ANALYSIS OF CONSTRUCTION WORKER INJURY INFORMATION FROM A WORKERS' COMPENSATION DATABASE

By

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A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
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To all who provided the mentorship and support which made this milestone possible, with special recognition to Dr. Jimmie Hinze, Dr. Raymond Issa, Dr. David Suchman, and Ron Anderson.

In memory of my father, William J. Godfrey

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In an effort to identify profiles of types and severity of injuries experienced by construction workers, my study sought to describe injuries sustained by construction workers at various occupational experience levels (e.g., laborers, apprentices, foremen), who performed in various occupational work areas (e.g., carpentry, masonry, electrical work) on construction sites. This study examined workers' compensation (WC) claims for the 46,056 construction workers. Claims information was provided by a large workers' compensation insurance provider. Injury frequencies and injury severity levels were calculated and compared across gender, age, job tenure (i.e., time between date of hire and date of injury), body region effected by injury, specific body part injured, nature of injury, cause of injury, and agent of injury. I used claims data reported to a large private insurance company according to National Council on Compensation Insurance job classifications. All injuries were examined as well as injuries sustained to each of six body regions: head; neck; trunk; upper extremities; lower extremities; and multiple body regions or body systems (MBRBS). Injured workers were generally young, averaging 37 years. Older workers tended to sustain more severe injuries; especially injuries to the neck, trunk, and lower extremities. Neck, MBRBS, and trunk injuries were the most severe injuries among the six

body regions. Laborers sustained an inordinate amount of injuries to each of the body regions. They also sustained some of the most severe injuries to all six body regions. Journeymen sustained the most severe injuries to the upper extremities, as well as having the most severe MBRBS injuries. Injuries to the brain, cervical vertebrae, and heart were the most severe injuries. The eyes, thumb, and sacrum and/or coccyx, sustained the least severe injuries. Crushing to multiple body regions and to the head and myocardial infarctions were the most severe injuries. The occupational work area of the worker at the time of injury had no effect on the severity of the injury sustained.

CHAPTER 1
INTRODUCTION

The construction industry is diverse. According to the Uinited States Department of Labor Beuraue of Labor Statistics (USDOL-BLS), within the United States, construction employment is 30 percent of total employment in the goods-producing sectors (including manufacturing, natural resources and mining), while construction establishments account for 62 percent of all goods-producing establishments (USDOL BLS, 2006a). In the U.S. economy as a whole (goods-producing and service-providing sectors), construction employs about 5.4 percent of all workers and accounts for 9.8 percent of all establishments.

Current employment statistics estimates show the total average annual construction employment rising from 5,536,000 in 1996 to an all-time high of 7,277,000 in 2005, surpassing the previous high achieved in 2004 (USDOL-BLS, 2006a). Numerous construction enterprises deliver a diversity of services from residential building renovation and development to major infrastructure projects. In the area of occupational safety, the construction industry continues to be one of the most dangerous occupational settings for workers. In 2005, there were 1,186 fatal occupational injuries in construction and 414,900 nonfatal injuries and illnesses (USDOL-BLS, 2006b). The nonfatal injuries and illnesses incidence rate was 6.3 per 100 full-time workers in construction compared to 4.6 per 100 full-time workers in all private industry (USDOL-BLS, 2006c).

Workers on construction sites face multiple and varied threats to safety. The variability of risk of injury within the construction industry has also been demonstrated. For instance, previous analyses have shown that risk of injury is higher for workers in certain construction domains, such as building construction and site development, than in others, such as roadway construction (Lowery et al., 1998). Risk has also been found to be higher for special trade contractors than for other types of contractors (Glazner et al., 1998). Other analyses have shown differences in the proportionate distribution of injuries among trades (Helander, 1991; Hunting et al., in press] and by phase and type of construction (OSHA, 1992b; Construction Safety Association of Ontario, 1995). While such studies establish the variation in risk of injury among trades, types of contractors and broad construction domains, they are limited in their ability to detect the specific types of work activities associated with injury, and information necessary for allocating safety resources and preventing injury. Even studies focusing on a single trade may not reflect this variation insofar as members of that trade are involved in a variety of work activities.

Over the years, especially the past three decades, considerable resources have been committed to reducing the number of construction worker fatalities, non-fatal injuries of varying degrees of severity, and illnesses that result from exposure to various substances encountered in the construction industry. Despite these efforts, the construction industry remains one of the most dangerous industries for workers (Leigh and Miller, 1997). Each year nearly 1200 construction workers die on construction projects and nearly half a million workers are injured. The problem is serious and deserves further research to continue to make improvements.

Workers' compensation (WC) has often been utilized as a source of workers' data for occupations at high risk of injury and illness and analyzed for those occpations' demographics and industrial characteristics. Workers' compensation data have been used previously to generate worker fatality and injury profiles for the construction industry (Hinze, J., 2006; Horowitz, B., and McCall, B., 2005; Lombardi, D. A., et. al., 2005; Dement, J., Lipscomb, H., et. al., 2003; Enders, L. and Walker, W., 2003; Dement, J.M., and Lipscomb, H., 1999; Lipscomb, H. J. et. al., 1997 Cattledge, G.H. et. al., 1996). Because this type of data often report on both fatal and nonfatal accidents providing information on employee demographics, injury type, injured body part, severity, agent of loss, the injury costs, job tenure, disability length, and regular occupation of the worker. The data allows for the assessment of multiple risk factors associated with construction work among large employee populations. The data also record information about the day and month of injury which can further be examined for possible associations with the number of injuries sustained by the construction workers (Coleman, 1984).

Through a detailed review and analysis of workers' compensation data from a private insurance provider, my study study will contribute to the literature on workplace injuries in the construction industry. Specifically, relationships will be examined between factors such as specific injury types, affected body part, specific types of work (e.g., iron and steel erection, glass installation, etc.) and specific occupational role (e.g., boilermaker, electrician, carpenter, laborer, etc.) thus permitting the development of safety strategies specific to these variables. The types of work associated with high injury rates or particularly severe injuries on construction sites will also be identified, thus allowing owners, contractors, and safety professionals to direct their safety efforts toward the specific activities presenting particularly high risk. Because these claims data also record information on the day and month of injury, time of occurrence factors will also be examined for possible associations with work-related injuries experienced by workers in the construction industry.

CHAPTER 2
LITERATURE REVIEW

Construction is one of the largest industries in the United States, employing approximately 7.3 million individuals. In the U.S. economy the construction industry employs about 5% to 6% of all workers. It is well known that construction is one of the most dangerous industries. Construction work frequently involves cluttered work environments, extreme temperatures, confided work spaces, elevated work spaces, operation of power tools and heavy machinery, use of various sharp objects, overhead tasks, and work demanding frequent bending, twisting and strenuous handling of equipment and materials of significant weight. The work environment in construction is subject to constant flux and imposes the need for workers to be attentive to potential new hazards. Construction is also characterized by a highly transient worker population which frequently change employers and work sites.

According to the United States Bureau of Labor Statistics (USDOL-BLS, 2006b) the private construction industry accounted for 1,186 fatal work injuries, the most of any industry sector and accounted for nearly one out of every five fatal work injuries recorded in 2005. Reasons for the higher worker fatality rates in the construction industry include contact with high-voltage industrial wiring and machinery (Ore and Casini, 1996; Pratt, Kisner and Moore, 1997; Robinson, C.F., Peterson, M., and Palu, 1999), exposure to toxic agents (Dorevich, Forst, Conroy and Levy, 2002), working at elevations which increase the risk of serious falls, involvement in work related activities that increase the risk of fatal encounters with heavy equipment (Pratt et. al., 1997; Cattledge, Hendricks and Stancvich, 1996), and materials, and motor vehicles (Ore and Fosbroke, 1997).

In 2005 about 22 percent of all fatal on-the-job injuries occurred in construction, over three times its 6% share of the total employment (USDOL-BLS, 2006b). From 1992 through 2005 and there was an increase of fatalities within the US construction industry as a percent of all occupational fatalities (see Figure 2- 1).

The trend of a reduced frequency of occupational fatalities among all industries between 1992 and 2005 suggests a slightly reversed trend within the US construction industry; however, this does not show the increase in construction employment that occurred during this period (see Figure 2- 2 and Figure 2- 3).

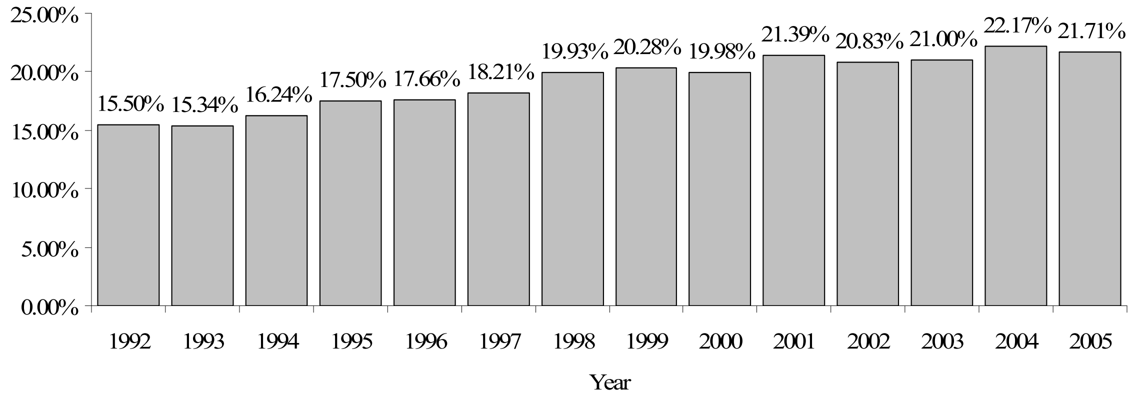

Figure 2- 1.Yearly construction fatalities as a percent of all occupational fatalities (USDOL-BLS, 2006b).

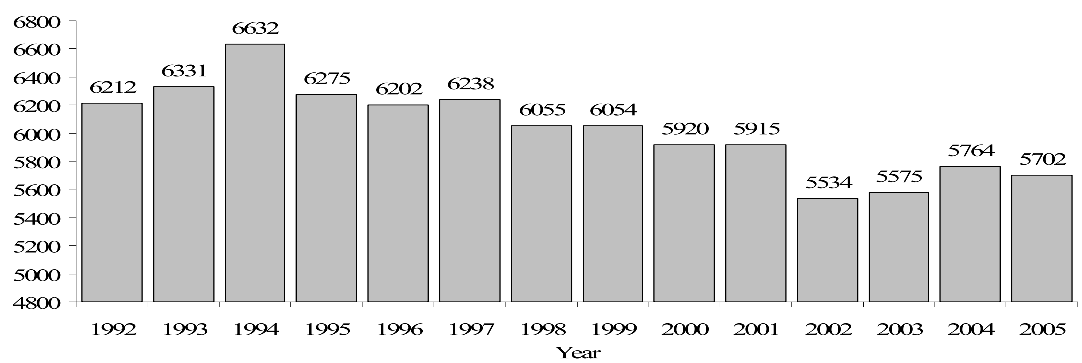

Figure 2- 2. Frequency of occupation fatalities for all industries 1992-2005. (USDOL-LS, 2006b).

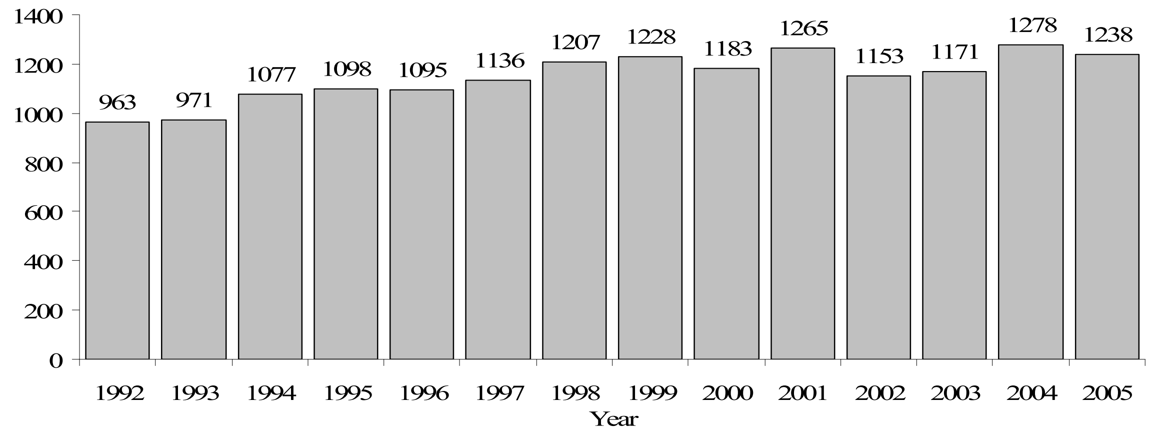

Figure 2- 3. Frequency of occupation fatalities for the construction industry, 1992-2005. (USDOL-BLS, 2006b).

Every day on the job, construction workers face the probability of a fatal, work-related injury that is over 2.5 times higher than that experienced by other US workers in private industry (BLS, 1992 - 2005).

The construction industry is also identified as having high rates of reported nonfatal occupational injuries (Gillen et. al., 1997), including eye injuries (Lombardi et. al., 2005; Welsh, et. al., 2001), hearing damage (Hessel, 2000), musculoskeletal disorders (Goldsheyder, 2004; Schneider, 2001; Lipscomb et. al, 1997; Holmstrom, et. al.., 1995) , burns (Islam, et al., 2000; Zwerling et. al., 1996), and psychosocial disorders (Savitz, Boyle and Holmgreen, 1994).

In 2005, there were 4 lost workday cases per 100 full time equivalent construction workers compared to a rate of 3/100 full time equivalent workers in all private industry; the rate in construction exceeded all other sectors (USDOL-BLS, 2006c). Non-fatal injury rates in all industries and injury rates in construction, in particular, have been declining. Within this overall decline, there has been a decline in injuries resulting in time away from work.

Demgraphic factors such as gender and age have been associated with increased injury risk for construction workers. Research suggests that female construction workers have a higher overall rate of fatalities than male workers, although males have higher fatality rates for some specific tasks or causes such as electrocutions (Ore and Casini, 1996; Kines, P., 2002; Ore, T., 1998; Ore, T. and Stout, N.A., 1997). Welch, Goldenhar and Hunting (2000) have shown that women working in construction have a different pattern of fatal injuries than male workers. They have also shown that female construction workers have different patterns of various nonfatal injuries when compared with males working in construction.

Age was found to be correlated with the causes of occupational injuries in the construction industry. Several studies have shown that young workers (< 30 years) are involved in more work-related injuries, especially those caused by hand tools, (Chau, N. et. al., 2003; Chau, N. et. al., 2002) due to lack of experience. Research has shown that health problems, especially related to musculoskeletal injuries, increase with advancing age (de Zwart and Frings-Dresen, 1999). Age (> 30 years) has been positively correlated with number of hospitalizations and duration of sick leave (Chau, N. et. al., 2004). Brenner and Ahern (2000) have shown that older construction workers find it more difficult to recover after an accident than younger workers. In a study of teens working in the homebuilding industry in North Carolina, Lipscomb and Li (2001) found that teens had higher rates of eye and foot injuries but lower rates of lower back injuries than older workers. Teen workers revealed a higher rate of injury types attributable to cuts and scratches but fewer injuries resulting from sprains and strains than older workers.

USDOL-BLS Classifications of Construction Occupational Injury and Illness

The Occupational Injury and Illness Classification System (OIICS) was developed by the United States Department of Labor's (USDOL) Bureau of Labor Statistics (BLS) to establish a set of procedures for selecting and recording facts related to an occupational injury, illness, or fatality (USDOL-BLS, 1992). OIICS is designed to be as compatible as possible with the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9 CM), which is widely used in the medical community.

The Occupational Injury and Illness Classification System contains a code structure for Part of Body Affected. This is the part of body directly affected by the identified nature of injury or illness. The Part of Body Affected code structure is arranged in order from the top of the body (Head) to the bottom of the body (Lower Extremities). The Part of Body Affected divisions are arranged as follows:

- Head
- Neck (including throat)
- Trunk
- Upper extremities
- Lower extremities
- Body systems
- Multiple body parts
- Other body parts
- Nonclassifiable.

For this report classifications for nature of injury type, cause of injury, industry, and employment activity mimics the system established by the National Council of Compensation Insurance (NCCI). The majority of U.S. jurisdictions use the NCCI as their workers' compensation rating bureau. NCCI sets rules regarding how an occupational injury or illness becomes classified along several dimensions (nature of injury, cause of injury, type of business enterprise, type of employment activity). This classification system utilizes around 600 classification codes. These codes and the rules of applying these codes are detailed in *The Scopes of Basic Manual Classifications* (NCCI, 2007).

The NCCI cause code is used to describe what caused an injury or occupational disease. This code is divided into the following nine categories. The ninth category "All Other Claims, NOC (Not Otherwise Classified)," accounts for recorded events that had no cause code assigned to them:

- Burn or exposure: includes hot or cold objects, chemical fire, welding, scalds, temperature exposure, and radiation.
- Caught in or between; includes caught in or between machinery, an object being handled, and miscellaneous objects such as earth slides or collapsing buildings.
- Puncture or cut: includes punctures, cuts, or scrapes as a result of broken glass, hand tools, utensils, power tools, appliances or guns.
- Fall, trip, or slip: includes falling from a different level or on the same level, ladder, scaffolding falls, slipping on liquid or grease, ice or snow slips, and falls into openings.
- Vehicle related: includes collisions with another vehicle or fixed object, rollovers, rough riding, and airplane, water or rail vehicle crashes.
-
- Strain, jump or lift: includes jumping, twisting, holding or carrying objects, lifting, pushing, pulling, reaching, overexertion, and throwing.
-
- Hit against or step on object: includes moving machine parts, objects being lifted, sanding, or scraping operations, stationary objects, and stepping on sharp objects.
- Struck by object: includes falling or flying objects, hand tools or machines in use, coworkers, motor vehicles, moving machine parts and objects handled by others.
- All other claims (noc): includes animal and insect bites, explosions, foreign body in eye, injury or stress from assault, absorption, injection or inhalation, and causes that occur over a period of time.

To describe the nature of an injury or occupational illness, NCCI applies a “nature code,” divided into the following nine categories. The ninth category, “All Other Claims (NOC),” designates injuries or illnesses that did not have a code assigned to them.

- Sprain or rupture; includes strains, dislocations, hernias, organ ruptures, and trauma to joints or muscles.
- Bruise or swelling: includes contusions, broken blood vessels, and inflammation.
- Laceration or abrasion: includes slivers, lodged small objects, open wounds, scrapes, and needle sticks.
- Fracture: includes any breaking of a bone.
- Occupational disease: includes repetitive motion, loss of hearing or sight, respiratory conditions, poisoning, mental disorders, radiation, heart disease, cancer, aids, carpal tunnel, and any disease resulting from work related experiences.
- Amputation: includes a loss of limb that involves bone, loss of part of an organ, enucleation, or severance of a body part.
- Burn or exposure: includes electrical shock, chemical burns, temperature extremes, freezing, sunburns, heat stroke, and lightning.
- Multiple injuries
- All other claims (noc): includes asphyxiation, loss of circulation, infection, concussion, heart problems, vision loss, hearing loss, poisoning, fainting, and no physical or psychological injuries.

A review of USDOL-BLS occupation injury and fatality data between 1992 and 2005 showed that the greatest percentage (see Figure 2- 4) of all fatalities among all industries in the US (N = 84,414) during this duration resulted from injury to multiple body parts (n = 30,833; 36.53%). Fatalities attributed to head injuries ranked second (n = 20,409; 24.18%) followed by injuries to the trunk (n = 16,241; 19.24%), body systems (n = 13,688; 16.22%), neck injuries (n = 1,730; 2.05%), lower extremities (n = 809; 0.96%), and injuries to upper extremities having the lowest rate of fatality among all the industries (n = 211; 0.25%). The construction industry showed a similar body part profile for fatal injuries during the same time period (see Figure 2- 5).

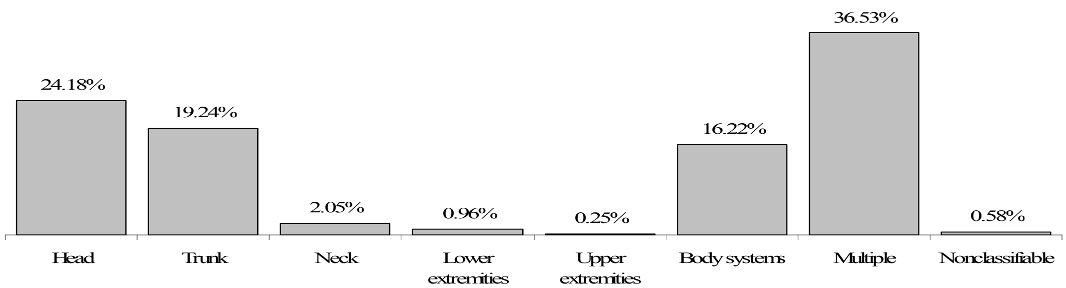

Figure 2- 4. Percentage of fatalities between 1992 and 2005 (All Industries). (USDOL-BLS, 2006b

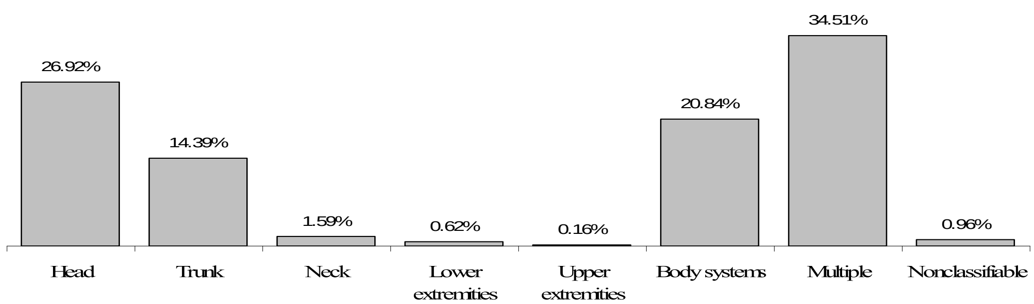

Figure 2- 5. Percentage of fatalities between 1992 and 2005 (Construction Industry), (USDOL-BLS, 2006b)

The construction industry exhibited a significantly higher proportion of all fatalities attributable to head, body systems, and unclassifiable injuries than displayed by all other injuries between 1992 and 2005 (USDOL-BLS, 2006b) (see Table 2- 1).

Table 2- 2 shows the chi square table comparisons of the proportion of specific body part regions attributed to nonfatal injuries by USDOL-BLS between the construction industry and all industries between 1992 and 2005. The construction industry showed a significantly higher proportion of nonfatal injuries attributable to injuries to the head and lower extremities than for all industries. The construction industry had a higher proportion of nonfatal eye injuries [4.94% (N = 127,392) of all non-

fatal injuries in the construction industry] than was shown among all industries [3.40% (N = 831,915) of all non-fatal injuries in all industries]. This difference was significant, X^2 (1, N = 27, 033,307) = 16,174.93, p < .001.

Table 2- 1. Body part region injured as a proportion of all fatalities between 1992 and 2005

Body part region	All industries		Construction industry		*df = 1,* N = 100,477	
	N	Proportion of total fatalities	N	Proportion of total fatalities	X^2	$p <$
Head	20,409	24.18%	4,324	26.92%	54.67	0.001
Body systems	13,688	16.22%	3,348	20.84%	205.25	0.001
Nonclassifiable	493	0.58%	155	0.96%	30.56	0.001
Trunk	16,241	19.24%	2,311	14.39%	211.08	0.001
Neck	1,730	2.05%	256	1.59%	14.46	0.001
Lower extremities	809	0.96%	100	0.62%	16.98	0.001
Upper extremities	211	0.25%	26	0.16%	4.45	0.05
Multiple body parts	30,833	36.53%	5,543	34.51%	23.79	0.001
Total	84,414	100%	16,063	100%		

Table 2- 2. Body part region injured as a proportion of all non-fatalities between 1992 2005.

Body region	All industries		Construction industry		*df* = 1, N = 100,477	
	N	Proportion of all non-fatal injuries	N	Proportion of all non-fatal injuries	X^2	$P <$
Head	1,625,927	6.65%	209,774	*8.14%*	8183.43	0.001
Lower extremities	4,988,516	20.40%	617,459	*23.96%*	17,960.72	0.001
Trunk	9,153,036	*37.43%*	874,286	33.92%	434.41	0.001
Upper extremities	5,607,231	*22.93%*	586,462	22.75%	40.11	0.001
Neck	425,886	*1.74%*	35,811	1.39%	1721.45	0.001
Multiple body parts	2,100,387	*8.59%*	204,258	7.92%	1316.84	0.001
Body systems	331,844	*1.36%*	26,088	1.01%	2,121.05	0.001
Nonclassifiable	223,039	0.91%	23,303	0.90%	1.61	0.10
Total	24,455,866	100%	2,577,441	100%		

Head Injuries

Head injuries included any injuries to the skull, scalp, brain, ears, eyes, nose, teeth, mouth, soft tissue of the head, and facial bones (Hannon, P. & Knapp, K., 2006, p. 123). Any combination of brain, scalp, skull with or without ears, eyes, nose, mouth, teeth, face, or neck are coded as “multiple head injury,” which also includes injuries to the head not otherwise classified. Because of the constantly changing conditions at worksites, the construction industry is particularly hazardous with respect to head injuries (Janicak, C.A., 1998). Dangers to construction workers include falls from heights (Gillen, M. et al., 1997; Huang, X. and Hinze, J., 2003), being hit by falling or swinging objects, and collapse of buildings or trenches. Workers may be hit by falling bricks, or tools, fall from scaffolds or ladders, or fall through insufficiently blocked holes in floors or roofs (Kines, P., 2002; Kisner, S. and Fosbroke, D., 1994). The chief causes for head injuries are motor vehicle accidents and falls (Anderson, D., Miller, J. and Kalsbeek, W.; 1983), also major causes of other injuries for construction workers. Falls and vehicle incidents and being struck by objects were identified as major sources of head injuries and of fatalities resulting from head injuries in the construction industry (US-BLS, 1997).

Injury Types and Mechanisms

Injuries to the skull include any injury to the cranial bones (see Figure 2- 6). Although the skull is tough, resilient, and provides excellent protection for the brain, a severe impact or blow can result in fracture of the skull and may be accompanied by injury to the brain. Some of the different types of skull fractures include:

- Simple: a break in the bone without damage to the skin.
- Linear or hairline: a break in a cranial bone resembling a thn line, without splintering, depression, or distortion of bone.

- Depressed: a break in a cranial bone (or crushed portion of skull) with depression of the bone in toward the brain.

- Compound: abreak in or loss of skin and splintering of the bone. Along with the fracture, brain injury, such as hematoma (bleeding) may occur.

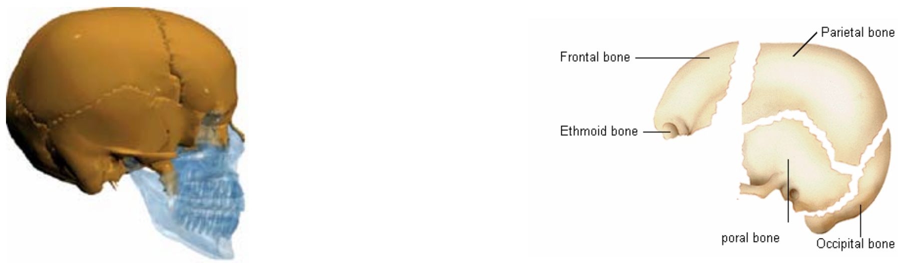

Figure 2- 6. Position of the cranium (left) and bones of the cranium (right) (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

The **scalp** is the anatomical area bordered by the face anteriorly and the neck to the sides and posteriorly. It is usually described as having five layers. Scalp injuries are usually the result of direct impact but may not be apparent in inflicted head injuries (Hannon, P. & Knapp, K., 2006, 1996, p. 124). When present, these may manifest as abrasion, bruising, laceration, or a burn. Punctures of the scalp, skull and brain may result from penetrating objects such as nails from pneumatic nail guns (Buchalter, G.M., et al., 2002; Beaver, A.C. and Cheatham, M.L., 1999; Bock, H., Neu, M., Betz, P., and Seidl, S. 2001).

Injuries to the brain include any brain concussion or brain damage (Stone, D.J., 1996, pp. 11-1 – 11-30). The brain is divided into four main sections: cerebrum, brain stem, diencephalons and cerebellum (see Figure 2- 7). The cerebrum controls deliberate actions and is also the center of intelligence, learning and teaching ability, memory, will and feelings. The cerebellum coordinates movements, is responsible for balance and orientation in space. The brain stem controls (among other things) respiration, blood circulation, sleeping/waking rhythm and attention, and is directly or indirectly connected to all parts of the central nervous system.

Types of injury to the brain may include anoxic brain injury, contusion/concussion, coup/contrecoup, diffuse axonal injury (DAI), or hematoma (epidural and subdural). An anoxic brain injury is caused by a lack of oxygen to the brain. It usually results from lack of blood flow due to injury or bleeding and will cause swelling of brain tissue (Stone, D.J., 1996, p. 11-6).

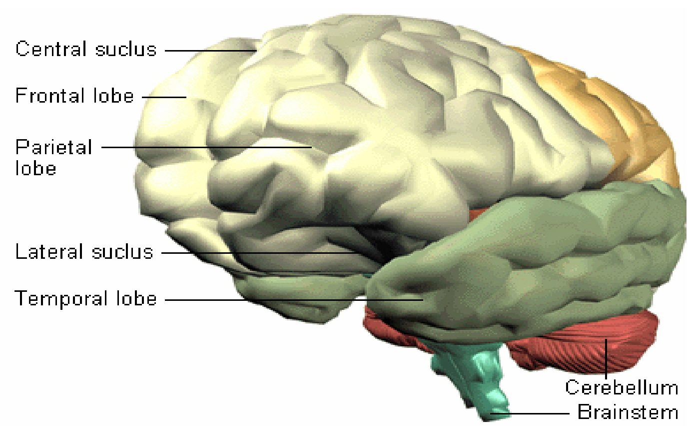

Figure 2- 7. Structure and lobes of the brain. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Contusion or concussion is often mislabeled a “mild” injury to the brain resulting in bruising of brain tissue. This injury may cause headaches, vomiting, dizziness and problems with memory or concentration. It does not require surgery. While there is little or no loss of consciousness, the long-term results certainly may not be “mild.” A coup injury is caused when the brain is propelled against one side of the skull. Because brain tissue is suspended in fluid, it often rebounds and collides with the opposite side of the skull. When it strikes both sides of the skull, the injury is sometimes called a contrecoup injury.

Diffuse axonal injury (DAI) results when a rotational or shearing force is exerted on the nerve fibers (Hannon, P. and Knapp, K., 2006, p. 131). DAI may cause a loss of consciousness, or coma, which may last from a short time to an indefinite period.

Epidural hematoma is an accumulation of blood between the skull and the top lining of the brain. This clot may cause pressure changes in the brain, and emergency surgery may be necessary. The size of the clot will dictate the necessity of surgery. This bleeding may increase pressure on the brain, causing it to be forced down the spinal column, compressing the brain stem and resulting in death. An intracerebral hemmorhage is a blood clot deep in the middle of the brain that is hard to remove. Pressure from this clot may cause tissue damage, and surgery may be needed to relieve the pressure. A subdural hematoma refers to the formation of a blood clot between the brain tissue and the dura. If it occurs slowly over several weeks it is referred to as a subdural hematoma; if it occurs quickly it is referred to an acute subdural hematoma. The clot may cause pressure and require surgical removal.

Injuries to the ear include any injury to the outer ear, middle ear, inner ear, and/or results in partial or complete loss of hearing. The outer ear includes the auricle and the auditory canal. The middle ear includes the tympanic membrane (eardrum), eustachian tube and tympanic cavity. The Eustachian tube, which creates a connection to the nasopharyngeal space, opens out into the tympanic cavity. The tympanic cavity is a space filled with air, which is lined by a mucous membrane. Its three auditory ossicles are named after their appearance: hammer, anvil and stirrup (see Figure 2- 8). This assembly is responsible for the transmission of sound (Stone, D.J., 1996, pp. 10-3 – 10-30).

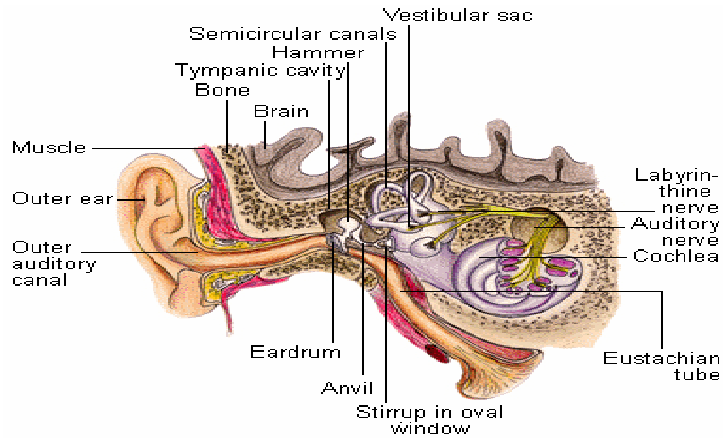

Figure 2- 8. Structure of the ear (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Ear injuries can occur in a variety of ways. A forceful, direct blow to the side of the head can increase air pressure inside the ear canal, leading to a ruptured eardrum or a disruption of the tiny bones in the inner ear that transmit sound. Extremely loud, explosive noises can increase the air pressure inside the ear canal and damage the eardrum (acoustic trauma). Dramatic decreases in atmospheric pressure changes can cause the eustachian tube to compress, which prevents air from entering the middle ear (Stone, D.J., 1996, pp. 10-7 -10-11). This leaves the middle ear unable to compensate for the change in pressure outside the ear. Kilburn, Warhsaw and Hanscom (1992) concluded that there was a link between hearing loss, attributable especially to the use of air impact power tools, and balance dysfunction among construction iron workers, thus increasing the risk of falls from heights. Injuries of the inner ear can occur to welders, when molten metal and a hot spark fall into the ear while welding. This injury can cause deafness as well as facial nerve injury (Panosian, M.S. and Dutcher, P.O., 1994).

Cuts or scrapes may injure the outer ear or ear canal. Aggressive or inappropriate techniques when cleaning the ear canal can cause irritation or injury. Burns or frostbite can cause ear injuries. Objects placed forcefully in the ear can cause injury.

Injury to the eye includes any compromise to the eye and/or optic nerve (visual organ) which may or may not result in a partial or complete, temporary or permanent, loss of vision (Welch, L.S., et. al., 2001; Lipscomb, H.J., et. al., 1999). The visual organ consists of the two eyeballs with the visual nerves and the corresponding cranial nerve tracts, together with different adjuvant features such as the eye muscles, the eyelids and the lacrimal system with the tear glands (see Figure 2- 9). Eye injuries comprise a significant proportion of all construction work related injuries (Welch, L.S., et. al., 2001). Welders and carpenters are at particular risk for eye injuries (Lombardi, D.A. et al., 2005; Lipscomb, H.J., et al., 1999)

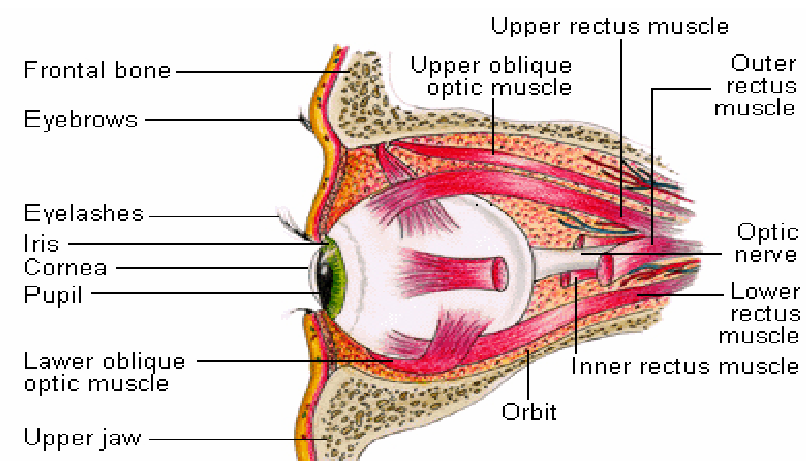

Figure 2- 9. Structure of the eye.(Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Eye injuries range from the very minor, to the catastrophic, resulting in permanent loss of vision. Eyes may be subject to injury due to chemical exposures and/or burns. These are often the result of a splash of liquid getting in the eye (Welch, L.S., et al., 2001). Chemical burns can occur in a number of ways. Many chemicals are simply irritants to the eye and do not usually cause permanent damage. However, acids and alkalis are highly caustic and can cause severe damage (Islam, S.S., et. al., 2000).

The cornea is somewhat of a transparent skin that covers the eye. A corneal abrasion is a scratch or an abrasion of that skin. Corneal abrasions often result from being "poked" in the eye, often from a finger, tree branch, or other foreign object. Traumatic iritis (inflammation of the iris) can occur in the same way as a corneal abrasion. However, this injury is more associated with a blow to the eye from a blunt object, such as a fist or a club. The iris is a muscle that controls the amount of light that enters the eye through the pupil (CantMedia, 2007).

Hyphemas result from bleeding in the eye that occurs in the front part of the eye, in the space between the cornea and the iris. Orbital blowout fractures are cracking or breaks of the facial bones surrounding the eye. These injuries are associated with significant force from a blunt object to the eye and surrounding structures.

Lacerations (cuts) to the eyelids and the conjunctiva (mucous membranes) commonly are caused by sharp objects but can also occur from a fall. Lacerations to the cornea and the sclera are very serious and are frequently associated with blunt trauma of flying objects. Foreign bodies in the eye could be any objects that get into the eye. Corneal foreign bodies become embedded in the cornea but have not penetrated the eye itself. Metal foreign bodies in the cornea can cause a rust stain, which also requires treatment. Intraorbital foreign bodies are in the orbit (or eye socket) but have not penetrated the eye. Intraocular foreign bodies are injuries in which the globe of the eye has been penetrated by the object (Dannenberg, A.L., et. al., 1992).

The cornea (the clear window of tissue on the front of the eyeball; see Figure 1-10), can be damaged easily by exposure to ultraviolet radiation from the sun and from other sources of ultraviolet light, such as a welder's arc or even a halogen desk lamp. The cornea takes the brunt of the damage if proper eye protection is not worn. A corneal flash burn (also called ultraviolet keratitis) can be viewed as a sunburn of the eye surface. Corneal damage from a corneal flash burn may cause pain, temporary reduction in vision, or permanent partial or complete loss of vision (Islam, S.S., et. al., 2000).

The nose serves primarily to moisten, warm and clean the air to prepare it for the lungs. The nasal sinuses are also involved in this. At the same time, the nose is also a sensory organ because this is where the olfactory organ is located. The structure of the outer nose consists of the root of the nose (radix nasi) to which the bridge of the nose is attached (see Figure 2- 10). This is held by the nasal bones. The sides of the nose extend to either side of the bridge of the nose and form the nostrils in combination with the tip of the nose consisting of cartilage.

