	0.578	0.609, 1.318	**0.164**	**0.003**	**0.049, 0.546**	**0.133**	**0.001**	**0.040, 0.439**
Hazardous condition NEC*	1.058	0.282	0.955, 1.173	**0.866**	**0.038**	**0.756, 0.992**	0.927	0.329	0.796, 1.079	**0.732**	**0.000**	**0.650, 0.824**
No hazardous condition	**0.634**	**0.007**	**0.455, 0.884**	0.671	0.131	0.400, 1.126	**0.514**	**0.004**	**0.327, 0.809**	**0.494**	**0.002**	**0.315, 0.774**
Location												
Location 6	1.000			N/A			1.000			N/A		
Location 1	**0.550**	**0.000**	**0.490, 0.618**	N/A			**0.726**	**0.000**	**0.621, 0.848**	N/A		
Location 2	**0.583**	**0.000**	**0.524, 0.648**	N/A			**0.663**	**0.000**	**0.570, 0.772**	N/A		
Location 3	**1.511**	**0.000**	**1.266, 1.805**	N/A			**1.565**	**0.000**	**1.265, 1.935**	N/A		
Location 4	**0.156**	**0.000**	**0.140, 1.175**	N/A			**0.134**	**0.000**	**0.116, 0.154**	N/A		
Location 5	**0.503**	**0.000**	**0.418, 0.604**	N/A			**0.506**	**0.000**	**0.397, 0.646**	N/A		
Pay code												
Exempt	**1.000**			N/A			1.000			N/A		
Engineer	**0.800**	**0.019**	**0.664, 0.963**	N/A			0.851	0.186	0.669, 1.081	N/A		
Production & Maintenance	**1.397**	**0.000**	**1.248, 1.564**	N/A			**1.449**	**0.000**	**1.242, 1.692**	N/A		
Manager	1.032	0.808	0.802, 1.327	N/A			1.032	0.850	0.747, 1.426	N/A		
Non-Exempt	1.122	0.123	0.969, 1.298	N/A			1.087	0.416	0.889, 1.329	N/A		
Gender												
Female	1.000			1.000			1.000			1.000		
Male	-	NS		**2.669**	**0.000**	**2.037, 3.498**	-	NS		**1.906**	**0.006**	**1.205, 3.015**
Union												
P&M worker, Location 3 & 4	N/A			1.000			N/A			1.000		
P&M worker, Location 1,2,5,6	N/A			**12.090**	**0.000**	**6.379, 22.911**	N/A			**2.748**	**0.000**	**2.404, 3.140**
Work shift												
1st shift				1.000			1.000			1.000		
2nd shift	-	NS		**1.190**	**0.005**	**1.053, 1.346**	-	NS		-	NS	
3rd shift	-	NS		1.046	0.769	0.773, 1.415	-	NS		-	NS	

Table 3.11, cont. Factors influencing recordability of occupational injury.

Outcome: recordable injury	**2002-2006**						**2004-2006**					
	location, pay code			**union**			**location, pay code**			**union**		
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Gender x Union interaction	N/A			**0.376**	**0.000**	**0.282, 0.501**	N/A			-	NS	
Reporting delay x Union interaction	N/A			**0.996**	**0.003**	**0.994, 0.999**	N/A			-	NS	
Age x Union interaction	N/A			**0.984**	**0.013**	**0.972, 0.997**	N/A			-	NS	
Number of injuries x Union interaction				-	NS					**1.621**	**0.000**	**1.336, 1.967**
Gender x Age interaction	-	NS		-	NS		-	NS		**0.990**	**0.032**	**0.981, 0.999**
Age x Number of injuries interaction	-	NS		**0.991**	**0.038**	**0.982, 1.000**	-	NS		**0.989**	**0.003**	**0.982, 0.996**
Age	**0.995**	**0.004**	**0.992, 0.999**	**1.012**	**0.042**	**1.000, 1.024**	**0.994**	**0.008**	**0.990, 0.999**	**1.009**	**0.040**	**1.000, 1.017**
Number of injuries (cumulative, log)	**0.876**	**0.000**	**0.837, 0.917**	1.346	0.178	0.873, 2.075	**0.917**	**0.004**	**0.865, 0.973**	1.029	0.874	0.719, 1.474
Tenure	**0.996**	**0.001**	**0.994, 0.998**	**0.989**	**0.000**	**0.986, 0.993**	-	NS		**0.993**	**0.000**	**0.990, 0.995**
Reporting delay	-	NS		**1.003**	**0.009**	**1.001, 1.006**	**1.001**	**0.021**	**1.000, 1.002**	**1.001**	**0.041**	**1.000, 1.002**

*Not Elsewhere Classified

**Personal Protective Equipment

Excessive noise was a risk factor for recordable injuries in all analyses except the five-year analysis limited to P&M workers, in which excessive noise actually put workers at decreased risk of recordable injury. Questionable record-keeping practices in 2002 and 2003 at one non-union location may explain the inconsistent results.

No employee characteristics were found to be risk factors for recordable injuries, but several employee characteristics significantly decreased the risk of recordability. Injury characteristics of rubbed, abraded, cut, puncture-type injuries cut the risk of recordability in half.

To determine which employee and work factors influence recordability of occupational injuries, injury characteristics were omitted in multivariate logistic regression analyses (Table 3.12). Factors that significantly increased the risk of an injury being recordable on the OSHA log, nevertheless had a mild effect (OR<1.2), with the exception of union affiliation, which increased the risk by more than 3.5 times. When analysis was limited to P&M workers, male employees were 1.75 times as likely to sustain a recordable injury compared to females; however, since the age-gender interaction term was significant, age is modifying this risk.

Several factors significantly decreased the risk of recordability. Employees working in Location 4 were 15 percent as likely to have a recordable injury as those working in Location 6. Likewise, employees working in Locations 1, 2, and 5 were about half as likely as workers in Location 6 to have a recordable injury.

Table 3.12. Employee/work factors influencing recordability of occupational injury.

Outcome: recordable injury	Location/pay code			Union/P&M		
	OR	p	95% CI	OR	p	95% CI
Age	1.000	0.820	0.995, 1.006	1.003	0.274	0.998, 1.009
Union	N/A			**3.537**	**0.000**	**3.285, 3.807**
Tenure	**0.993**	**0.000**	**0.991, 0.995**	**0.988**	**0.000**	**0.986, 0.990**
Reporting delay	**1.003**	**0.000**	**1.002, 1.003**	**1.003**	**0.000**	**1.002, 1.004**
Gender x Age interaction	**0.993**	**0.026**	**0.986, 0.999**	**0.987**	**0.000**	**0.981, 0.994**
Gender						
Female	1.000			1.000		
Male	1.300	0.112	0.940, 1.799	**1.758**	**0.000**	**1.283, 2.409**
Shift						
1st shift	1.000			1.000		
2nd shift	**0.915**	**0.004**	**0.862, 0.972**	**1.089**	**0.003**	**1.029, 1.154**
3rd shift	**1.192**	**0.028**	**1.019, 1.395**	1.153	0.071	0.988, 1.345
Number of injuries						
1 injury	1.000			1.000		
>1 injury	**0.994**	**0.004**	**0.876, 0.976**	**0.927**	**0.002**	**0.883, 0.974**
Location						
Location 6	1.000			N/A		
Location 1	**0.430**	**0.000**	**0.395, 0.469**	N/A		
Location 2	**0.507**	**0.000**	**0.475, 0.541**	N/A		
Location 3	1.173	0.058	0.995, 1.385	N/A		
Location 4	**0.140**	**0.000**	**0.128, 0.154**	N/A		
Location 5	**0.448**	**0.000**	**0.379, 0.530**	N/A		
Pay code						
Exempt	1.000			N/A		
Engineer	**0.679**	**0.000**	**0.570, 0.810**	N/A		
Production & Maintenance	**1.417**	**0.000**	**1.270, 1.582**	N/A		
Manager	0.933	0.574	0.732, 1.188	N/A		
Non-Exempt	1.089	0.224	0.949, 1.250	N/A		

Null Hypothesis 2*: There are no differences in risk factors affecting restricted days following occupational injuries among employees in a large manufacturing company, after adjusting for pay code, union location, and number of injuries.*

This null hypothesis was rejected. Injuries resulting in restricted days are considered more severe than injuries requiring only medical treatment. In both the five-year and the three-year analyses, injury characteristics significantly influenced the likelihood of restricted days (Table 3.13).

Table 3.13. Factors influencing restricted days following occupational injury.