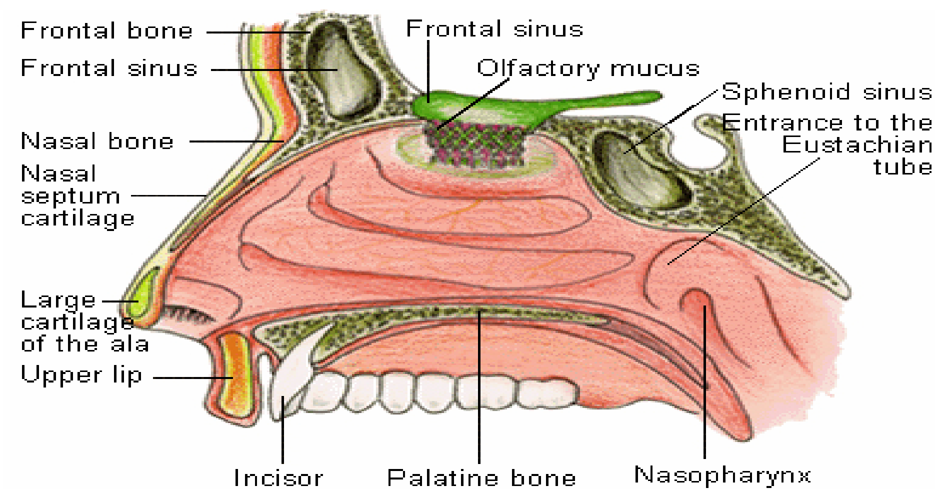

Figure 2- 10. Structure of the nasal cavity. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Injuries to the nose include all injuries to the external area of the nose and internal components of the nose. Injuries to the internal nasal location would include injuries to the nasopharynx, nasal passages, sinuses, injuries to multiple internal nasal locations and any internal nasal location not otherwise classified. Nasal injury results from fractures, dislocations, foreign bodies, chemical irritants, or burns. Construction workers are at higher risk for all facial injuries, including those to the nose. Falls from a height and being struck by an object are the most common causes of these injuries (Lipscomb, H.J., et al., 2003 & 2006; Exadaktylos, A.K. et al., 2001).

All severe blows to the nose may result in a nasal fracture (Harrison, D.H., 1979). After such a blow, the nose may appear slightly deformed as well as shifted laterally or depressed. Other symptoms include: pain, swelling, airway obstruction, epistaxis (profuse bleeding from the nose), crepitance (the crackling heard and the sensation felt when broken bones are moved over each other), ecchymosis (a purplish area of the nose resulting from fracture and caused by extravasation of blood into the skin), septal hematoma (a mass of extravasated blood confined within the nasal septum), rhinitis (an inflammation of the mucous membranes that line the nasal passages), and nasal vestibular stenosis (a narrowing of the nasal passages) (ContMedia, 2007).

In addition to fracture, trauma may be caused by chemical inhalation. This is normally due to repetitive inhalation of toxic materials that may, in addition to irritating the nasal passages, cause damage to the lower respiratory tract and lungs. Irritant gases may cause damage by direct contact with membranes and a subsequent chemical reaction can result in membrane damage. Some common irritants that may be encountered in workplace include: cleaning solutions and powders, ammonia, environmental tobacco smoke, bleach, metalworking fluids, ozone, sulfur dioxide, paint thinners, arsenic, chromic acid, copper dust and mists (Frampton. M. and Utell, M. J., 1995).

The mouth consists of the oral cavity, with the teeth and the tongue (see **Error! Reference source not found.**- 11). The lips close the cavity to the outside, and on the inside it borders on the throat (pharynx). The skin of the lips on the outside is hairless, without pigments and only slightly cornified. The highly vasculated derma has a red shimmer and gives the lips their red color. Numerous nerves make the lips sensitive to touch. The throat constitutes the connection to the openings of the digestive and respiratory systems. The upper part of the oral cavity, the roof of the mouth, is divided into the front hard palate and the rear soft palate (Hannon, P. and Knapp, K., 2006).

The lower boundary of the oral cavity consists of the mandible, on which the tongue lies. The mucous membrane of the mouth secretes mucous, which together with the saliva from the salivary glands, keeps the inside of the mouth moist. The oral cavity is held at the sides by the jaw muscles and at the bottom by the muscles of the bottom of the mouth. In addition to the oral cavity's tasks involved in taking in food, testing it (taste), crushing it with the teeth and tongue and preparing it for digestion with certain salivary enzymes, it is also involved in phonation (speech).

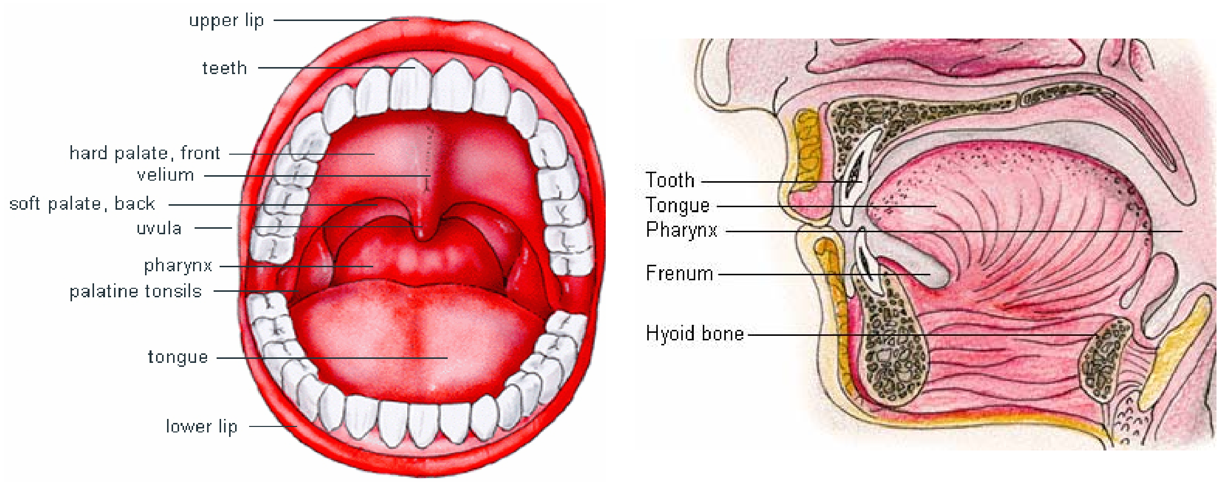

Figure 2- 11. Front and side view of the structure of the mouth. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Mouth injuries may involve the teeth, jaw, lips, tongue, inner cheeks, gums, roof of the mouth (hard or soft palates), or tonsils. Even a small cut or puncture inside the mouth may bleed profusely because there are many blood vessels in the head and neck area. Teeth may be injured during a fall or when struck by an object when performing an occupational activity. A tooth may be knocked out (avulsed). An injury could crack, chip, or break a tooth, or make a tooth change color. A tooth also may be loose or moved in position (dental luxation) or jammed into the gum (intruded) (Hannon, P. and Knapp, K., 2006, p. 128).

An injury to the mouth or lips may cause a large, loose flap of tissue or a gaping wound that may need stitches. The piece of skin between the lips and gums or under the tongue may tear or rip. Usually this type of injury will heal without stitches. It is generally not a concern unless the tear was caused by physical trauma. An injury to the roof of the mouth, the back of the throat, or a tonsil can injure deeper tissues in the head or neck. These injuries can happen when a worker falls with or onto a pointed object, such as at the end of rebar.

Neck Injuries

Injuries to the neck include injuries to the middle and lower throat (vocal chords, larynx, laryngopharynx, pharynx), windpipe (trachea), any multiple internal neck injuries, and any internal neck injury not receiving a specific classification. Injuries to the external area of the neck and throat are also classified as neck injuries. Neck injuries would also include any injury to the spinal column bone in the neck, which includes the first seven bones of the spinal column (C1-C7: cervical vertebrae), discs (spinal column cartilage in the neck), and injury to nerve tissue in the neck (spinal chord). The most common injuries to the neck among construction workers include sprains and musculoskeletal pain, as well as contusions, abrasions and impalement from foreign bodies (Hunting, K.L., et al., 1999). Injuries to the spinal column are usually life threatening. Foreign bodies intruding the neck area, such as those produced from nail gun accidents can also present a great threat to life (Buchalter, G.M., et al., 2002; Beaver, A.C. and Cheatham, M.L., 1999).

Throat & Trachea

The throat is a tube-like structure about 12 cm in length, which is divided into three sections. These are the upper throat (nasal pharynx), the middle throat (oral pharynx) and the lower throat (laryngeal pharynx). The middle section and lower section belong to the esophagus. The respiratory section consists of the upper part and the middle section. This means that the windpipe (trachea) and epiglottis cross in the middle section. When swallowing, the air passage is interrupted by the soft palate, the base of the tongue and the epiglottis.

Vertebrae of the Neck (Cervical Vertebrae)

The human vertebral column is on the rear side of the body. Its main functions are to support the body, to cushion it (especially to protect the brain against shocks) and to protect the spinal cord. The human vertebral column consists of 33-34 vertebrae, which are designated according to the region of the body in which they are found (Hannon, P. and Knapp, K., pp. 111-115). The cervical vertebral column has 7 cervical vertebrae (C1-C7). The cervical vertebral column can be inclined approximately 90 degrees backwards, 40 degrees forwards and 35 degrees to the side (see Figure 2- 12).

The individual vertebrae are separated from one another by intervertebral discs. They function like shock absorbers. Various ligaments between the vertebral processes cover almost the entire vertebral column.

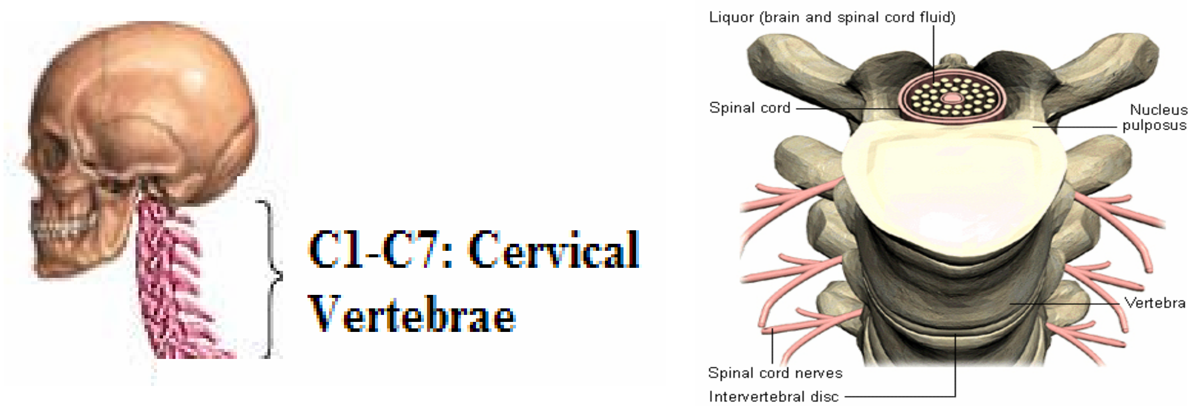

Figure 2- 12. Vertebrae of the neck (left) and structure of the vertebral column (right).(Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Injury Types and Mechanisms

Common injuries to the neck include muscle spasms, which are tight, contracting movement of the muscles in the neck. Neck spasms are often the result of injury and overuse. A muscle strain is a tear in the small muscle fibers that slide over one another during movement to produce contraction. Sometimes this tear can be microscopic, or can cause bleeding or overstretched fibers. Muscle strains are often caused by overuse, a sudden and strong usage including whiplash and sudden contact with objects, or too much tension (e.g., lifting heavy weights). Musculoskeletal injuries of the neck are common among construction workers (Schneider, S.P., 2001). At higher risk of these strain injuries of the neck are crane operators, painters and insulators (Holmstrom, E., Moritz, U., and Engholm, G., 1995).

The neck is quite vulnerable to fractures. A fracture is a break in a bone. Neck fractures must be taken very seriously, because of the risk of a broken neck, and paralysis of the body below the site of the injury. Paralysis happens when the spinal cord becomes damaged due to the injury (Hannon, P. and Knapp, K., 2006, pp. 111-115). Lesser neck fractures might cause pain, tingling, numbness or varying degrees of paralysis. Impact such as from car crashes, falls, sudden impacts with objects or people are common causes of occupational neck fractures.

Trunk Injuries

Trunk (ventral body cavity) injuries include any injury to the upper and lower back, spinal column cartilage in the back, spinal chord, thorax (chest), sacrum and coccyx, and pelvis. This would also include injuries to the exterior posterior of the pelvis and hip area (e.g., buttocks). Trunk injuries also include injury to internal organs (see Figure 2- 13) of the thorax (heart and lungs), abdomen (stomach, lower esophagus, small or large intestines, liver, gall bladder, spleen, pancreas, kidneys, appendix) and groin. Multiple trunk injuries include those injuries which effect any combination of the hip, abdomen and chest (Hannon, P. and Knapp. K., 2006, pp. 151-159).

A large portion of occupational injuries to the trunk are a result of blunt trauma, which can range from minor to fatal. It is not uncommon for some trunk injuries, even severe ones, to go undiagnosed for quite some time. The liver, spleen and kidneys are the most commonly injured organs of the abdomen.

Injuries of the Thoracic Cavity

Unlike the abdomen the thorax is less complicated, containing far fewer organs which allows for injuries in the region to be more predictable. However, injuries within the thoracic area often present themselves as the most life threatening (apart from the brain). The thorax is the superior portion of the ventral body cavity, separated from the abdominal cavity by the diaphragm. In general, the thorax is a hard shell containing the following components: the heart, lungs, trachea, esophagus, aorta, and other major blood vessels. The ribs and the sternum (see Figure 2-13) surround the entire cavity, providing a protective shell, and along with the diaphragm and intercostal muscles, facilitate breathing (see Figure 2- 14). The intercostal muscles consist of two layers, and the fibers cross each other almost at right angles. The intercostal muscles starting at the inner edge of the costal arches are referred to as inner muscles. They lower the ribs on breathing out. The outer intercostal muscles lift the ribs on breathing in. Finally, there is another group of intercostal muscles, the innermost. They are separated from the inner muscles by the intercostals nerves and are also respiratory muscles (ContMedia Human 3D Advanced Internet Edition, 2007).

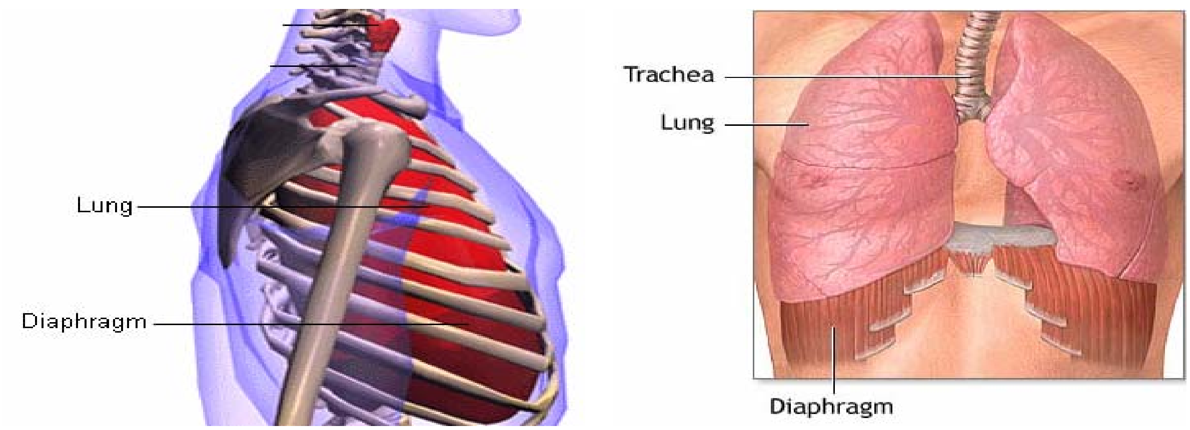

Figure 2-13. Side view of thorax (ribs, lungs and diaphragm). (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

The thorax is generally more difficult to injure due to the protected nature of the cavity. Approximately 75 percent of all thoracic injuries occur along with injuries to other cavities, mainly the skull or abdomen (Ghista, 1982).

The impact mechanisms for blunt trauma injuries of the thorax are essentially the same as that for the abdomen (Hannon, P. and Knapp, K., 2006, p. 158). Fracturing of the bone structures can cause compression and eventual puncture of the nearby organs. Shear forces resulting from deceleration and consequent tissue strain may cause tearing a fixed attachment point. An increase in internal pressure within the thoracic cavity can result in bursting or rupturing of organs and tissues.

Ribs and Sternum

The sternum is a flat bone with three segments connected by strong connective tissue and cartilage (see Figure 2-16). There are twelve sets of ribs. Ribs 1 to 7 connect directly to the sternum. They also connect to the thoracic vertebrae (Hannon, P. and Knapp, K., 2006, pp. 162-163). Ribs 8 to 10 attach only to the cartilage of rib 7, and ribs 11 to 12 have no direct connection at all to the sternum (see Figure 2- 14).

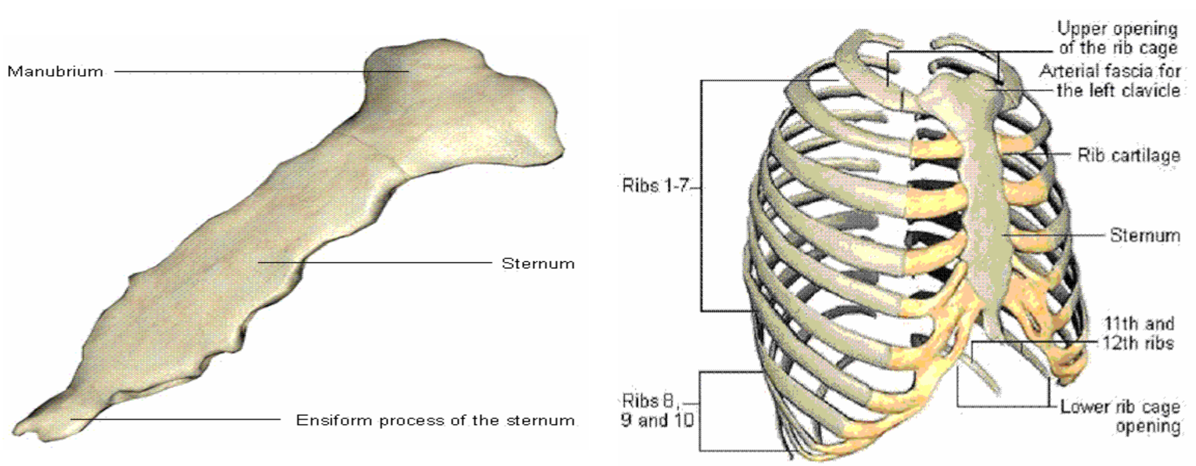

Figure 2- 14. Detail of the sternum (left) and ribs 1 to 12 (right). (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

The rib cartilage allows for a large amount of bending strain before fracture occurs. Because ribs 1 and 2 are also protected by the shoulder, they are difficult to fracture. When these ribs do fracture, there are almost always additional injuries. The most frequently fractured ribs in occupational settings are 5 to 9 (Islam, S.S. et al., 2001). There are two types of bending rib fractures: a direct bending where fracture occurs at the impact site and an indirect bending where a load is transmitted to a weaker part of the rib (Schmidtt, K, Niederer, P. and Walz, F., 2004, p. 95).

When there are four or more complete rib fractures, the chest wall becomes unstable, a condition that is termed “flail chest.” This causes a paradoxical movement upon patient inhalation, preventing the lung from properly filling with air. A serious flail chest can be fatal unless respiratory assistance is provided.

Heart and Thoracic Blood Vessels

The heart has two major anchor points: the diaphragm at the apex and the major vessels at the superior end (see Figure 2- 15).Penetrating trauma directly to the heart causes extensive bleeding and usually death. Blunt trauma can include temporary electrical irregularities, complete myocardial infarction (i.e., heart attack caused when an area of heart muscle dies or is permanently damaged because of an inadequate supply of oxygen), contusions, lacerations, embolism (sudden interruption of blood flow) from thrombosis (clot), partial tearing of the tissue, or rupture (Hannon, P. and Knapp, K., 2006, p. 163).

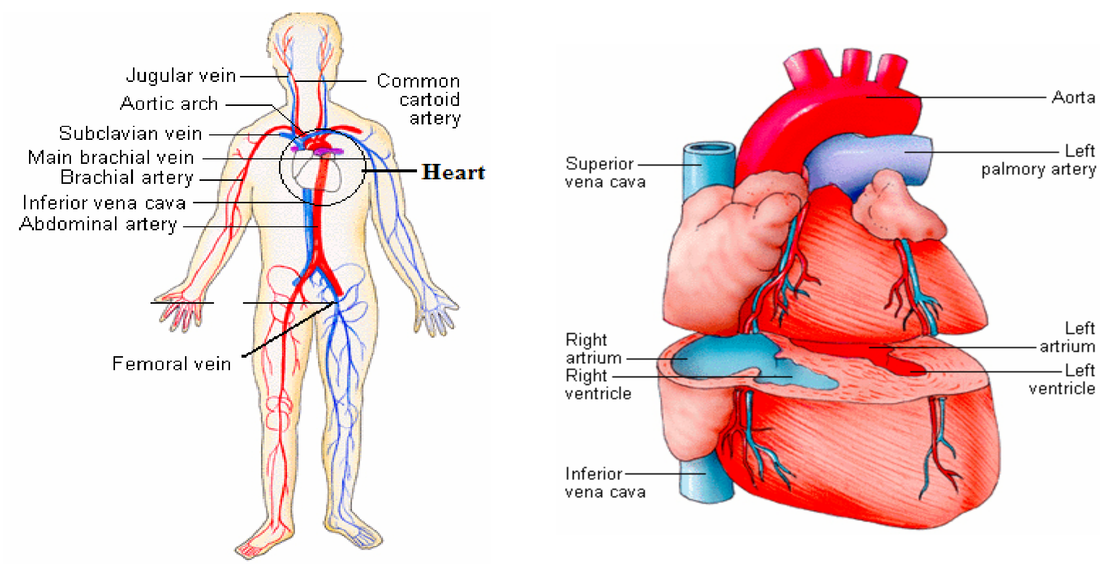

Figure 2-15. Position of the hear (left) and structure of the heart with cross sectional view (right). (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

The mechanisms for these injuries can include puncture from a rib or sternum fracture, compression of ribs and adjacent organs without rib fracture, or tension loads resulting from lengthening deformation of the heart (Schmidtt, K., Niederer, P., and

Walz, F., 2004, p. 97). Any injury in which the heart bleeds openly and is unable to continue circulating blood is usually fatal. Rupture and laceration are the most likely mechanisms resulting from blunt trauma to the thorax. The most common mechanisms of injury were found to be motor vehicle crashes followed by falls and struck by accidents (Ochsner et. al 1989).

Exposures to various materials and activities, such as welding (Sjogren, B., et al., 2002) in construction may increase a worker's risk of developing various types of heart disease. The most prevelant form of heart disease is myocardial infarction (heart attack). In an occupational setting, heart disease must be evaluated with a view to both background and precipitating factors (Hannon, P. and Knapp, K., 2006, pp. 163-164). Background factors include such factors as smoking, family history, and preexisting illnesses which further potentiates heart disease (e.g. diabetes and hypertension). Precipitating factors (occupationally event based) include noise, heat and cold, shift work, and emotional stress. The heart may also be damaged by toxic substances.

Precipitating factors for a heart attack can include physical overexertion, excessive heat or humidity and emotional crisis. Construction work in general has shown a high risk of death and permanent disability due to heart disease. Specific construction occupations that are at high risk for death and permanent disability due to heart disease include laborers, carpenters, and electricians (Leigh, J.P. and Miller, T.R., 1998).

Trachea, Esophagus and Diaphragm

Injuries to the respiratory system mainly concern lung injuries. Injuries to the lungs are the most common thoracic injury and can range from minor to fatal (Schmidtt, K., Niederer, P. and Walz, F., 2004, p. 96). The lungs are commonly lacerated by rib fractures (see Figure 2- 16). If substantial, the laceration may lead to the development of minor to serious pneumothorax (collection of air or gas in the space [pleural cavity] surrounding the lungs) which prevents the lung from fully expanding upon inhalation. A similar lung injury that occurs from either penetrating trauma or rib puncture is the hemothorax (a collection of blood in the space between the chest wall and the lung).

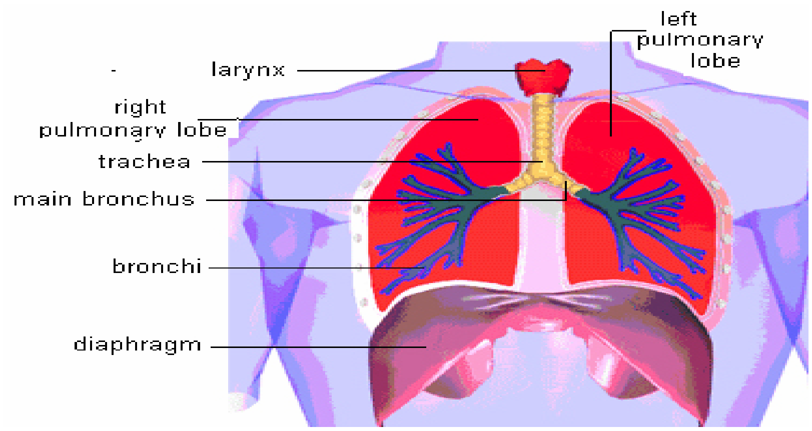

Figure 2- 16. The larynx, pulmonary lobes and bronchi of the lungs, and diaphragm. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

This has similar effects as a pneumothorax by preventing the full expansion of the lung. It is also possible to have a hemo-pneumothorax, where both blood and air invade the pleural cavity. Other injuries of thoracic organs include rupture of the trachea, rupture of the espohagus, and laceration of the diaphragm. The latter possibly results in a partial protrusion through a weak point or tear in the thin muscular wall that holds the abdominal organs in place (hernia). Because construction work exposes workers to a greater risk of falls and struck-by incidents, they are highly susceptible to traumatic injuries of the lung and surrounding tissue.

Liver

The liver is the largest gland in the body, as well as the largest abdominal organ (see Figure 2- 17). The liver is responsible for a large number of essential body functions, including metabolism of carbohydrates, lipids, and proteins; blood plasma synthesis;

vitamin and mineral metabolism; digestion; and the removal of certain toxins, hormones and bacteria from the body. Lacerations and blunt trauma to the liver are the most dangerous abdominal injuries. Lacerations may occur from direct impact compression, puncture from rib fractures, deformation due to compression of other organs, or increased blood flow pressure upon impact (Hannon, P., and Knapp, K., 2006, p. 155).

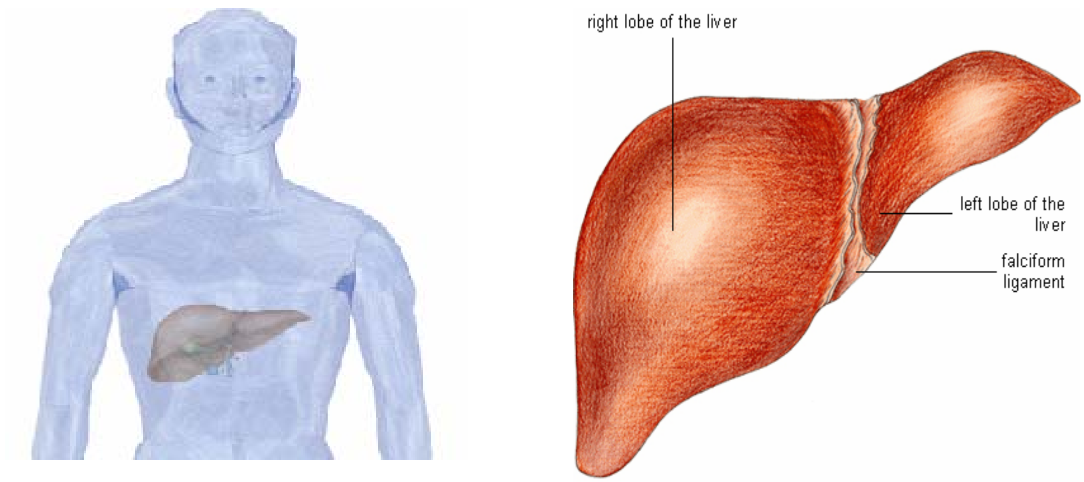

Figure 2- 17. The position (left), in the human body, and the exterior structure (right) of the liver. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Spleen

The spleen is the most commonly injured organ of the abdomen from blunt trauma (Schmidtt, K., Niederer, P., and Walz, F., 2004, pp. 113-115). It is partially protected by the lower left rib cage and is the largest lymph organ and is the site for red blood cell storage. The spleen also filters bacteria and cellular debris from the blood. Being a highly vascularized organ, when ruptured or damaged, fatal hemorrhaging in the spleen may result. Injuries to the spleen range from minor non-bleeding capsular injuries to multiple lacerations and extensive hemorrhaging (see Figure 2- 18).

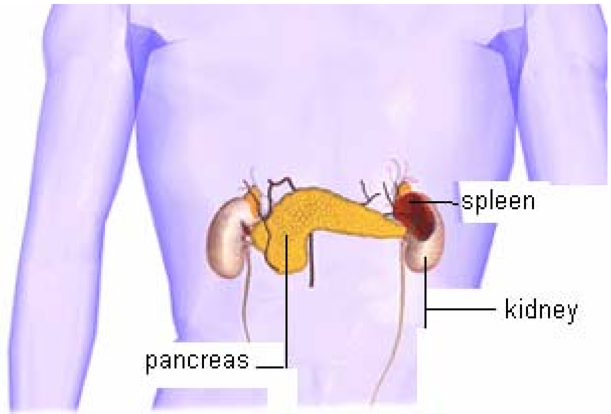

Figure 2- 18. Positions of the spleen kidneys and pancreas in the human body. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Kidneys

The two kidneys are located in the lumbar region (see Figure 2- 18), on both sides of the spinal column behind the connective tissue of the abdominal cavity, protected by the lower ribs. Because of their location, the kidneys are more susceptible to side and rear direct impacts. The kidneys have no ligament structure to hold them in place. The renal veins and arteries serve as their primary attachments to the abdominal aorta and inferior vena cava (Hannon, P. and Knapp, K., 2006, p. 156). Such attachments make the kidneys highly vulnerable to stretch injuries of the blood vessels and potential detachment.

The function of the kidneys is closely linked with the vascular system. The kidneys control the balance of salts and minerals, regulate the balance of liquid and are also involved in adjusting the levels of acids and alkalis in the body. So the main task of the kidneys is to maintain the constant balance of the normal composition of the blood and therefore all other body fluids. The kidneys must recognize and decide which substances need to be excreted and which have to stay in the purified blood in the body. Injuries of the kidneys can be as minor as a contusion but have the potential to be fatal if there are extensive lacerations or, as previously described, if a detachment injury occurs. In extreme cases, kidney failure is possible (Hannon, P. and Knapp, K., 2006, p. 156).

Pancreas

The pancreas serves two functions. It aids in digestion and produces hormones that regulate glucose metabolism (Hannon, P. and Knapp, K., 2006, p. 156). The pancreas is fairly deep within the abdominal cavity and is fairly well protected from injury due to the surrounding tissues (see Figure 2- 18).

Pancreatic injuries account for 1 to 2 percent of the abdominal injuries (Yoganandan et. al., 2001). However, pancreatic rupture can occur in either compression or shear, particularly against the spinal column. Because this injury normally occurs with other abdominal injuries, pancreatic injuries often get overlooked. An extreme delay in detection can lead to serious illness.

Stomach

The stomach is a large, hollow organ located in the middle region of the abdomen (see Figure 2- 19). While it is not uncommon to see stomach a injury due to a penetrating wound, a stomach injury due to blunt trauma is infrequent and typically not life threatening. The stomach is highly compressible and resistant to bursting. Because of the extremely low levels of bacteria present in the stomach, any rupture is unlikely to cause infection in the peritoneum (membrane lining of the abdominal cavity). Contents of the stomach may explode through the esophagus and mouth following a high magnitude blunt impact. This may result in mild irritation to the linings of the esophagus and mouth (Hannon, P., and Knapp, K., 2006, p. 157).

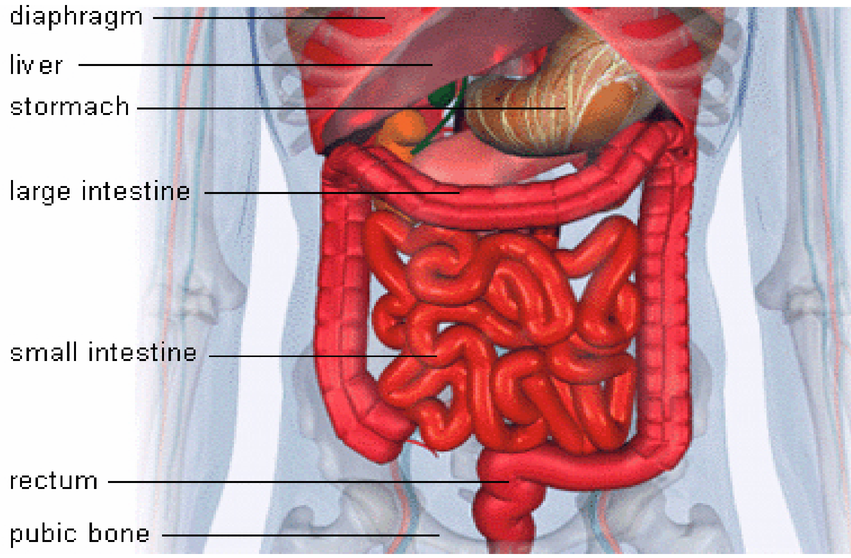

Figure 2- 19. Positions of the organs of the lower digestive system in the human body. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Small and Large Intestine

The small and large intestines travel through most of the central and lower portions of the abdominal cavity (see Figure 2- 19). The small intestine is the portion of the digestive system most responsible for absorption of nutrients from food into the bloodstream. Located around the periphery of the small intestine, the large intestine consists of the cecum, appendix, colon (ascending and descending), rectum, and the anal canal (anus). The large intestine is the portion of the digestive system most responsible for absorption of water from the indigestible residue of food (Hannon, P., and Knapp, K., 2006, p. 157).

Similar to the stomach, the potential for compression or burst in the duodenum increases when it is full and blunt trauma is possible. The structures of both the small and large intestine are fairly moveable within the cavity and yield well to compressive and tension loads. The most frequent blunt trauma injury to the small intestine is a shearing tear near the large intestine attachment due to deceleration or an acute compression tear.

However, it is generally a penetrating wound, from a sharp object, that results in injury of the small intestine (Schmidtt, K., Niederer, P., and Walz, F., 2004, p. 117).

Like the small intestine, the large intestine is more frequently injured by penetrating trauma. However, because it has several anchor points to the abdominal wall and other organs, a rupture of the transverse colon may also occur from compression against the spinal column. Blunt trauma injury to the colon comprises about 5 percent of all abdominal injuries reported (Yoganandan et. al., 2001).

Abdominal Wall

It is possible to tear the lining of the abdominal wall without injuring any other organs. However, a complete tear may lead to a traumatic hernia, where various organs may be pushed outside the cavity itself. Depending upon the degree of extrusion of the traumatic abdominal hernia and the degree to which blood flow to organs is reduced or eliminated, the severity of the injury will vary (Stone, D.J., 1996, pp. 9-5 – 9-18).

Gall Bladder

The gall bladder is a storage site for the bile that is secreted in the liver, with a common duct that empties into the duodenum. The gall bladder is well protected from injury, being located inferior and posterior to the liver (see Figure 2- 20). Injuries to the bile ducts can occur with a crushing blow to the posterior torso. Another possible, though not highly probable, injury mechanism described by Yoganandan et al. (2001) is that the bile duct may be ruptured upon the rapid emptying of the gall bladder into the common duct coupled with a simultaneous shearing force during distention of the duct.

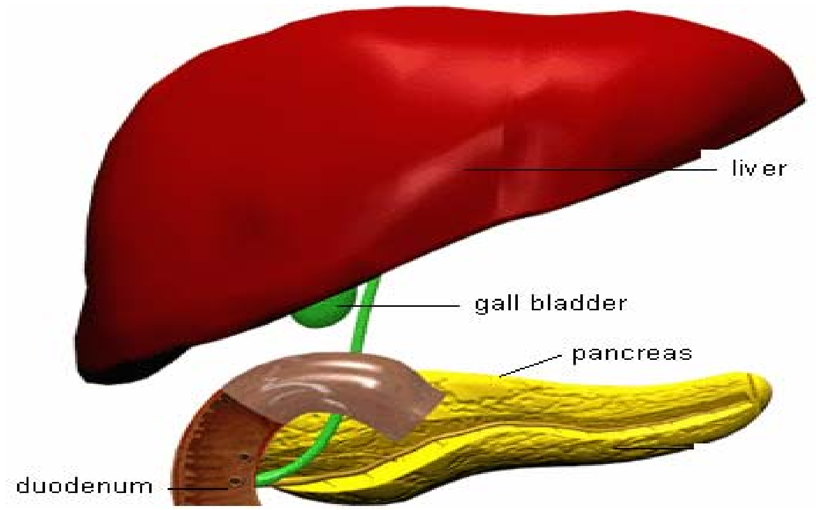

Figure 2- 20. Position of the gall bladder. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Urinary Bladder

The urinary bladder is located on the floor of the pelvic cavity (see Figure 2- 21). The muscle tissue of the bladder is highly distensible. The empty bladder has strong, thick walls that become thinner as the bladder fills. As the bladder fills, it places pressure on the peritoneum. The potential for injury increases as the bladder continues to extend. Any sudden increase in lower abdominal pressure due to a compression load may cause a distended bladder to rupture at the weakest point, similar to a balloon (Hannon, P., and Knapp, K., 2006, p. 158).

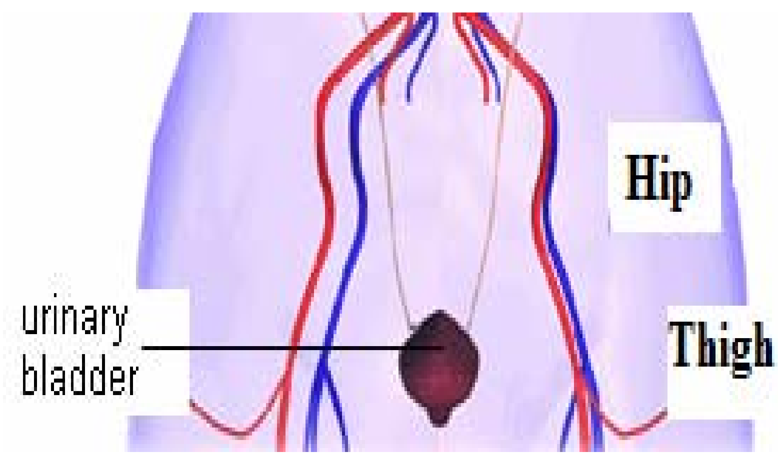

Figure 2- 21. The position of the urinary bladder. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Reproductive Organs (Male & Female)

The female uterus, a strong hick-walled hollow organ remains fairly tolerant to blunt impact forces until a woman becomes pregnant. A woman's ovaries are well protected deep in the pelvic cavity and are often not subject to injury. The pregnant uterus, however effectively changes the vulnerability of the uterus as well as other organs to injury. By putting other organs under strain, it is easier to injure other organs through blunt impacts that might in the absence of the fetal state, be minor. A full-term fetus occupies much of the abdominal cavity. This is of particular concern in motor vehicle accidents and falls. It has been suggested that modifications to seat belts and steering wheel positioning could be made to better accommodate pregnant drivers (DeSantis et. al., 1999).

The organs of the male reproductive system are located outside the lower abdominal cavity. Such an exterior location makes both the penis and testicles susceptible to trauma resulting from impact with a blunt object or puncture resulting from penetration by a sharp object (Stone, D.J., 1996, p. 14-5).

Pelvis

The pelvis links the lower extremities to the spine. The pelvis is a ring of bones basically composed of four bones: two hipbones (ilium) form the side and front walls while the sacrum and the coccyx form the rear wall (see Figure 2- 22). Mechanically, the pelvis provides the only path to transmit the weight of the trunk to the ground. The hipbones consist of three fused bones (ilium, ischium, pubis) and also host the acetabulum, which is the cup-shaped articular cavity forming one part of the hip joint. The pubic bone and the pubic symphysis form the frontal part of the pelvis. The pubic bones are often subject to injury (Hannon, P., and Knapp, K., 2006, pp. 257-262).

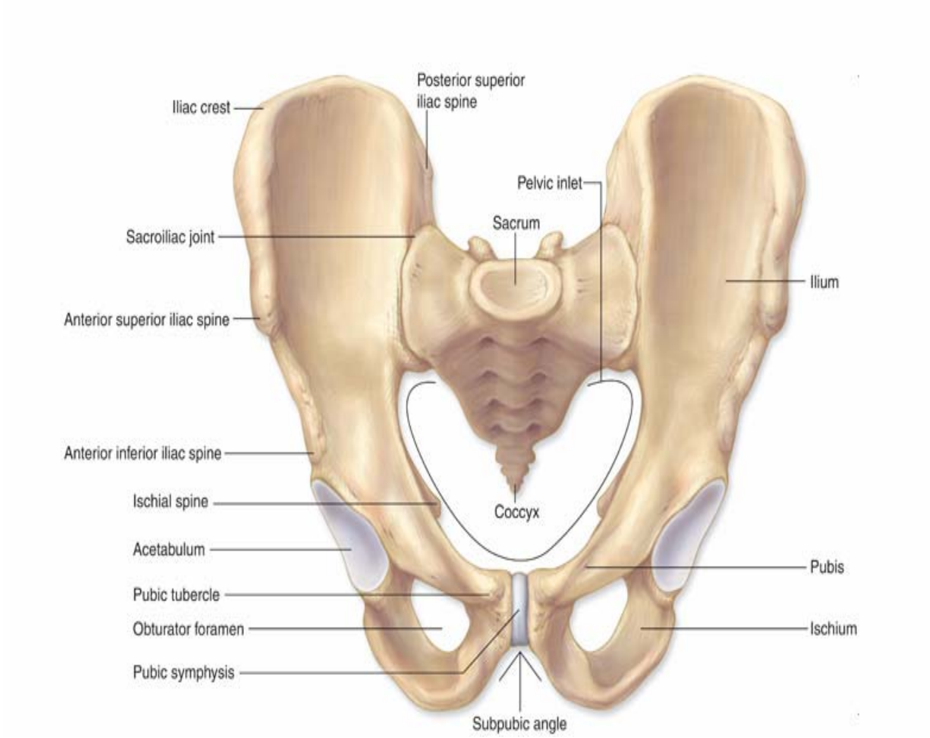

Figure 2- 22. The bones of the pelvis. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Located at the rear wall of the pelvis, the sacrum is a fusion of the sacral vertebrae with sacral nerve (e.g. the sciatic nerve) that arise from the spinal cord passing the sacrum. Major blood vessels are also located near the sacrum and the coccyx.

Fractures of the pelvis bones, resulting from falls or struck by (usually motor vehicle) , are the most common injuries sustained in accidents. Injuries to the pelvis are categorized clinically as isolated fracture of the pelvic ring, multiple fracture of the pelvic ring, sacrum fracture and associated injuries. Sacrum fracture occurs in extensive pelvic injuries. Sacral nerves are often in danger of injury in these types of injury. Additional injury, especially hemorrhage, can be associated with pelvic fractures (Schmidtt, K., Niederer, P., and Walz, F., 2004, pp. 114-116).

Due to the fact that the pelvis and the proximal femur (see Figure 2-22) are often injured simultaneously, such injuries are commonly referred to as hip injury, thus fractures involving the proximal part of the femur are commonly call hip fractures. The hip is frequently injured in falls. A lateral loading on the hip commonly causes the femur neck to fracture. Dislocation of the hip joint can result from lateral impact.

From a biomechanical point of view, the underlying mechanisms of pelvic fracture are either compression, vertical shear or a combination thereof. If the pelvis is subjected to vertical loading, shear can cause fracture as well as rupture of ligaments (Schmidtt, K., Niederer, P., and Walz, F., 2004, pp. 125-132). There are four possible types of fracture mechanisms: direct loading, indirect loading, repetitive loading and penetration.

Thoracic and Lumbar Spine (Thoracolumbar Spine)

Injuries to the trunk include any injury to thoracic (T1-T12) and lumbar vertebrae (L1-L15) (see Figure 2- 23). Injuries to the thoracolumbar spine tend to be minor compared to cervical spine injuries. Back pain is commonly reported after various types of collisions and severe injuries to the spinal cord can occur. Injuries to the soft tissue of the thoracolumbar spine are also common. The soft tissues involved are the intervertebral discs, the various ligaments, the facet joints, the muscles and tendons attached to the vertebral column. A usual complaint of this type of injury is lower back pain. Incidents provoking this complaint range from minor rear-end collisions in motor vehicles to severe impacts from struck by material or falls. In some cases the back pain is associated with disc rupture or disc bulge. Such injuries are generally the result of a slow degenerative process commonly associated with repetitive motion mechanisms (Stone, D.J., 1996, pp. 6-6 – 6-43)

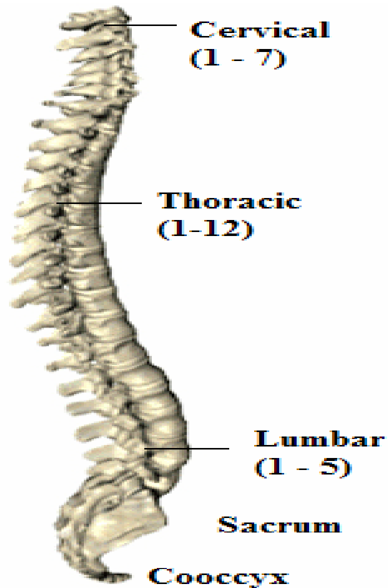

Figure 2- 23. Side view of the vertebral column. Each vertebra is numbered according to the part of the spine it is in, e.g., the lumbar vertebrae are L1 through L5. (Source: ContMedia Human 3D Advanced Internet Edition, 2007).

Upper Extremities

Injuries to the upper extremities, though generally not life threatening, nonetheless can cause long-term impairment associated with significant costs (Mital, A., Pennathur, A., and Kansal, A., 1999). Generally the upper extremities can be divided into four different parts: the shoulders (or shoulder girdle), the arms, the forearms and the hands (includes wrists) (see Figure 2- 24).

The shoulder is comprised of the scapula, clavicle, and the joint articulations that attach the upper extremities to the torso. The arm is formed by the humerus and is linked to the shoulder by the shoulder joint which is probably the most mobile joint in the human body. The elbow joint connects the arm to the forearm which consists of the ulna and the radius. The wrist joint, finally, connects the forearm to the hand. Associated muscles and soft tissue complete the four parts of the extremitiesStone, D.J., 1996, pp. 2-4 – 2-9).

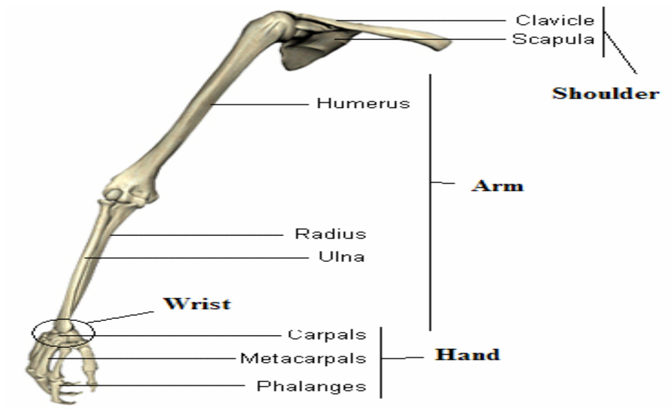

Figure 2- 24. Bones of the upper extremities (Modified from ContMedia Human 3D Advanced Internet Edition, 2007).

Types and Mechanisms of Injury

The major mechanisms of injury to the upper extremities are falls, blows, exertion (such as lifting), and repetitive motion (Mital, A., Pennathur, A., and Kansal, A., 1999). Falls are a common hazard in many construction occupations. Falls on an outstretched hand may produce any of several skeletal injuries, including fractures of the wrist, radius, ulna or humerus, as well as ligamentous and muscle injuries. Falls directly on the shoulder or elbow may produce serious fractures or dislocations.

Blows (e.g. being struck by a moving object) to the elbow or arm are also a common mechanism of injury. Being caught in between or within pieces of equipment is another source of injury. Repetitive motion injuries (overuse), repetitive stress injuries and cumulative trauma disorders are increasingly identified as sources of occupational injuries (Muggleton, J.M., Allen, R., and Chappell, P.H., 1999).

Contusions (bruises) and lacerations (cuts) are often only skin injuries. Significant injuries of this type are most often associated with deeper injuries such as fractures or damage to nerve or tendon.

Occupational burns to upper extremities are common and include thermal (scalds, flash and contact burns), chemical, microwave and electrical burns (Stone, D.J., 1996, pp.

2-13 – 2-15). Thermal and chemical burns are more common on the hand. Electrical burns usually involve the hand as the point of entry, but a great deal of tissue may be damaged as the current passes through the upper extremity.

Chemical burns may be caused by organic and inorganic acids, alkaline substances and phosphorous. Workers in steel production and manufacturing facilities are subject to frequent exposure to sulfuric and nitric acid while hydrochloric acid is often present in areas where chemical and refinery work is being done. Construction workers may also be at risk of alkali burns from ammonium hydroxide, potassium hydroxide and sodium hydroxide (Vannier and Rose, 1991).

Major vascular injuries to the upper extremities include vessel lacerations, which may accompany any severe open injury, fracture or laceration, and the compartment syndrome, in which pressure builds up in the tissue, compressing the arteries and blocking off (occlusion) the blood supply to the muscles and nerves of one of the compartments of the upper limb (Mital, A., Pennathur, A., and Kansal, A., 1999).

Crushing injuries of the upper extremities are most often associated with different types of equipment and machinery, such as conveyor belts, gears and pistons, industrial presses, and the handling of heavy materials. Most crushes are such where the skin remains intact. However, the internal damage may still be extreme. Crushing injuries may produce severe arterial damage through rupture, spasm or clotting (thrombosis). There is frequently severe muscle injury associated with crushing injuries, which is often sufficient to produce compartment syndrome from swelling alone. Nerves are often damaged as a result crushing injuries. The bone fractures that occur in crushing injuries usually fracture multiple bone fragments (Butler, R.J., Durbin, D.L., and Helvacian, N.M., 1996).

Fractures of the upper extremities are relatively common and frequently the result of falls, particularly on the outstretched arm. Falls may fracture any bones in the upper extremity, depending on the type of fall and the age of the person. Shoulder fractures may also be caused by falling objects (Hannon, P., and Knapp, K., 2006, pp. 239-240, 247, 252-253). Construction workers are particularly susceptible to these injuries; typically a hand tool or other piece of equipment is accidentally dropped or kicked off a scaffold above (Islam, S.S., et. al., 2001).

Joint injuries to the upper extremities are common (Mital, A., Pennathur, A., and Kansal, A., 1999). The shoulder is particularly vulnerable and is the most frequently dislocated joint in the body. Joint injuries vary in severity, but they primarily affect the ligaments and other soft tissue structures that stabilize the joint. Ligament stress or strain is referred to as a sprain, which does not alter the bones of the joint but may render the joint very unstable. Joints may also experience a dislocation in which the joint surfaces are no longer in congruity (the ball is out of the socket).

Tendon injuries, not of the hand, are usually the result of a chronic combination of overuse and degeneration due to aging. Tendon injuries may also occur acutely, following a laceration, or may suddenly rupture following chronic wear and tear. The two major sites for tendon injury in the upper extremities, excluding the hands, are the rotator cuff of the shoulder and at the elbow. Inflammation of a tendon (tendonitis) may develop at the shoulder or the elbow. Tendon ruptures are rare but do occur during acute episodes of trauma. The biceps tendon can rupture at the shoulder and at the elbow. Repeated overhead lifting is thought to be an important factor in rupture as well as tendonitis of the bicep at the shoulder. Triceps tendon ruptures are very rare and are generally caused by a fall or blow. Tendon lacerations are common in the hands, where the tendons are abundant and superficially located. In the arm, a deep laceration may cut a tendon (Gerr, F., Letz, R., and Landrigan, P.J., 1991).

Muscle ailments are frequent occupational health problems. In the arm and shoulder, the most common condition is the occupational cervicobrachial disorder (Gerr, Letz, and Landrigan, 1991), a painful condition of the neck and shoulder commonly seen in sedentary workers whose shoulders remain stationary but whose arms are involved in frequent fine-motor activity.

Injuries to the nerves that operate the shoulder are uncommon but may occur in blunt trauma, lacerations, and motor vehicle accidents. Fractures and dislocations may also cause nerve trauma (Hannon, P., and Knapp, K. 2006, p. 236).

Hand Injuries

Occupational hand injuries may be classified into two categories: acute and chronic. The most common form of chronic injury is overuse (repetitive motion disorder). These injuries include carpal tunnel syndrome, tenosynovitis and other syndromes (Muggleton, J.M., Allen, R., and Chappell, P.H., 1999).

Acute hand injuries include lacerations to the skin, nerves, and tendons; puncture wounds; thermal, chemical and electrical injuries; fractures; vascular injuries; and complex injuries, including avulsion (tearing away), amputation and crush injuries.

Lower Extremities

The lower extremities include the thigh, knee, lower leg, ankle and foot (see Figure 2- 25). The femur is the long bone of the leg and is connected by the hip joint to the pelvis and linked to the knee at the patella. Two bones, the tibia and the fibula, form the lower leg between the knee and the ankle. The knee is the joint that connects the femur and the lower leg. Vulnerable structures of the knee, such as the patella, are often subjected to direct impact. A strong musculature surrounds the legs. The foot is adjoined to the lower leg. The foot consists of several bones. These include the tarsal bones and the phalanges (toes).

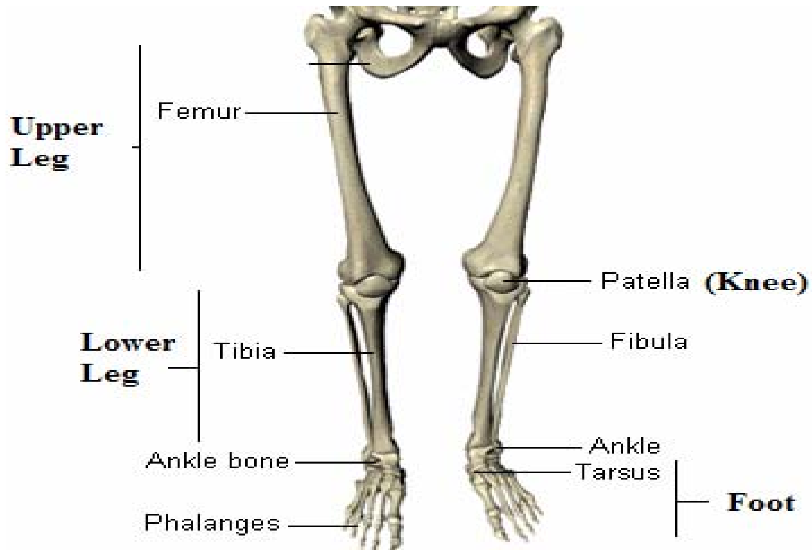

Figure 2- 25. Bones of the lower extremities ((Modified from ContMedia Human 3D Advanced Internet Edition, 2007).

Types and Mechanisms of Injury

Acute injuries to the upper and lower leg and knee may be caused by direct trauma, such as a blow or a motor vehicle accident. Falls from a sufficient height can cause fractures to the long bones (femur, tibia and fibula). Chronic occupational leg injuries are related to the postural demands of specific jobs.

Knee injuries are commonly a result of a direct blow to the knee. A heavy hammer might be used to strike objects in front of a worker who misses, resulting in a blow to the knee. Motor vehicle accidents account for much of the direct trauma to the lower extremities. Another common mechanism of knee injury involves a twisting motion.

Damage can occur to the ligaments and menisci. Injury occurs when the foot is fixed and the thigh turns. Within the construction industry it is common for twisting to occur in situations in which the worker is attempting to escape an external force about to roll into the worker's body. Chronic injury to the knee is a feature of occupations in which workers kneel or squat frequently. Construction workers at risk for chronic knee problems include, floor layers, carpet layers, stone cutters, tile setters, cement and concrete finishers, dry-wall-installers and lathers, and carpenters (Jensen, L.K. et al., 2000; Welch, L.S., et al., 1999; J; Tanaka, S. et al., 1989).

The most common knee injuries are sprains and meniscal tears (tears in the crescent-shaped cartilage of the knee). Contusions (bruises), bursitis (inflammation of a burs, or sac) and chondromalacia patellae (softening of the cartilage in the kneecap) account for the majority of the remainder (Jensen, L.K., and Eenberg, W., 1996).

Fractures to the knee do occur but are unusual. Patellar fractures may result from blunt trauma, as in a direct blow to the front of the knee. A fracture to the tibia at the knee may occur in a fall from a height (Goldsheyer, D. et al., 2004; Jensen, L.K., et al., 2000; Schneider, SP. 2001; Lipscomb, H.J., et al., 1997). Fractures of the femur can occur and are generally due to being struck by an object moving with extreme force. Motor vehicle accidents and falls from heights account for the majority of these injuries (Islam, S.S. et al, 2001; Schneider, 2001).

Lower extremity injuries in the workplace (other than those to the foot, ankle and knee) are uncommon. Leg and thigh injuries do occur; in addition to mild contusions (bruising). Such injuries range from burns to severe, open fractures.

Burns can be classified into three types: thermal, chemical and electrical. There are several different mechanisms of sustaining thermal burns, including scalds, contact and flash burns. For the legs, the usual types of burns result from spills of a hot liquid (a scald) or chemical. Electrical injuries involving the leg usually also affect the upper extremity and the rest of the body. Roofers, road crews, and iron and steel workers are at higher risk for scalds (Horowitz, I.B., 2001; Islam, S.S., et al., 2000).

Muscle injuries to the leg include contusions, crushing injuries and ruptures. Contusions or bruises are generally caused by blunt trauma. Crushing injuries to the legs may result from material, equipment or vehicles rolling on the legs. Crushing injuries can be life threatening. Leg muscle ruptures in the workplace usually involve the calf (Schneider, S.P., 2001).

Ankle and Foot

Occupational injuries to the foot and ankle are very prevalent within the construction industry (Schneider, S.P., 2001). Roofers, sheet metal workers, and machine repairers are typically at risk of such injuries (Hunting, K.L., 1999).

The most common mechanism of foot injury is an object falling on or rolling over the foot, which may produce a contusion (bruise), lacerations, crushing injury, fracture or, very rarely, amputation. The most common ankle injury is a sprain, usually resulting from twisting the ankle during a slip or fall. Blunt trauma may occur when the ankle is struck by a moving object (Oleske, D.M., Hahn, J.J.,and Leibold, M., 1992).

Acute injuries to the foot and ankle usually result from obvious trauma. An object may fall on or roll over the foot, or strike the ankle. The ankle may twist after a slip or fall. Chronic foot pain has been associated with factors that include footwear, floor surfaces, posture, body weight and congenital abnormalities.

The vast majority of acute foot injuries result from objects being dropped onto the toes or the midfoot. In mild cases, there are only contusions. In more severe cases, there may be skin lacerations or fractures. Fractures of the foot are frequently multiple, due to the close proximity of the bones of the foot. Lacerations and other skin wounds include puncture wounds, high pressure injection wounds and degloving injuries. Puncture wounds result most commonly when a worker steps on a sharp object. High pressure injection injuries are associated with the use of tools such as pressure washers, paint and grease guns (Oleske, D.M., Hahn, J.J. and Leibold, M., 1992). De-gloving injuries to the foot occur when the foot is trapped and subjected to forces that shear off the skin and other tissue.

Crushing injuries are most frequently caused by blunt trauma. The foot may be run over by a motor vehicle or other heavy equipment, or stuck by a falling object. Fractures are common in crushing injuries. Such fractures are usually multiple.

Burns to the foot and ankle may result from scalding, chemical exposure or electrical contact. Scalds to the foot and ankle can occur with molten metals, bitumen and molten plastic. Roofers, road crews and felters are some of the workers likely to be affected. Contact burns have been reported by welders, caused by hot metal fragments falling inside their footwear (Horwitz, I.B., and McCall, B.P., 2005; Islam, S.S., et al., 2000). Chemical burns to the foot and ankle, though uncommon in the construction industry, do occur and are usually associated with acidic or alkaline spills onto clothing or into footwear. Concrete workers may be at risk for such injuries (Lewis, P.M. et al. 2004). Electrical burns to the foot almost always involve a high-voltage electrical injury. In such injuries, the hand is usually the site of entry and the foot is the exit site. Wounds created by current entry usually resemble a burn, whereas the tissue at the exit looks as if it exploded (Cawley, J.C., and Homce, G.T., 2003).

Foot fractures usually involve the toes. Fractures of the long bones of the foot (metatarsals) are most often associated with direct blows, as in crushing injuries. Fractures of the heel bone are rare but frequently highly disabling. The usual mechanism is a fall from a height onto one or both feet, producing a crushing injury to the heel bone. Most commonly, the worker falls from scaffolding or a ladder (Huang, X. and Hinze, J., 2003; Gillen, M., F., Beaumont, J.J., and McLoughlin, E., 1997).

Ankle fractures commonly result from an inversion injury, in which the foot is forcibly tilted inward, causing damage to the lateral ligaments. The mechanisms are similar to that causing sprains but of greater force. Sprains are the most common ankle injury usually resulting from a fall onto the twisted foot. A sprain is the twisting or straining of a joint so that some of the ligaments and other structures are torn or distorted but the bones remain in place. The majority of sprains to the ankle result from slips and trips (Schneider, S.P., 2001; Lipscomb, H.J. et al., 1997). Slips tend to occur when the floor surface changes unexpectedly and becomes wet or oily. Trips occur when there is an unexpected object in the worker's path.

CHAPTER 3
METHODOLOGY

The focus of this investigation was twofold; first, to examine the frequency of injuries experienced by construction workers relative to several demographic and occupational factors, and second, to explore possible relationships between the severity of injuries to construction workers and several demographic and occupational factors.

The research was based on workers' compensation data records provided by a large private insurance company. The data provided information on the nature of the construction injuries, along with demographic information. The data were well suited to satisfy the objectives of my study. The use of insurance claims data can be especially valuable for population based studies and are particularly well suited for occupational injury surveillance studies (Connell, F., Diehr, P. and Hart, L.G., 1987). This insurance provider maintains a proprietary information management system that contains patient demographic and injury data, as well as outpatient treatment, diagnostic, and billing information. For my study, only claims from individuals working in the construction industry (N = 46,056) from 1992 through January 2006 were analyzed.

For each of the 46,056 claims, considerable information was provided regarding the following non-continuous (nominal), and continuous (ordinal and scalar) variables:

- Non-Continuous
    - Nominal variables
        - Gender
        - Marital status
        - Month of injury
        - Day of the week
        - General body region
        - Body part
        - General nature of injury
        - Nature of injury
        - General cause of injury
        - Cause of injury

        - General agent of injury
        - Agent of injury
        - Occupational work area
        - Occupational experience level
- Continuous
    - Ordinal variables
        - Age category
        - Injury type (converted to injury severity scale)
        - Job tenure category
    - Scalar variable
        - Number of dependents
        - Year of injury
        - Age

The information that was not utilized pertained to the monetary costs of injuries. Some information, such as race and other "sensitive" data were not made available for this research. Job tenure was generated by calculating the number of days between the date of hire of the injured worker and the date of injury occurrence. The data set included information on workers' "Occupational work area" (the type of work being performed by the worker at the time of the injury), "Nature of injury," specific "Body part" affected, "Injury type" (converted to injury severity score), "Cause of injury," "Agent of injury," and, and SIC classification.

The nature of injury or illness describes the principal physical characteristics of the injury or illness. Examples of "nature of injury" include amputation, burn, contusion, etc. APPENDIX A lists all of the nature of injury codes utilized and the respective labels and descriptions for each code.

"Body Part" identifies the part of the body directly affected by the injury. Examples of the "Body Part" affected by the injury include brain, skull, arm, finger, shoulder, toes, etc. APPENDIX B lists all of the labels and definitions used to code the part of the body variable. A "General Body Region" code was then generated by assigning specific body parts affected, as listed in APPENDIX B, to their respective body region as described within the USDOL-BLS Occupational Injury and Illness Classification Manual (1992). From this point on the "General Body Region" shall be referred to as "Body Region" The body region division was organized as follows

- Head: this region includes the uppermost parts of the body. This region consists of the skull, its contents, and related external structures.
- Neck: this division classifies that portion of the body that connects the head to the torso or trunk. This region is bounded by the jaw/chin and cranial region at the top and the shoulder at the bottom.
- Upper extremities: this division classifies the extremities that are bounded by the shoulder at the top with the fingers as the lowermost part. This includes bones, cartilage, muscles, skin, subcutaneous tissue, veins and arteries.
- Trunk: this division classifies the main part of the body, to which the head and limbs are attached. The area is bounded by the neck, arms, and legs. This includes bones, cartilage, internal organs and structures, muscles, nerves, skin, subcutaneous tissue, tendons, veins and arteries, and internal organs and structures.
- Lower extremities: this division classifies the appendages that are bounded by the hip at the top with the toes as the lowermost part. This includes bones, cartilage, muscles, skin, subcutaneous tissue, veins and arteries.
- Multiple body parts or body systems: this division classifies multiple body parts from two or more of the aforementioned divisions. This division also contains the various systems of the body. This code also applies when the functioning of an entire body system has been affected without specific injury to any other part of the body.

The original data set provided information regarding the relative severity of the injuries through information given in an "Injury Type" field. The system for the classification of an injury complied with National Counsel on Compensation Insurance (NCCI) classification system. Based on payments made to claimants by the insuring agent, injuries were assigned to one of the following eight classifications:

- Death
- Permanent total disability: this is a condition where the injured party is not able to work at any gainful employment for the remaining lifetime.
- Permanent partial disability: this is a condition where the injured worker's earning capacity is impaired for life, but the worker is able to work at reduced efficiency.
- Wage-loss and no impairment benefit: this is where wage loss benefits are paid and no impairment benefit is paid or payable. This includes compensation for temporary disability.
- Wage-loss and impairment benefit: this is where both wages loss benefits and impairment benefits are paid. Includes compensation for temporary disability.
- Temporary injury (temporary total or temporary partial benefits): this is a condition where the injured worker is unable to work at all while recovering from the injury, but that worker is expected to recover.
- Medical only: this is any injury that resulted only in payment of medical expenses, without any compensable time lost from work.
- Contract medical: this is a contracted medical only cost which cannot be allocated to an individual claim.

Each of these classifications was subsequently assigned an "Injury Severity Score" value from one to five, with five being the most severe injury (i.e., death). Permanent total disabilities and permanent partial disabilities were assigned injury severity score values of four and three, respectively. Following consultation with a representative from the private insurer, the provider of the claims data, it was decided to collapse or combine the two wage-loss classifications along with the temporary injury classification into a single group titled "Temporary Injury." This classification was assigned an injury severity score value of two. Similarly, "Medical Only" and "Contract Medical" classifications were truncated into a single classification titled "Medical Only." Medical only injuries received the lowest injury severity score of one. The resulting five levels of "Injury Severity" are listed below. These scores were used to describe the relative severity level of injury.

- Medical only
- Temporary injury
- Permanent partial disability
- Permanent total disability
- Death

The “Cause of injury” variable indicates the identified cause of the injury. There were seventy-five possible causes (see Appendix C) that could be assigned to an injury. Each of these specific causes of injury was subsequently assigned to one of the following eight “General Cause of injury” categories.

- Burned or scalded from exposure to heat or cold.
- Caught in or in-between.
- Injured by a cut, puncture or scrape.
- Injured by a fall or slip.
- Injury involving a motor vehicle (includes motorized cars, snowmobiles, forklifts, etc.)
- Injured by straining.
- Injured by striking against or stepping on an object.
- Injured by being struck by an object.

The “Agent of Injury” variable indicates the material, hazard or object that directly caused or contributed to the injury or illness. Specific injuries were assigned to one of 113 possible “Agent of Injury” classifications. APPENDIX D provides a list of the specific “Agent of Injury” classifications. An additional variable was generated from the agent of injury classifications to establish a broader “General Agent of Injury” variable. The 21 categories for “General Agent of Injury” are also listed in APPENDIX D.

Only those workers classified within the USDOL’ Standard Industrial Classification (SIC) system as working within the construction industry (Division C) included in my study. Division C includes establishments primarily engaged in construction. The term construction includes new work, additions, alterations, reconstruction, installations, and repairs. Construction activities are generally administered or managed from a relatively fixed place of business, but the actual construction work may be performed at one or more different sites.

The variable “Major SIC Group” was generated to identify the three broad types of construction activities covered in Division C. See APPENDIX E for detailed descriptions for each of the categories. Code = 15 was building construction by general contractors or by operative builders. Code = 16 was heavy construction other than building by general contractors and special trade contractors; and Code = 17 was construction activity by other special trade contractors.

- Building construction general contractors and operative builders (code = 15): this major group includes general contractors and operative builders primarily engaged in the construction of residential, farm, industrial, commercial, or other buildings. Examples include the following:
  - General contractors-single-family houses (code = 1521)
  - General contractors-residential buildings, other than single-family (code = 1522)
  - Operative buildings (code = 1531)
  - General contractors-industrial buildings and warehouses (code = 1541)
  - General contractors-nonresidential buildings, other than industrial buildings and warehouses (code = 1542)
  - Sic code: building construction general contactors – not elsewhere classified (code = 1543)
- Heavy construction other than building construction contractors (code = 16): this major group includes general contractors primarily engaged in heavy construction other than building, such as highways and streets, bridges, sewers, railroads, irrigation projects, flood control projects and marine construction, and special trade contractors primarily engaged in activities of a type that are clearly specialized for such heavy construction and are not normally performed on buildings or building-related projects. Examples include the following:
  - Highway and street construction, except elevated highways (code = 1611)
  - Heavy construction, except highway and street (code = 1612)
- Construction special trade contractors (code = 17): this major group includes special trade contractors who undertake activities of a type that are specialized either to building construction, including work on mobile homes, or to both building and nonbuilding projects. These activities include painting (including bridge painting and traffic lane painting), electrical work (including work on bridges, power lines, and power plants), carpentry work, plumbing, heating, air-conditioning, roofing, and sheet metal work. Special trade contractors may work under subcontract with the general contractor, performing only part of the work covered by the general contract, or they may work directly for the owner. Special trade contractors for the most part perform their work at the site of construction, although they also may have shops where they perform work

incidental to the job site (prefabrication). Examples include the following:

- Plumbing, heating and air-conditioning (code = 1711)
- Painting and paper hanging (code = 1721)
- Electrical work (code = 1731)
- Masonry, stonework, tile setting, and plastering (code = 1740)
- Masonry, stone setting, and other stone work (code = 1741)
- Plastering, drywall, acoustical, and insulation work (code = 1742)
- Terrazzo, tile, marble, and mosaic work (code = 1743)
- Carpentry and floor work (code = 1741)
- Carpentry work (code = 1751)
- Floor laying and other floor work – not elsewhere classified (code = 1752)
- Roofing, siding, and sheet metal work (code = 1761)
- Concrete work (code = 1771)
- Water well drilling (code = 1781)
- Miscellaneous special trade contractors (code = 1790)
- Structural steel erection (code = 1791)
- Glass and glazing work (code = 1793)
- Excavation work (code = 1794)
- Wrecking and demolition work (code = 1795)
- Installation or erection of building equipment – not elsewhere classified (code = 1796)
- Special trade contractors – not elsewhere classified (code = 1799)

Special trade contractors are primarily engaged in specialized construction activities, such as plumbing, painting, and electrical work, and work for general contractors under subcontract or directly for property owners. General contractors usually assume responsibility for an entire construction project, but may subcontract to others some or all of the actual construction work or those portions of the project that require special skills or equipment. General contractors thus may or may not have construction workers on their payroll.

Information was provided on the trades or occupations of the injured workers. The occupation coding structure was adapted from the National Council on Compensation Insurance's (NCCI) SCOPES Manual of Basic Classifications (2007). The original data set provided each claimant's "Regular Occupation Activity" in conformance with the NCCI Scopes system. Examples include carpentry, door installation, concrete or cement work, concrete pre-cast wall panel installation, asbestos contractor, sign installation, fire suppression systems installation or repair, etc. Information provided in the data set regarding the SIC and NCCI classifications was used to generate an "Occupational work area" variable, with 95 associated classifications (see APPENDIX EI) which attempted to indicate the specific occupational activity being performed at the time of injury occurrence.

In an attempt to reflect the workers' experience levels within their particular occupational areas the variable "Experience Level " was generated by extrapolating the experience level (e.g., laborer, helper, apprentice, journeyman, etc.) from information provided in the original data set. The following ten categories were applied to this variable:

- Worker – this was used when no specific experience level could be determined. This level was excluded from analysis when comparing measures relative to the injured workers occupational experience level.
- Laborer – this indicated workers who assisted other construction workers to build or repair buildings, roads, bridges, dams, and other construction projects, and perform other unskilled tasks at construction sites.
- Helper/assistant - this included workers in occupations concerned with helping more skilled workers in the construction trades.
- Apprentice - include workers who are learning the craft or trade through on-the-job training and a formal apprenticeship training program.
- Journeyman –this included any craft workers who have completed an apprenticeship program.
- Foreman –this included any worker who is in charge of a construction crew. Generally a construction worker with many years of experience and talent. The foreman is a wealth of knowledge and a key asset to the project.
- Field supervision –this included assistant superintendents, superintendents, assistant project managers and project managers.
- Executive –this included company representatives at an executive management level (ceo, cfo, v.p., president, etc.)
- Professional –this included any engineers, architects, designers, etc.
- Administrative – this included all clerical workers, administrative, and support personnel

assigned to a particular construction project.

Statistical Analysis

The statistical analysis of the data were conducted at two levels; (1) the entire data set of injuries was examined for the injury distribution by basic variables (age, age group, gender, general nature of injury, nature of injury, general cause of injury, general agent of injury, agent of injury, job tenure on date of injury, year of injury, month of injury, day of the week of injury, occupational work areas, and occupational experience levels), and (2) an analysis of injuries specific to “Body Region” (Head, Neck, Truck, Upper Extremities, and Lower Extremities). In this analysis, all data were examined and evaluated by injury distributions.

Means comparisons were performed for the continuous variables of age and injury severity. For two independent groups of subjects (such as gender, and new hires and non-new hires) the independent t-test was performed to determine whether the groups came from populations with the same mean for the variables of interest (age or injury severity) (Norusis, M.J., 2005). Figure 3- 1 shows the protocol for multiple comparisons of age and injury severity means; analysis of variance (ANOVA) or the Welch robust test was used to assess equality of means. Subsequently, the Tukey’s b range test, was utilized for a pair-wise multiple comparison of means (Aspelmeier, 2002). The decision to conduct either an ANOVA or the Welch test was made based on the results of the Levene test for equality of variances (age or injury severity scores) between the classifications of a given variable (Aspelmeier, 2002). All statistical analysis was performed using SPSS® for Windows® Graduate Pack 13.0.

Age and injury frequency and relative frequency distributions were generated for all the variables of interest. For example, in Table 3- 1 the injury frequencies and relative frequencies are displayed for eight “Experience Level” categories. All groups were ranked according to descending frequency magnitudes.

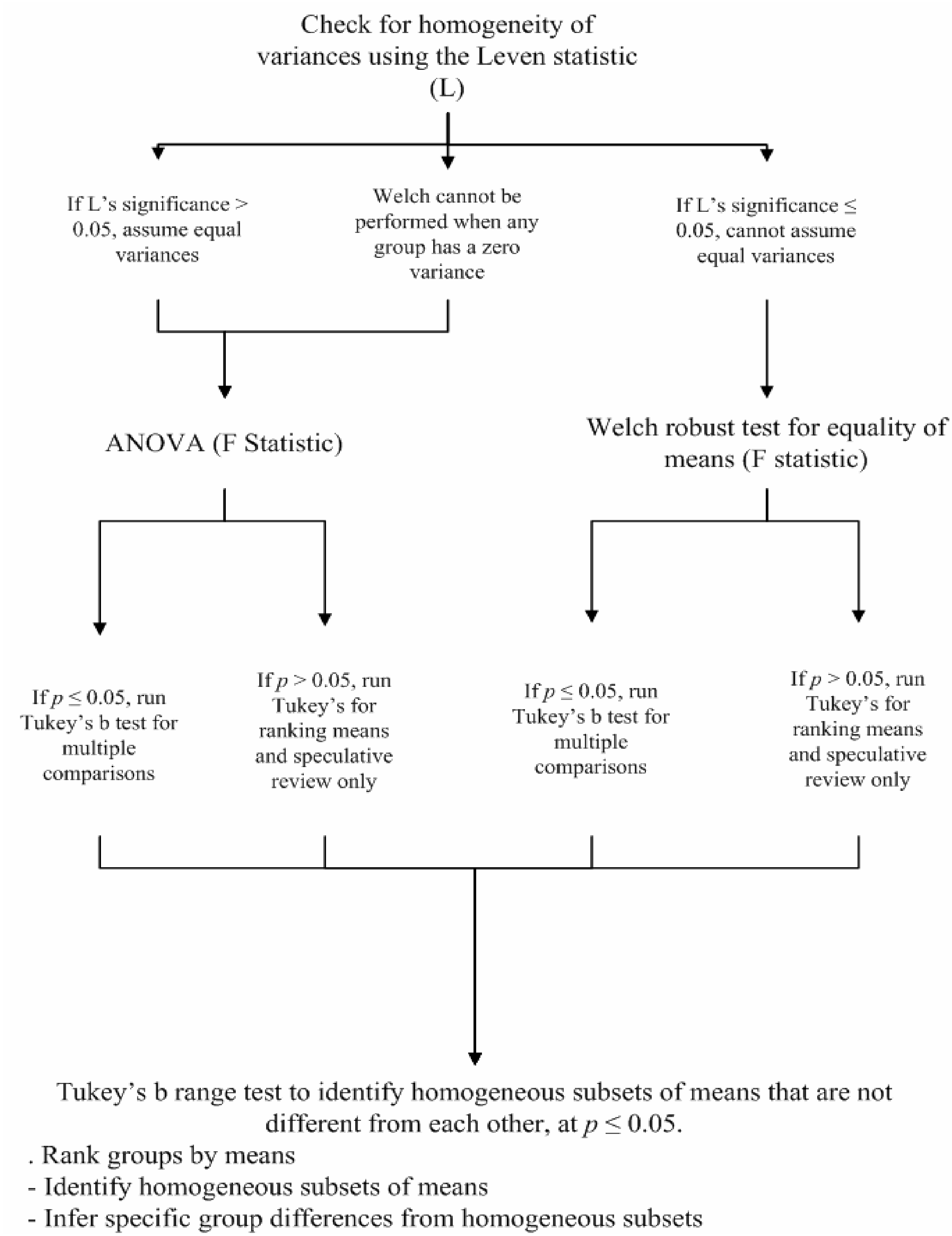

Figure 3- 1. Protocol for statistical multiple comparison of means (Aspelmeier, 2002).