Outcome: Restricted days (categorical)	2002-2006						2004-2006					
	Location, pay code			Union/P&M			Location, pay code			Union/P&M		
	Number of records:		11786	Number of records:		11788	Number of records:		6042	Number of records:		6010
	Number of employees:		6536	Number of employees:		6537	Number of employees:		3830	Number of employees:		3800
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Type of injury												
All other types of injury	1.000			1.000			1.000			1.000		
Struck against object	**0.841**	**0.003**	**0.749, 0.944**	0.920	0.149	0.821, 1.030	**0.812**	**0.012**	**0.690, 0.956**	0.898	0.167	0.771, 1.046
Fall to walkway/work surface	1.012	0.835	0.902, 1.136	0.955	0.415	0.854, 1.067	1.184	0.061	0.992, 1.412	0.968	0.658	0.837, 1.119
Rubbed, abraded, cut, puncture by object	0.875	0.107	0.743, 1.029	0.933	0.394	0.795, 1.094	0.962	0.733	0.772, 1.199	0.954	0.654	0.778, 1.170
Rubbed, abraded, cut, puncture NEC	**0.564**	**0.000**	**0.464, 0.684**	**0.544**	**0.000**	**0.450, 0.658**	**0.619**	**0.000**	**0.474, 0.809**	**0.668**	**0.002**	**0.520, 0.857**
Overexertion in lifting	**1.699**	**0.000**	**1.538, 1.875**	**1.762**	**0.000**	**1.601, 1.940**	**1.537**	**0.000**	**1.334, 1.772**	**1.659**	**0.000**	**1.458, 1.888**
Overexertion in pushing/pulling	**1.481**	**0.000**	**1.315, 1.669**	**1.677**	**0.000**	**1.493, 1.885**	**1.236**	**0.012**	**1.048, 1.458**	**1.458**	**0.000**	**1.248, 1.703**
Repetitive motion in shop operations	**1.869**	**0.000**	**1.670, 2.091**	**2.064**	**0.000**	**1.854, 2.299**	**1.794**	**0.000**	**1.522, 2.115**	**1.962**	**0.000**	**1.688, 2.280**
Repetitive motion NEC	**1.558**	**0.000**	**1.408, 1.725**	**1.621**	**0.000**	**1.471, 1.787**	**1.468**	**0.000**	**1.265, 1.705**	**1.478**	**0.000**	**1.297, 1.684**
Unclassified, insufficient data	**0.419**	**0.000**	**0.369, 0.477**	**0.371**	**0.000**	**0.327, 0.420**	**0.436**	**0.000**	**0.356, 0.534**	**0.399**	**0.000**	**0.335, 0.475**
Body part injured												
All other body parts	1.000			1.000			1.000			1.000		
Elbow	**1.392**	**0.000**	**1.245, 1.557**	**1.264**	**0.000**	**1.134, 1.409**	**1.534**	**0.000**	**1.303, 1.807**	**1.453**	**0.000**	**1.232, 1.648**
Wrist	**2.040**	**0.000**	**1.849, 2.251**	**1.783**	**0.000**	**1.622, 1.959**	**2.255**	**0.000**	**1.936, 2.626**	**1.929**	**0.000**	**1.700, 2.190**
Fingers	**1.677**	**0.000**	**1.515, 1.857**	**1.564**	**0.000**	**1.416, 1.727**	**1.830**	**0.000**	**1.587, 2.110**	**1.547**	**0.000**	**1.357, 1.763**
Back	**1.621**	**0.000**	**1.494, 1.760**	**1.713**	**0.000**	**1.581, 1.855**	**1.597**	**0.000**	**1.419, 1.798**	**1.653**	**0.000**	**1.484, 1.840**
Shoulders	**2.544**	**0.000**	**2.302, 2.811**	**2.517**	**0.000**	**2.284, 2.773**	**2.422**	**0.000**	**2.102, 2.790**	**2.404**	**0.000**	**2.117, 2.730**
Knee	**2.354**	**0.000**	**2.146, 2.581**	**2.477**	**0.000**	**2.263, 2.711**	**2.349**	**0.000**	**2.060, 2.678**	**2.413**	**0.000**	**2.142, 2.717**
Unsafe act												
All other unsafe acts	1.000			1.000			1.000			1.000		
Fail to use available PPE	**0.488**	**0.000**	**0.359, 0.664**	**0.414**	**0.000**	**0.308, 0.556**	**0.428**	**0.001**	**0.262, 0.699**	**0.266**	**0.000**	**0.174, 0.408**
Fail to use adequate/proper PPE	**0.343**	**0.000**	**0.249, 0.473**	**0.326**	**0.000**	**0.238, 0.446**	**0.224**	**0.000**	**0.144, 0.347**	**0.139**	**0.000**	**0.091, 0.213**
Fail to use material handling aids/get help	**1.559**	**0.000**	**1.330, 1.828**	**1.346**	**0.000**	**1.152, 1.572**	**1.653**	**0.000**	**1.302, 2.100**	0.988	0.907	0.805, 1.212
Inattention to footings, surroundings	**1.212**	**0.003**	**1.068, 1.375**	1.104	0.113	0.977, 1.247	**1.509**	**0.000**	**1.272, 1.791**	**0.809**	**0.002**	**0.705, 0.928**
No unsafe act	**0.758**	**0.000**	**0.679, 0.847**	**0.637**	**0.000**	**0.573, 0.707**	**0.829**	**0.012**	**0.717, 0.960**	**0.478**	**0.000**	**0.429, 0.532**
Nature of injury												
All other injury dispositions	1.000			1.000			1.000			1.000		
Cut, laceration, puncture	**0.583**	**0.000**	**0.521, 0.653**	**0.546**	**0.000**	**0.489, 0.610**	**0.677**	**0.000**	**0.581, 0.791**	**0.593**	**0.000**	**0.515, 0.685**
Inflamed joints, tendons, muscles	**2.418**	**0.000**	**2.194, 2.665**	**2.440**	**0.000**	**2.220, 2.683**	**2.261**	**0.000**	**2.270, 3.027**	**2.517**	**0.000**	**2.217, 2.858**
Sprains, strains	**2.425**	**0.000**	**2.257, 2.605**	**2.225**	**0.000**	**2.075, 2.385**	**2.759**	**0.000**	**2.485, 3.063**	**2.351**	**0.000**	**2.142, 2.580**
Pain, unspecified cause	**2.015**	**0.000**	**1.855, 2.188**	**2.070**	**0.000**	**1.909, 2.244**	**2.031**	**0.000**	**1.793, 2.301**	**2.035**	**0.000**	**1.817, 2.279**

Table 3.13, cont. Factors influencing restricted days following occupational injury.

Outcome: Restricted days (categorical)	2002-2006						2004-2006					
	Location, pay code			Union/P&M			Location, pay code			Union/P&M		
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Hazardous condition												
All other hazardous conditions	1.000			1.000			N/A			N/A		
Slippery	1.021	0.885	0.769, 1.356	**0.659**	**0.002**	**0.503, 0.862**	N/A			N/A		
Worn, cracked, frayed, broken	**1.197**	**0.318**	**0.841, 1.704**	1.017	0.923	0.721, 1.436	N/A			N/A		
Excessive noise	**0.928**	**0.000**	**0.034, 0.255**	**0.075**	**0.000**	**0.027, 0.206**	N/A			N/A		
Lack of safe access	1.159	0.381	0.833, 1.612	1.116	0.514	0.803, 1.549	N/A			N/A		
Hazardous method, procedure	1.061	0.637	0.830, 1.356	1.020	0.872	0.802, 1.297	N/A			N/A		
Hazardous condition NEC	1.065	0.237	0.959, 1.184	**0.693**	**0.000**	**0.635, 0.757**	N/A			N/A		
No hazardous condition	**0.557**	**0.002**	**0.388, 0800**	**0.457**	**0.000**	**0.320, 0.654**	N/A			N/A		
Location												
Location 6	1.000			N/A			1.000			N/A		
Location 1	**0.460**	**0.000**	**0.409, 0.517**	N/A			**0.523**	**0.000**	**0.444, 0.616**	N/A		
Location 2	**0.362**	**0.000**	**0.324, 0.404**	N/A			**0.434**	**0.000**	**0.377, 0.500**	N/A		
Location 3	0.999	0.998	0.858, 1.162	N/A			0.953	0.638	0.779, 1.165	N/A		
Location 4	**0.113**	**0.000**	**0.907, 0.132**	N/A			**0.178**	**0.000**	**0.119, 0.266**	N/A		
Location 5	**0.647**	**0.000**	**0.536, 0.782**	N/A			**0.717**	**0.010**	**0.557, 0.923**	N/A		
Pay Code												
Exempt	1.000			N/A			1.000			N/A		
Engineer	**0.703**	**0.001**	**0.567, 0.870**	N/A			0.570	0.105	0.289, 1.125	N/A		
Production & Maintenance	**2.155**	**0.000**	**1.916, 2.424**	N/A			**1.867**	**0.001**	**1.304, 2.671**	N/A		
Manager	**0.385**	**0.000**	**0.272, 0.546**	N/A			**0.373**	**0.005**	**0.187, 0.743**	N/A		
Non-Exempt	1.079	0.326	0.928, 1.257	N/A			0.919	0.715	0.583, 1.447	N/A		
Gender												
Female	1.000			1.000			1.000			1.000		
Male	**0.898**	**0.001**	**0.845, 0.954**	-	NS		-	NS		-	NS	
Union												
P&M worker, Location 3 & 4	N/A			1.000			N/A			1.000		
P&M worker, Location 1,2,5,6	N/A			**3.014**	**0.000**	**2.682, 3.387**	N/A			**2.552**	**0.000**	**2.193, 2.970**
Work shift												
1st shift	1.000			1.000			1.000			1.000		
2nd shift	1.010	0.756	0.950, 1.073	**1.214**	**0.000**	**1.143, 1.288**	-	NS		-	NS	
3rd shift	**0.822**	**0.011**	**0.707, 0.957**	**0.812**	**0.007**	**0.698, 0.944**	-	NS		-	NS	
Number injuries x union	-	NS		**1.564**	**0.000**	**1.304, 1.876**	-	NS		**1.504**	**0.000**	**1.203, 1.880**
Age	**0.994**	**0.001**	**0.991, 0.998**	**0.995**	**0.006**	**0.992, 0.999**	-	NS		-	NS	
Number of injuries (cumulative, log)	**0.947**	**0.017**	**0.906, 0.990**	**0.644**	**0.000**	**0.540, 0.769**	-	NS		**0.704**	**0.001**	**0.568, 0.874**
Tenure	**0.988**	**0.000**	**0.985, 0.991**	**0.984**	**0.000**	**0.981, 0.986**	**0.985**	**0.000**	**0.980, 0.989**	**0.984**	**0.000**	**0.981, 0.987**
Commuting distance	-	NS		**1.000**	**0.014**	**0.999, 1.000**	-	NS		-	NS	
Hearing loss	-	NS		-	NS		**0.911**	**0.025**	**0.839, 0.988**	-	NS	

Hazardous conditions were not included in the 2004-2006 analysis because estimates were diverging and predictions were missing when hazardous conditions were included.

Repetitive motion and overexertion injuries increased the risk of restricted days following an injury (OR=1.2-2.1). Injuries to wrist, shoulder, and knee were about twice as likely to result in restricted days, compared to injuries to "all other" body parts. Inflamed joints, tendons, muscles; sprains/strains; and pain of unspecified cause put employees at more than twice the risk of incurring restricted days following an injury.

Working in Locations 1, 2, 4, or 5 put employees at reduced risk of incurring restricted days, compared to Location 6. Working as an engineer or manager also decreased the risk of restricted days following occupational injury. Men were slightly less likely than women to sustain an injury that resulted in restricted days, but this relationship was not significant when the analysis was limited to P&M workers.

When analyses focused on employees rather than injuries, few risk factors surfaced for restricted days (Table 3.14). Working in P&M doubled the risk (OR=2.065, $p<0.001$), and working in a union location nearly doubled the risk (OR=1.980, $p<0.001$) for restricted days.

Employees who worked in any other location were less likely to sustain a restricted-days injury, compared to workers in Location 6. Managers and engineers were significantly less likely to incur restricted days following occupational injury. Men were slightly less likely than women to sustain an injury that resulted in restricted days.

Table 3.14. Employee factors influencing restricted days following occupational injury.

Outcome: Restricted days	location/pay code			union/P&M		
	OR	p	95% CI	OR	p	95% CI
Age	**0.994**	**0.002**	**0.991, 9.998**	**0.993**	**0.000**	**0.989, 0.996**
Union	N/A			**1.980**	**0.000**	**1.752, 2.237**
Tenure	**0.982**	**0.000**	**0.979, 0.986**	**0.973**	**0.000**	**0.970, 0.977**
Reporting delay	**1.000**	**0.032**	**1.000, 1.001**	**1.000**	**0.001**	**1.000, 1.001**
Hearing Loss	**0.935**	**0.023**	**0.882, 0.991**	**0.926**	**0.008**	**0.875, 0.980**
Commuting distance	-	NS		**0.995**	**0.046**	**0.999, 1.000**
Number of injuries						
1 injury	1.000			1.000		
>1 injury	-	NS		**0.950**	**0.049**	**0.903, 1.000**
Gender						
Female	1.000			1.000		
Male	**0.821**	**0.000**	**0.771, 0.874**	**0.783**	**0.000**	**0.737, 0.833**
Shift						
1st shift	1.000			1.000		
2nd shift	-	NS		**1.098**	**0.001**	**1.039, 1.161**
3rd shift	-	NS		0.947	0.445	0.823, 1.089
Location						
Location 6	1.000			N/A		
Location 1	**0.372**	**0.000**	**0.337, 0.411**	N/A		
Location 2	**0.368**	**0.000**	**0.342, 0.396**	N/A		
Location 3	**0.758**	**0.000**	**0.657, 0.874**	N/A		
Location 4	**0.129**	**0.000**	**0.095, 0.175**	N/A		
Location 5	**0.572**	**0.000**	**0.482, 0.679**	N/A		
Pay code						
Exempt	1.000			N/A		
Engineer	**0.469**	**0.002**	**0.290, 0.759**	N/A		
Production & Maintenance	**2.065**	**0.000**	**1.610, 2.647**	N/A		
Manager	**0.336**	**0.000**	**0.209, 0.572**	N/A		
Non-Exempt	0.855	0.325	0.625, 1.168	N/A		

Null Hypothesis 3*: There are no differences in risk factors affecting lost days following occupational injuries among employees in a large manufacturing company, after adjusting for pay code, union location, and number of injuries.*

This null hypothesis was rejected. Injuries with lost days were the most severe injuries analyzed in this study. As with recordable injuries and injuries with restricted days, injury characteristics were influential in determining whether an injury resulted in lost days (Table 3.15).

Table 3.15. Factors influencing lost days following occupational injury.

Outcome: Lost days (categorical)	2002-2006						2004-2006					
	location, pay code			union			location, pay code			union		
	Number of records:		11819	Number of records:		11768	Number of records:		6008	Number of records:		6010
	Number of employees:		6575	Number of employees:		6528	Number of employees:		3798	Number of employees:		3800
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Type of injury												
All other types of injury	1.000			1.000			1.000			1.000		
Struck against object	**0.845**	**0.026**	**0.730, 0.980**	0.888	0.115	0.767, 1.029	0.886	0.249	0.722, 1.088	0.918	0.411	0.748, 1.126
Fall to walkway/work surface	**1.405**	**0.000**	**1.243, 1.588**	**1.327**	**0.000**	**1.177, 1.497**	**1.369**	**0.000**	**1.159, 1.618**	**1.269**	**0.004**	**1.077, 1.495**
Rubbed, abraded, cut, puncture by object	**0.639**	**0.002**	**0.479, 0.854**	**0.663**	**0.005**	**0.497, 0.884**	0.794	0.234	0.543, 1.161	0.810	0.273	0.555, 1.181
Rubbed, abraded, cut, puncture NEC	**0.525**	**0.000**	**0.379, 0.727**	**0.509**	**0.000**	**0.369, 0.702**	0.702	0.099	0.461, 1.069	0.704	0.100	0.464, 1.070
Overexertion in lifting	**1.510**	**0.000**	**1.368, 1.667**	**1.565**	**0.000**	**1.419, 1.726**	**1.524**	**0.000**	**1.326, 1.752**	**1.565**	**0.000**	**1.363, 1.797**
Overexertion in pushing/pulling	**1.286**	**0.000**	**1.139, 1.452**	**1.372**	**0.000**	**1.216, 1.548**	**1.280**	**0.004**	**1.080, 1.516**	**1.346**	**0.001**	**1.137, 1.593**
Repetitive motion in shop operations	**1.948**	**0.000**	**1.739, 2.182**	**2.102**	**0.000**	**1.881, 2.349**	**2.207**	**0.000**	**1.878, 2.595**	**2.369**	**0.000**	**2.024, 2.774**
Repetitive motion NEC	**1.352**	**0.000**	**1.215, 1.504**	**1.446**	**0.000**	**1.303, 1.606**	**1.527**	**0.000**	**1.318, 1.769**	**1.587**	**0.000**	**1.373, 1.833**
Unclassified, insufficient data	**0.481**	**0.000**	**0.409, 0.566**	**0.422**	**0.000**	**0.360, 0.495**	**0.357**	**0.000**	**0.273, 0.468**	**0.319**	**0.000**	**0.244, 0.416**
Body part injured												
All other body parts	1.000			1.000			1.000			1.000		
Elbow	**0.802**	**0.001**	**0.701, 0.917**	**0.767**	**0.000**	**0.671, 0.877**	0.905	0.295	0.752, 1.091	0.884	0.192	0.734, 1.064
Wrist	**1.794**	**0.000**	**1.614, 1.994**	**1.700**	**0.000**	**1.531, 1.886**	**2.094**	**0.000**	**1.810, 2.423**	**1.997**	**0.000**	**1.731, 2.305**
Fingers	0.907	0.185	0.785, 1.048	0.886	0.097	0.768, 1.022	0.994	0.953	0.814, 1.214	0.968	0.750	0.793, 1.182
Back	**1.867**	**0.000**	**1.710, 2.038**	**1.919**	**0.000**	**1.759, 2.094**	**1.781**	**0.000**	**1.572, 2.018**	**1.828**	**0.000**	**1.614, 2.069**
Shoulders	**1.780**	**0.000**	**1.610, 1.967**	**1.788**	**0.000**	**1.618, 1.975**	**2.040**	**0.000**	**1.777, 2.342**	**2.051**	**0.000**	**1.788, 2.353**
Knee	**2.430**	**0.000**	**2.207, 2.675**	**2.530**	**0.000**	**2.300, 2.783**	**2.779**	**0.000**	**2.438, 3.169**	**2.890**	**0.000**	**2.537, 3.292**
Unsafe act												
All other unsafe acts	1.000			1.000			1.000			1.000		
Fail to use available PPE	**0.519**	**0.009**	**0.318, 0.847**	**0.419**	**0.000**	**0.260, 0.676**	0.561	0.118	0.271, 1.159	**0.461**	**0.033**	**0.226, 0.939**
Fail to use adequate/proper PPE	**0.413**	**0.000**	**0.269, 0.633**	**0.388**	**0.000**	**0.254, 0.592**	**0.330**	**0.001**	**0.169, 0.644**	**0.314**	**0.001**	**0.162, 0.609**
Fail to use material handling aids/get help	**1.238**	**0.012**	**1.049, 1.462**	1.097	0.261	0.933, 1.290	**1.325**	**0.028**	**1.031, 1.703**	1.244	0.082	0.972, 1.590
Inattention to footings, surroundings	**1.217**	**0.012**	**1.043, 1.420**	1.095	0.233	0.943, 1.272	1.182	0.138	0.948, 1.475	1.102	0.377	0.888, 1.368
No unsafe act	1.121	0.091	0.982, 1.279	0.926	0.230	0.816, 1.050	1.167	0.111	0.965, 1.412	1.023	0.804	0.854, 1.226
Nature of injury												
All other injury dispositions	1.000			1.000			1.000			1.000		
Cut, laceration, puncture	**0.398**	**0.000**	**0.336, 0.472**	**0.382**	**0.000**	**0.323, 0.453**	**0.344**	**0.000**	**0.271, 0.436**	**0.336**	**0.000**	**0.265, 0.426**
Inflamed joints, tendons, muscles	**1.317**	**0.000**	**1.184, 1.464**	**1.362**	**0.000**	**1.226, 1.513**	1.150	0.065	0.991, 1.334	**1.198**	**0.016**	**1.034, 1.388**
Sprains, strains	**1.217**	**0.000**	**1.122, 1.320**	**1.195**	**0.000**	**1.102, 1.295**	**1.181**	**0.004**	**1.056, 1.321**	**1.170**	**0.006**	**1.046, 1.308**
Pain, unspecified cause	**1.685**	**0.000**	**1.541, 1.841**	**1.776**	**0.000**	**1.626, 1.939**	**1.531**	**0.000**	**1.345, 1.744**	**1.594**	**0.000**	**1.401, 1.813**

Table 3.15, cont. Factors influencing lost days following occupational injury.