Table 3- 1. Experience level of injured workers.

Occupational experience level	Number of injuries	%	Cumulative %
Laborer	7,917	55.04%	55.04%
Apprentice	1,578	10.97%	66.01%
Foreman	1,449	10.07%	76.09%
Journeyman	1,358	9.44%	85.53%
Helper / assistant	752	5.23%	90.76%
Field supervision	614	4.27%	95.02%
Administrative	448	3.11%	98.14%
Professional	267	1.86%	100.00%
Total	14,383	100.00%	

Comparisons of injury severity means were conducted by the following variables of interest:

- Age group
- Body part injured
- General nature of injury
- Nature of injury
- General cause of injury
- Cause of injury
- General agent of injury
- Occupational experience level of the injured worker
- Occupational work area of the injured worker
- Month of occurrence of the injury
- Day of week of occurrence of the injury

For binary variables (such as gender) an independent t-test was conducted to compare means. For multiple comparisons of means the Tukey's b range test (a.k.a., Tukey's Wholly Significant Difference test) was conducted to identify homogeneous subsets of means that were not different from each other, at $p \leq 0.05$.

For example, the ranking of the occupational experience levels by their respective injury severity means are shown in Figure 3- 2. The Tukey's b test also identifies homogeneous subsets of means that were not significantly different from each other, at $p \leq 0.05$ (indicated by vertical transparent boxes in Figure 3- 2). Thus, the figure shows that the injury severity means for the first seven categories of occupational experience level were not significantly different at $p \leq$

0.05. From the arrangement of the homogeneous subsets, specific mean differences between groups were inferred. For example, the arrangement of the homogeneous subsets in Figure 3-2were used to subsequently generate Figure 3- 3 which shows that “Journeyman” level workers had a significantly greater injury severity mean, at $p \leq 0.05$, than that for “Administrative” level workers.

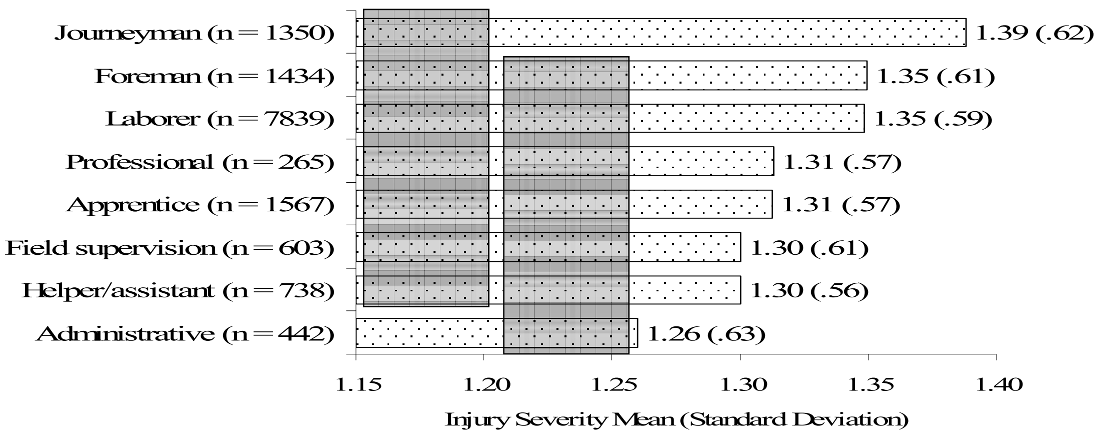

Figure 3- 2. Comparison of injury severity means by occupational experience levels.

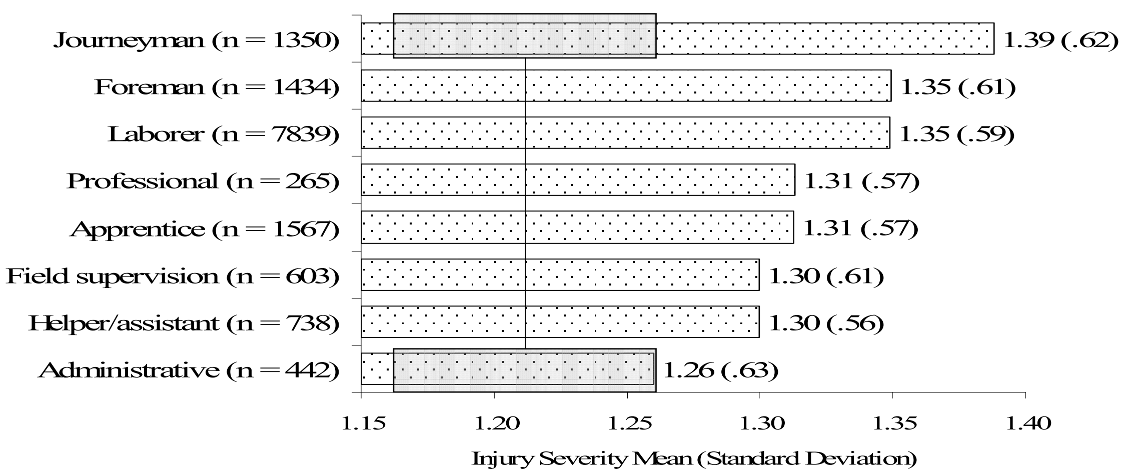

Figure 3- 3. Differences of injury severity means by occupational experience levels.

Prior to the use of the Tukey’s b range test to rank groups by their means and identify homogeneous subsets of means, either an ANOVA test or Welch robust test for equality of means was conducted to determine if significant differences between groups, at $p \leq 0.05$, existed. Whether to use the ANOVA or the Welch test was predicated upon the outcome of the Levene test of homogeneity of age or injury severity score variances between groups. If the significance of Levene test statistic (L) was greater than 0.05, equal variances were assumed and the ANOVA was performed. If the significance for L was less than or equal to 0.05, equal variances were not assumed and the Welch test was conducted. Figure 3- 1 shows the decision protocol for the statistical multiple comparisons of means (Aspelmeier, 2002).

Following the analysis of the broad scope of all the variables, further analysis was conducted focusing on injuries to the six "Body Regions" (Head, Neck, Upper Extremities, Trunk, Lower Extremities and Multiple Body Parts or Body Systems). Injury distributions were generated for each of the individual variables with respect to each of the six "Body Regions." For all of the ordinal and scalar measures, additional Welch tests or ANOVA test and multiple comparisons of means tests, as described above, were conducted to further explore possible significant relationships between variables specific to the "Body Regions."

CHAPTER 4
RESULTS

A large private insurance company (workers' compensation carrier) provided information on 46,016 construction worker injuries that occurred between 1992 and 2006. The identities of the injured workers were not provided so some workers may have appeared more than once in the dataset, i.e., workers who might have been injured more than once could not be identified. In my study, each claim or injury was counted as a separate injury case, and the entire dataset was referred to as representing "46,056 injured workers." Each injury case was accompanied by several descriptors related to the injured worker and the injury that was sustained. The injury severity was the primary dependent variable for this dataset. Frequency distributions, relative frequency (%) and percentage cumulative frequency were generated for the injuries for all of the categories with respect to each of the variables. A tabular arrangement of these data was prepared.

For binomial variables (e.g. gender, new hires or non-new hires) an independent t-test was conducted to determine possible differences between the average injury severity between the two groups. Each injury was assigned an injury severity score ranging from one with one being the lowest severity ascertained and five being death. The actual severity descriptions associated with each score was as follows;

1. Medical only
2. Temporary injury
3. Permanent partial disability
4. Permanent total disability
5. Death

An alpha level of $p \leq 0.05$ was used for all statistical tests to assert statistically significant findings. A Levene test of homogeneity of variances of injury severity scores for the classifications for each examined variable was performed to decide whether to use the Welch robust test of equality of means or the Analysis of Variance (ANOVA) to compare the mean levels. If the Levene test (L) statistical significance was greater than 0.05, equal variances were assumed, and the ANOVA test was conducted to evaluate significant injury severity mean differences between categories. If the Levene statistical significance was less than or equal to 0.05, equal variances was not assumed, and the Welch robust test of equality of means was conducted. The Welch statistic was used instead of the Brown-Forsythe statistic because it was considered to be more powerful and more conservative (Norusis, M., 2000, p. 152).

When the injury severity score variance of one or more of the categories being compared was zero, then the Welch test could not be conducted. In this situation, the ANOVA test was used in lieu of the Welch test. If the test statistic of either the ANOVA or the Welch test was significant at or below the desired alpha (p) of 0.05, then at least one category had a significantly different injury severity mean of another category within the variable. After it was determined that differences existed among the means, the Tukey's Wholly Significant Difference (Tukey's b) post hoc range test was used to determine which means differed. The Tukey's b range test also identified homogeneous subsets of means that were not different of each other at $p = 0.05$. The Tukey's b test also generated a ranking of categories according to their descending magnitude of mean values. Because of the ranking capabilities of the Tukey's b and the test's potential to identify possible differences between groups contrary to the results of either the Welch or the ANOVA tests, the Tukey's b was still run after the results of the Welch or ANOVA indicated no significant differences, at $p \leq 0.05$, between variable groups. Similar tests were often run to also examine the variable associations with age.

Demographic Characteristics

Gender

Gender designation was provided for 44,743 of the injury cases. Over 95% of the injured workers were male (see Table 4- 1). The effect of gender on injury severity was not statistically significant, F = (1, 44,117) = .74, $p > .30$.

Table 4- 1. Gender of injured workers.

Gender	Number of injuries	%	Cumulative %
Male	42,841	95.75%	95.75%
Female	1,902	4.25%	100.00%
Total	44,743	100.00%	

The variable "General Occupational Experience" provided information on the experience level of workers, and this was examined in relation to education, training, and apprenticeship /internship experience prior to the event leading to the injury. The relationship between gender and "General Occupational Experience" was examined for 14,125 worker injuries. Table 4- 2 displays the distribution, by percentage, of workers within their respective gender categories by the "General Occupational Experience" levels. Over 50% of both male and female workers were classified as laborers. Over 11% of the male (n = 1,475) and 10% of the female (n = 81) workers were at the apprentice level. The relative frequency (10.50%) of injuries among male foremen (n = 1,401) exceeded the frequency (2.81%) of female foremen, (n = 22). Similarly, there was a higher relative frequency (9.87%) among male journeymen, (n = 1,317) than among female journeymen, 3.07% (n = 24). For both male and female workers the relative frequency of helper or assistant level workers was virtually 5%. The percentage of field supervisors among males (4.44%, n = 593) exceeded that for female supervisors (1.53%, n = 12). For the administrative and professional levels, the relative frequencies among females, 15.45% (n = 121) and 3.58% (n = 28), respectively, exceeded that of males, 2.36% (n = 315) and 1.76% (n = 235).

Table 4- 2. Comparison of injury frequencies between males and females by occupational experience level.

General occupational experience level	Male			Female		
	Number of injuries	%	Cumulative %	Number of injuries	%	Cumulative %
Laborer	7,310	54.79%	54.79%	454	57.98%	57.98%
Apprentice	1,475	11.06%	65.85%	81	10.34%	68.32%
Foreman	1,401	10.50%	76.35%	22	2.81%	71.13%
Journeyman	1,317	9.87%	86.22%	24	3.07%	74.20%
Helper/assistant	696	5.22%	91.43%	41	5.24%	79.44%
Field supervision	593	4.44%	95.88%	12	1.53%	80.97%
Administrative	315	2.36%	98.24%	121	15.45%	96.42%
Professional	235	1.76%	100.00%	28	3.58%	100.00%
Total	13,342	100.00%		783	100.00%	

The distribution of injury frequencies and relative frequencies for "Nature of Injury" categories for male and female workers are shown in Table 4- 3 and Table 4- 4. For both male (n = 11,131) and female (n = 563) workers, strain injuries had the highest relative frequency of all the 'Nature of Injury" classifications. The top ten "Nature of Injury" categories, in terms of relative frequency of injuries, were the same for both males and females. However, their respective order by magnitude differs. For males the top ten "Nature of Injury" groups by relative frequency were as follow:

1. Strains, 28.66% (n = 11,131,)
2. Lacerations, 16.62% (n = 6,456)
3. Contusions, 13.90% (n = 5,397)
4. Foreign body, 9.44% (n = 3,666)
5. Sprain, 6.05%, (n = 2,350)
6. Fracture, 5.97% (n = 2,317)
7. Puncture, 5.04% (n = 1,956)
8. Inflammation, 2.54%, (n = 986)
9. Burn, 2.16% (n = 839)
10. Multiple Injuries, 1.63% (n = 635)

For female workers the top ten "Nature of Injury" classifications by relative frequency were as follows:

1. Strains, 33.85% (n = 563)
2. Contusions, 19.60% (n = 326)
3. Lacerations, 9.32% (n = 155)
4. Sprains, 7.46% (n = 124)
5. Foreign body, 6.37% (n = 106)
6. Fractures, 5.41% (n = 90)
7. Inflammation, 3.97% (n = 66)
8. Punctures, 2.59% (n = 43)
9. Multiple Injuries, 1.80% (n = 30)
10. Burns, 1.56% (n = 26)

These top ten groups account for over 91% of all the injuries reported for both the male and female workers. For female workers, respiratory disorders (n = 19) and carpal tunnel syndrome (n = 18) each accounted for just over 1% of all the reported injuries. For male workers, respiratory injuries represented less than 0.05% (n = 164) and carpal tunnel syndrome less than 0.20% (n = 78) of all the reported injuries for the 'Nature of Injury" classifications. Myocardial infarctions showed the highest overall injury severity mean, with a higher relative frequency for males, 0.12% (n = 45) than for females, 0.06% (n = 1).

Over 25% of the male injuries(n = 11,493) and over 30% of the female injuries (n = 545) were caused by straining while performing some type of task or motion (see Table 4- 5 and Table 4- 6).

Just over 16% (n = 6,601) of the male and 23% (n = 413) of the female injuries were caused by a fall or slip. Around 14% (n = 5,654) of the injuries of males and 11% (n = 203) of the injuries to females resulted of being struck by an object or person. Being cut, punctured or scraped by an object accounted for almost 13% (n = 5,283) of the injuries to male workers and 7% of the injuries to female workers (n = 117). Almost ten % of the injuries of males were attributed to foreign matter in the eyes (n = 9.52%), while foreign matter in the eyes accounted

Table 4- 3. Injuries to males by nature of injury.

	Male workers		
Nature of injury	Number of injuries	%	Cumulative %
Strain	11,131	28.66%	28.66%
Laceration	6,456	16.62%	45.28%
Contusion	5,397	13.90%	59.18%
Foreign body	3,666	9.44%	68.62%
Sprain	2,350	6.05%	74.67%
Fracture	2,317	5.97%	80.63%
Puncture	1,956	5.04%	85.67%
Inflammation	986	2.54%	88.21%
Burn	839	2.16%	90.37%
Multiple injuries	635	1.63%	92.01%
Crushing	441	1.14%	93.14%
Rupture	433	1.11%	94.26%
Hernia	375	0.97%	95.22%
Infection	206	0.53%	95.75%
Dislocation	193	0.50%	96.25%
Asbestosis	172	0.44%	96.69%
Respiratory disorder	164	0.42%	97.11%
Dermatitis	137	0.35%	97.47%
Electric shock	116	0.30%	97.77%
Heat prostration	110	0.28%	98.05%
Occupational disease NOC	101	0.26%	98.31%
Amputation	85	0.22%	98.53%
Chemical poisoning	85	0.22%	98.75%
Carpal tunnel sryndrome	78	0.20%	98.95%
Concussion	73	0.19%	99.13%
Severance	66	0.17%	99.30%
Poisoning NOC	55	0.14%	99.45%
Hearing loss or impairment	51	0.13%	99.58%
Myocardial infarction	45	0.12%	99.69%
Enucleation	29	0.07%	99.77%
Mental stress/disorder	29	0.07%	99.84%
Syncope	19	0.05%	99.89%
Asphyxiation	18	0.05%	99.94%
Angina pectoris	9	0.02%	99.96%
Silicosis	8	0.02%	99.98%
Freezing	7	0.02%	100.00%
Total	38,838	100.00%	

Tabel 4- 4. Injuries to females by nature of injury.

Female workers			
Nature of injury	Number of injuries	%	Cumulative %
Strain	563	33.85%	33.85%
Contusion	326	19.60%	53.45%
Laceration	155	9.32%	62.77%
Sprain	124	7.46%	70.23%
Foreign body	106	6.37%	76.60%
Fracture	90	5.41%	82.02%
Inflammation	66	3.97%	85.98%
Puncture	43	2.59%	88.57%
Multiple Injuries	30	1.80%	90.37%
Burn	26	1.56%	91.94%
Respiratory disorder	19	1.14%	93.08%
Carpal tunnel sydrome	18	1.08%	94.16%
Rupture	14	0.84%	95.00%
Dermatitis	12	0.72%	95.73%
Crushing	9	0.54%	96.27%
Dislocation	9	0.54%	96.81%
Heat prostration	9	0.54%	97.35%
Occupational disease NOC	8	0.48%	97.83%
Infection	5	0.30%	98.13%
Chemical poisoning	5	0.30%	98.43%
Electric shock	4	0.24%	98.67%
Hernia	4	0.24%	98.91%
Asbestosis	3	0.18%	99.09%
Mental stress/disorder	3	0.18%	99.27%
Concussion	2	0.12%	99.39%
Hearing loss or impairment	2	0.12%	99.51%
General poinoning	2	0.12%	99.63%
Amputation	1	0.06%	99.69%
Enucleation	1	0.06%	99.75%
Freezing	1	0.06%	99.82%
Myocardial infarction	1	0.06%	99.88%
Severance	1	0.06%	99.94%
Asphyxiation	1	0.06%	100.00%
Toal	1,663	100.00%	

Table 4- 5. Injuries to males by general cause of injury

General cause of injury	Number of injuries	%	Cumulative %
Strain	11,493	28.25%	28.25%
Fall or slip	6,601	16.22%	44.47%
Struck by	5,654	13.90%	58.37%
Cut, puncture, or scrape	5,283	12.98%	71.35%
Foreign matter	3,874	9.52%	80.87%
Striling against or stepping on	2,714	6.67%	87.55%
Caught in or between	2,227	5.47%	93.02%
Absorption, ingestion or inhalation	1,082	2.66%	95.68%
Burn or Scalded By	887	2.18%	97.86%
Contact with An Organism	495	1.22%	99.07%
Motor vehicle	378	0.93%	100.00%
Total	40,688	100.00%	

Table 4- 6. Injuries to females by general cause of injury.

General nature of injury	Number of injuries	%	Cumulative %
Strain	545	30.60%	30.60%
Fell or slipped	413	23.19%	53.79%
Struck or injured by	203	11.40%	65.19%
Striling against or stepping on	132	7.41%	72.60%
Foreign matter	120	6.74%	79.34%
Cut, puncture, or scrape by	117	6.57%	85.91%
Caught in or between	74	4.15%	90.06%
Absorption, ingestion or inhalation	73	4.10%	94.16%
Contact with an organism	47	2.64%	96.80%
Burn or scalded by	35	1.97%	98.76%
Motor vehicle	22	1.24%	100.00%
Total	1,781	100.00%	

for less than 7% of the injuries of females. Striking against or stepping on an object (males = 2,714; females = 132) combined with being Caught in or between an object or objects (males = 2,227; females = 74) resulted in over 12% of the injuries to male workers and just over 11% of the injuries to female workers. Absorption, inhalation or ingestion of a substance (males = 1,082; females = 73), being burned or scalded by contact with an object or substance (males = 887; females = 35), contact with an organism (males = 495; females = 47) and activities involving a motor vehicle (males = 378; females = 22) combined to account for less than 7% of the injuries to males and over 10% of the injuries to females.

The distribution of injury severity means for the six “Body Region” categories by gender is displayed in Table 4- 7. Information on these variables was provided for 44,069 workers. Over 16% of the male injuries (n = 6,970) and over 12% of the female injuries (n = 238) were head injuries. Injuries to the neck accounted for slightly over 2% of all the injuries to males (n = 885) and almost 3% of the injuries to females (n = 506). Almost 30% of the males (n = 12,118) experienced injuries to the upper extremities while 27% of the females (n = 506) sustained injuries to the upper extremities. Trunk injuries accounted for approximately 25% of both the male injuries (n = 10,765), and the female injuries (n =506). Lower extremities accounted for over 22% (n = 415) of the female injuries and over 20% (n = 8,485) of the male injuries. Females sustained a higher relative frequency of multiple body part or body systems injuries, 10.75% (n = 201) versus 7.05% (n = 2,977) for male workers

The injury severity means associated with each of the “Body region” categories for male and female workers are shown in Table 4- 7. An analysis of variance was conducted to compare, between male and females workers, the injury severity means for each of the “Body region” classifications. The results showed that injury severity was not significantly different, at $p \leq 0.05$, on the basis of gender with respect to all of the ‘Body Region” groups (see Table 4- 8).

Differences between injury severity means of the six “Body Region” categories were also explored further by gender. The results of the Levene test of homogeneity of variances of the injury severity scores by the “Body Region” categories for male workers did not allow for the assumption of equal variance, L (5, 42,194) = 1204.44, $p < .001$. The results of the subsequent

Welch robust test of equality of injury severity means indicated that, among males, at least one of the “Body Region” categories had a significantly different injury severity mean than one of

Table 4- 7. Comparison between males and females of injury severity means by body region.

Body region	Gender	N	% of gender group*	Mean injury severity”	σ
Head	Male	6970	16.52%	1.11	0.40
	Female	238	12.73%	1.12	0.36
Neck	Male	885	2.10%	1.47	0.70
	Female	55	2.94%	1.60	0.83
Upper extremities	Male	12118	28.72%	1.26	0.54
	Female	506	27.07%	1.27	0.52
Trunk	Male	10765	25.51%	1.45	0.64
	Female	454	24.29%	1.43	0.61
Lower extremities	Male	8485	20.11%	1.40	0.62
	Female	415	22.20%	1.39	0.63
Multiple body parts/body systems (MBRBS)	Male	2977	7.05%	1.47	0.75
	Female	201	10.75%	1.43	0.70

Males = 42,200; Females = 1,869

Table 4- 8. ANOVA, comparison, by gender, of injury severity means by body region.

Body region		Sum of squares	df	Mean square	*F*	*p**
Head	Between groups	0.00	1	0.01	0.04	0.84
	Within groups	1158.96	7206	0.16		
	Total	1158.97	7207			
Neck	Between groups	0.83	1	0.83	1.66	0.20
	Within groups	467.83	938	0.50		
	Total	468.65	939			
Upper extremities	Between groups	0.01	1	0.01	0.04	0.85
	Within groups	3717.06	12622	0.29		
	Total	3717.07	12623			
Trunk	Between groups	0.09	1	0.09	0.22	0.64
	Within groups	4555.11	11217	0.41		
	Total	4555.20	11218			
Lower extremities	Between groups	0.02	1	0.02	0.05	0.82
	Within groups	3445.35	8898	0.39		
	Total	3445.37	8899			
Multiple body parts/body systems (MBRBS)	Between groups	0.25	1	0.25	0.45	0.50
	Within groups	1760.78	3176	0.55		
	Total	1761.03	3177			

* Significance assumed at $p \leq 0.05$

the other groups, F (5, 6,996.94) = 506.08, $p < .001$. This result was confirmed by the results of the Tukey's b range test for injury severity means, significant at $p \leq 0.05$, for the "Body Region" categories.

Figure 4- 1 shows the distribution of injury severity means, in descending magnitudes, associated with each of the six "Body Region" categories for male workers. Homogenous groupings, indicated by the transparent boxes, indicated lack of significant difference of injury severity means, at $p \leq 0.05$, between the respective "Body Region" categories. The least severe injuries were head injuries which were less severe that upper extremity injuries and these were less severe than the lower extremity injuries.

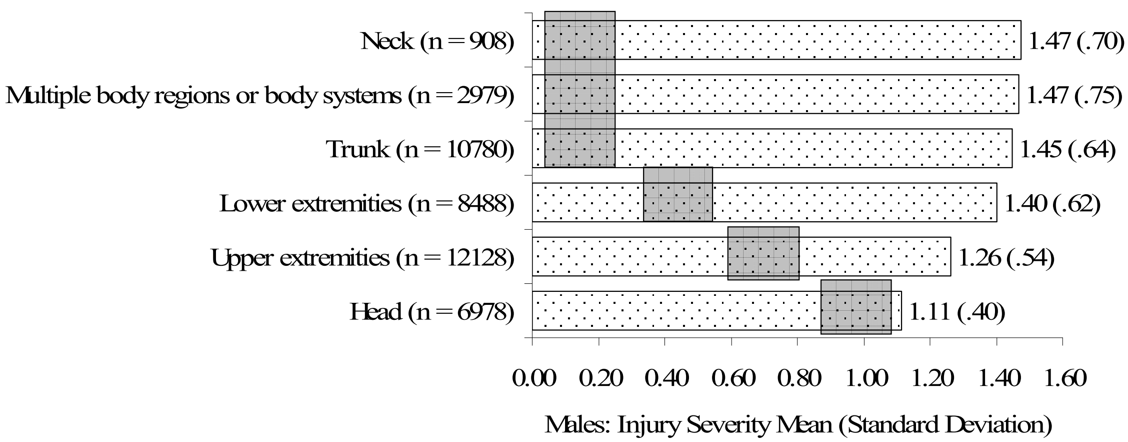

Figure 4- 1. Comparison of injury severity means by body region for injuries to male workers.

Significant differences of injury severity means exist between specific body regions among male workers are illustrated in Figure 4- . The homogeneous group of injuries to the neck (μ = 1.47), multiple body parts or body systems (μ = 1.47) and trunk (μ = 1.45) had a significantly higher injury severity mean, at $p \leq 0.05$, than for all of the remaining "Body Region" categories. Injuries to the lower extremities had a significantly greater, at $p \leq 0.05$, injury severity mean (μ = 1.40) than injuries to the upper extremities (μ = 1.26). Injuries to the head exhibited an injury severity mean (μ = 1.11) significantly lower, at $p \leq 0.05$, than all of the remaining "Body Region" categories.

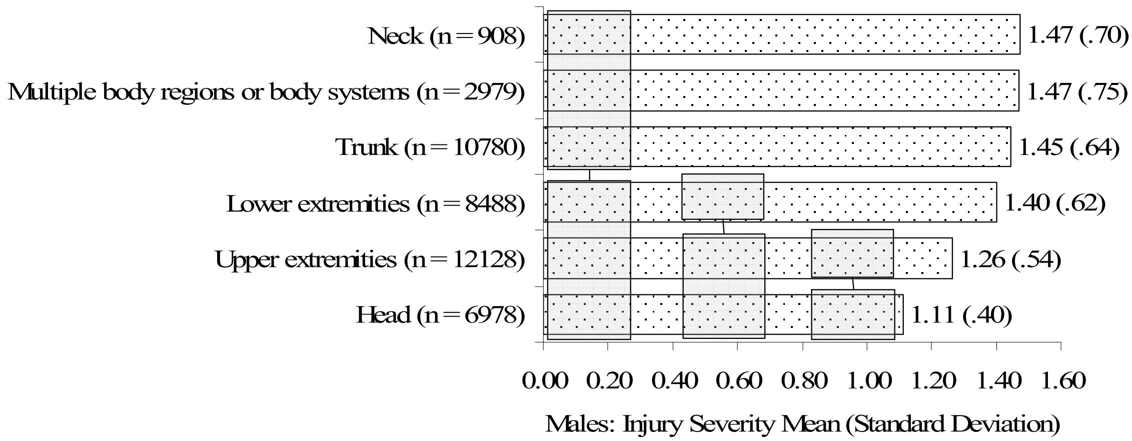

Figure 4- 2. Difference of injury severity means between body regions for injuries to male workers.

For female workers, no assumption of equal variance of injury severity scores by "Body Region" category could be made, L (5, 1,863) = 48.44, $p < .001$. The results of the Welch robusf of equality of injury severity means by the body regions for females indicated that at least one of these regions had a significantly different injury severity mean than one of the other body regions, F (5, 405.82) = 21.40, $p < .001$. This was confirmed by the results of the Tukey's b range test (see Figure 4 – 3).

As shown in Figure 4- 3, among female workers, neck injuries had the highest injury severity mean (μ = 1.60) followed by injuries to multiple body parts or body systems (μ = 1.43), trunk (μ = 1.43), lower extremities (μ = 1.40), upper extremities (μ = 1.27), and head injuries (μ = 1.12).

At $p \leq 0.05$, the results of the Tukey's b range test indicated that, among female workers, neck injuries exhibited a significantly higher injury severity mean than injuries to the lower and upper extremities, and head injuries. Injuries to multiple body parts or body systems, the trunk region, and lower extremities each had a significantly greater injury severity mean, at $p \leq 0.05$, than injuries to the head (see Figure 4- 4).

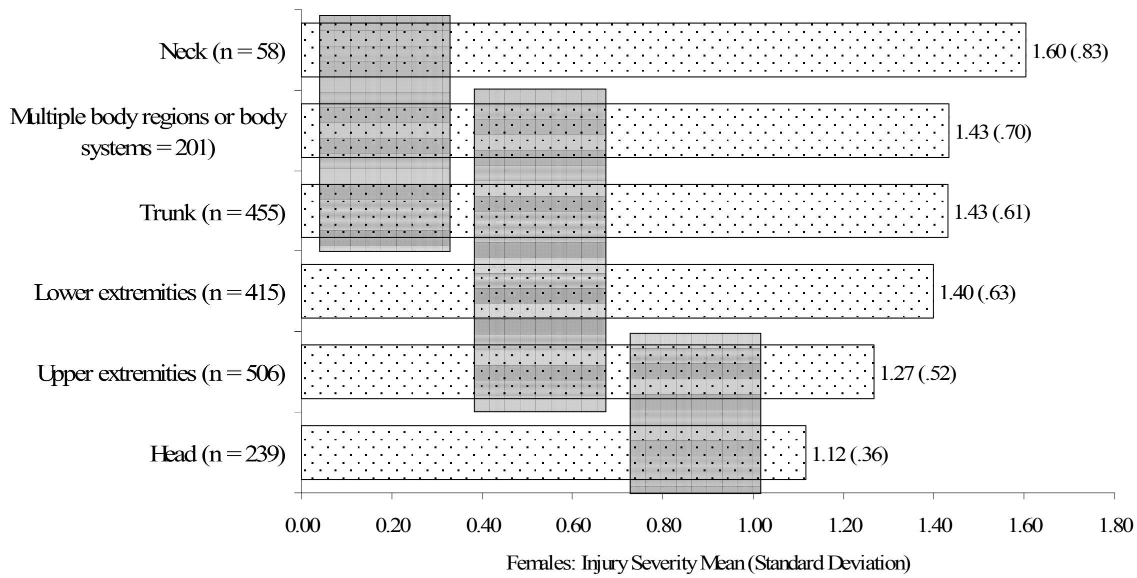

Figure 4- 3. Comparison injury severity means by body region for female workers.

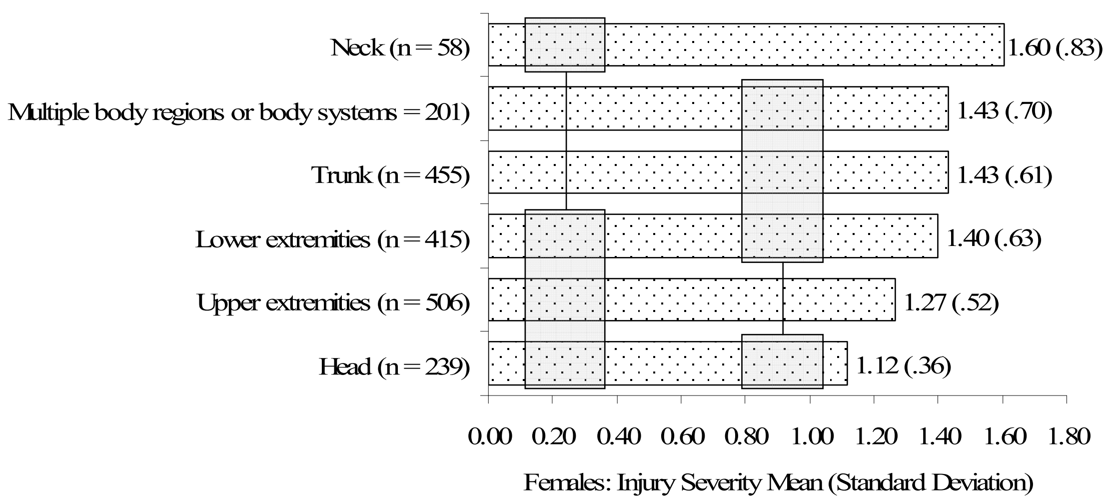

Figure 4- 4. Difference of injury severity means between body regions for female workers.

Marital Status

Information on marital status was provided for 30,762 construction worker workers. Table 4- 9 shows the distribution of worker injuries for the five "Marital Status" classifications. Over 57% (n = 17,621) of the injured workers were married and over 38% (n = 11,825) were single.

Divorced (n = 976), separated (n = 246) and widowed (n = 94) workers constituted less than 5% of the workers.

Table 4- 9. Injuries by marital status.

Marital status	Number of injuries	%	Cumulative %
Married	17,621	57.28%	57.28%
Single	11,825	38.44%	95.72%
Divorced	976	3.17%	98.89%
Separated	246	0.80%	99.69%
Widowed	94	0.31%	100.00%
Total	30,762	100.00%	

The Levene statistic was use to check for homogeneity of variances of injury severity scores for the five "Marital Status" categories. The results of this test did not allow for an assumption of equal variances, L (4, 30,513) = 4, $p < .001$. The subsequent Welch robust test of equality of means was conducted to explore possible differences between injury severity means of the different "Marital Status" groups. The results of this test indicated that at least one of the marital status classifications was associated with a significantly different injury severity mean of one of the other classifications, F (4, 504.96) = 6.87, $p < .001$. However, the results of the Tukey's b range test for injury severity means could not confirm any significant differences between the "Marital Status" groups, at $p \leq 0.05$. Figure 4- 5 ranks the five 'Marital Status" groups by descending magnitudes of injury severity mean. As the transparent box indicates, there were no significantly different, at p ≤ 0.05, injury severity means between any of the marital status classifications.

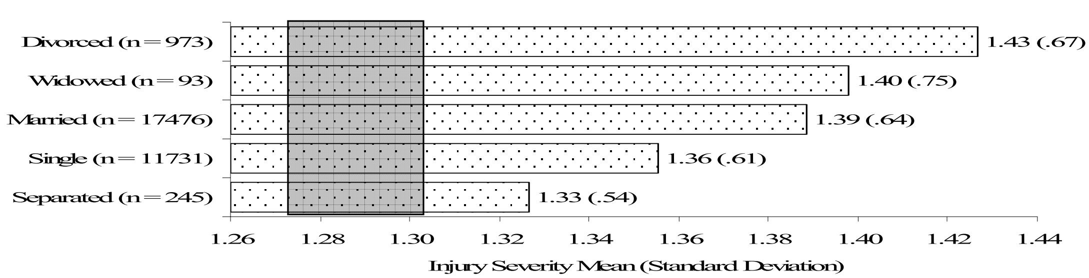

Figure 4- 5. Comparison of injury severity means by marital status.

Number of Dependents

Information regarding the total number of dependents for each injured worker was provided in 11,446 cases. A fairly equivalent number of injured workers reported having one dependent (30.6%, n = 3,500) or two dependents (30.0%, n = 3,438). Almost 80% of the injured workers (79.7%, n = 9,013) reported having one to three dependents. Less than 20% of the workers (17.7%, n = 2,027) had between four and six dependents. The remaining workers with dependents (3.5%, n = 406) claimed seven or more children. Injured workers who were married but for which the number of dependents was not given were initially assumed to have no dependents. The married workers with no dependents had an injury severity mean of 1.38 (σ = 0.63). By observation of the injury severity mean for married workers with no dependents, there is no difference of injury severity means for the number of dependents.

Equal variances of injury severity scores could not be assumed for the three "Number of Dependents" groupings, L (2, 11,365) = 25.18, $p \leq 0.05$. The results of the Welch robust test of equality of means showed that a statistically significant difference existed between these categories with respect to injury severity means, F (2, 1,01.34) = 10.49, $p \leq .001$. The Tukey's b range test was conducted to rank the "Number of Dependents" categories according to their respective mean injury severity levels. Figure 4- 6 shows this distribution in descending order of injury severity. Boxed groupings show group means that are not significantly different, at $p \leq 0.05$, of each other. Despite the significant F value of the Welch test, no statistically significant difference, at $p \leq 0.05$, was found between the "Number of Dependents" categories.

Age

Age was provided for 14,963 of the 46,056 cases. The mean age of injured workers was 37.71 years, with age ranging of 15 and 77 years. Table 4- 10 displays the distribution of all the injured workers by age. Workers within the 30 to 39 (n = 4,350), 20 to 29 (n = 3,900), and 40 to

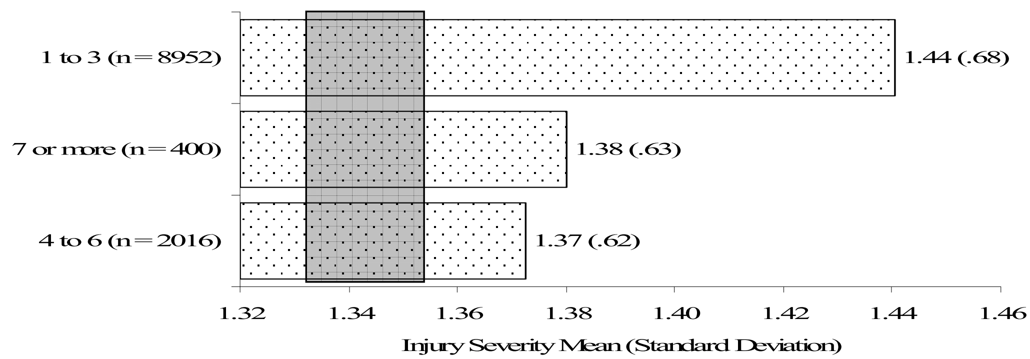

Figure 4- 6. Comparison of injury severity means by number of dependents.