Outcome: Lost days (categorical)	2002-2006						2004-2006					
	location, pay code			union			location, pay code			union		
	Number of records:		11819	Number of records:		11768	Number of records:		6008	Number of records:		6010
	Number of employees:		6575	Number of employees:		6528	Number of employees:		3798	Number of employees:		3800
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Hazardous condition												
All other hazardous conditions	1.000			1.000			1.000			1.000		
Slippery	1.093	0.582	0.797, 1.499	0.774	0.100	0.570, 1.050	1.200	0.429	0.764, 1.884	0.848	0.457	0.550, 1.309
Worn, cracked, frayed, broken	0.888	0.583	0.582, 1.356	0.821	0.354	0.540, 1.247	0.857	0.599	0.482, 1.522	0.759	0.341	0.431, 1.339
Excessive noise	**0.029**	**0.001**	**0.004, 0.221**	**0.026**	**0.000**	**0.003, 0.201**	**0.080**	**0.018**	**0.010, 0.644**	**0.058**	**0.007**	**0.007, 0.459**
Lack of safe access	1.171	0.375	0.826, 1.662	1.152	0.426	0.813, 1.630	1.610	0.470	0.442, 5.860	0.886	0.852	0.247, 3.170
Hazardous method, procedure	1.192	0.153	0.937, 1.516	1.168	0.202	0.920, 1.482	0.448	0.429	0.061, 3.274	0.301	0.231	0.042, 2.143
Hazardous condition NEC	**0.869**	**0.028**	**0.767, 0.985**	**0.632**	**0.000**	**0.567, 0.704**	0.904	0.294	0.748, 1.092	**0.640**	**0.000**	**0.546, 0.750**
No hazardous condition	0.951	0.807	0.635, 1.423	0.756	0.169	0.507, 1.126	0.735	0.365	0.377, 1.430	0.572	0.097	0.296, 1.106
Location												
Location 6	1.000			N/A			1.000			N/A		
Location 1	**0.405**	**0.000**	**0.347, 0.473**	N/A			**0.448**	**0.000**	**0.364, 0.551**	N/A		
Location 2	**0.482**	**0.000**	**0.423, 0.549**	N/A			**0.540**	**0.000**	**0.450, 0.648**	N/A		
Location 3	**0.476**	**0.000**	**0.390, 0.581**	N/A			**0.564**	**0.000**	**0.441, 0.721**	N/A		
Location 4	**0.169**	**0.000**	**0.136, 0.209**	N/A			**0.150**	**0.000**	**0.111, 0.204**	N/A		
Location 5	**0.410**	**0.000**	**0.316, 0.532**	N/A			**0.357**	**0.000**	**0.245, 0.520**	N/A		
Pay Code												
Exempt	1.000			N/A			1.000			N/A		
Engineer	**0.693**	**0.010**	**0.525, 0.915**	N/A			**0.572**	**0.005**	**0.387, 0.846**	N/A		
Production & Maintenance	**1.705**	**0.000**	**1.482, 1.962**	N/A			**1.597**	**0.000**	**1.311, 1.947**	N/A		
Manager	0.898	0.551	0.630, 1.279	N/A			1.012	0.958	0.645, 1.587	N/A		
Non-Exempt	**1.215**	**0.036**	**1.013, 1.458**	N/A			1.132	0.360	0.868, 1.478	N/A		
Gender												
Female	1.000			1.000			1.000			1.000		
Male	**2.146**	**0.000**	**1.419, 3.246**	**2.766**	**0.000**	**1.843, 4.152**	-	NS		-	NS	
Union												
P&M worker, Location 3 & 4	N/A			1.000			N/A			1.000		
P&M worker, Location 1,2,5,6	N/A			**6.334**	**0.000**	**3.336, 12.028**	N/A			**2.603**	**0.000**	**2.083, 3.252**
Work shift												
1st shift	1.000			1.000			1.000			1.000		
2nd shift	**1.132**	**0.000**	**1.058, 1.211**	**1.253**	**0.000**	**1.173, 1.339**	**1.143**	**0.005**	**1.041, 1.256**	**1.256**	**0.000**	**1.146, 1.377**
3rd shift	**1.274**	**0.003**	**1.088, 1.492**	**1.257**	**0.005**	**1.073, 1.471**	**1.355**	**0.004**	**1.101, 1.668**	**1.359**	**0.004**	**1.104, 1.672**

Table 3.15, cont. Factors influencing lost days following occupational injury.

Outcome: Lost days (categorical)	2002-2006						2004-2006					
	location, pay code			union			location, pay code			union		
	Number of records:		11819	Number of records:		11768	Number of records:		6008	Number of records:		6010
	Number of employees:		6575	Number of employees:		6528	Number of employees:		3798	Number of employees:		3800
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Gender x Age interaction	**0.983**	**0.000**	**0.975, 0.991**	**0.979**	**0.000**	**0.971, 0.987**	-	NS		-	NS	
Gender x Tenure interaction	-	NS		**1.025**	**0.006**	**1.007, 1.043**	-	NS		-	NS	
Number of injuries x Age interaction	-	NS		-	NS		-	NS		**0.985**	**0.001**	**0.976, 0.994**
Number of injuries (cumulative, log) x Tenure interaction	-	NS		**0.993**	**0.035**	**0.987, 1.000**	-	NS		-	NS	
Number of injuries x Union interaction	N/A			**1.677**	**0.000**	**1.258, 2.235**	N/A			**1.898**	**0.001**	**1.309, 2.753**
Age x Union interaction	N/A			**0.984**	**0.019**	**0.970, 0.997**	N/A			-	NS	
Age	**1.015**	**0.000**	**1.008, 1.022**	**1.033**	**0.000**	**1.019, 1.049**	-	NS		**1.012**	**0.000**	**1.005, 1.018**
Number of injuries (cumulative, log)	-	NS		**0.683**	**0.009**	**0.514, 0.907**	-	NS		1.196	0.508	0.704, 2.034
Tenure	**0.992**	**0.000**	**0.989, 0.996**	**0.992**	**0.000**	**0.988, 0.996**	**0.995**	**0.010**	**0.990, 0.999**	**0.991**	**0.000**	**0.987, 0.995**
Reporting delay	**1.002**	**0.000**	**1.001, 1.002**	**1.002**	**0.000**	**1.001, 1.002**	**1.002**	**0.000**	**1.001, 1.003**	**1.002**	**0.000**	**1.001, 1.003**

Repetitive motion and overexertion injuries posed the greatest risk for lost days. Injuries to the knees, back, shoulder, and wrist increased employees' risk of lost days.

Working in a union location put employees at significant risk for lost-days injury (OR=6.334, $p<0.001$). Male workers as well as workers on second and third shift were at increased risk for lost days. Workers at all locations were at decreased risk for lost days compared to workers at Location 6.

When injury characteristics were eliminated from analyses, few significant risk factors were identified as increasing the risk of lost days following occupational injury (Table 3.16). Male employees and employees working in a union location were at the greatest risk for lost days, but the effect was modified by age as seen in the significant age-gender interaction.

A number of significant interaction variables were identified in the models for recordable injury, and injuries with restricted and lost days. Union affiliation had an interaction effect with age (OR=0.984) and number of injuries (OR=1.677) on lost day injuries. The union-number of injuries interaction was also significant when the outcome was restricted days (OR=1.564). For recordable injuries, significant interactions were found between unions and gender (OR=0.376), reporting delay (OR=0.996), and age (OR=0.984).

Table 3.16. Employee factors influencing lost days following occupational injury.

Outcome: Lost Days	Location/pay code			Union/P&M		
	OR	p	95% CI	OR	p	95% CI
Age	**1.017**	**0.000**	**1.010, 1.024**	**1.018**	**0.000**	**1.011, 1.025**
Union	N/A			**4.467**	**0.000**	**3.904, 5.111**
Tenure	**0.988**	**0.000**	**0.985, 0.991**	**0.984**	**0.000**	**0.981, 0.987**
Reporting delay	**1.003**	**0.000**	**1.002, 1.003**	**1.003**	**0.000**	**1.002, 1.003**
Gender x Age interaction	**0.981**	**0.000**	**0.973, 0.988**	**0.976**	**0.000**	**0.968, 0.983**
Gender						
Female	1.000			1.000		
Male	**2.245**	**0.000**	**1.529, 3.296**	**2.870**	**0.000**	**1.991, 4.139**
Shift						
1st shift	1.000			1.000		
2nd shift	**1.110**	**0.001**	**1.043, 1.182**	**1.354**	**0.000**	**1.274, 1.438**
3rd shift	**1.380**	**0.000**	**1.191, 1.599**	**1.302**	**0.000**	**1.126, 1.506**
Location						
Location 6	1.000			N/A		
Location 1	**0.311**	**0.000**	**0.274, 0.354**	N/A		
Location 2	**0.373**	**0.000**	**0.341, 0.407**	N/A		
Location 3	**0.405**	**0.000**	**0.336, 0.488**	N/A		
Location 4	**0.118**	**0.000**	**0.096, 0.144**	N/A		
Location 5	**0.369**	**0.000**	**0.288, 0.472**	N/A		
Pay code						
Exempt	1.000			N/A		
Engineer	**0.578**	**0.000**	**0.434, 0.734**	N/A		
Production & Maintenance	**1.751**	**0.000**	**1.535, 1.999**	N/A		
Manager	0.803	0.213	0.568, 1.135	N/A		
Non-Exempt	**1.195**	**0.046**	**1.003, 1.425**	N/A		

Professional experience led me to believe that employees who experience injuries repeatedly are somehow different from those who are injured just once. Thus, in addition to examining the data to identify factors influencing severity of occupational injury, data were analyzed to determine whether differences exist among those who had one or more than one injury during the five-year period.

Null Hypothesis 4*: There are no differences in risk factors among employees with multiple injuries versus single injuries in a large manufacturing company, after adjusting for pay code and union location.*

This null hypothesis was rejected. Several statistically-significant factors were influential in employees having more than one injury (Table 3.17). Production and Maintenance workers were seven times more likely to have more than one injury compared to exempt employees (OR=7.101, p<0.001). Workers in Location 1, 2, and 4 were more than twice as likely (OR=2.024-2.573, p<0.001), as workers in Location 6 to have multiple injuries. Having a hearing loss was found to be a significant risk factor associated with multiple injuries in both location/pay code (OR=1.141, p<0.001) and union/P&M (1.205, p<0.000) analyses. Men were at greater risk than women (OR=2.314, p<0.001), with older men less likely to have more than one injury. Second and third shift workers were at lower risk (OR=0.674-0.838, p<0.001) than those working first shift.

Table 3.17. Employee factors influencing multiple occupational injuries.

Outcome: >1 injury	Location/pay code			Union/P&M		
	OR	p	95% CI	OR	p	95% CI
Age	1.000	0.933	0.992, 1.009	**1.008**	**0.040**	**1.000, 1.016**
Hearing loss	**1.141**	**0.000**	**1.072, 1.214**	**1.205**	**0.000**	**1.134, 1.280**
Tenure	**1.017**	**0.000**	**1.013, 1.020**	**1.020**	**0.000**	**1.016, 1.024**
Report delay	-	NS		**0.999**	**0.003**	**0.999, 1.000**
Commuting distance	**0.999**	**0.001**	**0.999, 1.000**	**0.999**	**0.001**	**0.999, 1.000**
Union	N/A			**1.219**	**0.001**	**1.081, 1.376**
Gender x Age interaction	**0.989**	**0.013**	**0.980, 0.998**	**0.981**	**0.000**	**0.972, 0.989**
Shift						
Shift 1	1.000			1.000		
Shift 2	**0.838**	**0.000**	**0.789, 0.890**	**0.828**	**0.000**	**0.781, 0.878**
Shift 3	**0.674**	**0.000**	**0.584, 0.779**	**0.682**	**0.000**	**0.592, 0.786**
Gender						
Female	1.000			1.000		
Male	1.428	0.114	0.918, 2.222	**2.314**	**0.000**	**1.514, 3.536**
Pay Code						
Exempt	1.000			N/A		
Engineer	1.132	0.563	0.744, 1.720	N/A		
Production & Maintenance	**7.101**	**0.000**	**5.543, 9.097**	N/A		
Manager	**0.590**	**0.015**	**0.385, 0.904**	N/A		
Non-Exempt	**1.745**	**0.000**	**1.297, 2.347**	N/A		
Location						
Location 6	1.000			N/A		
Location 1	**2.024**	**0.000**	**1.807, 2.267**	N/A		
Location 2	**2.224**	**0.000**	**2.041, 2.424**	N/A		
Location 3	**0.737**	**0.000**	**0.637, 0.852**	N/A		
Location 4	**2.573**	**0.000**	**2.032, 3.258**	N/A		
Location 5	**0.510**	**0.000**	**0.432, 0.602**	N/A		

Employers are most interested in research results that can be used to improve their health and safety programs. With limited resources for intervention, employers are likely to use research findings to target specific types of injuries that can have the greatest impact. Identifying risk factors for various types of injuries is a step toward making the desired impact.

Null Hypothesis 5*: There are no differences in risk factors for different types of injuries in a large manufacturing employer.*

This null hypothesis was rejected. When an injury type was specified, eight types of injuries were cited in 47 percent of the injuries (Table 3.4). Repetitive motion and overexertion injuries were associated with recordability, restricted days, and lost days (Tables 3.11, 3.13, 3.15). Risk factors associated with those injury types (compared to all other types) are shown in Table 3.18. P&M workers and non-exempt employees were at increased risk for all three types of injuries, compared to exempt employees. Men were at an increased risk for repetitive motion (shop operations) injuries, but not for overexertion injuries or repetitive motion injuries overall.

Compared to first shift workers, employees who worked second and third shift had reduced risk of all three types of injuries, except for overexertion injuries in third-shift workers. Workers in Locations 1, 2, 3, and 4 were at lower risk for overexertion injuries compared to workers in Location 6, but those working in Location 2 had an increased risk for all repetitive motion injuries, and a greater risk for injuries due to repetitive motion in shop operations.

Table 3.18. Employee and work factors influencing type of injury.

	All repetitive motion (shop & NEC)			Repetitive motion - shop			Overexertion		
	OR	p	95% CI	OR	p	95% CI	OR	p	95% CI
Age	**0.994**	**0.004**	**0.989, 0.998**	1.004	0.556	0.990, 1.019	-	NS	
Number of injuries (cumulative log)	-	NS		**1.110**	**0.006**	**1.031, 1.195**	-	NS	
Tenure	**0.983**	**0.000**	**0.979, 0.986**	**0.979**	**0.000**	**0.973, 0.986**	-	NS	
Commuting distance	-	NS		-	NS		**0.999**	**0.031**	**0.999, 1.000**
Report delay	**1.002**	**0.000**	**1.001, 1.003**	**1.001**	**0.003**	**1.000, 1.002**	**1.001**	**0.000**	**1.001, 1.002**
Gender x Age interaction	-	NS		**0.967**	**0.000**	**0.952, 0.982**	-	NS	
Shift									
Shift 1	1.000			1.000			1.000		
Shift 2	0.972	0.485	0.899, 1.052	**0.840**	**0.003**	**0.750, 0.941**	**0.889**	**0.004**	**0.821, 0.964**
Shift 3	**0.713**	**0.002**	**0.573, 0.887**	**0.660**	**0.012**	**0.477, 0.914**	1.186	0.082	0.978, 1.438
Gender									
Female	1.000			1.000			1.000		
Male	**0.740**	**0.000**	**0.684, 0.800**	**6.444**	**0.000**	**2.952, 14.064**	-	NS	
Pay Code									
Exempt	1.000			1.000			1.000		
Engineer	0.804	0.391	0.489, 1.323	1.920	0.428	0.382, 9.647	0.819	0.294	0.563, 1.190
Production & Maintenance	**6.372**	**0.000**	**4.395, 8.228**	**52.488**	**0.000**	**16.593, 166.030**	**2.784**	**0.000**	**2.280, 3.399**
Manager	0.823	0.590	0.406, 1.670	3.394	0.187	0.554, 20.803	1.019	0.941	0.627, 1.655
Non-Exempt	**2.216**	**0.000**	**1.638, 2.997**	**5.739**	**0.006**	**1.646, 20.007**	**2.023**	**0.000**	**1.586, 2.581**
Location									
Location 6	1.000			1.000			1.000		
Location 1	**0.501**	**0.000**	**0.422, 0.594**	**0.387**	**0.000**	**0.294, 0.511**	**0.682**	**0.000**	**0.593, 0.784**
Location 2	**1.803**	**0.000**	**1.651, 1.968**	**2.549**	**0.000**	**2.281, 2.849**	**0.511**	**0.000**	**0.456, 0.574**
Location 3	**0.416**	**0.000**	**0.319, 0.543**	**0.602**	**0.001**	**0.442, 0.819**	**0.703**	**0.002**	**0.565, 0.874**
Location 4	1.115	0.125	0.970, 1.282	**0.482**	**0.000**	**0.364, 0.640**	**0.470**	**0.000**	**0.397, 0.558**
Location 5	0.776	0.073	0.588, 1.024	0.731	0.133	0.485, 1.101	0.913	0.462	0.716, 1.164

CHAPTER 4

DISCUSSION

This study analyzed injury data over a five-year period (2002-2006) at a large US manufacturing company, using existing injury, health, and demographic data. Data from six locations were analyzed to identify factors influential in recordable injuries, and injuries with restricted days and lost days. As anticipated, differences between male and female employees were found for recordable injuries, restricted days, and lost days. Contrary to expectation, commuting distance was not a significant influential factor for the outcome variables, and hearing loss was influential in only one analysis. Greater age and job tenure were influential variables for some, though not all, analyses.