49 (n = 3,893) age groups each comprised over 26% of the workers for whom age information was provided. Workers aged 50 through 59 years accounted for over 13% (n = 2,067) of these cases. Workers 60 years of age or older comprised just over 3% (n = 452) of the cases. Workers under the age of 20 made up just over 2% (n = 301) of all the cases.

A multiple comparison of mean ages was conducted for the "General Occupational Experience" categories. Equal variances of ages could not be assumed for the eight "General Occupational Experience" categories, L (7, 4,615) = 30.10, $p \leq 0.01$. Subsequently, the Welch robust test of equality of means indicated that at least one of the "General Occupational Experience" categories had a significantly different mean age than another, F (7, 496.74) = 155.79, $p \leq .001$. This result was confirmed by the results of the Tukey's b range test.

Table 4- 10. Injuries by age.

Age group (years)	Number of injuries	%	Cumulative %
30 - 39	4,350	29.07%	29.07%
20 - 29	3,900	26.06%	55.13%
40 - 49	3,893	26.02%	81.15%
50 - 59	2,067	13.81%	94.97%
60 - 69	414	2.77%	97.73%
Under 20	301	2.01%	99.74%
Over 69	38	0.25%	100.00%
Total	14,963	100.00%	

Figure 4- 7, displays the results of the Tukey's b range test. Field supervisory level workers had the highest mean age of 45.33 years. Foremen ranked second according to age (μ =

42.37), followed by professionals (μ = 41.07), journeymen (μ = 40.67), administrative level workers (μ = 39.97), laborers (μ = 35.72), and helpers or assistants (μ = 30.91). Apprentice level workers had the lowest mean age of 28.66 years.

Supervisors, including superintendents and assistant superintendents, were significantly older, at $p \leq 0.05$, than all other experience level categories (see Figure 4- 8). Workers at the foreman level had a significantly higher, at $p \leq 0.05$, mean age than did administrative workers, laborers, helpers or assistants, and apprentices. The mean ages of professionals, journeymen, and administrative level workers were significantly greater, at $p \leq 0.05$, than that of laborers, helpers and assistants, and apprentices. Laborers had a significantly greater mean age, at $p \leq 0.05$, than did helpers and assistants/apprentices.

The severity of injury was examined with respect to the age of the injured workers. Workers whose date of hire was 30 days or less of the date of injury (e.g., "New Hires") were excluded of initial consideration under the assumption that most new workers would be receiving safety training and orientation within the first 30 days of hire. To avoid the confounding effect of the training, "new hires" were excluded.

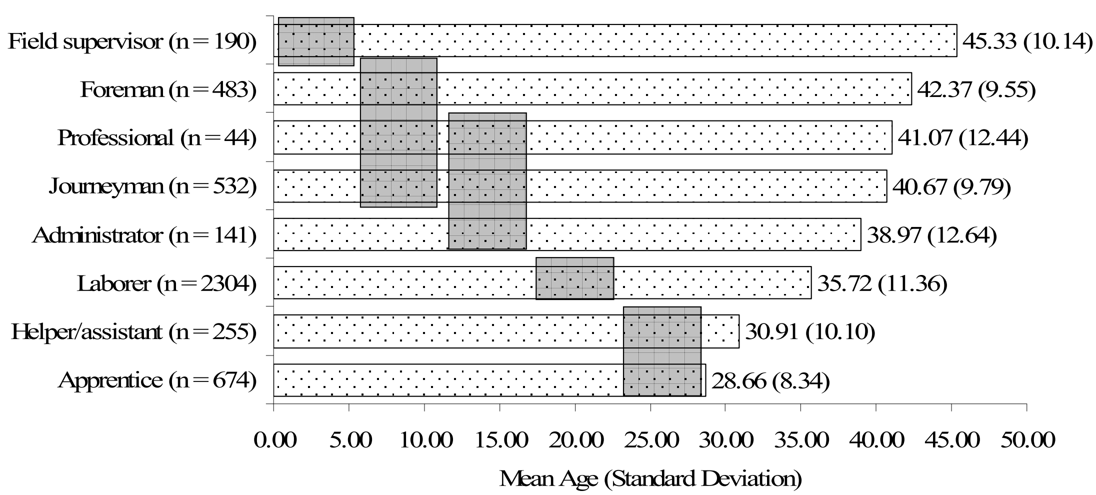

Figure 4- 7. Comparison of mean ages by occupational experience level.

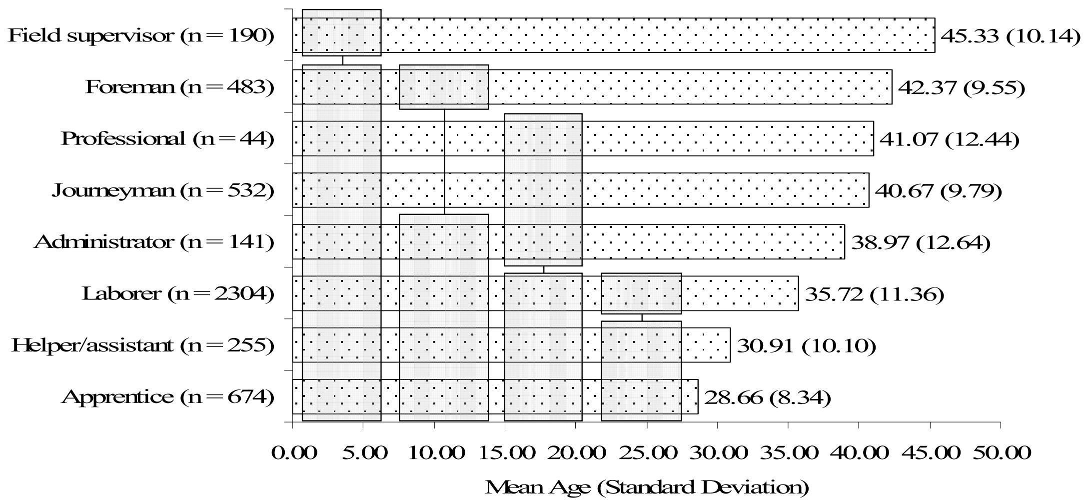

Figure 4- 8. Differences of mean ages between general occupational experience levels.

The Levene statistic was conducted to check for homogeneity of injury severity scores for the seven age groupings for non-new hires. This statistic revealed that equal variance between the age groups could not be assumed, L (6, 9,412) = 80.31, $p \leq .001$. The results of the Welch robust test of equality of means showed that at least one of the age groups had a significantly different injury severity mean of one or more of the other age groupings. F (6, 296.28) = 28.53, $p \leq .01$. This was confirmed by the subsequent Tukey's b range test.

Using the Tukey's b mean range test, a multiple comparison of injury severity means test was conducted with the "Age Group" variable for non-new hires. From Figure 4- 9, it is observed that as non-new hires got older the severity of injury increased. Among non-new hires, workers over the age of 69 had the highest injury severity mean (μ = 1.85), followed by workers between the ages of 60 and 69 years (μ = 1.55), workers of 50 to 59 years of age (μ = 1.39), workers 40 to 49 years of age (μ = 1.38), 30 to 39 years old (μ = 1.32), and workers 20 to 29 years of age (μ = 1.22). Workers under the age of 20 years had the lowest injury severity mean, equal to 1.30, among the non-new hire workers.

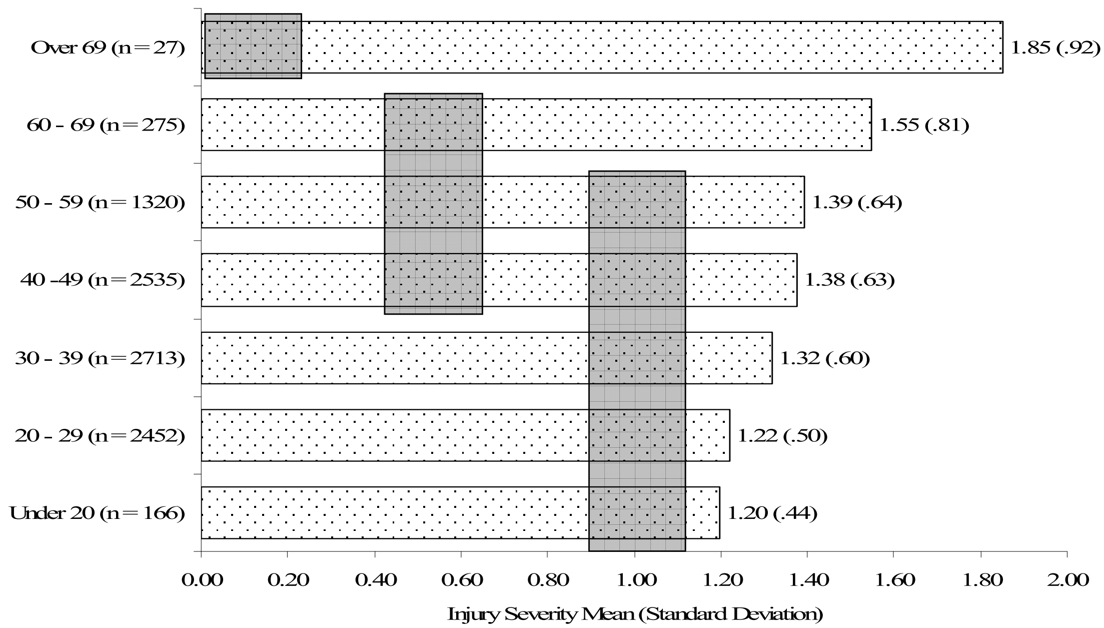

Figure 4- 9. Comparison of injury severity means by age for non-new hires.

From the homogeneous groupings of injury severity means shown in Figure 4- 9, significant differences of injury severity means, at $p \leq 0.05$, between specific age groups among non-new hires were determined (see Figure 4- 10). It was observed that non-new hires who were over 69 years of age had a significantly higher injury severity mean, at $p \leq 0.05$, than all of the other non-new hires. It was also observed that the workers between the age of 60 and 69 had a significantly higher injury severity mean, at $p \leq 0.05$, than workers under the age of 40.

A similar analysis was conducted to examine injury severity means by age for workers who had been employed by the current employer for less than 30 days at the date of the injury. It was determined that equal variance could not be assumed, L (6, 2,376) = 24.36, $p \leq .01$. The subsequent Welch robust test of equality of means showed that for these new employees at least one of age grouping had a significantly different injury severity mean of one or more of the other age groups, F (6, 108.31) = 8.72, $p \leq .001$. This result was confirmed by the results of the Tukey's b range test.

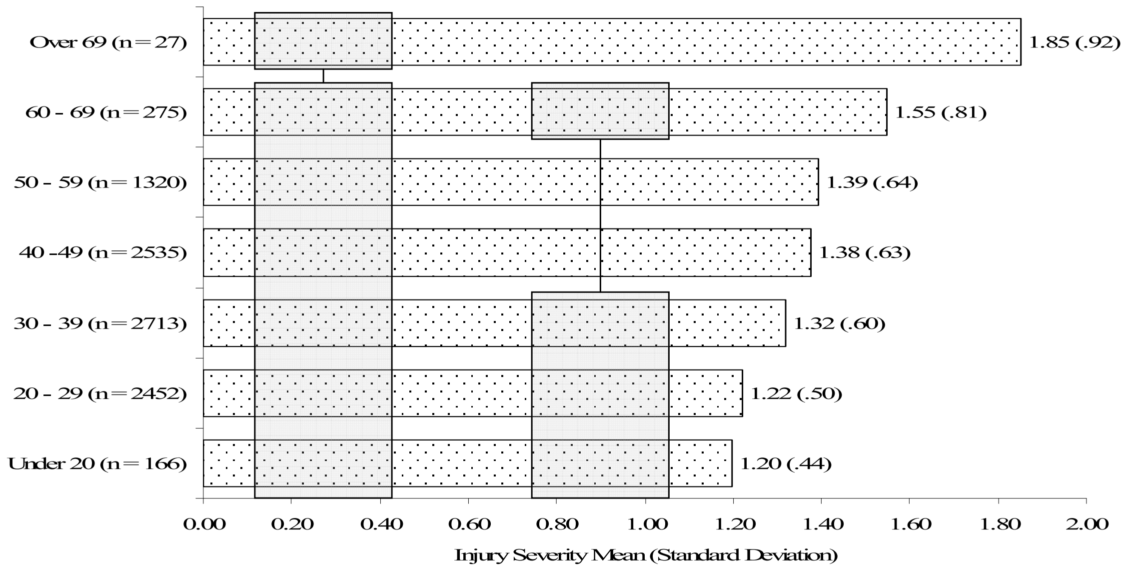

Figure 4- 10. Differences of injury severity means between age groups of non-new hires.

The distribution of injury severity means following a Tukey's b means range test are shown in Figure 4-. Workers over the age of 69 years (μ = 1.60) had the highest injury severity mean among new hires. This was followed by injury severity means associated with new hires between the ages of 60 and 69 years of age (μ = 1.51), 40 and 49 (μ = 1.43), 50 and 59 (μ = 1.43), new hires under 20 years of age (μ = 1.35), and new hires between 30 and 39 years of age (μ = 1.32). Workers between the ages of 20 and 29 years had the lowest injury severity mean (μ = 1.23).

From the homogeneous groupings of injury severity means shown in Figure 4- 11, significant differences of injury severity means, at $p \leq 0.05$, between specific age groups among the new hires were identified. It was observed that new hires who were over 69 years of age had a significantly higher injury severity mean, at $p \leq 0.05$, than new hires with ages between 20 and 29 years (see Figure 4- 12).

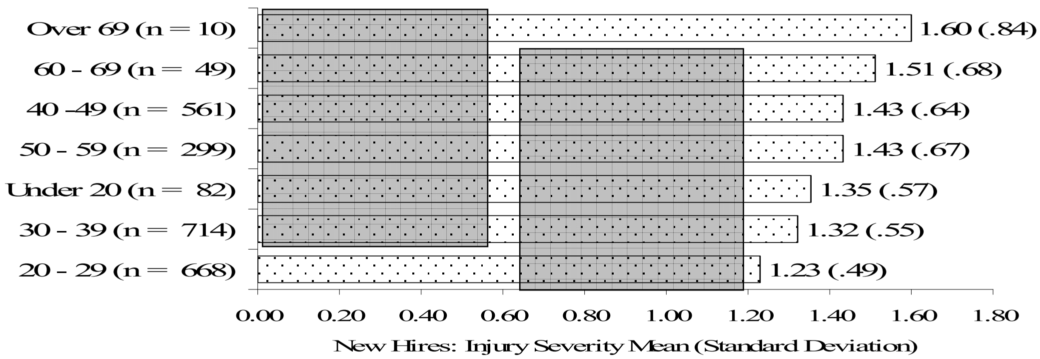

Figure 4- 11. Comparison of injury severity means by age of new hires.

Figure 4-12. Differences of injury severity means between ages of new hires.

An independent samples t-test showed that there was no statistically significant difference in injury severity means between new hires ($\mu = 1.38$) and workers who had been working for more than 30 days prior to being injured ($\mu = 1.36$), t (34,177) = 1.79, $p > 0.05$. A similar investigation was conducted to compare injury severity means between new and non-new hires with respect to age. Figure 4- 13 shows the means comparisons by age. The results showed that that new hires had significantly higher injury severity means than did non-new hires within both the under 20 age group (t (242) = 2.45, $p < 0.001$) and the 40 to 49 years age group (t (3,081) = 1.93, $p < 0.01$) categories. There were no other statistically significant differences, at $p \leq 0.05$, for the remaining age groups. A change in the trend among workers 60 years of age or older was displayed. The workers between the age of 60 and 69 and workers older than 69 years of age showed a reverse trend in which non new hires had a higher injury severity mean than did new hires.

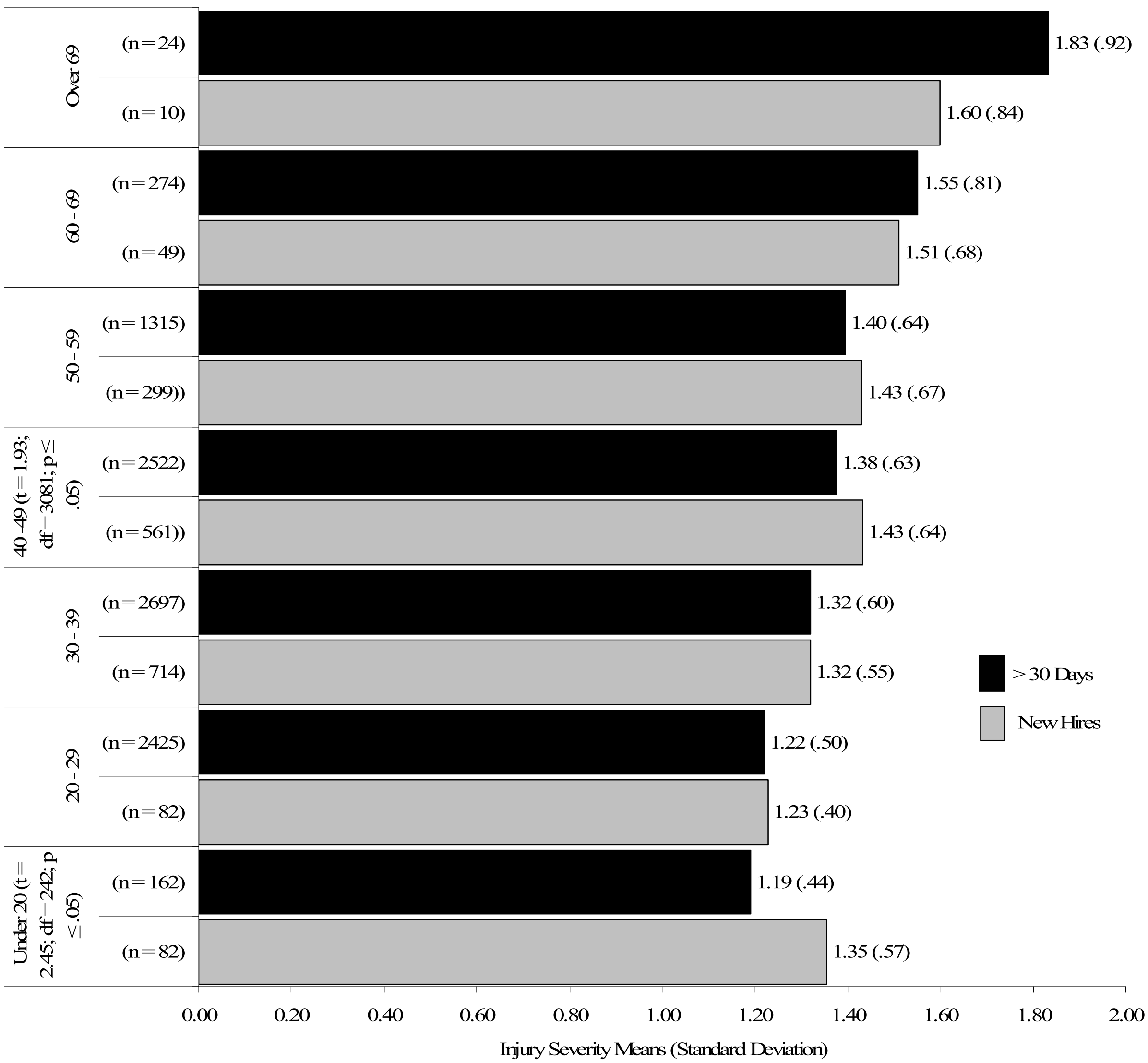

Figure 4- 13. Differences of injury severity mean between new hire and non-new hire workers by age. (Independent Sample t-test statistics are given for those comparisons which showed significant differences at $p \leq 0.05$).

Job Tenure

Information regarding the length of time that had transpired from the date of hire to the date of the injury (job tenure) was provided for 12,023 workers. Over 34% of the injuries occurred within the first 60 days of employment with the firm. Figure 4- 14 displays a decrease in injuries by tenure. Within the first 60 days of hire an injury occurred at an approximate rate of 200 per day. For workers whose employment tenure was between 61 days and a year there was a rate of approximately 40 injuries per day.

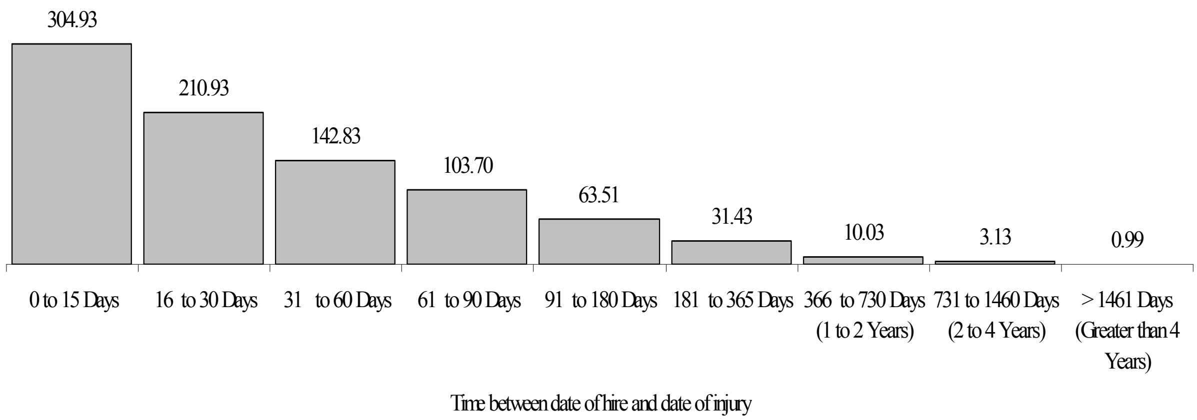

Figure 4- 14. Daily injury rate by job tenure.

A test for homogeneity of variance showed that an equal variance of injury severity levels could not be assumed between the eight tenure categories, L (8, 34,170) = 5.94, $p \leq 0.05$. A subsequent Welch robust test of equality of injury severity means for these eight tenure categories showed that at least one of these groups had a statistically significant different injury severity mean than at least one of the other groups, F (8, 391.13) = 2.66, $p \leq .01$. This result was confirmed with the Tukey's b range test.

The Tukey's b range test was conducted to identify specific differences between injury severity means for the eight tenure categories. Figure 4- 15 shows the distribution of the injury severity means, in descending injury severity mean levels, for the eight tenure categories. Workers who had a job tenure greater than 4 years prior to the injury had the highest injury severity mean (μ = 1.39). The remaining tenure categories, according to descending injury severity mean levels, are as follows: one to two years (μ = 1.38), zero to 15 days (μ = 1.38), two to four years (μ = 1.38), between 16 and 30 days (μ = 1.37), between 31 and 60 days (μ = 1.36), of 91 through 180 days (μ = 1.35). Workers with job tenure between 181 and 365 days prior to the injury event had the lowest injury severity mean (μ = 1.34).

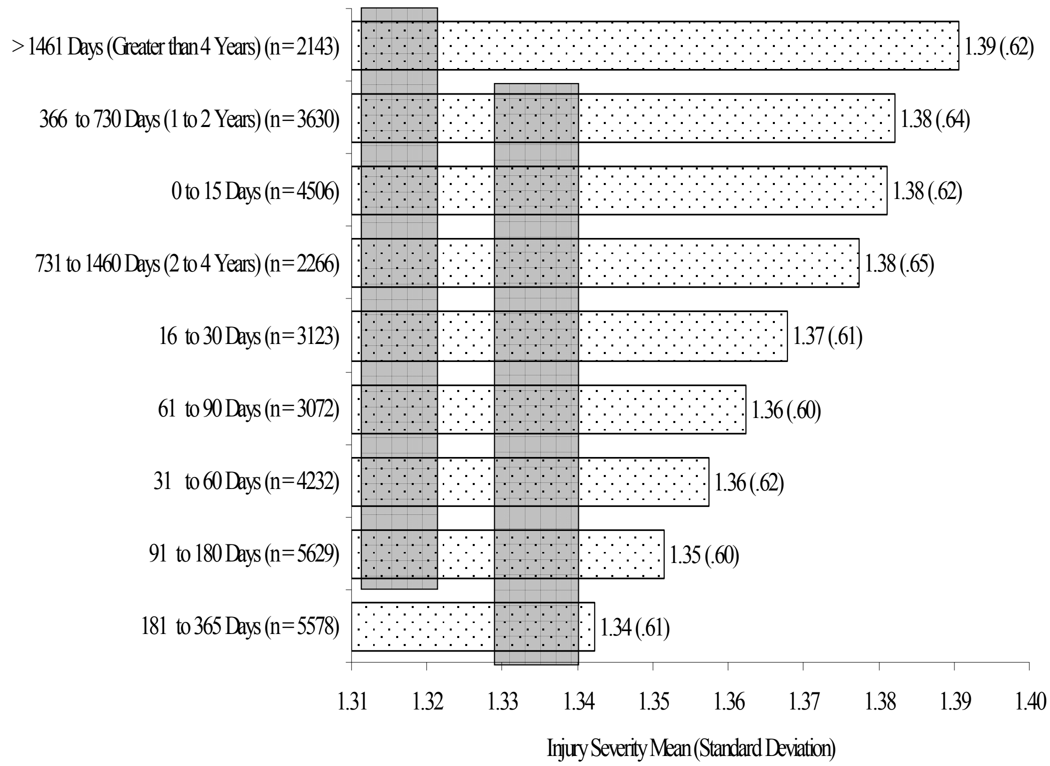

Figure 4- 15. Comparison of injury severity means by job tenure.

From the homogeneous groupings of injury severity means shown in Figure 4- 15 significant differences of injury severity means, at $p \leq 0.05$, between specific job tenure categories among workers was examined (see Figure 4- 16). It was observed that workers who were employed for more than 4 years prior to experiencing their injuries had a significantly higher injury severity mean, at $p \leq 0.05$, than workers who were employed between six months and one year prior to experiencing their injuries.

Occupational Work Area

Information regarding the workers' "General Occupational Work Area" (work area) was identifiable for 46,056 workers. For statistical analysis, workers, whose work area was not specified, were grouped as "Workers/Unspecified Trades," with the result making up the largest group, 24.36% (n = 11,219). Injuries to workers identified as working in the areas of carpentry, electrical work, and iron/steel work combined for about 35% of the total number of injuries (see Table 4- 11).

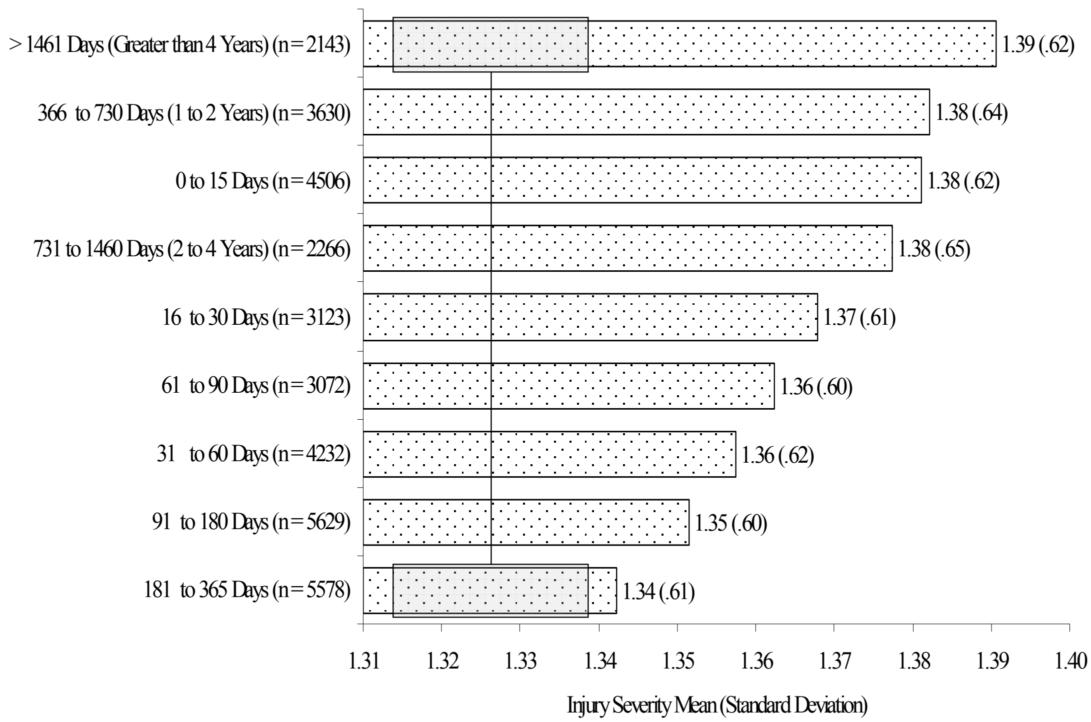

Figure 4- 16. Comparison of injury severity means by job tenure.

The relationship of injury severity and general occupational work area was examined. Homogeneity of variance of injury severity for the 42 occupational work areas was examined using the Levene statistic. The results of this statistic did not allow the assumption of equal variances, L (41, 34,424) = 12.378, $p \leq 0.05$. The results of a subsequent Welch robust test of equality of injury severity means indicated that at least one of these work areas had a significantly different injury severity mean of at least one of the other work areas, F (41, 1,250.27) = 5.19, $p \leq .001$; however, this was not supported by the subsequent Tukey's b range test.

The Tukey's b means range test was used to rank, in descending order, the 42 work areas according to their respective injury severity means (see Figure 4- 17). Injuries to landscape workers ($\mu = 1.44$) and technicians/mechanics ($\mu = 1.44$) ranked as the most severe, followed by injuries to roofers ($\mu = 1.43$), flag persons ($\mu = 1.43$), and Flooring, tile, or carpeting workers ($\mu = 1.42$), the five worker areas with the highest injury severity means. Injuries to clerical workers ($\mu = 1.22$) ranked the lowest with respect to injury severity mean. In combination with injuries to clerical workers, injuries to professional engineers ($\mu = 1.24$), acoustic ceiling installers ($\mu = 1.25$), field engineers ($\mu = 1.25$) and welders ($\mu = 1.25$) had the five lowest ranked injury severity means. The Tukey's b test did not identify any specific, significantly different, at $p \leq 0.05$, injury severity means between any of the work areas.

Occupational Experience Level by General Occupational Work Area

Injury information was provided on eight categories of worker occupational experience level for 14,383 workers (seeTable 4- 12). Laborers (n = 7,917) made up just over 55% of the workers. Apprentice level workers (n = 1,578), foremen (n = 1,449), and journeymen (n = 1,358) each accounted for about 10% of the injuries. Injuries to helpers or assistants (n = 752) made up slightly over five % of the injuries for the eight occupational experience levels. Injuries to field supervisors (n = 614), administrative personnel (n = 448) and professional level workers (n = 267) combined to account for less than 10% of the injuries.

Injury severity by occupational experience level was examined. The results of the Levene test did not support an assumption of equal variances of injury severity scores for the eight occupational experience levels, L (7, 14,230) = 10.14, $p < 0.001$. The results of the subsequent Welch test indicated that at least one of the experience levels was significantly different, with regards to respective injury severity means, of one of the other levels, F (7, 2,053.70) = 4.10, $p < 0.001$. Figure 4- 17 shows that this result was confirmed by the results of the Tukey's range test.

Table 4- 11. Injuries by occupational work areas of injured workers.

Occupational work area	Number of injuries	%	Cumulative %
Workers/unspecified trades	11219	24.36%	24.36%
Carpentry	6488	14.09%	38.45%
Electrical	5375	11.67%	50.12%
Iron/steel	4227	9.18%	59.30%
Technical repair and maintenance	2059	4.47%	63.77%
Concrete	2047	4.44%	68.21%
Pipe fitting/laying	1994	4.33%	72.54%
Plumbing	1368	2.97%	75.51%
Masonry	1278	2.77%	78.29%
Epuiment or machinery operations	1278	2.77%	81.06%
Sheet metal	1225	2.66%	83.72%
Boilermaking	1037	2.25%	85.97%
Welding	697	1.51%	87.49%
Millwright work	687	1.49%	88.98%
Supervising	583	1.27%	90.24%
Painting/ plasterering	558	1.21%	91.45%
Drywall	494	1.07%	92.53%
Driving	349	0.76%	93.28%
Insulation	331	0.72%	94.00%
Lineman	276	0.60%	94.60%
Glazing	253	0.55%	95.15%
Clerical	253	0.55%	95.70%
Roofing	252	0.55%	96.25%
Steam fitting	239	0.52%	96.77%
Managing	195	0.42%	97.19%
Sprinkler fitting	164	0.36%	97.55%
Inspecting	144	0.31%	97.86%
Flooring, tile, carpeting	138	0.30%	98.16%
Engineering	121	0.26%	98.42%
Scaffold erection	108	0.23%	98.66%
Security	83	0.18%	98.84%
Lathing	79	0.17%	99.01%
Conveyor systems work	77	0.17%	99.18%
HVAC/refrigeration	62	0.13%	99.31%
Waterproofing	56	0.12%	99.43%
Rigging	51	0.11%	99.54%
Material handling	51	0.11%	99.65%
Surveying	35	0.08%	99.73%
Hod carrying	33	0.07%	99.80%
Field engineering	31	0.07%	99.87%
Landscaping	25	0.05%	99.92%
Acoustic ceiling work	21	0.05%	99.97%
Flagging	15	0.03%	100.00%
Total	46056	100.00%	

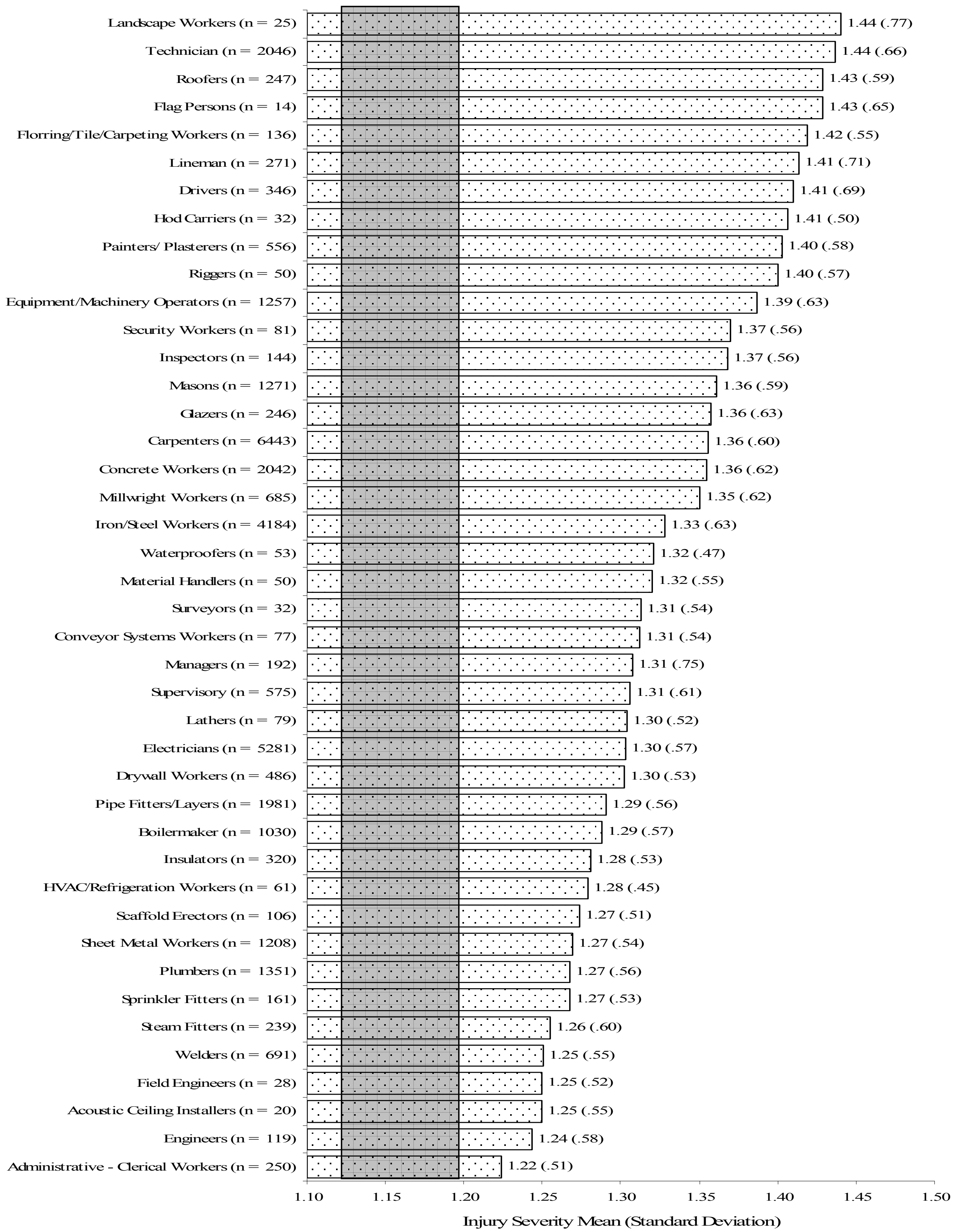

Figure 4- 17. Comparison of injury severity means by occupational work area.

Table 4- 12. Injuries by occupational experience level of injured worker.

Occupational Experience Level	Number of injuries	%	Cumulative %
Laborer	7,917	55.04%	55.04%
Apprentice	1,578	10.97%	66.01%
Foreman	1,449	10.07%	76.09%
Journeyman	1,358	9.44%	85.53%
Helper/assistant	752	5.23%	90.76%
Field supervisor	614	4.27%	95.02%
Administrator	448	3.11%	98.14%
Professional	267	1.86%	100.00%
Total	14,383	100.00%	

Of the Tukey's b range test, it was shown that journeymen had the highest injury severity mean (μ = 1.39), followed by foremen (μ = 1.35), laborers (μ = 1.35), professionals (μ = 1.31), apprentices (μ = 1.31), field supervisory level workers, (μ = 1.30) and helpers or assistants (μ = 1.30). Administrative level workers had the lowest associated injury severity mean (μ = 1.26) (see Figure 4- 18).

Two homogeneous groups of injury severity means were identified, thus supporting the results of the Welch test (see Figure 4- 18). It was further determined that journeymen had a significantly greater injury severity mean, at $p \leq 0.05$, than that for administrative level personnel (see Figure 4- 19).

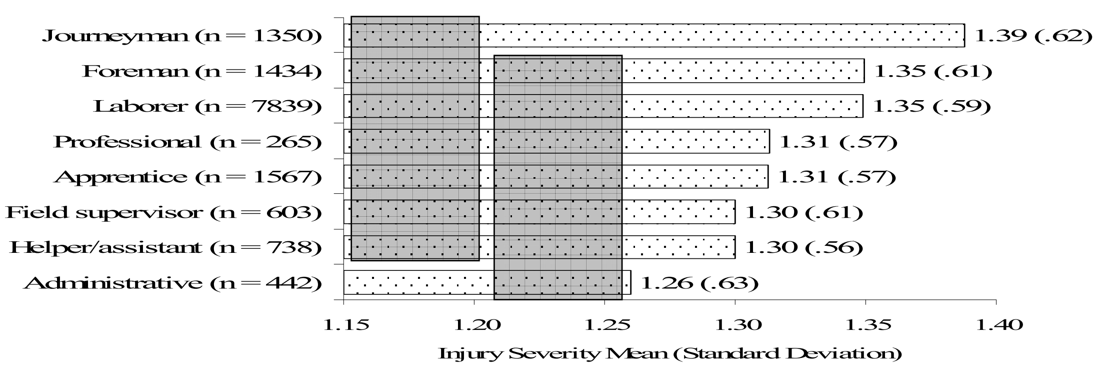

Figure 4- 18. Comparison of injury severity means by occupational experience level.