Working in a union location was found to be a significant risk factor for recordable injuries as well as injuries with restricted days and lost days, but union was also an effect modifier with other variables. Working second shift was inconsistently found to be a risk factor for recordable injuries, restricted days, and lost days. Injury characteristics were significant factors for all levels of injury severity, which led me to modify the theoretical framework that I created as a basis for this research into injury severity.

This epidemiological analysis of occupational injuries in a large US manufacturing employer was designed to provide descriptive information about work-related injuries, and to identify factors associated with injury severity. A number of analyses were done to achieve those goals, and those analyses have been presented in the Results section. For brevity and clarity, this discussion will center on the five-year, full dataset analyses, that include locations and job codes, unless otherwise specified. While there were some issues identified that may lead the reader to question the integrity of the data for one location or time period, the fact that these are actually the data held by the company compels me to consider those data "real" and thus usable.

The results of this study differed from information found in the literature and national statistics in several ways. In this large manufacturing company, sprain/strain injuries accounted for 29 percent of all injuries in the five years of occupational injuries, a smaller percentage than the national results of 35 percent (USDL 06-1982, 2006). The BLS also reports that 9.6 injuries per 1000 workers involved days away from work, but in this large manufacturing company, the numbers were far greater: With 7654 injuries resulting in lost days during the five-year period, the 68,556 FTEs in the six work locations experienced 22.3 lost-days injuries per 1000 workers annually. Nationally, the manufacturing sector experienced 6.3 non-fatal occupational injuries per 100 FTE (USDL 06-1982, 2006). In the present study, this large manufacturer experienced 10.6 non-fatal occupational injuries per 100 FTE. Repetitive motion injuries were more common in the United States (1.35 cases per 100 FTE), than they were in this manufacturing employer (0.93 cases per 100 FTE).

Personal risk factors

As illustrated in the Theoretical Model (Figure 1.1), a number of personal physical and psychological factors, as well as job and organizational factors, have been associated with risk of injury in the workplace. This epidemiological study of occupational injuries over a five-year period permitted measurement of the impact of some of those variables on occupational injury severity in a large US manufacturing company. Many factors, however, could not be included in the analysis due to data unavailability and methods used.

Age is often associated with occupational injuries (Kemmlert and Lundholm, 2001; Saleh, Fuortes, Vaughn and Bauer, 2001; Salminen, 2004; MMWR, 2006; Breslin, Koehoorn, Smith and Manno, 2003; Layne and Pollack, 2004; Grandjean et al., 2006). In the present study advancing age was an inconsistent risk factor for injury severity; age was statistically significant but hovering very closely to an odds ratio of 1.0. These findings were similar to other research demonstrating that younger workers have more injuries and older workers have more severe injuries (Salminen, 2004; MMWR, 2006; Breslin, Koehoorn, Smith and Manno, 2003; Layne and Pollack, 2004; Grandjean et al., 2006). Breslin and Smith (2005) contend that job type, not age, is responsible for injury. In the present study, even when controlling for pay code, older age was a marginal risk factor for lost time (OR=1.018) when employee and workplace factors were examined. Age was found to be a mild effect modifier with gender (OR=0.979) for the most severe injuries (lost days) when analysis included the entire data set (but not for the limited, three-year data set). Age, combined separately with union status, gender, and number of injuries, were found to be significant interaction terms affecting injury severity (recordability and lost days).

Information about employees' race or ethnic background was not available from the company. In the United States, minorities are over-represented in blue-collar and service jobs (Murray, 2003), which may explain why race may be a risk factor for occupational injury. Research has shown that production employees have more injuries than professional employees (Oh and Shin, 2003; LaFlamme and Eilert-Petersson, 2001), but when controlling for job type, no association is found between race and non-fatal injury at work (Oh and Shin, 2003). Although production workers in my study were at greater risk for more severe injuries, race was not included in any analyses.

Consistent with the literature previously cited, gender was a significant risk factor for occupational injury severity in this study. In analyses of injury, employee, and workplace characteristics, male P&M employees were at greater risk for recordable injuries (OR=2.669) and for injuries with lost days (OR=2.766). When injury characteristics were excluded from analyses, male P&M employees were at greater risk for recordable injuries (OR=1.758) and lost-days injuries (OR=2.870), but for restricted-days injuries, men had a reduced risk (OR=0.783). When analysis was limited to specific job titles, as recommended by other researchers (Smith, Huang, Ho and Chen, 2006), females were found to have more than 60 percent of the injuries in the Assembler Wire Group B job, but without figures for the number of females working in that job title, true gender-related risk of injury in unknown. Men were also at much greater risk for repetitive motion (shop operations) injuries (OR=6.262).

The literature suggests that fatigue plays a role in occupational injury. Hearing loss is a personal factor that may result in fatigue if the individual has to strain, focus, and concentrate on conversations in order to understand what is being said (Hicks and Tharpe, 2002). In this study, hearing loss was not a significant risk factor for recordable injuries or injuries with lost days. Employees with high-frequency hearing loss were at a slightly reduced risk for injuries with restricted days (OR=0.911) in the limited, three-year data set, and increased risk for having more than one injury (OR=1.205). Commuting distance was used as a proxy for fatigue, assuming that workers who traveled farther had less personal time, and therefore had less opportunity to adequately rest between work shifts. A long commuting distance, although statistically significant, had essentially no impact on injuries with restricted days (OR=1.000, p=0.014) in the five-year data set that was limited to P&M workers. Likewise, commuting distance was a significant factor for more than one injury (OR=0.999, p=0.001), but had no real impact. Another proxy for fatigue, hours worked in the pay period preceding the injury, was unavailable for inclusion in the analyses. It is impossible to draw conclusions about fatigue from these data. Whether employees were not fatigued due to hearing loss and commuting distance, or fatigue from hearing loss and long commute does not contribute to occupational injury severity, these results do not support any inference. If data could be gathered assessing fatigue levels or number of hours of sleep prior to the injury, those data could be incorporated into future research of occupational injury severity.

In the present study, long tenure was mildly protective for recordable injuries (OR=0.989-0.996) and injuries with restricted days (OR=0.984-0.988) and lost days (OR=0.988-0.992). These findings were consistent with findings in other studies (Oh & Shin, 2003; Breslin & Smith, 2006; Collins, Smith, Baker & Warner, 1999), indicating more experienced workers are less likely to have occupational injuries. From these data, one cannot determine whether experience is the causal factor that enables long-term employees to have fewer or less severe injuries. It is possible that the most fit, those with the greatest resilience, or those more focused and less "accident-prone" survive in the workplace over the long term. Long tenure was found to be a slight risk factor for more than one injury (OR=1.017, 1.020), but was mildly protective for repetitive motion injuries (OR=0.979-0.983).

Repetitive motion injuries, like hearing loss injuries, are more accurately described as illnesses, because no single event can be identified as independently causing the problem. While employees and their managers are trained to report injuries immediately (and most do), the nature of some injury, such as cumulative trauma or repetitive motion, results in late reporting. Repeating the same actions/exposure over an extended period of time, without adequate rest, is the reason for that type of condition and it is often difficult to pinpoint when the problem was first identified. Additionally, laceration/cut/puncture injuries can get infected if not cleaned properly, and the infection may require more extensive medical treatment. Although the literature previously cited failed to address the impact of delayed reporting of injuries, personal experience led me to believe this variable might impact the severity of an injury. In this study, lost days (OR=1.002) and OSHA log recordability (OR=1.003) were significantly (and imperceptibly) more likely when reporting injury was delayed. Early intervention of repetitive motion injuries can minimize severity and facilitate ergonomic interventions.

High body-mass index (BMI) and obesity are associated with occupational injury (Hou, Hsu, Lin and Liang, 2007); others suggest they are confounding or effect-modifying variables (Nakata et al., 2006; Schulte et al., 2007). Height and weight to calculate Body Mass Index (BMI) were requested as data variables; however, weight and height are rarely measured on injured employees. When BMI was included in the analysis, the number of observations was considerably reduced, so BMI was excluded from the analyses. Given the possibility of elevated BMI being a risk factor for severity of occupational injuries, a suggestion will be made to routinely measure height and weight of employees who are injured.

Organizational risk factors

This study's findings that among injured P&M employees, working second shift was a marginal risk factor for recordable injuries (OR=1.190) and injuries with restricted (OR=1.214) or lost days (OR=1.253), support similar findings by Folkard and Lombardi (2006), who conclude night shift is associated with increased risk of injury. Conversely, this study found second and third shifts to be somewhat protective for having more than one injury (second shift OR=0.838; third shift OR=0.674). The results of this study must be viewed with caution, however. The shift data provided by the company may not accurately reflect the shift worked at the time of injury. Further, no information was supplied regarding any requirements to rotate shifts, or how much rest time employees had during their shift, a factor shown to influence injury risk (Folkard and Lombardi, 2006).

Four work locations in this study have collective bargaining agreements with unions that represent employees, but individual union membership information was unavailable for this study. Although Krause, Frank, Kasinger, Sullivan and Sinclair (2001) conclude that individual union membership has no effect on *disability*, they did not study union membership on occupational *injuries*. Since individual union status was not known, work locations were dichotomized into union (Locations 1, 2, 5, 6) and non-union (Locations 3, 4). Although some engineering groups are represented by unions, only P&M (labor) workers were included in analyses of union's effect on injuries. Union affiliation was consistently found to be a risk factor for recordable injuries (OR=12.090) and injuries with restricted (OR=3.014) and lost days (OR=6.334). Union location was also shown to be an effect modifier when separately combined with gender, reporting delay, age, and number of injuries. The two non-union locations (Locations 3 and 4) had the highest and lowest ratios of recordable-to-non-recordable injuries. Location 3 had the highest rate of recordable injuries (10.4 per 100 employees per year), and Location 4 had the lowest rate of recordable injuries (3.4 per 100 employees per year). Both locations had similar number of total injuries per employee (13.4 and 12.3) and similar recordable injuries per year (146 and 150.8), but the employee population for Location 4 (n=4158) was nearly three times greater than that of Location 3 (n=1785).

Most large employers have safety programs emphasizing prevention of injuries. OSHA requires training programs in many of its standards. Grau, Martinez, Agut and Salanova (2002) find that workers receiving safety training have better attitudes toward safety, and Duffy (2003) concludes lack of task training is associated with increased injury risk. Indeed, Shannon and Vidmar (2007) estimate that 42 percent of lost-days injuries in Canada could be prevented with improved health and safety programs. I made no attempt to measure the effect of this company's safety training, which may be considered a weakness in my study.

Vrendenburgh (2002) indicates "proactive management practices" are associated with reduced injury rates. That is, employers with a management commitment to safety, rewards for safe behaviors, strong communication/good feedback, and employee involvement in safety programs establish a culture of safety. Huang, Ho, Smith and Chen (2006) describe four dimensions of "safety climate": management commitment to safety, return-to-work policies, post-injury administration, and safety training. These researchers contend that the number of workplace injuries would be reduced if injured employees were treated fairly. Intervention studies in Israel demonstrate an improvement in employees' safety performance after supervisors modify their processes of monitoring and rewarding employees' safety performance (Zohar and Luria, 2003). In a population of transportation workers, Wallace, Popp and Mondore (2006) find organizational support and management-employee relations predict a strong safety climate and influence injury rates.

Research indicates employees engage in unsafe behavior in spite of the received training (Wachs and Parker-Conrad, 1989). One study performed in a hospital work environment indicates a poor organizational climate (low vs. high organizational support) and elevated workloads are associated with needlestick injuries and "close calls" (Clarke, Rockett, Sloane and Aiken, 2002). Conflicts with supervisors or colleagues, and high emotional demands at work are correlated with occupational injury in a long-term study of Dutch workers (Swaen, van Amelsvoort, Bultmann, Slangen and Kant, 2004). Milczarek and Najmiec's (2004) study of Polish metallurgic workers suggests employees experiencing occupational injuries have fewer "safety culture" attitudes than the uninjured workers. A study of workers in small and medium manufacturing companies in Japan identifies occupational injuries associated with elevated workloads, increased cognitive demands, and reduced job satisfaction (Nakata et al., 2006). Boedeker (2001) identifies lack of job control (repetitive tasks, low decision latitude, monotony) and increased physical demand as factors associated with increased risk of lost-time injuries. In a cross-sectional survey study of line-paced manufacturing assembly operations, 37 percent of workers report at least one laceration in the previous year and an injury rate of 83 lacerations per 100 workers (Bell and MacDonald, 2003). Although safety climate is an organizational factor that can influence injury rates, I made no attempt to measure the effect of safety climate on injury severity in this large manufacturing company.

The methods used in this epidemiological analysis of injuries precluded assessment of most organizational factor influences on occupational injury severity. Since organizational factors have been shown to be significantly associated with injury, additional research using different methodology may further explain why different work locations work have differing occupational injury experiences.

Characteristics of injuries

The Theoretical Framework (Figure 1.1) included personal factors and work/organizational factors, but failed to take into account the impact of the injury itself on the severity of the injury. Characteristics of the injury were included in the analysis because safety professionals requested them. The unsafe act, body part, type of incident, hazardous conditions, and nature of injury were variously significant for predicting recordability, restricted days, and lost days. When analyses excluded injury characteristics, significant variables differed slightly from analyses that included injury characteristics. Recognizing the role played by injury characteristics, I revised the Theoretical Framework for injury severity (Figure 4.1).

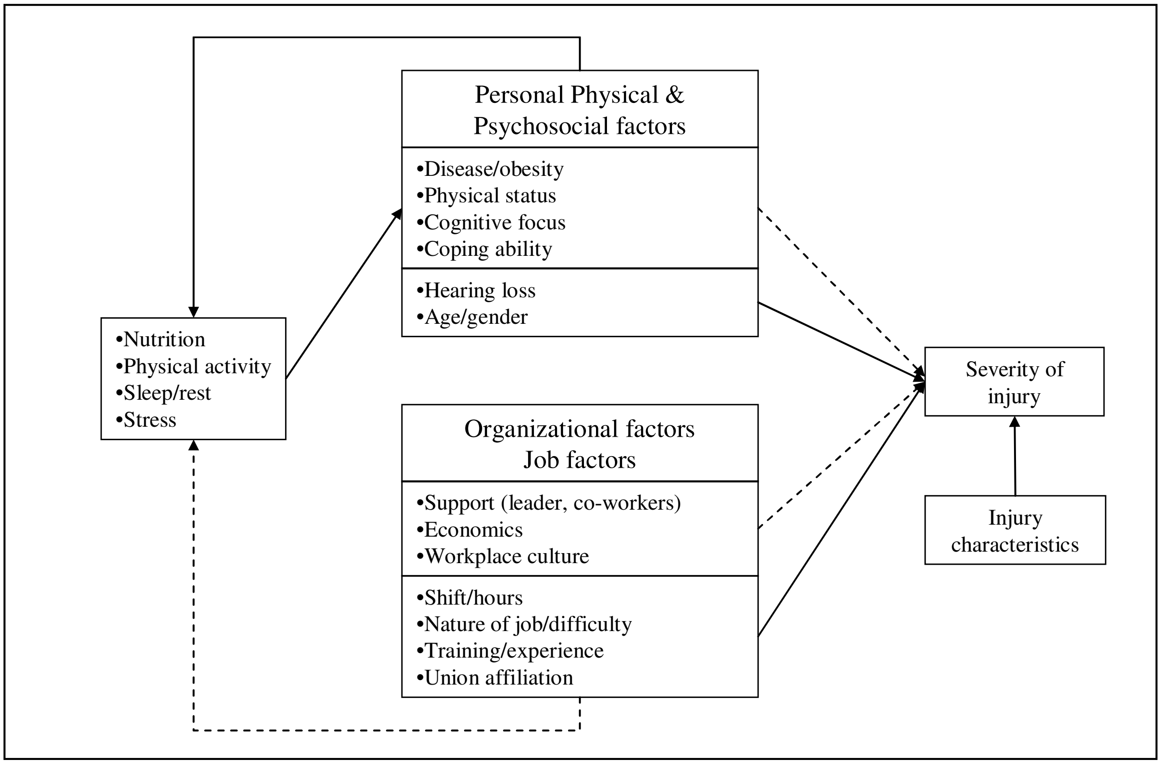

Figure 4.1. Theoretical framework of variables' influence on risk of injury severity.

From this study it appears that some organizational/job factors (shift, job type, experience, union affiliation) have an effect on severity of injury. Some personal factors also appear to be influential for injury severity (age, gender, hearing loss). However, this study did not address several personal factors that have been shown in previous studies to be associated with risk of injury. Additionally, while nutrition, physical activity, sleep, and stress have been shown to affect some personal characteristics, more research is needed to determine which of those personal characteristics (if any) influence severity of injury. Organizational factors such as shift, job difficulty, and experience may impact an employee's stress level or rest status, but this study did not address those relationships.

Musculoskeltal injury is associated with body position, movement, and amount/frequency of lift (Craig, Congleton, Kerk, Gaines and Jenkins, 2003), and can be the result of a single episode (injury) or cumulative trauma (illness). Oh and Shin (2003) indicate that body position and work activity are associated with occupational injury. The current study found that after repetitive motion (illness), overexertion in lifting objects (injury) was the most common type of incident found to be a significant influencing variable. Lost-workday musculoskeletal disorders constitute one-third of all job-related injuries and illnesses reported to BLS every year (29 CFR 1910).

As seen in national statistics, injuries to the back and upper extremities were common in this manufacturing company (Table 3.3), with knee being the only body part not fitting into that category. Nature of injury (Table 3.4), likewise, was indicative of musculoskeletal injuries, with the exception of cut/laceration/puncture injuries.

Prevention efforts

In addition to training employees to work safely, many companies institute other measures designed to prevent occupational injuries; however, effective prevention and control strategies in actual workplaces have been studied to a limited extent for industrial hygiene (Roelofs, Barbeau, Ellenbecker and Moure-Eraso, 2003). Shannon and Vidmar (2007) estimate that 42 percent of lost-days injuries in Ontario are preventable with improved safety and health programs. Due to the methods used to code workers' compensation data, Van Eerd et al. (2006) believe that the magnitude of musculoskeletal disorders is underestimated. Nevertheless, MSDs remain a leading concern in occupational safety and health (Courtney and Webster, 2001). An analysis of musculoskeletal injuries among manual handling workers in Hong Kong underscored that point: Far more musculoskeletal injuries involved multiple body parts than single-part injuries (65 percent versus 19 percent), and 85 percent of low back symptoms were associated with problems in other body parts (Yeung, Genaidy, Deddens, Alhemood and Leung, 2002).