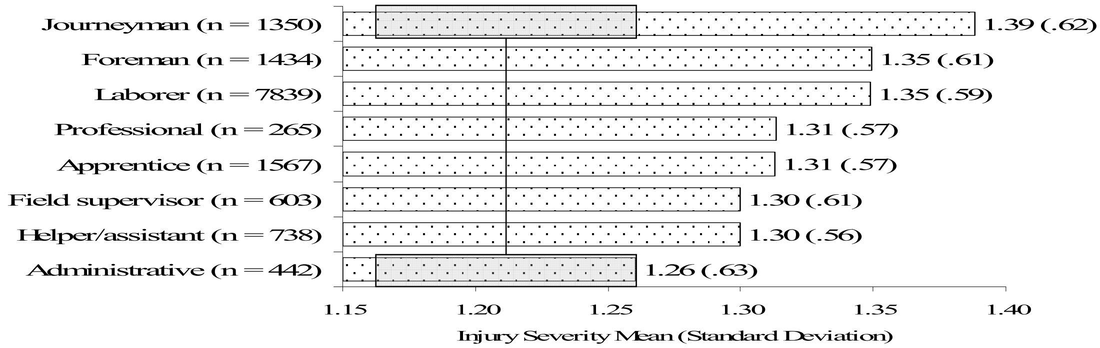

Figure 4- 19. Differences of injury severity means between occupational experience levels.

Laborers

The occupational experience level of workers was examined further for specific work areas. Table 4- 13 shows information on injuries was distributed by the occupational work areas for laborers, which was provided for 4,350 workers. Over 39% of the laborers were concrete workers (n = 1,700). Almost 24% of the laborers were associated with electrical work (n = 1,023), and slightly less than 20% of the laborers were involved in carpentry work (n = 833). Workers working in masonry (n = 375) or steel work (n = 368) areas each accounted for almost 9% of the injuries to laborers. Among laborers, sheet metal workers account for less than 2% of the workers (n = 51).

Table 4- 13. Injuries by occupational work area for laborers.

Occupational work area	Number of injuries	%	Cumulative %
Concrete	1,700	39.08%	39.08%
Electrical	1,023	23.52%	62.60%
Carpentry	833	19.15%	81.75%
Masonry	375	8.62%	90.37%
Iron/steel	368	8.46%	98.83%
Sheet metal	51	1.17%	100.00%
Total	4,350	100.00%	

The results of the Levene test supported an assumption of equal variances of injury severity scores for the six occupational areas for laborers, L (5, 4,339) = 2.05, $p > 0.05$. The results of the subsequent ANOVA test indicated that none of the occupational areas among laborers had a significantly different injury severity of one of the other work areas, F (5, 4,339) = 2.39, $p > 0.20$. This result was confirmed by the results of the Tukey's range test.

Despite the lack of any significant difference of injury severity means, at $p \leq 0.05$, between the work areas for laborers, a ranking of work areas by injury severity means was developed of the Tukey's b range test (see Figure 4- 20). It was shown that laborers doing electrical work had the highest injury severity mean ($\mu = 1.40$), followed by masonry work ($\mu = 1.37$), carpentry ($\mu = 1.36$), concrete work ($\mu = 1.35$), and iron and steel work ($\mu = 1.32$). Laborers involved in sheet metal work at the time of the injury had the lowest injury severity mean ($\mu = 1.29$).

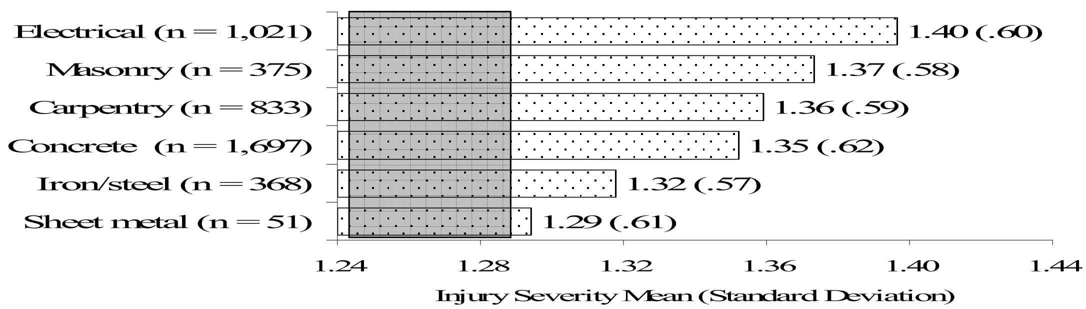

Figure 4- 20. Comparison of injury severity means by occupational work area for laborers.

Helpers or Assistants

Information regarding injuries by occupational work areas for helpers and assistants is shown on Table 4- 14. This information was provided for 439 workers. Over 25% of the helpers/assistants were involved in electrical work (n = 112), and approximately 18% of the helpers/assistants were involved in pipe fitting or pipe laying (n = 80). Almost 15% of the helpers/assistants sustained injuries when performing plumbing activities (n = 64). Slightly over 6% of the helpers/assistants were injured while either working with sheet metal (n = 28) or welding (n = 28).Each of the following work areas was associated with around five % or less of all the injuries to helpers or assistants:

- Masonry (n = 23)
- Iron/steel (n = 19)

- Technical repair and maintenace (n = 16)
- Painting or plastering (n = 13)
- Boilermaker (n = 11)
- Flooring, tile, or carpeting (n = 11)
- Insulation (n = 11)
- Conveyor systems (n = 7)
- Glazing (n = 2)
- HVAC/refrigeration (n = 1)
- Rigging (n = 1)

Table 4-14. Occupational work area of injured helpers and assistants.

Occupational work area	Number of injuries	%	Cumulative %
Electrical	112	25.51%	25.51%
Pipe fitting	80	18.22%	43.73%
Plumbing	64	14.58%	58.31%
Sheet metal	28	6.38%	64.69%
Welding	28	6.38%	71.07%
Masonry	23	5.24%	76.31%
Iron/steel	19	4.33%	80.64%
Technical repair and maintenace	16	3.64%	84.28%
Painting and plastering	13	2.96%	87.24%
Millwright work	12	2.73%	89.97%
Boilermaker	11	2.51%	92.48%
Flooring, tile, and carpeting	11	2.51%	94.99%
Insulation	11	2.51%	97.49%
Conveyor systems work	7	1.59%	99.09%
Glazing	2	0.46%	99.54%
HVAC/refrigeration	1	0.23%	99.77%
Rigging	1	0.23%	100.00%
Total	439	100.00%	

Because of the frequencies for both HVAC/Refrigeration and Rigging being below two, a Tukey's range test for the injury severity means could not be conducted. The results of an ANOVA showed that none of the occupational work areas differed significantly from one another with respect to injury severity means, $F(16, 410) = 0.90$, $p > 0.50$. Figure 4- 21 shows the ranking of 17 occupational areas, by injury severity mean.

Apprentice

Information regarding the general occupational work area of the apprentice level worker was provided for 1,393 workers. Table 4- 15 displays the distribution of these injuries by occupational work area for apprentices. Over 25% of the apprentices were performing electrical work (n = 367) and 25% were performing carpentry (n = 355) when they were injured. Almost 15% were involved in plumbing work (n = 214). Iron and steel work (n = 116) accounted for almost 12% of the injuries to apprentices. Workers working with concrete (n = 81) or sheet metal (n = 57) combined for almost 10% of the injuries to apprentices. The combination of the following work areas was associated with slightly more than 10% of the injuries to apprentices: masonry (n = 44, 3.16%), millwright (n = 35, 2.51%), painting or plastering (n = 33, 2.37%), sprinkler fitting (n = 17, 1.22%), boilermaker (n = 10, 0.72%), glazing (n = 10, 0.72%), flooring, tile, and carpeting (n = 4, 0.29%).

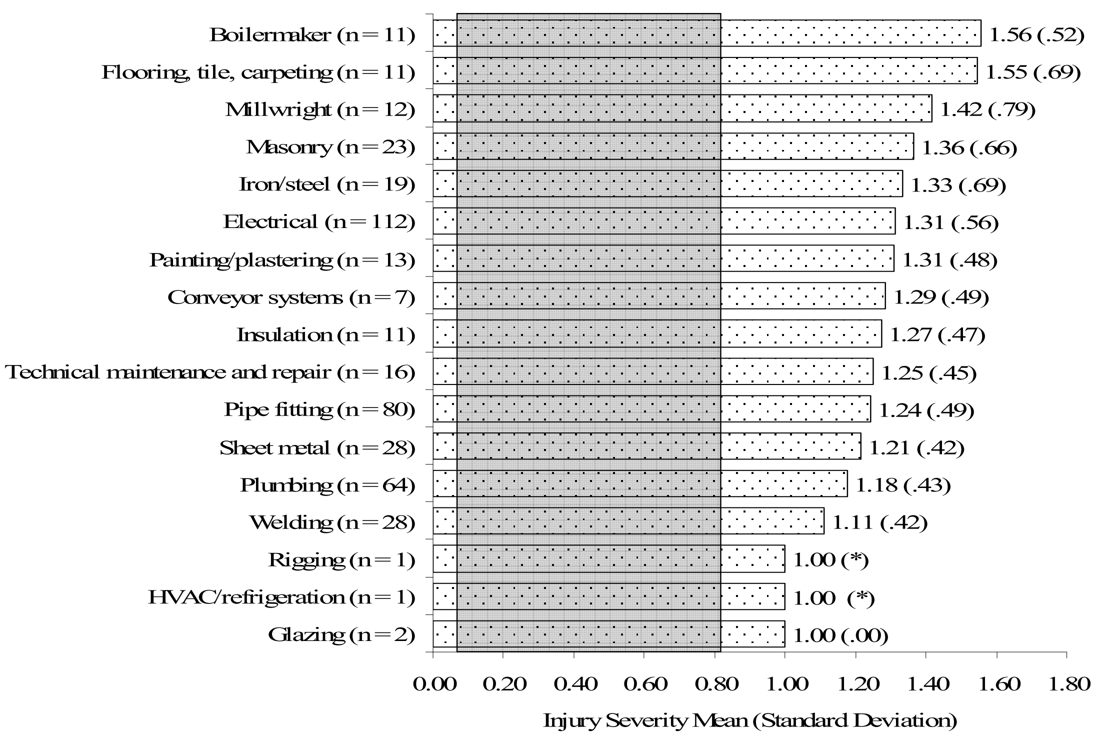

Figure 4- 21. Comparison of injury severity means by occupational work area of injured helpers or assistants.

Table 4- 15. Injuries to apprentices by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Electrical	367	26.35%	26.35%
Carpentry	355	25.48%	51.83%
Plumbing	214	15.36%	67.20%
Iron/steel	166	11.92%	79.11%
Concrete	81	5.81%	84.93%
Sheet metal	57	4.09%	89.02%
Masonry	44	3.16%	92.18%
Millwright work	35	2.51%	94.69%
Painting and plastering	33	2.37%	97.06%
Sprinkler fitting	17	1.22%	98.28%
Boilermaker	10	0.72%	99.00%
Glazing	10	0.72%	99.72%
Flooring, tile, and carpeting	4	0.29%	100.00%
Total	1,393	100.00%	

A Levene test of homogeneity of variances of injury severity scores for the 13 occupational work areas showed that an assumption of equal variances could not be made, L (12, 1,369) = 7.90, $p < 0.001$. The results of the subsequent Welch test of equality of injury severity means indicated that at least one of the occupational work areas among apprentices had a significantly different injury severity mean than one of the other work areas, F (12, 75.24) = 2.84, $p < 0.01$. This was not confirmed by the results of the Tukey's b range test.

The Tukey's b range was used to rank the occupational areas for apprentices by their respective injury severity means and to detect specific differences of the injury severity mean between the 13 occupational areas. The results of this test are shown in Figure 4- 22. No specific significant difference, at $p \leq 0.05$, of injury severity means was detected between any of the occupational areas among apprentices. Glazing ($\mu = 1.50$) and flooring, tile, carpeting ($\mu = 1.50$) work ranked the highest in terms of injury severity mean levels among apprentices. Sheet metal work ($\mu = 1.16$) and sprinkler fitting work ($\mu = 1.18$) displayed the lowest injury severity means among the occupational work areas for apprentices.

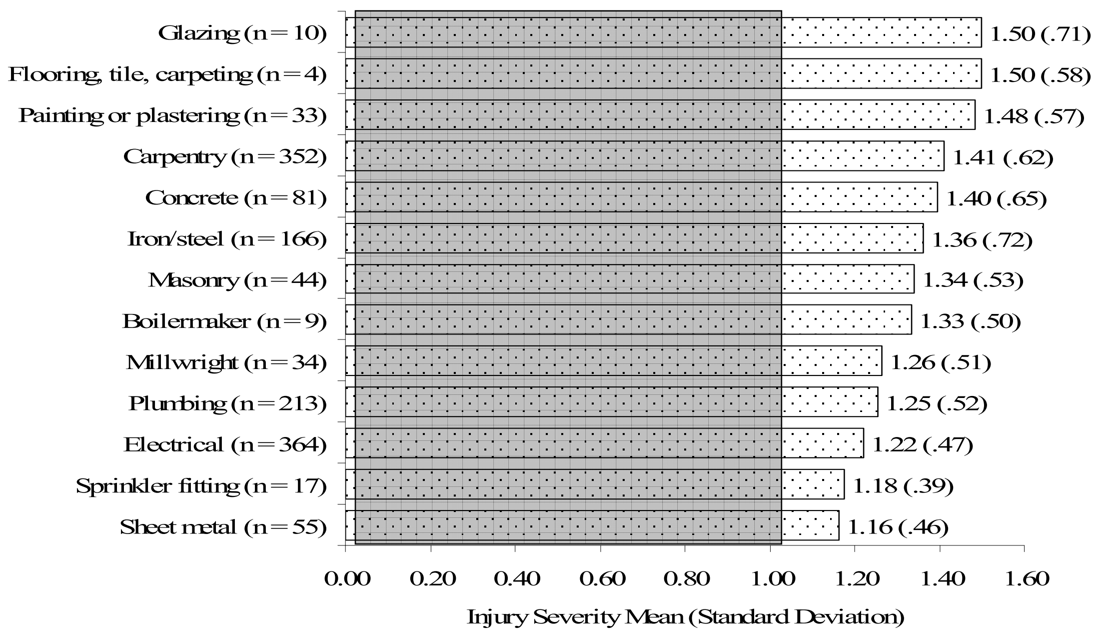

Figure 4- 22. Comparison of injury severity means by occupational work areas for injured apprentices.

Journeyman

Information regarding the general occupational work area of the journeyman level workers was provided for 890 workers. Table 4- 16 shows the injury distribution by the occupational work areas for journeymen. Over 27% of the journeymen were performing masonry work (n = 246), and over 26% were involved in electrical work (n = 238) at the time of their injuries. Injuries occurring while involved in carpentry work (n = 125, 14.04%) combined with sheet metal work (n = 123) accounted for almost 28% of the injuries to journeyman level workers. Almost 16% of the journeymen injuries were associated with plumbing (n = 82) and pipe fitting (n = 60) work. Work as linemen (n = 14), painters or plasterers (n = 2), was associated with less than 2% of the injuries to journeyman level workers.

A Levene test of homogeneity of variances of injury severity scores for the eight occupational work areas showed that an assumption of equal variances could not be made, L (7, 877) = 5.07, $p < 0.001$. The results of the subsequent Welch test of equality of injury severity means indicated that none of the occupational work areas among journeymen had a significantly different injury severity mean than and other work areas, F (7, 18.87) = 1.97, $p > 0.10$. This was confirmed by the results of the Tukey's b range test.

Table 4- 16. Injuries to journeymen by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Masonry	246	27.64%	27.64%
Electrical	238	26.74%	54.38%
Carpentry	125	14.04%	68.43%
Sheet metal	123	13.82%	82.25%
Plumbing	82	9.21%	91.46%
Pipe fitting/laying	60	6.74%	98.20%
Lineman work	14	1.57%	99.77%
Painting and plastering	2	0.22%	100.00%
Total	890	100.00%	

The Tukey's b range was used to rank the eight occupational areas for journeyman level workers by their respective injury severity means. The results of this test are reflected in Figure 4- 23. No significant difference, at $p \leq 0.05$, of injury severity means was detected between any of the occupational areas among journeymen. Carpentry ($\mu = 1.52$) had the highest injury severity mean among journeymen, followed by painting or plastering ($\mu = 1.50$), plumbing ($\mu = 1.49$), and pipe fitting or laying ($\mu = 1.43$). Journeyman level linemen had the lowest injury severity mean ($\mu = 1.21$), preceded by journeymen sheet metal workers ($\mu = 1.25$), electrical workers ($\mu = 1.36$) and masonry workers ($\mu = 1.37$).

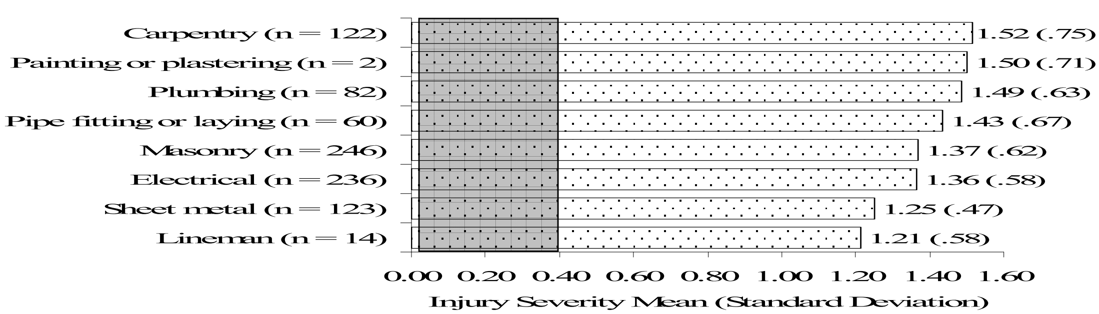

Figure 4- 23.Comparison of injury severity means by occupational work areas for injured journeymen.

Foreman

The injuries of foremen were examined. Table 4- 17 displays the distribution of injuries for four occupational work areas of journeymen, based on information provided for 269 workers. Almost 60% of the injuries to foremen were associated with carpentry work ($\mu = 161$). Foremen associated with electrical work accounted for over 26% ($n = 71$) of the injuries. Masonry work ($n = 29$, 10.78%) and concrete work ($n = 8$, 2.97%) accounted for slightly over 13% of the injuries to foremen.

Table 4- 17. Injuries to foremen by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Carpentry	161	59.85%	59.85%
Electrical	71	26.39%	86.24%
Masonry	29	10.78%	97.02%
Concrete	8	2.97%	100.00%
Total	269	100.00%	

The Levene test of homogeneity of variances of injury severity scores for the four occupational work areas identified among foremen showed that an assumption of equal variances of injury severity scores for the four occupational areas could be made, $L(3, 265) = 2.32$, $p > 0.07$. The results of the subsequent ANOVA test indicated that none of the occupational work areas among foremen had a significantly different injury severity mean than any of the other work areas, $F(3, 265) = 1.34$, $p > 0.30$. This was confirmed by the results of the Tukey's b range test.

The Tukey's b range was used to rank the eight occupational areas for foreman by their respective injury severity means. The results of this test are reflected in Figure 4- 24. Masonry work ($\mu = 1.52$) had the highest injury severity mean among foremen, followed by carpentry ($\mu = 1.48$), and electrical work ($\mu = 1.31$). Foremen associated with concrete work ($\mu = 1.25$) had the lowest injury severity mean. No significant difference, at $p \leq 0.05$, of injury severity means was detected between the occupational areas of foremen.

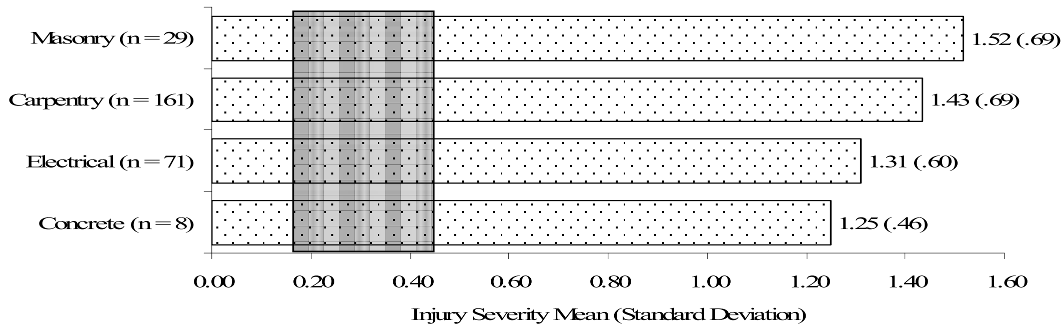

Figure 4- 24. Comparison of injury severity means by occupational work areas for injured foremen..

Supervisors

Information regarding injuries by the two general occupational area categories for field supervision level workers was provided in 614 cases. Table 4- 18 displays the injury distribution by the two occupational work areas for field supervisors. Almost 95% of the injuries to field supervisors were associated with superintendents (n = 583) while slightly more than five % of the injuries associated with field supervision level workers were to field engineers (n = 31).

Table 4- 18. Injuries to supervisors by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Superintendent	583	94.95%	94.95%
Field Engineers	31	5.05%	100.00%
Total	614	100.00%	

An independent t-test was conducted to compare injury severity means of the two general occupational work areas associated with field supervision. The results of the Levene test for equality of injury severity score variances for superintendents and field engineers allowed for the assumption of equal variances, L (601) = 0.84, $p > 0.30$. As Figure 4- 25 illustrates, the results of the subsequent t-test showed that, among field supervision level workers, superintendents (μ =

1.31) did not had a significantly different injury severity mean than that of field engineers (μ = 1.25), t (601) = 0.48, *p* > 0.60.

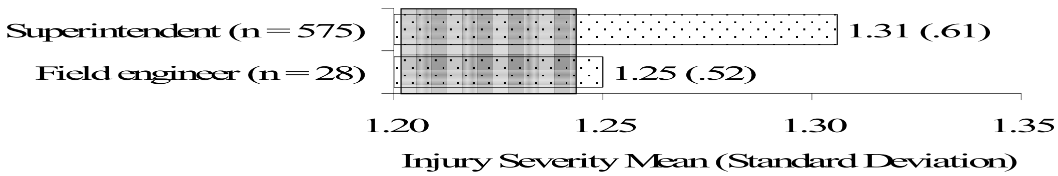

Figure 4- 25. Comparison of injury severity means by occupational work area of injured supervisors.

Professional

Information regarding the frequency of injuries associated with the two general occupational work areas identified as professional level workers was provided for 265 injured workers (see Table 4- 19). Slightly more than 45% of the injuries to professionals were to some type of professional engineer (n = 121). The remaining injuries to professional level workers were experienced by inspectors (n = 144, 54.34%).

Table 4- 19. Injury to professionals by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Inspector	144	54.34%	54.34%
Professional engineer	121	45.66%	100.00%
Total	265	100.00%	

An independent t-test was conducted to compare injury severity means for the two general occupational work areas associated with professional level workers. The results of the Levene test for equality of injury severity score variances for inspectors and professional engineers did not allow for the assumption of equal variances, L (261) = 5.67, *p* < 0.02. The results of the subsequent t-test showed that, among professional level workers, inspectors (μ = 1.37) did not had a significantly different injury severity mean than that of professional engineers (μ = 1.24), t (261) = 1.75, *p* > 0.08 (see Figure 4- 26).

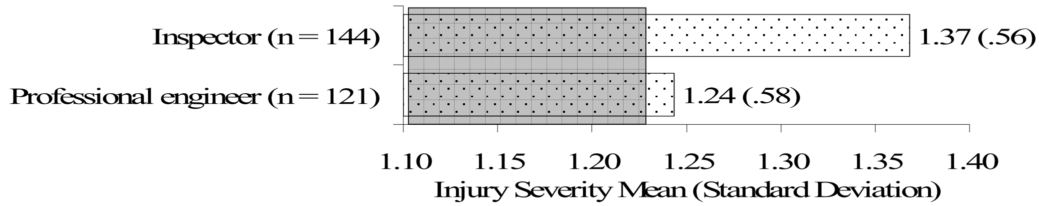

Figure 4- 26. Comparison of injury severity means by occupational work areas of injured professionals.

Administrators

Information for 448 injured workers was provided where the general occupational work area was identified as administrative. Table 4- 20 shows that over 56% of the injured administrative level workers were office and clerical workers (n = 253). The remaining 43.53% of the workers were managers of some type (n = 195).

Table 4- 20. Injuries to administrators by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Clerical	253	56.47%	56.47%
Management	195	43.53%	100.00%
Total	448	100.00%	

An independent t-test was conducted to compare injury severity means for the two general occupational work areas associated with administrative level workers. The results of the Levene test for equality of injury severity score variances for managers and office/clerical workers did not allow for the assumption of equal variances, L (440) = 7.713, $p < 0.01$. The results of the subsequent t-test showed that, among administrative level workers, even though managers had the higher injury severity mean (μ = 1. 31), it was not significantly different of the injury severity mean associated with office and clerical workers (μ = 1.22), t (440) = - 1.38, $p > 0.10$ (see Figure 4- 27).

Nature of Injury

Information on the “Nature of Injury” was provided for 41,475 workers. Strain injuries were the most common injuries to workers (n = 11,936). Table 4- 21 shows that over 80% of all the injuries to workers were distributed between strains (n = 11,936), lacerations (n = 6,779), contusions (n = 5,863), foreign bodies (n = 3,876), sprains (n = 2,534) and fractures (n = 2,446). The severity of injury was examined with respect to the “Nature of Injury” categories. The Levene statistic was conducted to check for homogeneity of variance of injury severity scores for the 36 “Nature of Injury” categories. This statistic revealed that equal variance between the age groups could not be assumed, L (35, 40,858) = 274.93, $p \leq .001$. The results of the Welch robust test of equality of means showed that at least one of the nature of injury groups had a significantly different injury severity mean than another category, F (35, 579.40) = 95.51, $p \leq .01$. This was confirmed by the subsequent Tukey’s b range test.

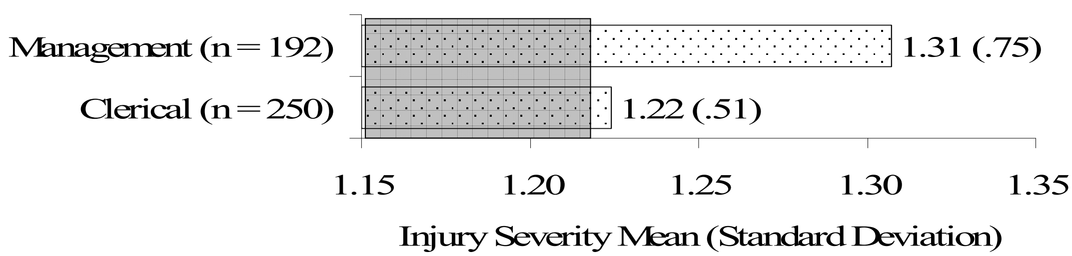

Figure 4- 27. Comparison of injury severity means by occupational work areas of injured administrators.

The top ten ranked nature of injury, according to injury severity mean are shown in Figure 4- 28. Myocardial infarctions ($\mu = 2.63$) and silicosis ($\mu = 2.63$) showed significantly higher, at $p \leq 0.05$, injury severity means than all of the remaining “Nature of Injury” categories. Ruptures ranked third in severity ($\mu = 2.27$) and this was shown to significantly greater, at $p \leq 0.05$, than all of the remaining “Nature of Injury” groups, except amputations ($\mu = 2.27$). Figure 4- 29 displays the bottom ten, by injury severity mean, nature of injury classifications. Enucleations ($\mu = 1.00$) showed the lowest injury severity mean, preceded by injuries of foreign bodies ($\mu = 1.04$), dermatitis ($\mu = 1.07$), punctures ($\mu = 1.12$), and lacerations ($\mu = 1.17$). Injuries of poisoning ranked 30th out of the 36 nature of injuries categories, $\mu = 1.20$. This was preceded by inflammations ($\mu = 1.21$), contusions ($\mu = 1.22$), heat prostration ($\mu = 1.22$), and burns ($\mu = 1.24$).

Table 4- 21. Injuries by nature of injury

Nature of injury	Number of injuries	%	Cumulative %
Strain	11,936	28.78%	28.78%
Laceration	6,779	16.34%	45.12%
Contusion	5,863	14.14%	59.26%
Foreign body	3,876	9.35%	68.61%
Sprain	2534	6.11%	74.72%
Fracture	2446	5.90%	80.61%
Puncture	2,052	4.95%	85.56%
Inflammation	1,077	2.60%	88.16%
Burn	883	2.13%	90.29%
Multiple injuries	701	1.69%	91.98%
Crushing	466	1.12%	93.10%
Rupture	450	1.08%	94.19%
Hernia	387	0.93%	95.12%
Infection	217	0.52%	95.64%
Dislocation	208	0.50%	96.14%
Respiratory disorder	192	0.46%	96.61%
Asbestosis	182	0.44%	97.05%
Dermatitis	151	0.36%	97.41%
Electric shock	122	0.29%	97.70%
Heat prostration	120	0.29%	97.99%
Occupational disease NOC	120	0.29%	98.28%
Carpal tunnel sryndrome	96	0.23%	98.51%
Chemical poisoning	91	0.22%	98.73%
Amputation	86	0.21%	98.94%
Concussion	79	0.19%	99.13%
Severance	67	0.16%	99.29%
Hearing loss or impairment	59	0.14%	99.43%
Poisoning NOC	59	0.14%	99.58%
Myocardial infarction	47	0.11%	99.69%
Mental stress/disorder	33	0.08%	99.77%
Enucleation	31	0.07%	99.84%
Syncope	20	0.05%	99.89%
Asphyxiation	19	0.05%	99.94%
Angina pectoris	9	0.02%	99.96%
Freezing	9	0.02%	99.98%
Silicosis	8	0.02%	100.00%
Total	41,475	100.00%	

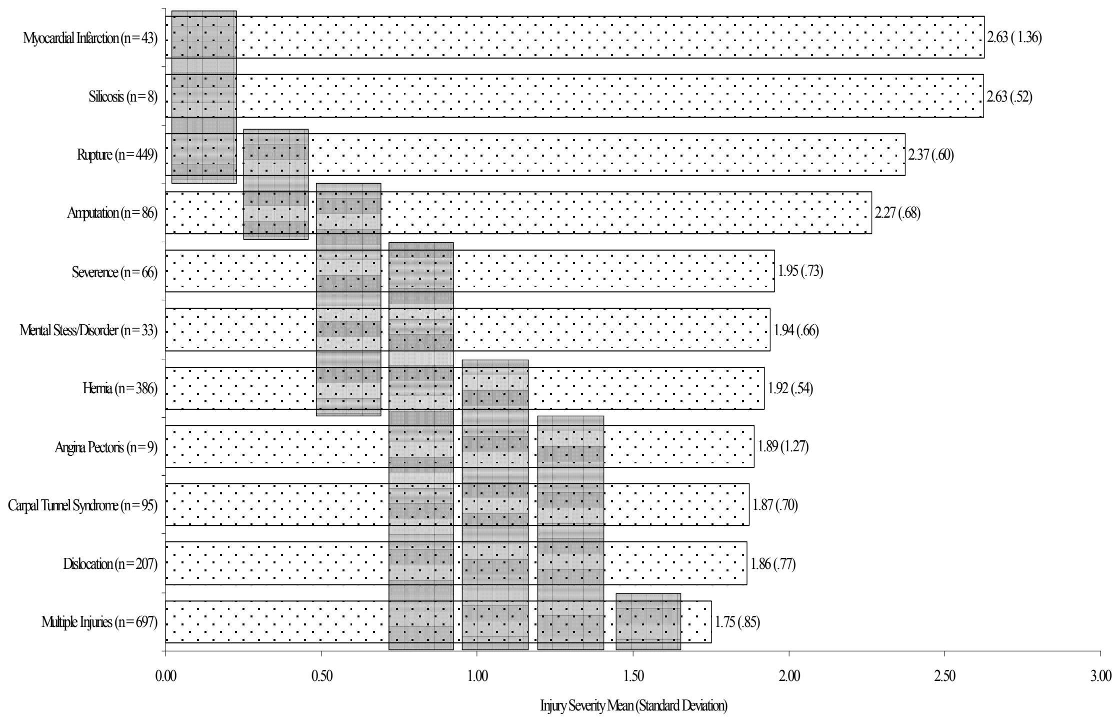

Figure 4- 28. Comparison of injury severity means by top ten nature of injury.

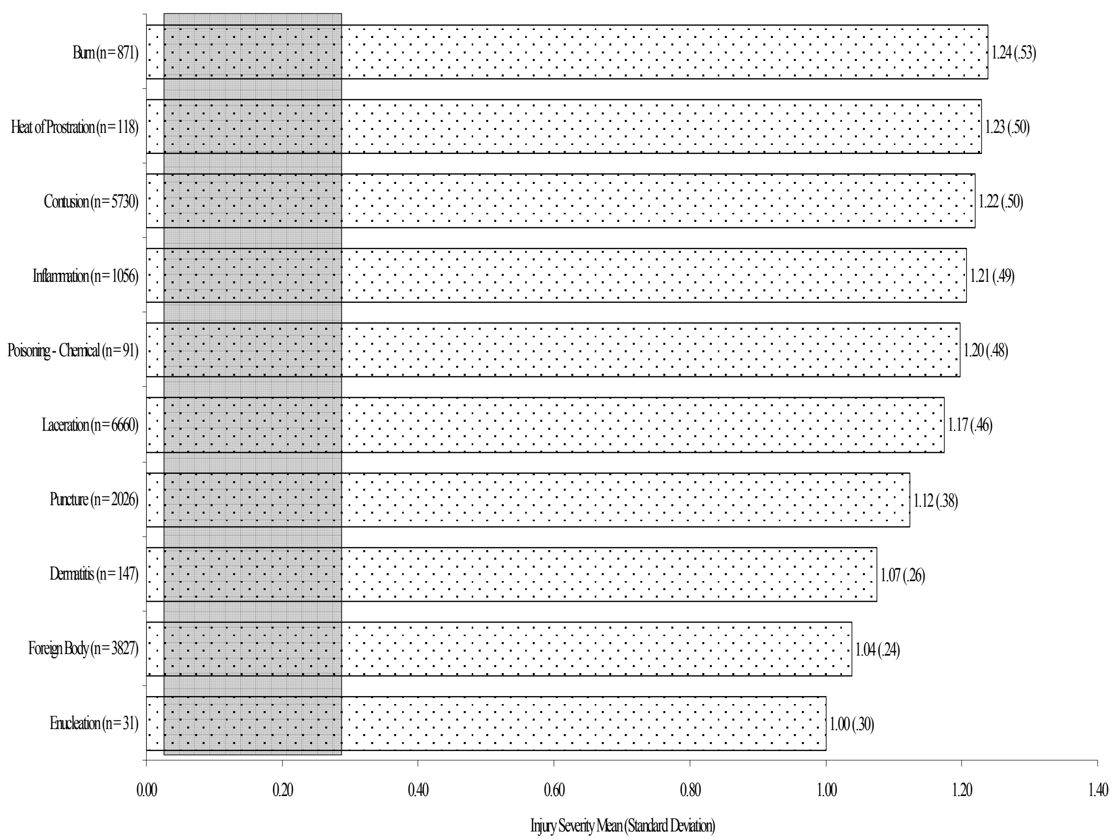

Figure 4- 29. Injury severity means for the bottom ten nature of injury.

Each of the “Nature of Injury” categories were assigned to one of the following three “General Nature of Injury” categories: Specific Injury, Occupational Disease or Cumulative Injury, and Multiple Injuries. Table 4- 22 shows the injury distribution for these “General Nature of Injury” categories. Specific injuries comprised over 96% (n = 44,360) of the total number of recorded injuries (n = 46,018). Multiple injuries (n = 701) and occupational diseases or cumulative injuries (n = 957) combined were less than 4% of the injuries.

Table 4- 22. Injuries by general nature of injury.

General nature of injury	Number of injuries	%	Cumulative %
Specific injury	44,360	96.40%	96.40%
Occupational disease or cumulative injury	957	2.08%	98.48%
Multiple injuries	701	1.52%	100.00%
Total	46,018	100.00%	

The relationship between injury severity and the general nature of the injury was examined. The results of the Levene test for homogeneity of variance of injury severity scores between the three “General Nature of Injury” categories did not allow an assumption of equal variance, L (2, 45,338) = 101.40, $p \leq 0.05$.

The results of a subsequent Welch robust test of equality of injury severity means for the “General Nature of Injury” categories showed that at least one of the “General Nature of Injury” categories had a significantly different injury severity mean than another category, F (2, 1,084.87) = 101.40, $p \leq .001$. This was confirmed by the subsequent Tukey’s b range test which identified specific injury severity means differences between the three categories.

The results for the Tukey’s b test are displayed in Figure 4- . Multiple injuries had the highest injury severity mean ($\mu = 1.75$), followed by occupational diseases or cumulative injuries ($\mu = 1.43$), and the least severe injuries occurred within the specific injuries category ($\mu = 1.32$). Three homogeneous subsets of severity means were identified by the Tukey’s b test.

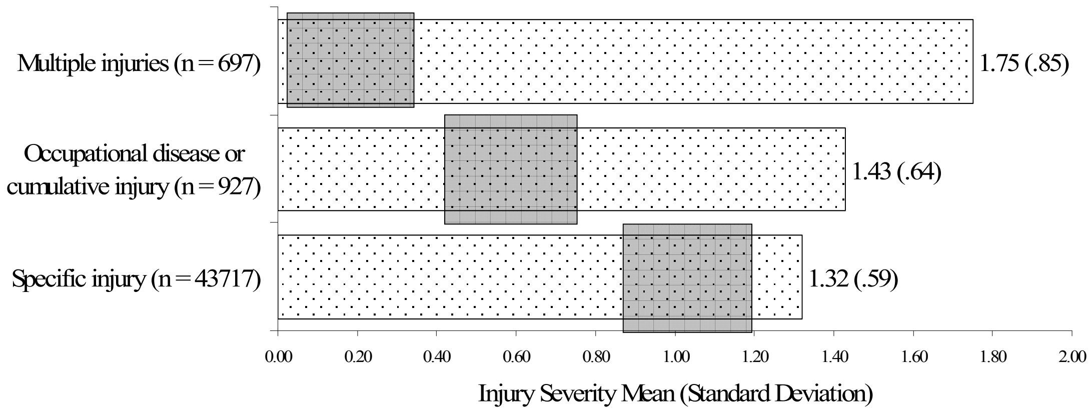

Figure 4- 30. Comparison of injury severity means by general nature of injury.

It was discerned from the three subsets shown in Figure 4- 30 that multiple body part injuries had a significantly higher severity mean, at $p \leq 0.05$, than that for both occupational disease and cumulative injuries, and for specific injuries (see Figure 4- 31). Occupational diseases and cumulative injuries had a significantly greater severity mean, at $p \leq 0.05$, than specific injuries.