In an effort to curb the number and severity of work-related musculoskeletal disorders (MSD), the last decade has seen an increase in the number of programs focusing on ergonomic solutions (i.e., interventions designed to enhance the worker-machine/workplace interface). A workplace ergonomics program decreases the risk of MSD, according to Ulin and Keyserling (2004). In a study conducted in a Thai manufacturing plant, incidence of low back pain was reduced in the intervention group that experienced engineering improvements, environmental improvements, and training and health education (Poosanthanasarn, Lohachit, Fungladda, Sriboorapa and Pulkate, 2005). A return-to-work program in Canada is effective in reducing costs for MSDs, although the program is designed for purposes other than prevention of MSDs (Badii, Keen, Yu and Yassi, 2006). Gauchard, Chau, Mur and Perrin (2001) recommend balance rehabilitation methods for individuals to reduce risk of falls. In an aging workforce, helping employees retrain their balance muscles can be particularly useful, since loss of balance is a common problem in the elderly. Loss of balance happens gradually, prior to the point of retirement.

Iyer, Haight, Castillo, Tink and Hawkins (2005) declare that safety interventions are not expected to have a lasting or immediate effect on injury incident rate. Personal experience leads me to disagree with that conclusion. For instance, use of ergonomic tools (lighter, smaller) can have a lasting impact on workplace safety, so long as the tools get continued use. Office equipment (chair, desk height, keyboard and mouse location) that have been adjusted ergonomically will continue to provide the intended effect. Any safety intervention requires on-going attention to ensure it continues to have the intended impact.

As a method of prevention, Swedish researchers recommend improvements to orderliness in the workplace (Kemmlert and Lundholm, 2001). Exporting high-risk jobs to developing countries may be a method of prevention in industrial countries. Breslin et al. (2007) attribute the gradual decline in the rate of Canadian occupational injuries to the export of hazardous jobs. From a public-health perspective, eliminating hazards in the work environment is more desirable than exporting job hazards to someplace else.

Although the company is proactive in various injury prevention efforts, in this study, none of these was evaluated for efficacy. If prevention methods are effective at this company, they may not be implemented to the same degree across all work sites. When evaluations of prevention programs are performed, effort should be made to identify where they are less effective so appropriate action can be taken to improve safety everywhere. Efficiency is gained by targeting prevention programs at injuries most likely to be recordable, or having restricted or lost days.

The company works closely with the unions to promote safe work practices and safe working conditions at the company. No known financial incentives for meeting safety targets are built into collective bargaining agreements, however. Findings from this study should be shared with the unions to encourage joint examination of factors that may be leading to greater risk of injury severity in union locations.

Limitations of this study

As previously mentioned, current demographic data, such as pay code, job title, work location, home zip code, and work shift used in this study may not accurately reflect those factors at time of injury. The work force is stable, and although production workers may transfer to different plants within a given city/region throughout their career, it is less likely that they would move to other locations across the country. It is unknown how long an employee will work in a particular job title, and this study made no effort to combine similar job titles for analyses. Likewise, limiting the analysis to a five-year block artificially categorized some employees as having a single injury, when there is no way to know how many injuries were experienced prior to 2002.

Questions remain regarding the quality of the data used in this study. Although the data were “real” and accurately produced by the electronic record-keeping system, there seemed to be clear differences among sites on how injuries were identified and recorded, and perhaps treated. Although two sets of analyses (three-year and five-year) were conducted, labeling one or the other as “correct” or “invalid” seemed inappropriate and outside of my scope as a researcher. Lack of information about the numbers of men and women in the employee population limited the comparison of results.

From this study, one cannot conclude that fewer lost days were purely the result of a less-severe injury (or vice-versa). While company standards exist for treating injuries and managing their care, variations do exist from location to location. This study's results do not permit inferences about work tasks, organizational climate, safety, or injury treatment practices.

Recommendations for the company

It appears from the data supplied by the company that some employee demographic data are not captured at the time of injury. If job title and work shift are important factors to consider when analyzing safety data, then this information should be preserved at the time of injury. Without attaching demographic data to injury data, it is difficult to do longitudinal analyses that could determine the efficacy of the safety program.

While practice standards continue to be developed for clinicians, medical and nursing practice often remains more of an "art" than a "science," allowing individual practitioners to treat similar injuries differently. Although "evidence-based practice" is becoming more common, without treatment standards and protocols, it is difficult to determine how treatment affects injury severity. A recommendation to the company is made to continue to migrate to treatment standards based on evidence of efficacy.

In order to get to the root cause of injuries, additional questions must be asked. To say that the injured employee was not attentive only gives a part of the reason for the incident. Why was he inattentive? How much rest does the employee get routinely? How many hours of sleep did he have the night before the incident? Are there personal life stressors that affect his ability to focus on his work activity? How much physical activity does he do during his off-work hours? If these questions are assessed, their responses can be included with other variables to determine their impact on injury severity.

Suggestions for future research

Future research should focus on determining what role, if any, is played by physical activity, fatigue, and stress on the risk of sustaining severe occupational injuries. Additional research is recommended on the impact of treatment methods to help build a base of evidence for treatment following occupational injury. Finally, research on prevention efforts is recommended to determine what works to prevent occupational injuries and to minimize severity of injuries when they do occur.

APPENDICES

Appendix A. Human Subjects Approval.

THE UNIVERSITY OF ARIZONA.

Human Subjects
Protection Program

1235 N. Mountain Ave.
P.O. Box 245137
Tucson, AZ 85724-5137
Tel: (520) 626-6721
http://irb.arizona.edu

23 July 2007

Eileen Lukes, Ph.D. Candidate
Advisor: Mary Kay O'Rourke, M.D.
Department of Psychiatry
AHSC, Room 7306D
PO Box 245002

RE: EPIDEMIOLOGY OF OCCUPATIONAL INJURIES IN A LARGE MANUFACTURING EMPLOYER, 2002-2006

Dear Ms. Lukes:

We received documents concerning your above cited project. Regulations published by the U.S. Department of Health and Human Services [45 CFR Part 46.101(b) (4)] exempt this type of research from review by our Institutional Review Board.

Exempt status is granted with the understanding that no further changes or additions will be made to the procedures followed (copies of which we have on file) without the review and approval of the Human Subjects Committee and your College or Departmental Review Committee. Any research related physical or psychological harm to any subject must also be reported to each committee.

Thank you for informing us of your work. If you have any questions concerning the above, please contact this office.

Sincerely,

Rebecca Dahl

Rebecca Dahl, R.N., Ph.D.
Director
Human Subjects Protection Program

cc: Departmental/College Review Committee

Arizona's First University – Since 1885.

Appendix B. Data requested for all injuries that occurred from 1/1/02 – 12/31/06

Date of injury
Time of injury
Date of report
Type of injury
Body part
Nature of injury (physical characteristic)
Event or exposure
Source of injury
Job title/code at time of injury
Work location at time of injury
Department at time of injury
Shift worked on day of injury
Recordability of injury
Lost work days [continuous]
Restricted work days [continuous]
Employee's home zip code at time of injury
Hearing test results (test prior to injury)
3000 Hz left ear
4000 Hz left ear
6000 Hz left ear
3000 Hz right ear
4000 Hz right ear
6000 Hz right ear
Age at time of injury
Gender
Median salary by job codes/titles
(employee identification number – removed after data are combined)
Number of hours worked in the last full pay period prior to injury date
Union status (Y/N)
Annual total hours <u>worked</u> by location (2002-2006)
Annual total hours <u>worked</u> by department (2002-2006)

Appendix C. ANSI Codes

Unsafe Act codes

Code	Description
Reason 100	Failure to use available personal protective equipment (goggles, gloves, masks, aprons, hats, lifelines, shoes, etc.)
Reason 110	Failure to use adequate/proper personal protective equipment
Reason 352	Failure to use material handling aids or obtain help
Reason 400	Inattention to footing or surroundings
Reason 990	No unsafe act
All other reasons	Comparison group

Body Part codes

Code	Description
Body 313	Elbow
Body 320	Wrist
Body 340	Finger(s)
Body 420	Back
Body 450	Shoulder
Body 513	Knee
All other body parts	Comparison group

Type of Accident codes

Code	Description
Type 011	Struck against stationary object
Type 051	Fall to walkway or working surface
Type 082	Rubbed, abraded, cut, or punctured by objects being handled (not vibrating)
Type 089	Rubbed, abraded, cut, or punctured (not elsewhere classified)
Type 121	Overexertion in lifting objects
Type 122	Overexertion in pushing/pulling objects
Type 402	Repetitive motion or tasks in shop operations (riveting, bucking, wrenching, etc.)
Type 409	Repetitive motion or tasks (not elsewhere classified)
Type 999	Unclassified, insufficient data
All other types	Comparison group

Appendix C, cont. ANSI Codes

Hazardous Conditions codes

Code	Description
Hazard 030	Slippery
Hazard 035	Worn, cracked, frayed, broken, etc.
Hazard 205	Excessive noise
Hazard 211	Lack of safe access
Hazard 300	Hazardous methods or procedures
Hazard 980	Hazardous conditions (not elsewhere classified)
Hazard 990	No hazardous conditions
All other hazards	Comparison group

Nature of Injury codes

Code	Description
Nature 170	Cut, laceration, puncture – open wound
Nature 260	Inflamed joints, tendons, muscles (not sprain/strain, dislocation)
Nature 310	Sprains, strains
Nature 910	Pain, unspecified cause
All other injury dispositions	Comparison group

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