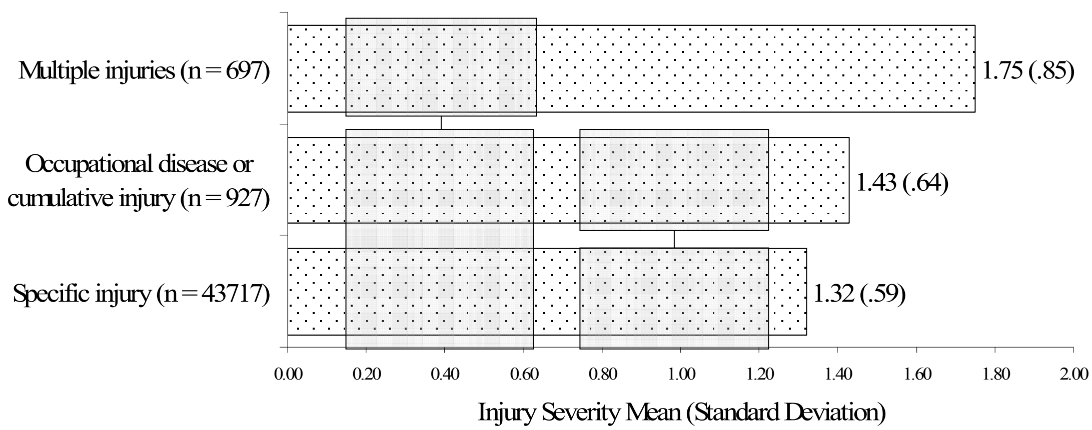

Figure 4- 31. Comparison of injury severity means by general nature of injuries.

The distribution of "Specific Injuries" by the "General Nature of Injury" is shown in Table 4- 23. Strains constituted almost 30% (n = 11,936) of the "Specific Injuries" experienced by the workers. Lacerations (n = 6,779) and contusions (n = 5,863), together, comprised over 30% of the "Specific Injuries." Foreign body (n = 3,876), sprains (n = 2,534), fractures (n = 2,446), and punctures (n = 2,052) combined to represent about 27% of the "Specific Injuries." Angina pectoris (n = 9, 0.02%) and freezing (n = 9, 0.02%) each occurred in less than 0.05% of the injury cases. Around 0.05% of the reported cases were either asphyxiation (n = 19) or syncope (n = 20). Syncope is the loss of consciousness resulting of insufficient blood flow to the brain. Enucleation, the removal of a part of the body, (e.g. eyeball) without cutting into the body, accounted in 0.08% (n = 31) of the "Specific Injuries." Myocardial infarctions (n = 47), general poisoning (n = 47), and severances (n = 67) each accounted for less than 0.20% of the specific injuries to workers. Amputations (n = 86) and concussions (n = 79) each constituted about 0.20% of the specific injuries to workers. Electric shocks (n = 122) and heat prostration (n = 120) accounted for around 0.30% of all the specific injuries to workers. Dislocations (n = 208) and infections (n = 217), accounted for slightly over one % of the entire specific injuries to workers. Hernia's (n = 387) amounted to just less than one % of the specific injuries to workers. Ruptures (n = 450) and crushing (n = 466) each accounted for nearly 1.15% of the specific injuries. Inflammations (n = 1,077) and burns (n = 883) together accounted for slightly less than five % of the specific injuries to workers.

The "Multiple Injuries" category of "General Nature of Injury" constituted its own "Nature of Injury" subcategory. Respiratory disorders (n = 192) and asbestosis (n =182) comprised over two thirds of the injuries within the "Occupational Disease or Cumulative Injury" category for "General Nature of Injury" (see Table 4- 24). Silicosis was the least represented (n = 8).

All 26 categories of "Specific Injury" were further examined to identify possible differences between injury severity means (see Figure 4- 32). Equal injury severity score variances for the "Specific Injury" in the "Nature of Injury" category was not assumed, L (25, 39,268) = 376-68, $p \leq 0.05$. Following the Welch robust test of equality of injury severity means it was found that at least one of the "Specific Injury" categories had a significantly different

Table 4- 23. Specific injuries by nature of injury.

Nature of Injury	Number of injuries	%	Cumulative %
Strain	11,936	29.96%	29.96%
Laceration	6,779	17.01%	46.97%
Contusion	5,863	14.72%	61.69%
Foreign body	3,876	9.73%	71.42%
Sprain	2,534	6.36%	77.78%
Fracture	2,446	6.14%	83.92%
Puncture	2,052	5.15%	89.07%
Inflammation	1,077	2.70%	91.77%
Burn	883	2.22%	93.99%
Crushing	466	1.17%	95.16%
Rupture	450	1.13%	96.29%
Hernia	387	0.97%	97.26%
Infection	217	0.54%	97.80%
Dislocation	208	0.52%	98.32%
Electric shock	122	0.31%	98.63%
Heat prostration	120	0.30%	98.93%
Amputation	86	0.22%	99.15%
Concussion	79	0.20%	99.34%
Severance	67	0.17%	99.51%
Poisoning NOC	59	0.15%	99.66%
Myocardial infarction	47	0.12%	99.78%
Enucleation	31	0.08%	99.86%
Syncope	20	0.05%	99.91%
Asphyxiation	19	0.05%	99.95%
Angina pectoris	9	0.02%	99.98%
Freezing	9	0.02%	100.00%
Total	39,842	100.00%	

Table 4- 24. Occupational diseases or cumulative injuries by nature of injury.

Nature of injury	Number of injuries	%	Cumulative %
Respiratory disorder	192	20.60%	20.60%
Asbestosis	182	19.53%	40.13%
Dermatitis	151	16.20%	56.33%
Occupational disease NOC	120	12.88%	69.21%
Carpal tunnel sryndrome	96	10.30%	79.51%
Chemical poisoning	91	9.76%	89.27%
Hearing loss or impairment	59	6.33%	95.60%
Mental stress/disorder	33	3.54%	99.14%
Silicosis	8	0.86%	100.00%
Total	932	100.00%	

injury severity mean of the other categories (F = 268.92; df = 25, 39,268; $p \leq 0.05$). Figure 4- 32 shows resulting ranking of injury severity means for the "Specific Injuries" following the Tukey's b range test. Specific injuries with the ten lowest injury severity means, of highest to lowest, include; syncope (μ = 1.30), burns (μ = 1.24), heat prostration (μ = 1.23), contusions (μ = 1.22), inflammations (μ = 1.21), lacerations (μ = 1.17), punctures (μ = 1.12), enucleations (μ = 1.10), and injuries of foreign bodies (μ = 1.04).

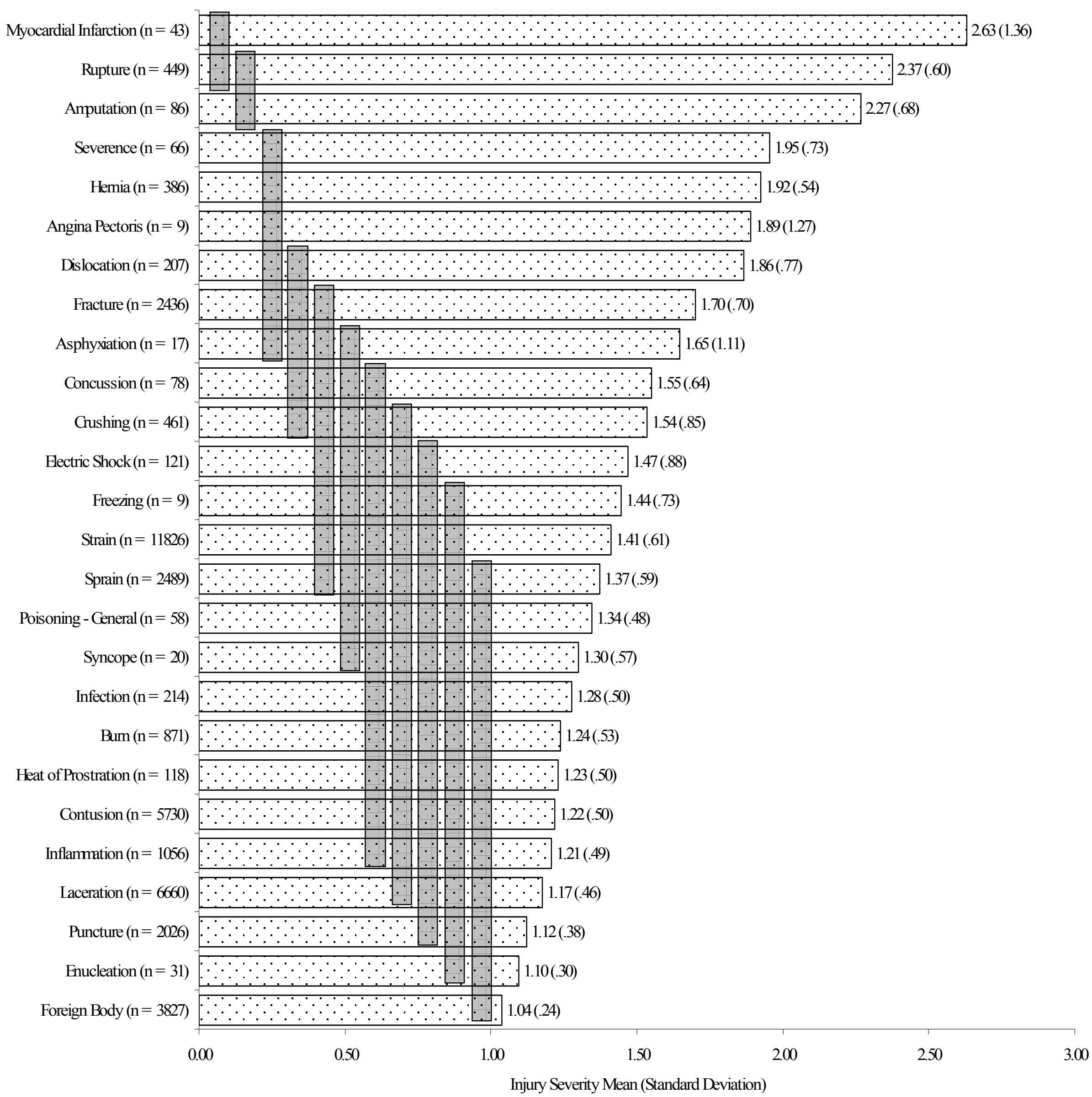

Figure 4- 32. Comparison of injury severity means by nature of injury for specific injuries.

Among "Specific Injuries," myocardial infarctions had the highest injury severity mean (μ = 2.63), which was significantly greater, $p \leq 0.05$, than all the remaining specific injury categories, except ruptures (μ = 2.37, .60) (see Figure 4- 33). Amputations ranked third in severity with a significantly higher, at $p \leq 0.05$, injury severity mean (μ = 2.27) than the remaining "Specific Injury" categories. Injuries of severances (μ = 1.95), hernias (μ = 1.92), angina pectoris (a disease marked by brief attacks of chest pain precipitated by deficient oxygenation of the heart muscles, μ = 1.89) showed significantly greater injury severity means than that for all of the remaining categories, except dislocations (μ = 1.86), fractures (μ = 1.70), and asphyxiations (μ = 1.65). At $p \leq 0.05$, dislocations displayed a significantly greater injury severity mean than that for injuries of electric shock, freezing, strains, sprains, poisoning, syncope, infections, and burns, heat prostration, contusions, inflammations, lacerations, punctures, enucleations, and injuries of foreign bodies.

Fractures had a significantly greater injury severity mean, at $p \leq 0.05$, than the same group of nature injury categories to dislocations, except injuries of electric shocks, freezing, strains, and sprains. Asphyxiation related injuries had a significantly higher injury severity mean, at $p \leq$ 0.05, than the same "Nature of Injury" groups as did fractures, except, poisoning, and syncope. Concussions showed significantly greater injury severities mean, at $p \leq 0.05$, than that for lacerations, punctures, enucleations, and Foreign body injuries. Injuries of crushing were significantly more severe, at $p \leq 0.05$, than puncture injuries, enucleations, and injuries attributed to foreign bodies. Electric shock injuries had a significantly greater injury severity mean, at $p \leq$ 0.05, than that of enucleations and injuries involving foreign bodies. Both freezing injuries and strains showed significantly greater injury severity means than that of injuries related to foreign bodies.

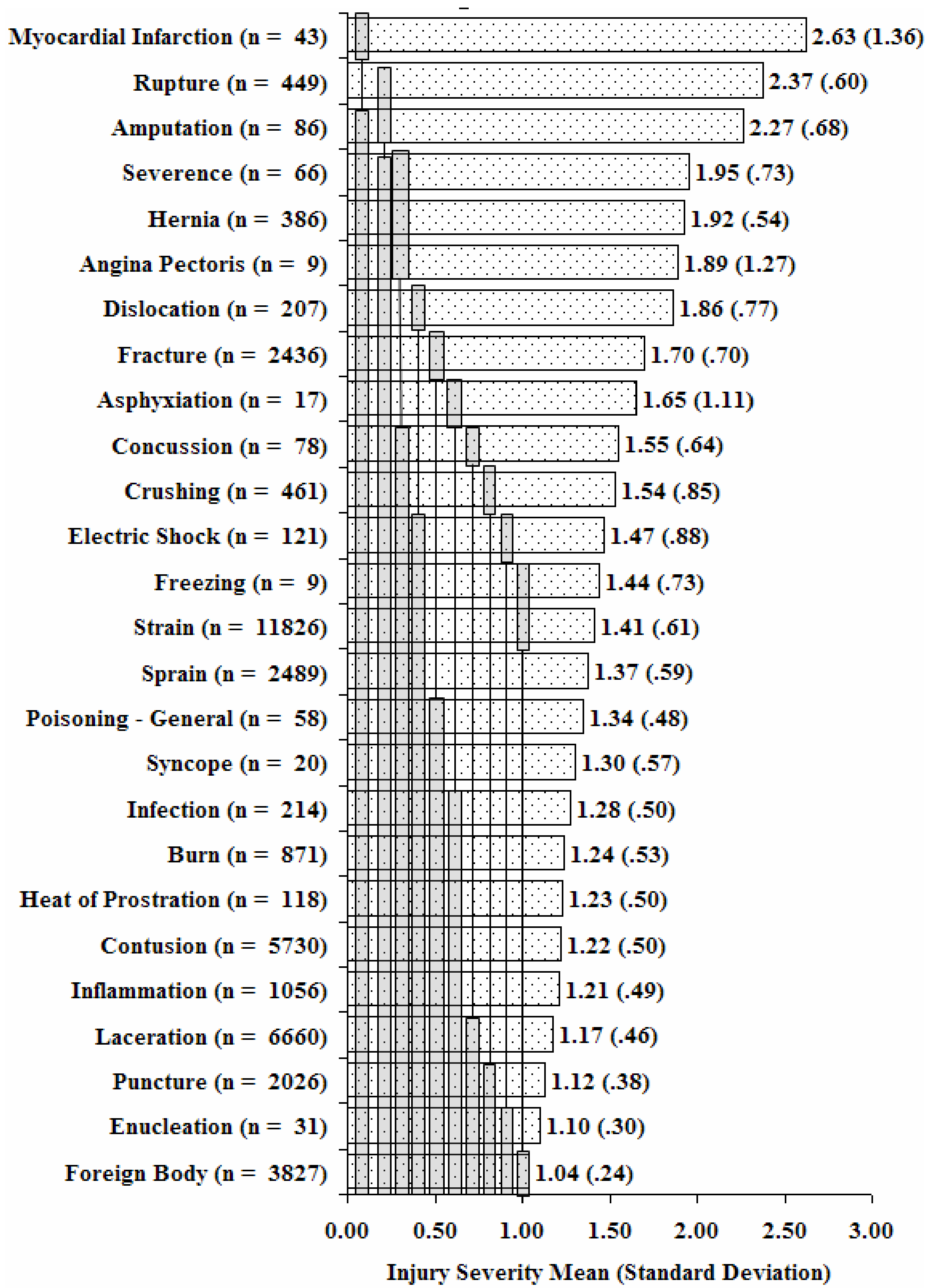

Figure 4- 33. Differences of injury severity means between nature of specific injuries.

A similar investigation of injury severity means was conducted for the classifications of the "Occupational Disease or Cumulative Injury" category. Following the Levene test for homogeneity of variance of injury severity scores for the nine occupational disorder or cumulative injuries equal variance was not assumed, L (8, 894) = 19.79, $p \leq 0.05$. A subsequent Welch robust test of the equality of injury severity means showed that at least one of these categories had a significantly different injury severity mean than the remaining groups ,F (8, 118.85) = 36.72, $p \leq .001$. Figure 4- 34 shows the results of a Tukey's b range test for injury severity means of the nine occupational disease/cumulative injury categories.

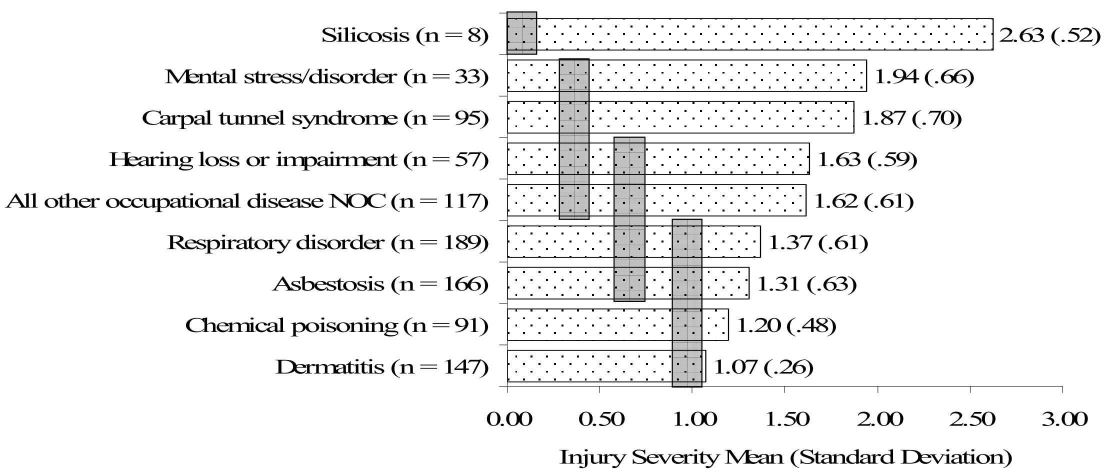

Figure 4- 34. Comparison of injury severity means by nature of occupational disease or cumulative injury.

Among occupational diseases or cumulative injuries, silicosis showed a significantly higher injury severity mean ($\mu = 2.63$) than all of the remaining categories (significant at $p \leq 0.05$) (see Figure 4- 35). Dermatitis ($\mu = 1.07$) and chemical poisoning ($\mu = 1.20$) were the two least severe categories and displayed significantly, at $p \leq 0.05$, lower injury severity means than all but asbestosis ($\mu = 1.31$) and respiratory disorders ($\mu = 1.37$). Both mental stress ($\mu = 1.94$) or mental disorders and carpal tunnel syndrome ($\mu = 1.87$) had significantly higher, at $p \leq 0.05$, injury severity means than respiratory disorders, asbestosis, chemical poisoning and dermatitis.

The injury severity mean for hearing loss or impairment injuries ($\mu = 1.63$) was significantly higher, at $p \leq 0.05$, than that for chemical poisoning and dermatitis.

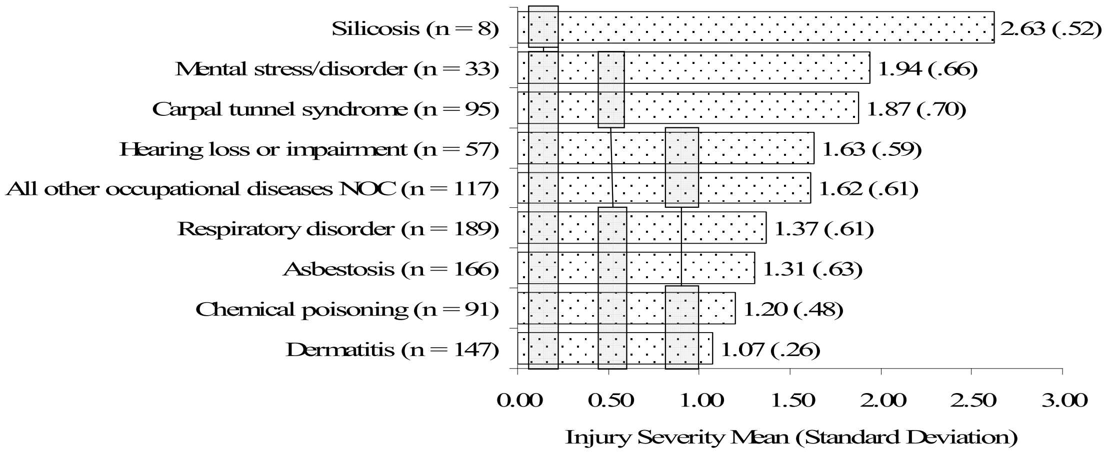

Figure 4- 35. Comparison of injury severity means by nature of occupational diseases and cumulative injuries.

Cause of Injury

Information regarding the number of injuries by the "General Cause of injury" was provided for 43,550 injury cases (see Table 4-). The three leading "General Cause of injury" classifications were straining during an occupational activity (n = 12,324, 28.30%), followed by falling or slipping (n = 7,179, 16.48%), and being struck by some kind of object or individual (n = 6,008, 13.80%). Table 4- 25 shows the entire distribution of injuries for the eleven "General Cause of injury" categories. Motor vehicles of some kind were the least frequent occurrences (n = 414, 0.95%).

It was determined that equal variance of injury severity scores could not be assumed, L (10, 42,906) = 952.83, $p \leq .001$. The Welch robust test of equality of injury severity means was conducted to examine possible differences in injury severity means between the eleven "General cause of injury" categories. The results of this test showed that a statistically significant difference existed between these categories with respect to injury severity means, F (10, 5,446.57) = 533.43, $p \leq .001$.

Table 4- 25. General cause of injury.

General cause of injury	Number of injuries	%	Cumulative %
Strain	12,324	28.30%	28.30%
Fall or slip	7,179	16.48%	44.78%
Struck by	6,008	13.80%	58.58%
Cut, puncture, or scrape	5,545	12.73%	71.31%
Foreign body	4,093	9.40%	80.71%
Striling against or stepping on	2,942	6.76%	87.47%
Caught in or between	2,348	5.39%	92.86%
Absorption, ingestion or inhalation	1,197	2.75%	95.61%
Burn	949	2.18%	97.79%
Animal or insected bite or sting^	551	1.27%	99.05%
Motor vehicle	414	0.95%	100.00%
Total	43,550	100.00%	

The Tukey'b range test was conducted to rank "General cause of injury" categories according to their respective mean injury severity levels. Figure 4- 36 shows this distribution in a descending order of injury severity magnitude. Injuries of motor vehicles ($\mu = 1.51$) and falls or slips ($\mu = 1.50$) were the highest ranked "Cause of Injury " classifications, with respect to injury severity means. Injuries of straining activity ranked third in severity ($\mu = 1.44$), followed by Caught in or between injuries ($\mu = 1.34$).

The general causes of injury that have significantly different injury severity means, at $p \leq 0.05$, than other causes of injury are shown in Figure 4- 37. Injuries caused by motor vehicles and falls or slips had significantly higher injury means than all of the remaining causes of injury. Injuries of strains showed a significantly greater injury severity mean than all of the other causes with a lower injury severity mean. Injuries caused by being Caught in or between something were associated with a significantly greater injury severity mean than injuries caused by burns or scalds, striking against or stepping on something, absorption, inhalation or ingestion of a substance, being cut, punctured or scraped, animal or insect bites or stings, and injuries caused by foreign matter in the eyes. As a group, the struck by injuries, burns and scalding injuries,

injuries caused by striking against or stepping on something, or absorption, inhalation, ingestion of a substance had significantly greater injury severity means than that of injuries of cuts, punctures, or scrapes, bites or stings of animals or insects, and injuries caused by foreign matter in the eyes. Animal or insect bites or stings, along with cuts, punctures and scrapes had significantly higher injury severity mean than injuries caused by foreign matter in the eyes.

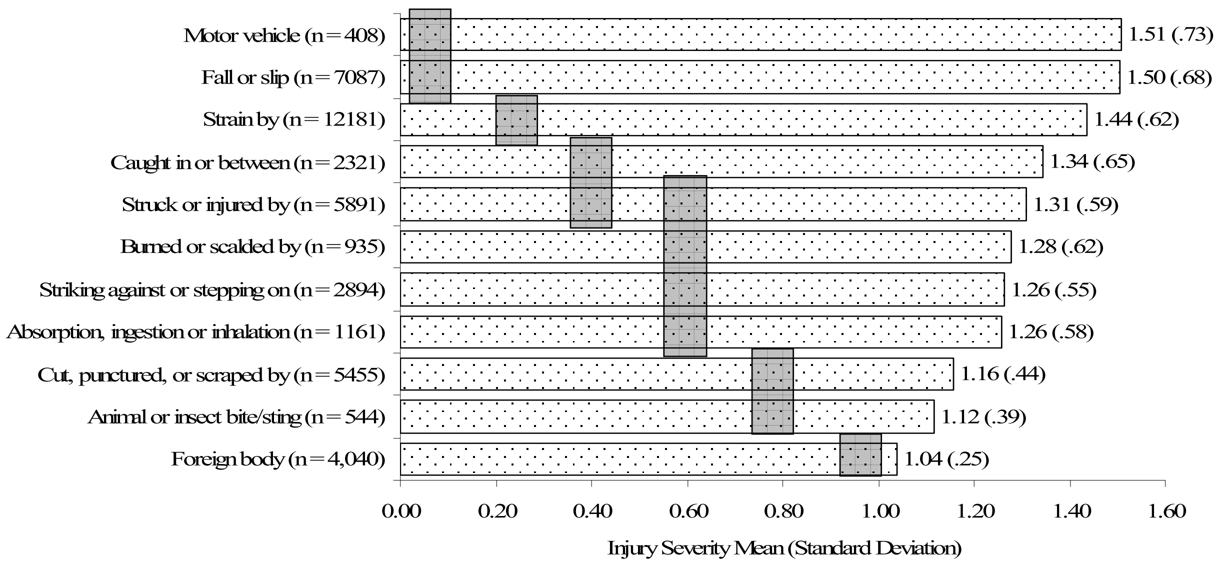

Figure 4- 36. Comparison of injury severity means by general cause of injury."

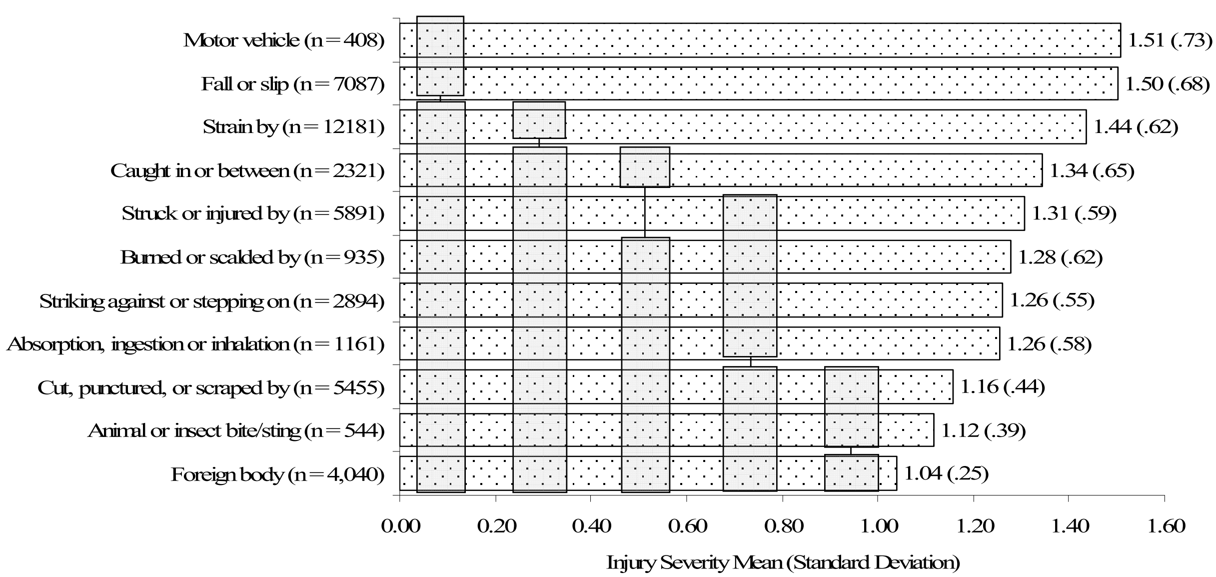

Figure 4- 37. Comparison of injury severity means by general cause of injury.

Burn

The specific "Cause of injury" contributing to injuries attributed to burns or scalds is shown in Table 4- 26. Over 25% (n = 240) of the injuries in which the "General cause of injury" was attributed to burns or scalds resulted of contact with an object or substance. Welding and electrical current combined for over 35% (n = 180) of the injuries caused by a burn or scald. Less than 10% of the burn or scalding injuries resulted of both temperature extremes (n = 54, 5.69%) and dust, gases, fumes, or vapors (n = 26, 2.74%).

Table 4- 26. Cause of burn injuries.

Cause of injury	Number of injuries	%	Cumulative %
Contact with object or substance	240	25.29%	25.29%
Welding	180	18.97%	44.26%
Electrical current	162	17.07%	61.33%
Acid	128	13.49%	74.82%
Fire	92	9.69%	84.51%
Steam or hot fluid	67	7.06%	91.57%
Temperature extremes	54	5.69%	97.26%
Dust, gases, fumes, or vapors	26	2.74%	100.00%
Total	949	100.00%	

Severity of injury was examined by the "Cause of Injury" categories resulting from burns or scalding. The Levene statistic did not allow the assumption of equal variance of injury severity scores for the nine "Cause of Injury" categories, L (7, 927) = 25.87, $p \leq .001$. A subsequent Welch robust test of equality of injury severity means showed that at least one of these categories had a statistically significant different injury severity mean than another one of categories, F (7, 219.74) = 8.74, $p \leq .001$, which was confirmed by the Tukey's b range test.

The Tukey's b range test was conducted to assess the severity of injuries of burns or scalds for the" Cause of Injury" categories (see Figure 4- 38). Burns by electrical current displayed the highest injury severity mean (μ = 1.49). This was followed by burns or scalding from contact with steam or hot fluids (μ = 1.40), of direct contact with fire or flames (μ = 1.39), exposure to dust, gases, fumes or vapors (μ = 1.35), and exposure to acid based chemicals (μ = 1.32. Burns of welding operations had the lowest injury severity mean (μ = 1.07)

As shown in Figure 4- 39, burns of electrical currents had a significantly higher injury severity mean, at $p \leq 0.05$, than burns attributed to temperature extremes and welding operations. Injuries caused by being burned or scalded by either contact with steam or a hot fluid and of direct contact with fire or flame had significantly greater injury severity means than injuries caused by burns of welding operations.

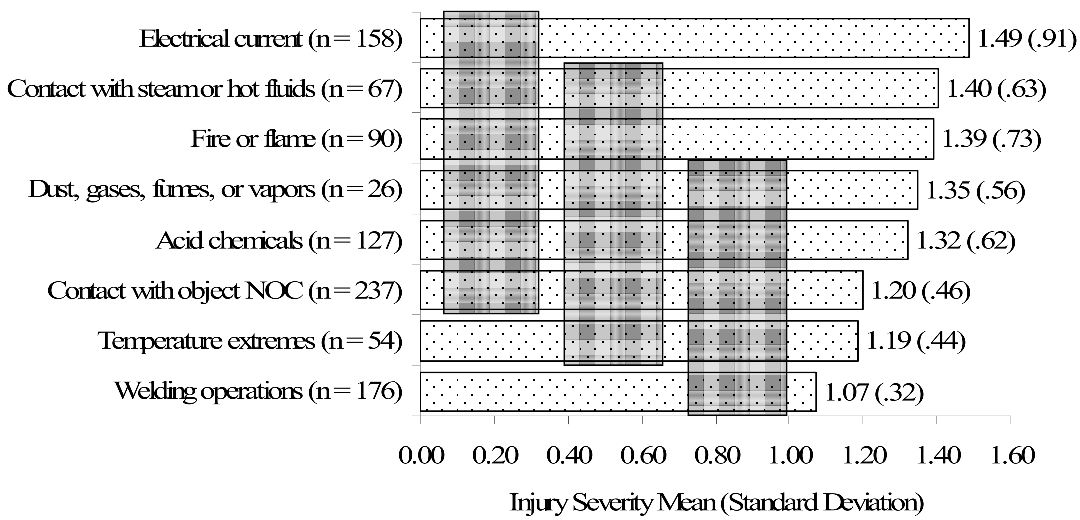

Figure 4- 38. Comparison of injury severity means by cause of burn injury.

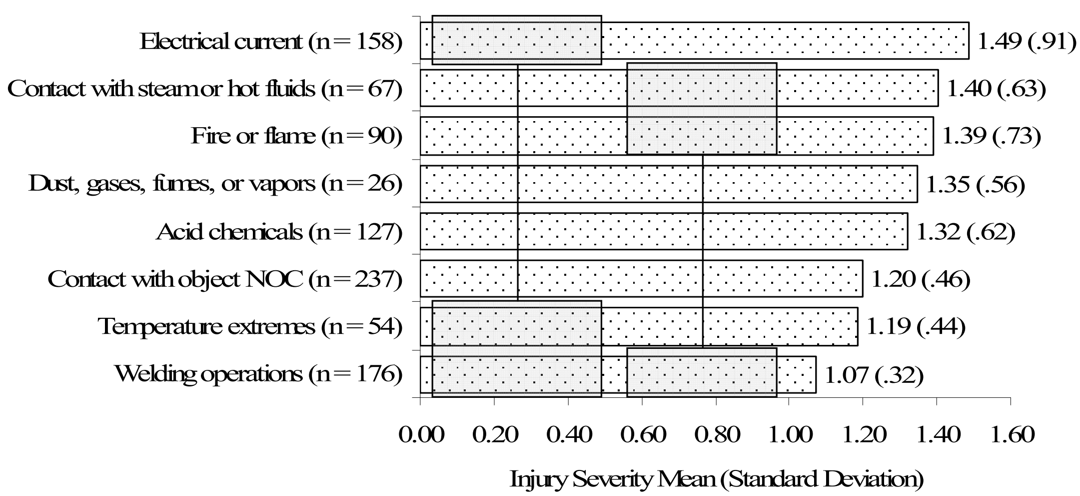

Figure 4- 39. Differences of injury severity means between causes of burn injuries.

Caught In or Between

The frequencies of Caught in or between related injuries were examined by their specific their causes. The injury severity means for each of the specific causes were also compared. Those injuries resulting from workers being caught in or between an object being handled accounted for over 54% (n = 1,289) of the total number of “Caught in or between” injuries. Table 4- 27 shows that being caught in or between some type of machine or machinery was associated with 17.59% (n = 413) of “Caught in or between” injuries. Being caught in or between collapsing materials was associated with 5.20% (n = 122) of the “Caught in or between” injuries.

Table 4- 27. Causes of caught in or between injuries.

Cause of injury	Number of injuries	%	Cumulative %
Object handled	1,289	54.90%	54.90%
Other NOC	524	22.32%	77.22%
Machine or machinery	413	17.59%	94.81%
Collapsing materials*	122	5.20%	100.00%
Total	2,348	100.00%	

* Include slides of earth and building collapse.

Severity of injury was examined for the four “Cause of injury” categories for “Caught in or between” injuries. The results of the Levene test for homogeneity of injury severity score variances did not allow for the assumption of equal variances for the five “Cause of injury” categories, L (3, 2,317) = 33.52, $p \leq .001$. The subsequent Welch test of equality of injury severity means showed that at least one of these categories had a statistically significant different injury severity mean than another one of categories, F (3, 467.07) = 12.57, $p \leq .001$.

The results of the Tukey’s b range test confirmed the results of the Welch test at $p \leq 0.05$ (see Figure 4- 40). Injuries caused by being Caught in or between a machine or some kind of machinery had the highest injury severity mean, $\mu = 1.54$. Injuries caused by being Caught in or between collapsing material, which includes earth slides and building collapses, displayed the second highest injury severity mean ($\mu = 1.40$), followed being Caught in or between miscellaneous objects not otherwise classified (μ = 1.35) and objects being handled by the either the injured worker and/or another worker (μ = 1.28).

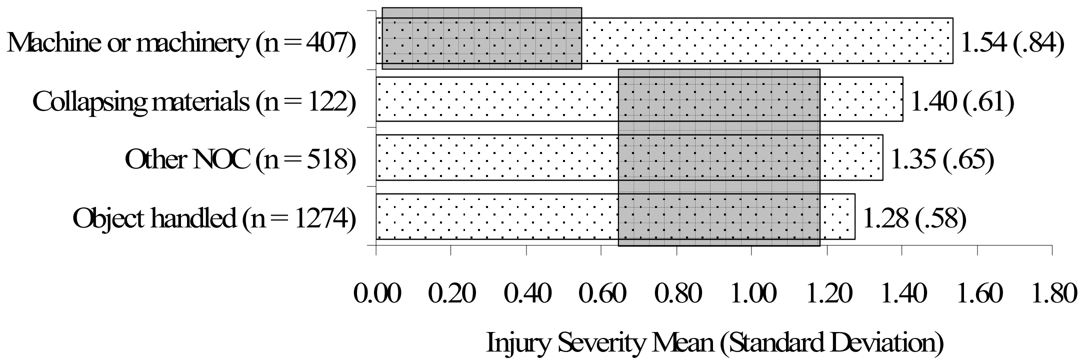

Figure 4- 40. Comparison of injury severity means by cause of caught in or between injuries.

The results of the Tukey's b range test are displayed in Figure 4- 41. Being Caught in or between a machine or machinery (μ = 1.54) resulted in a statistically higher injury severity mean, at $p \leq 0.05$, than all other "Caught in or between" injuries.

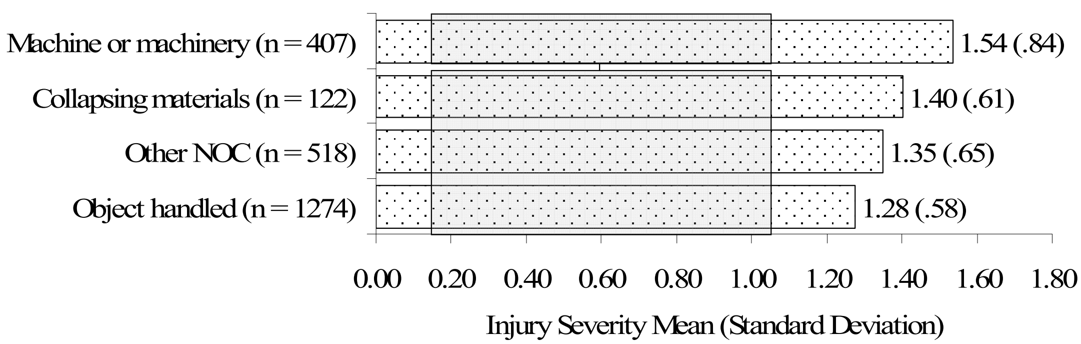

Figure 4- 41. Differences of injury severity means between causes of caught in or between injuries.

Cut, Punctured, or Scraped

Information regarding the specific "Cause of injury" associated with injuries generally caused by a cut, puncture or scrape was provided for 5,450 workers. Table 4- 28 shows the injury distribution for the five specific causes of cuts, punctures or scrapes. Objects being lifted or handled accounted for over 40% (n = 2282) of the cut, puncture or scrape induced injuries. Tools, powered and non-powered, accounted for nearly 30% of the injuries resulting in cuts, punctures or scrapes. Less than 2% (n = 59) of the injuries resulting in cuts, punctures or scraps were attributed to broken glass.

Table 4- 28. Causes of injury for cuts, punctures, and scrapes.

Cause of injury	Number of injuries	%	Cumulative %
Object being lifted or handled	2,282	41.15%	41.15%
Other NOC	1,586	28.60%	69.75%
Hand tool – non-powered	897	16.18%	85.93%
Powered hand tool	721	13.00%	98.93%
Broken glass	59	1.06%	100.00%
Total	5,545	100.00%	

An assumption of equal variances of injury severity scores for the five cause categories could not be made, L (4, 5,450) = 64.29, $p \leq .001$. The results of the subsequent Welch robust test of equality of injury severity means revealed that at least one of these categories had an injury severity mean that was significantly different of one of the other categories, F (4, 407.42) = 14.64, $p \leq .001$.

A Tukey's b range test was used to rank the cause categories for injuries resulting in a cut, puncture, or scrape, by their respective injury severity means (see Figure 4- 42). Cuts, punctures or scrapes resulting from the use of powered hand tools showed the highest injury severity mean ($\mu = 1.30$) among these injuries. Cuts, punctures or scrapes caused by broken glass ranked second with respect to injury severity mean ($\mu = 1.21$). This was followed by cuts, punctures, or scrapes from objects being lifted or handled ($\mu = 1.14$), from the use of non-powered hand tools ($\mu = 1.13$), and miscellaneous objects not otherwise classified ($\mu = 1.13$).

From the arrangement of homogeneous groupings of the injury severity means it was shown that cuts, punctures, or scrapes of powered hand tools had a significantly higher, at $p \leq 0.05$, severity mean than all the other categories, except for cuts, punctures or scrapes of broken glass (see Figure 4- 43).

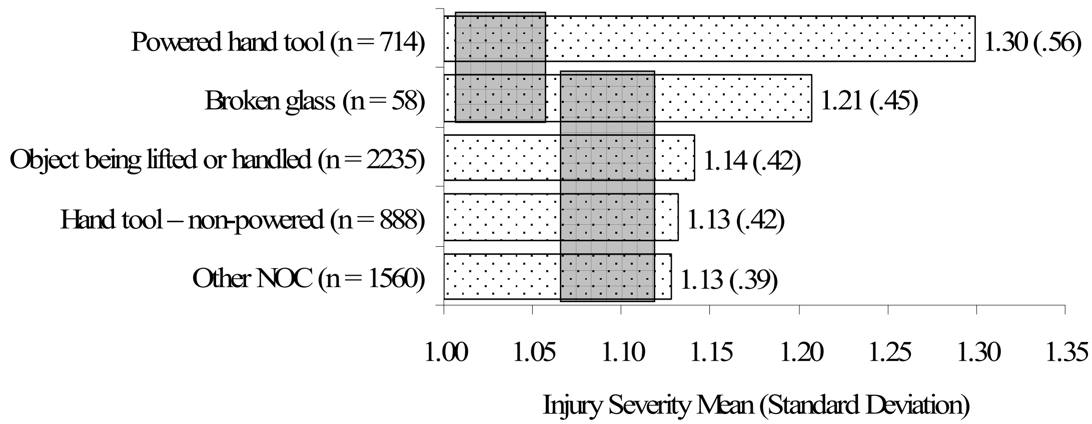

Figure 4- 42. Comparison of injury severity means by causes of cuts, punctures, and scrapes.

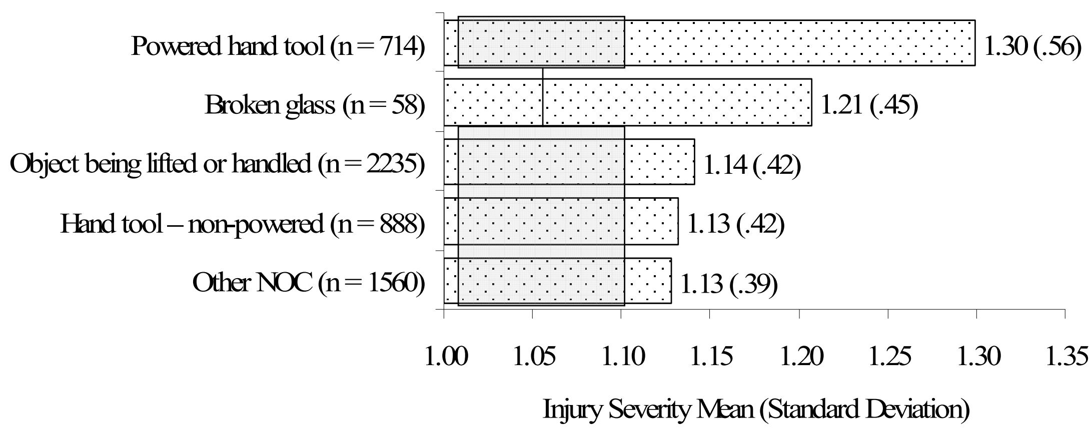

Figure 4- 43. Differences of injury severity means between causes of cuts, punctures, and scrapes.

Fall or Slip

The specific "Cause of injury" was provided for 7,179 workers who fell or slipped. Table 4- 29 shows the injury distribution of the eleven specific causes attributed to falling or slipping. Falls and slips from ladders or scaffolds (n = 1,388) of different levels (n = 1,400) or of the same level (n = 1,569) comprised about 20% of the total number of injuries of falls or slips. Less than 20% of the falls or slips were associated with the combined contributions of ice or snow (n = 589), slipping without a fall (n = 342), stairs (n = 328), openings (n = 313) and liquids and/or grease spills (n = 132).

Table 4- 29. Causes of injuries from falls and slips.

Cause of injury	Number of injuries	%	Cumulative %
On same level	1,569	21.86%	21.86%
From a different level	1,400	19.50%	41.36%
From a ladder or scaffold	1,388	19.33%	60.70%
Other NOC	1,118	15.57%	76.27%
On ice or snow	589	8.20%	84.47%
Slip (no fall)	342	4.76%	89.24%
On stairs	328	4.57%	93.81%
Into opening	313	4.36%	98.17%
From liquid or grease spill	132	1.84%	100.00%
Total	7,179	100.00%	

The results of the Levene test for homogeneity of variances of injury severity scores for the nine cause categories for falls or slips did not allow for the assumption of equal variances, L (8, 7,076) = 8.94, $p \leq .001$. The results of a subsequent Welch robust test of equality of injury severity means for the nine categories showed that at least one of these categories had a injury severity mean that was significantly different of at least one other category, F (7, 1,378.45) = 17.00, $p \leq .001$.

A Tukey's b range test was conducted to identify specific differences between the means of the nine cause categories for falls or slips. As shown in Figure 4- 44, the resulting ranking of the cause categories, by injury severity mean, for injuries of falls or slips, showed falls of ladders or scaffolding as having the highest injury severity mean ($\mu = 1.62$). This was followed by injuries of falls of different levels ($\mu = 1.60$), into openings ($\mu = 1.52$), and falls or slips on stairs ($\mu = 1.51$). Injuries caused by falls or slips on ice or snow ranked the lowest in terms of injury severity mean ($\mu = 1.38$).

A further examination of the Tukey's b the results showed that falls from ladders or scaffolds had an injury severity mean significantly greater, at $p \leq 0.05$, than that for falls or slips of liquid or grease spills, falls on the same level, other causes NOC, and injuries from falls or slips on ice or snow (see Figure 4- 45)). Injuries caused by falls from different levels showed a significantly greater injury severity mean, at $p \leq 0.05$, than injuries due to falls on the same level, falls or slip of causes NOC, and injuries from falls or slips on ice or snow. Falls into openings had a significantly greater injury severity mean, at $p \leq 0.05$, than falls or slips from miscellaneous causes NOC, and falls or slips on ice or snow.

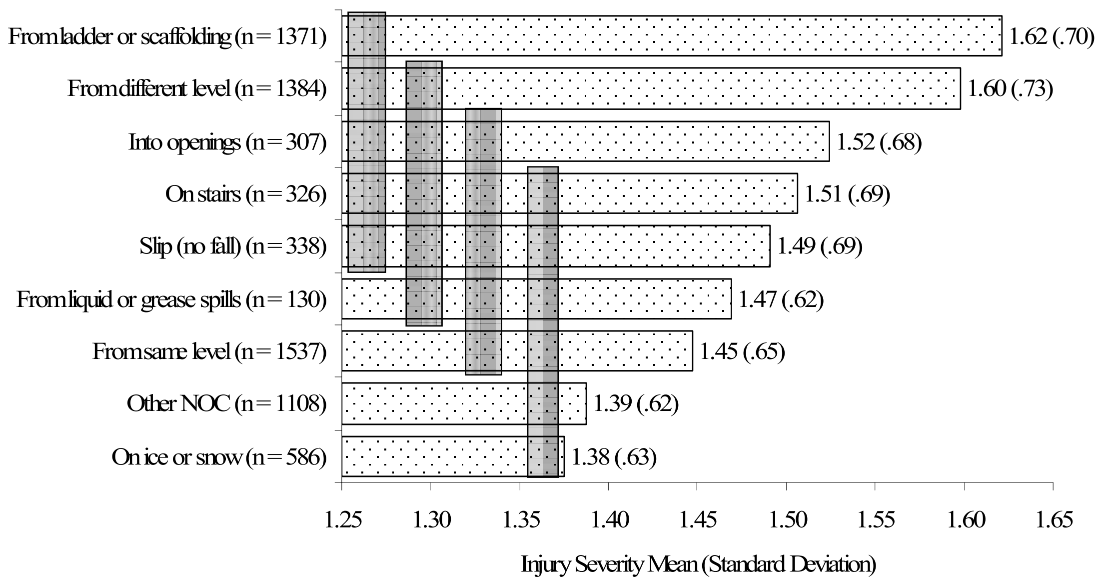

Figure 4-44. Comparison of injury severity means by causes of injuries from falls and slips.

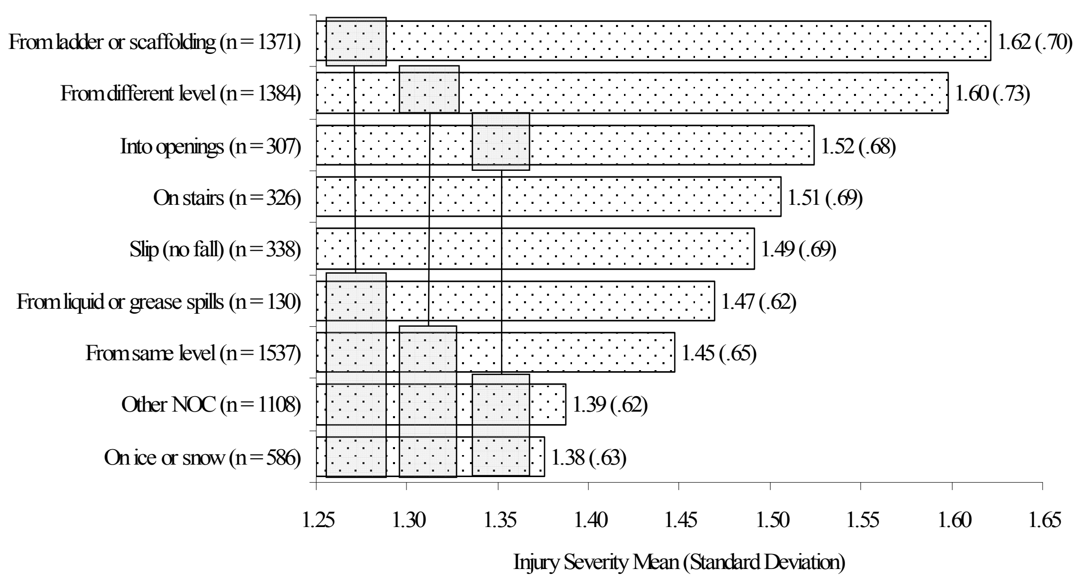

Figure 4- 45. Differences of injury severity means between causes of injury from falls and slips.

Motor Vehicle

Information regarding the specific cause of injury associated with injuries involving a motor vehicle was provided for 414 workers. Table 4- 30 shows the distribution of injuries for the four specific cause classifications associated with injuries due to motor vehicles. Events which involved a collision with another vehicle comprised over half of motor vehicle related injuries (n = 220). Injuries from upset of a motor vehicle account for around 13% of the motor vehicle injuries (n = 53). Less than 8% of the motor vehicle injuries were associated with a collision with a fixed object (n = 33).

The results of the Levene test for homogeneity of variances of injury severity scores for the four cause categories for motor vehicle related injuries allowed for the assumption of equal variance, L (3, 404) = 1.06, $p > .30$. A subsequent ANOVA of the injury severity means was used to identify possible differences in injury severity means between the four motor vehicle cause groups. The results of this test showed no significant differences of injury severity means between the groups, F (3, 404) = 1.66, $p > .30$.

Table 4- 30. Causes of injuries involving a motor vehicle.

Cause of injury	Number of injuries	%	Cumulative %
Collision with another vehicle	220	53.14%	53.14%
Other NOC	108	26.09%	79.23%
Vehicle upset	53	12.80%	92.03%
Collision with a fixed object	33	7.97%	100.00%
Total	414	100.00%	

The Tukey's b range test was still conducted in order to rank, in descending order, the four motor vehicle cause groups according to their respective injury severity means (see Figure 4-46). Collisions with fixed objects had the highest injury severity mean ($\mu = 1.58$), followed by collisions with another vehicle ($\mu = 1.55$), vehicle upsets ($\mu = 1.47$), and other motor vehicle incidences not otherwise classified ($\mu = 1.41$). Similar to the ANOVA statistic, the Tukey's b range test also showed no significant differences of severity means between any of the motor vehicle cause categories at $p \leq 0.05$.

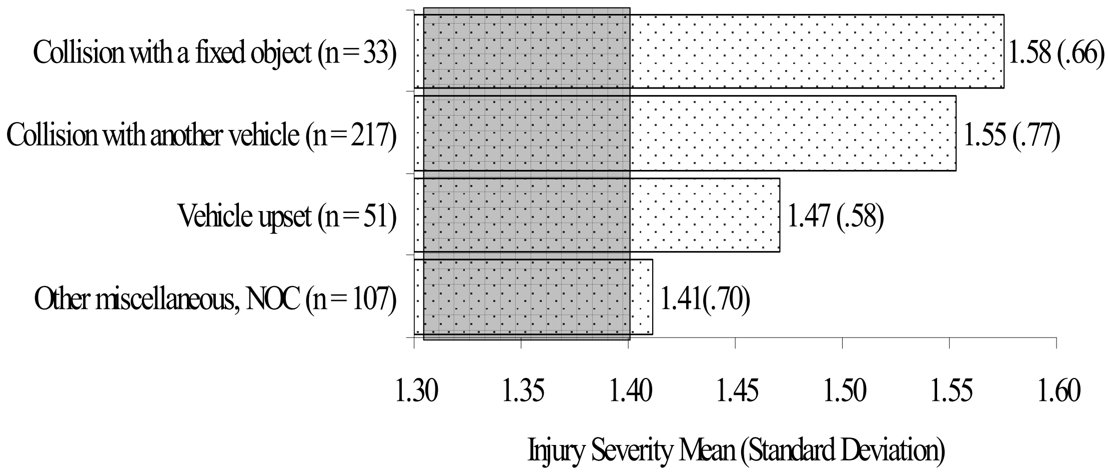

Figure 4- 46. Comparison of injury severity means by causes of injuries involving a motor vehicle.

Strain

The specific cause of strain related injuries was provided for 12,324 workers. Table 4- 31 shows the distribution of injuries for those activities or motions which resulted in a strain injury. Comprising over 30% of the strain related injuries, lifting (n = 3,840) had the highest frequency among strain related injuries. Pushing or pulling motions (n = 1,482), and climbing, walking or running activities (n = 1,440) combined to generate almost 15% of the strain related injuries. Activities involving holding or carrying an object (n = 739), the use of a hand tool or machine (n = 638), or a twisting motion (n = 626), combined to account for over 16% of strain related injuries. Kneeling or bending activities (n = 566), along with activities requiring repetitive motion (n = 467) or reaching (n = 250), were attributable to over 10% of the injuries from straining. Jumping (n = 133) and either wielding (i.e., the handling of a tool such as an axe or a bull float) or throwing (n = 53) motions combined for less than 2% of all strain injuries.

Table 4- 31. Causes of strain injuries.

Cause of injury	Number of injuries	%	Cumulative %
Lifting	3,840	31.16%	31.16%
Other NOC	2,090	16.96%	48.12%
Pushing or pulling	1,482	12.03%	60.14%
Climbing, walking, running	1,440	11.68%	71.83%
Holding or carrying	739	6.00%	77.83%
Hand tool or machine in use	638	5.18%	83.00%
Twisting	626	5.08%	88.08%
Kneeling and/or bending	566	4.59%	92.67%
Repetitive motion	467	3.79%	96.46%
Reaching	250	2.03%	98.49%
Jumping	133	1.08%	99.57%
Wielding or throwing	53	0.43%	100.00%
Total	12,324	100.00%	

The results of the Levene test for homogeneity of variance of injury severity scores for the twelve "Cause of injury" classifications for strain related activities did not support the assumption of equal variances of injury severity scores for the cause groups, L (11, 12,169) = 2.92, $p \leq .001$. Without this assumption, a Welch robust test of equality of injury severity means showed that at least one of the straining activities had a significantly different injury severity mean than at least one other activity, F (11, 1,181.39) = 5.65, $p \leq .001$.

In order to both rank the activities with respect to their individual injury severity means and detect specific differences in severity means between the activities, the Tukey's b range test was conducted (see Figure 4- 47 and Figure 4- 48). Strain injuries resulting from repetitive motions had the highest injury severity mean ($\mu = 1.65$), followed by strains from jumping ($\mu = 1.52$), holding or carrying an object ($\mu = 1.47$), wielding or throwing an object ($\mu = 1.46$), kneeling or bending ($\mu = 1.44$), and twisting motions ($\mu = 1.44$).

A further interpretation of the Tukey's b the results showed that strain injuries caused by repetitive motions had a significantly larger injury severity mean than all of the remaining cause categories for strain injuries, except strain injuries caused by jumping (see Figure 4- 48).

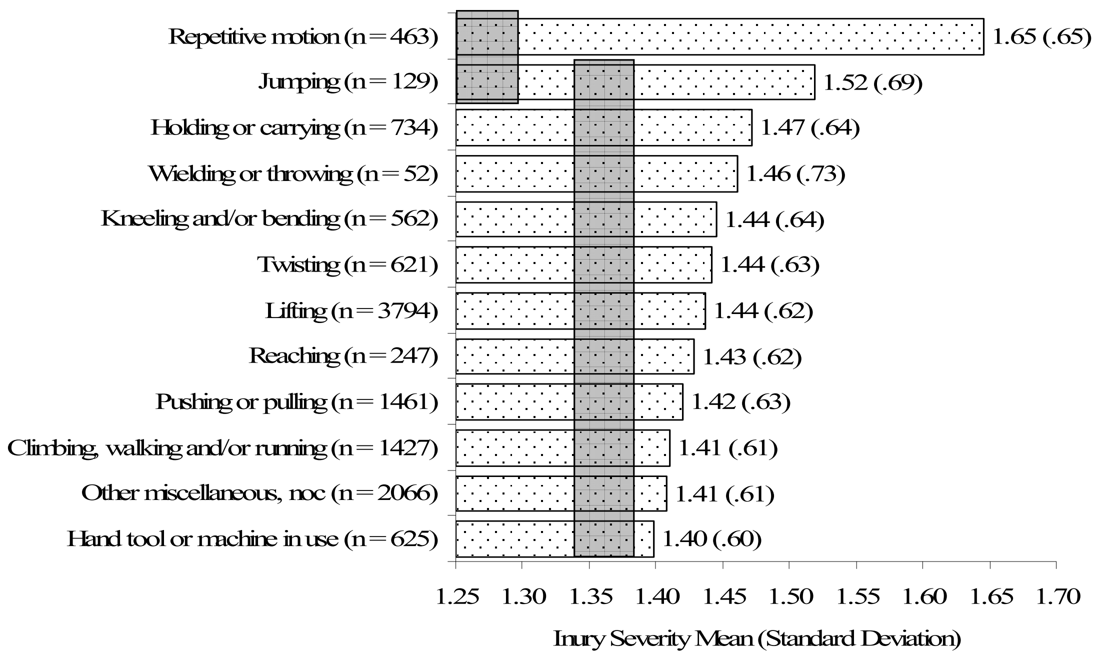

Figure 4- 47. Comparison of injury severity means by causes of strain injuries.

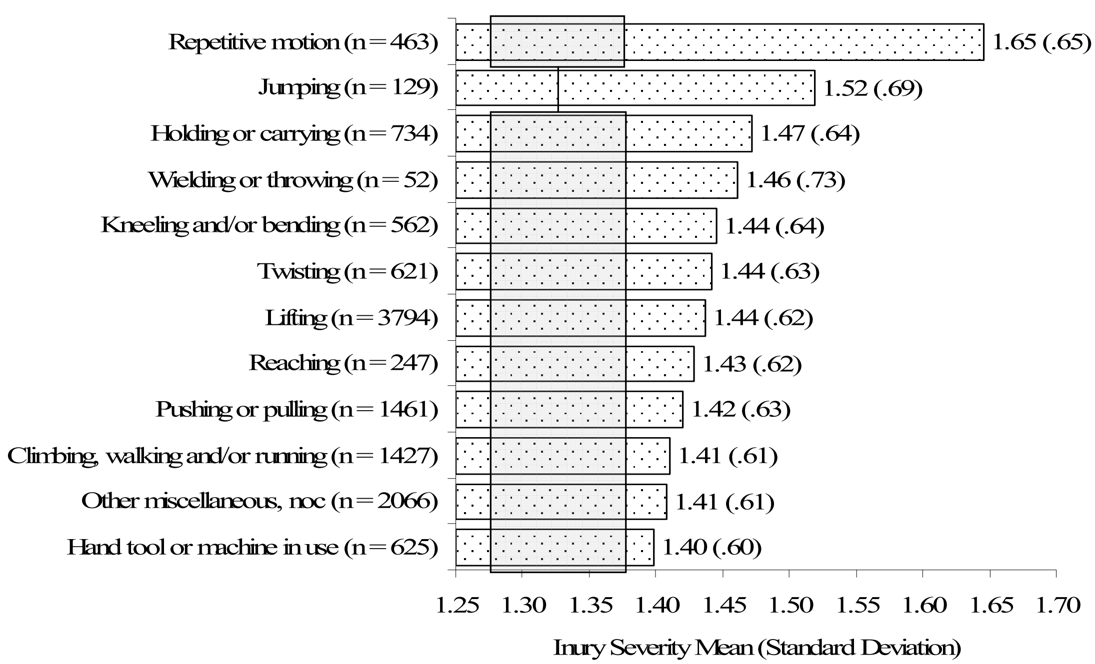

Figure 4- 48. Differences of injury severity means between causes of strain injuries.

Striking Against or Stepping On

Information regarding the specific cause of injuries was provided for 2,942 workers who were injured when they struck against or stepped on an object. Of the five possible causes, striking against or stepping on some type of stationary object comprised over 30% (n = 1,072) of these injuries (see Table 4- 32). This was followed by, in descending order, being struck by or stepping on an object being lifted or handled (13.87%, n = 408), a sharp object (10.30%, n = 303), and the moving parts of a machine (7.92%, n = 233).

Table 4- 32. Causes of striking against and stepping on injuries.

Cause of injury	Number of injuries	%	Cumulative %
Stationary object	1,072	36.44%	36.44%
Other NOC	926	31.48%	67.92%
Object being lifted of handled	408	13.87%	81.78%
Sharp object	303	10.30%	92.08%
Moving parts of machine	233	7.92%	100.00%
Total	2,942	100.00%	

The results of the Levene test for homogeneity of variance of injury severity scores for the five cause classifications for injuries associated with "Striking against or stepping on" could not support the assumption of equal variances of injury severity scores for the five 'Cause of injury" groups, L (4, 2,889) = 46.55, $p < .001$. A subsequent Welch robust test of equality of injury severity means showed that at least one of the striking against or stepping on classifications had a significantly different injury severity mean than at least one of the other classifications, F (4, 877.55) = 16.91, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

A Tukey's b range test was conducted to assess the severity of injuries from specific conditions when the worker experienced the injury while "Striking Against or Stepping On" a particular object (see Figure 4- 49). The most severe of these injuries was attributable to striking against the moving parts of a machine ($\mu = 1.48$). This was followed, in descending order, by injuries caused by striking against or stepping on an object being lifted or handled by the injured worker or another worker (μ = 1.27), a stationary object (μ = 1.27), other objects NOC (μ = 1.25), and striking against or stepping on a sharp object (μ = 1.11).

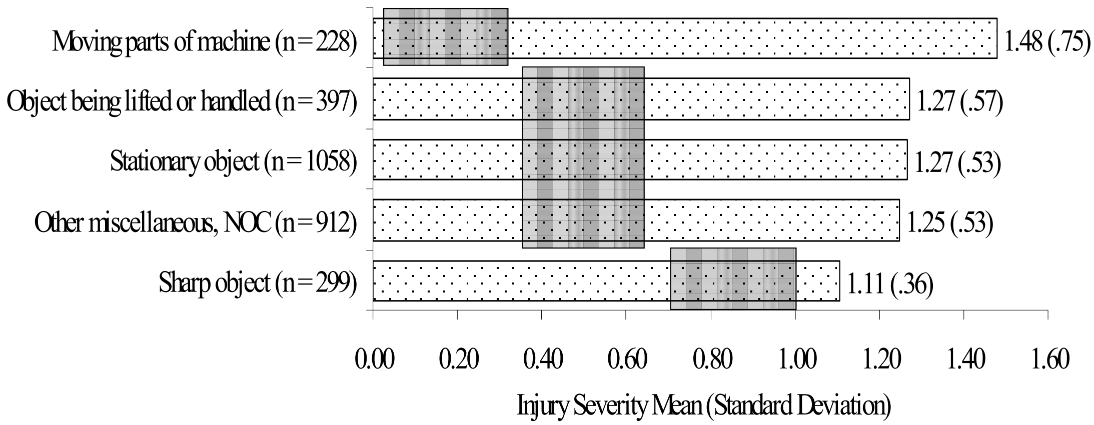

Figure 4- 49. Comparison of injury severity means by causes of injuries from striking against or stepping on.

Figure 4- 50 shows the specific differences of injury severity means between the five discrete causes of striking against or stepping on injuries. Injuries caused by striking against or stepping on moving parts of a machine had a significantly greater injury severity mean, at $p \leq 0.05$, than all of the other injury cause categories. Injuries caused by striking against or stepping on objects being lifted or handled, stationary objects, and other miscellaneous objects NOC, each had an injury severity mean significantly greater than that for injuries caused by striking against or stepping on a sharp object.

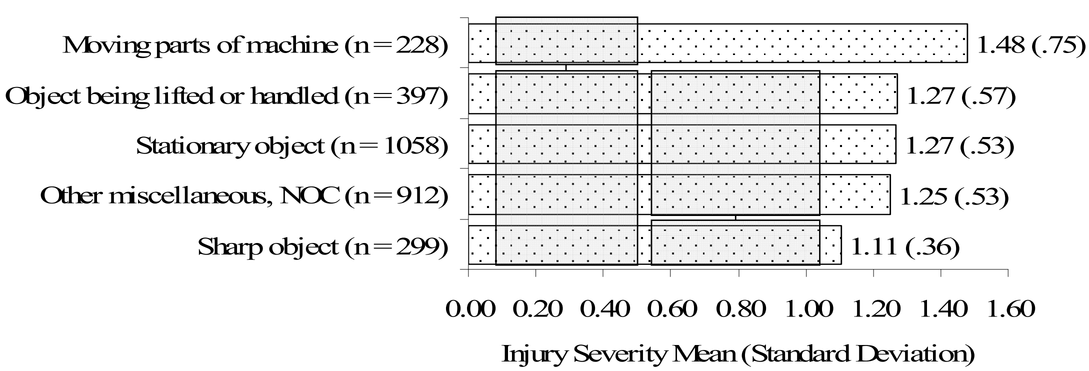

Figure 4- 50. Differences of injury severity means between causes of striking against or stepping on injuries.

Struck By

The specific cause of struck by injuries was provided for 6,008 workers. Table 4- 33 shows the distribution of injuries for those objects which resulted in a "Struck by" injury. Over 70% of the "Struck by" injuries were attributed to either an object being lifted or handled (n = 2,111) or a falling or flying object (n = 2,218). Being struck by a fellow worker was the least frequent of struck by injuries; however it was shown to be the third most severe type of struck by injury experienced by workers.

The results of the Levene test for homogeneity of variance of injury severity scores for the seven causes of "Struck by" injuries supported the assumption of equal variance, L (6, 5,884) = 27.03, $p \leq .01$. A subsequent Welch test of equality of injury severity means for the cause categories for struck by injuries showed that at least one of the "Struck by" groups had a significantly different injury severity mean than another group, F (6, 675.16) = 12.68, $p < .001$.

Table 4- 33. Causes of struck by injuries.

Cause of injury	Number of injuries	%	Cumulative %
Falling or flying object	2,218	36.92%	36.92%
Object being lifted or handled	2,111	35.14%	72.06%
Hand tool of machine in use	905	15.06%	87.12%
Object handled by others	262	4.36%	91.48%
Motor vehicle	204	3.40%	94.88%
Other NOC	200	3.33%	98.20%
Co-workers	108	1.80%	100.00%
Total	6,008	100.00%	

A Tukey's b range test was conducted to assess the severity of injuries of specific conditions identified when the worker experienced an injury due to being "Struck By" a particular object. The results of the Tukey's b test confirmed that there was a significant difference of injury severity means, at $p \leq 0.05$, between the seven struck by cause groups. The subsequent ranking of the specific causes of struck by injuries is shown in Figure 4- 51. Injuries caused by being struck by a motor vehicle had the highest injury severity mean, $\mu = 1.69$. Injuries caused by being struck by objects NOC ranked second ($\mu = 1.48$), followed by being struck by a fellow worker ($\mu = 1.46$), a falling or flying object ($\mu = 1.31$), objects being handled by others ($\mu = 1.31$), and objects being lifted or handled by the injured worker or other worker ($\mu = 1.28$). Struck by injuries involving hand tools or the use of a machine had the lowest injury severity mean ($\mu = 1.23$).

A subsequent examination of Figure 4- 51 showed that injuries caused by being struck by a motor vehicle had a significantly higher injury severity mean, at $p \leq 0.05$, than all of the remaining categories of struck by injuries (see Figure 4- 52). Injuries resulting from being struck by NOC objects, and fellow workers each had an injury severity mean significantly higher, at $p \leq 0.05$, than injuries which were caused by being struck by a falling or flying object, an object being handled by another person, an object being lifted or handled by the injured worker or coworker another individual, and hand tools or machinery being used.

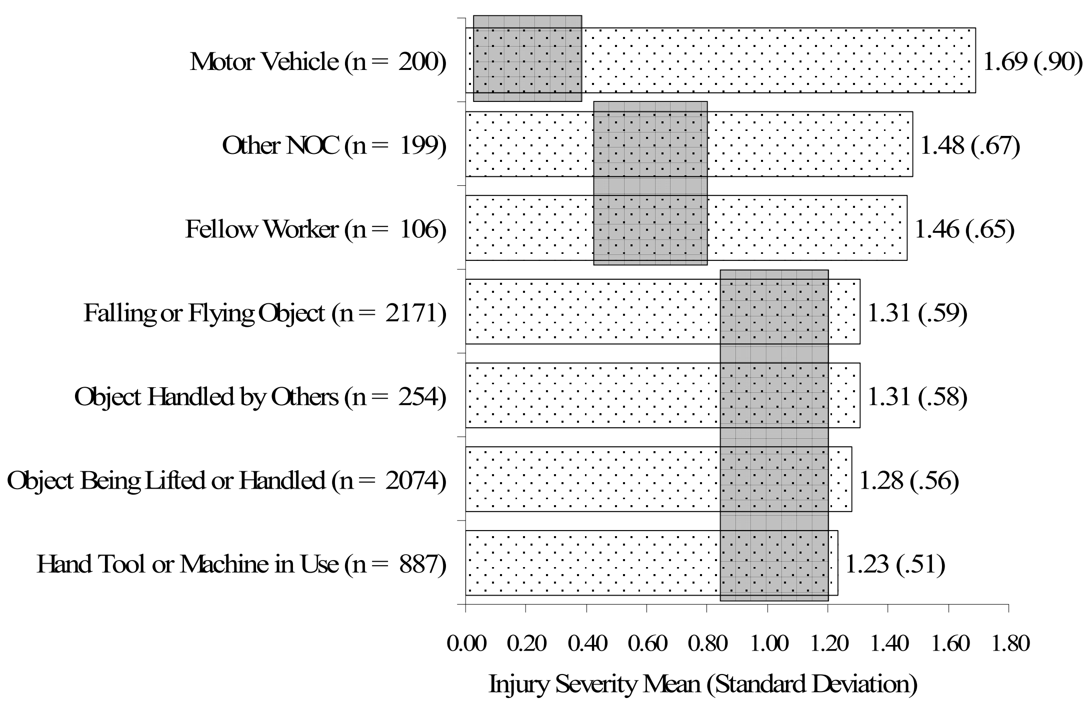

Figure 4- 51. Comparison of injury severity means by causes of struck by injuries.

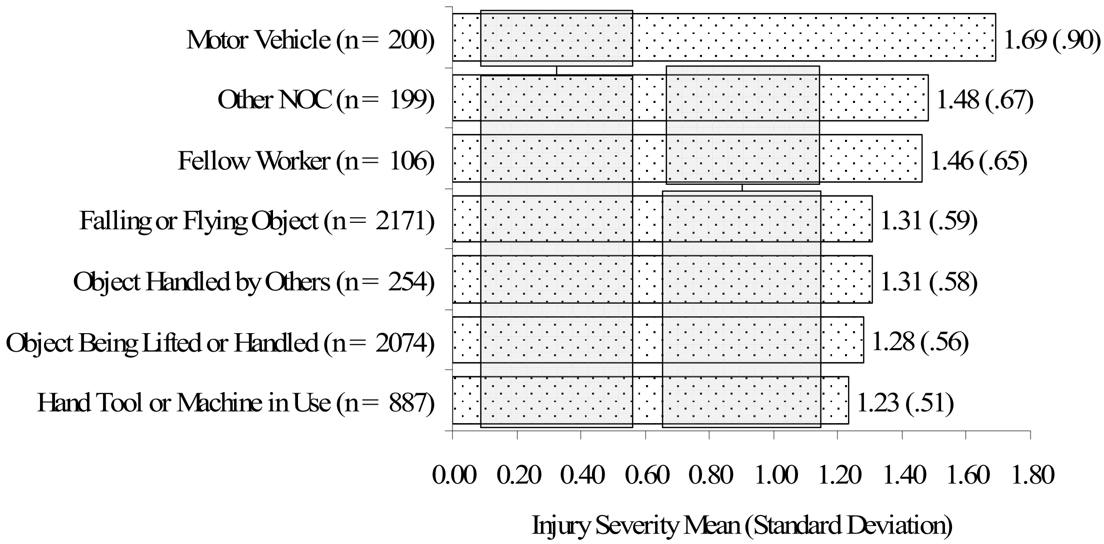

Figure 4- 52. Differences of injury severity means between causes of struck by injuries.

Agent of injury

The "Agent of Injury" was defined as that specific physical item that was identified as the actual person or object that was involved in the injury. The agent of injury directly contributed to the injury. Eighteen "General Agent of injury" categories were identified. Each of these categories was further delineated by associated "Agent of Injury" classifications.

General Agent of injury

Information regarding "General Agent of Injury" was provided for 30,307 worker injuries. Table 4- 34 shows the distribution of injuries by their respective general agent of injury classifications. The five leading "General Agent of injury" groups associated with injuries were materials (n = 13,971, 46.10%), tool(s) (n = 3,421, 11.29%), machinery (n = 2,326, 7.67), ladders/scaffolds (2,195, 7.24%), and change in surface texture (n = 1,790, 5.91%). Potholes (n = 84, 0.28%), manholes (n = 78, 0.26%), power lines or poles (n = 75, 0.25%), building material components (n = 46, 0.15%), and lead (n = 8, 0.03%) comprised less than two % of the total recorded injuries.

The results of the Levene test for homogeneity of variance of injury severity scores for the eighteen "General Agent of Injury" classifications did not support the assumption of equal variance, L (17, 29,809) = 110.25, $p \leq .001$. A subsequent Welch robust test of equality of injury severity means showed that at least one of the "General Agent of injury" classifications had a significantly different injury severity mean than another of these classifications, F (17, 486.88) = 47.65, $p < .001$. This was confirmed by the results of the Tukey's b range test, significant at $p \leq 0.05$ (see Figure 4- 53).

Table 4- 34. General agent of injury.

General agent of injury	Number of injuries	%	Cumulative %
Material	13,971	46.10%	46.10%
Tool	3,421	11.29%	57.39%
Machinery	2,326	7.67%	65.06%
Ladder/scaffold	2,195	7.24%	72.31%
Change in surface texture	1,790	5.91%	78.21%
Vehicle	1,417	4.68%	82.89%
Person	1,136	3.75%	86.64%
Organism	854	2.82%	89.45%
Chemical	826	2.73%	92.18%
Weather conditions	754	2.49%	94.67%
Sharp object - NOC	570	1.88%	96.55%
Furniture	522	1.72%	98.27%
Weighted item - NOC	234	0.77%	99.04%
Potholes	84	0.28%	99.32%
Manhole	78	0.26%	99.58%
Power lines or poles	75	0.25%	99.82%
Building exposure	46	0.15%	99.98%
Lead	8	0.03%	100.00%
Total	30,307	100.00%	

Among the "General Agent of Injury" categories, injuries involving a vehicle had the highest injury severity mean ($\mu = 1.52$), followed closely by exposure to lead ($\mu = 1.50$), ladders or scaffolds ($\mu = 1.50$), and weighted items ($\mu = 1.48$). Injury events brought on by a change in surface texture ranked fifth in terms of injury severity ($\mu = 1.46$). General agents of injury, ranking from 6th through 18th by injury severity mean were as follows; another person ($\mu = 1.43$), machinery (μ = 1.40), power lines or poles (μ = 1.39), weather conditions (μ = 1.38), furniture or furnishings (μ = 1.36), manholes (μ = 1.35), potholes (μ = 1.33), building exposure (μ = 1.32), tools (μ = 1.25), chemicals (μ = 1.23), sharp objects NOC (μ = 1.16), and organisms (μ = 1.15).

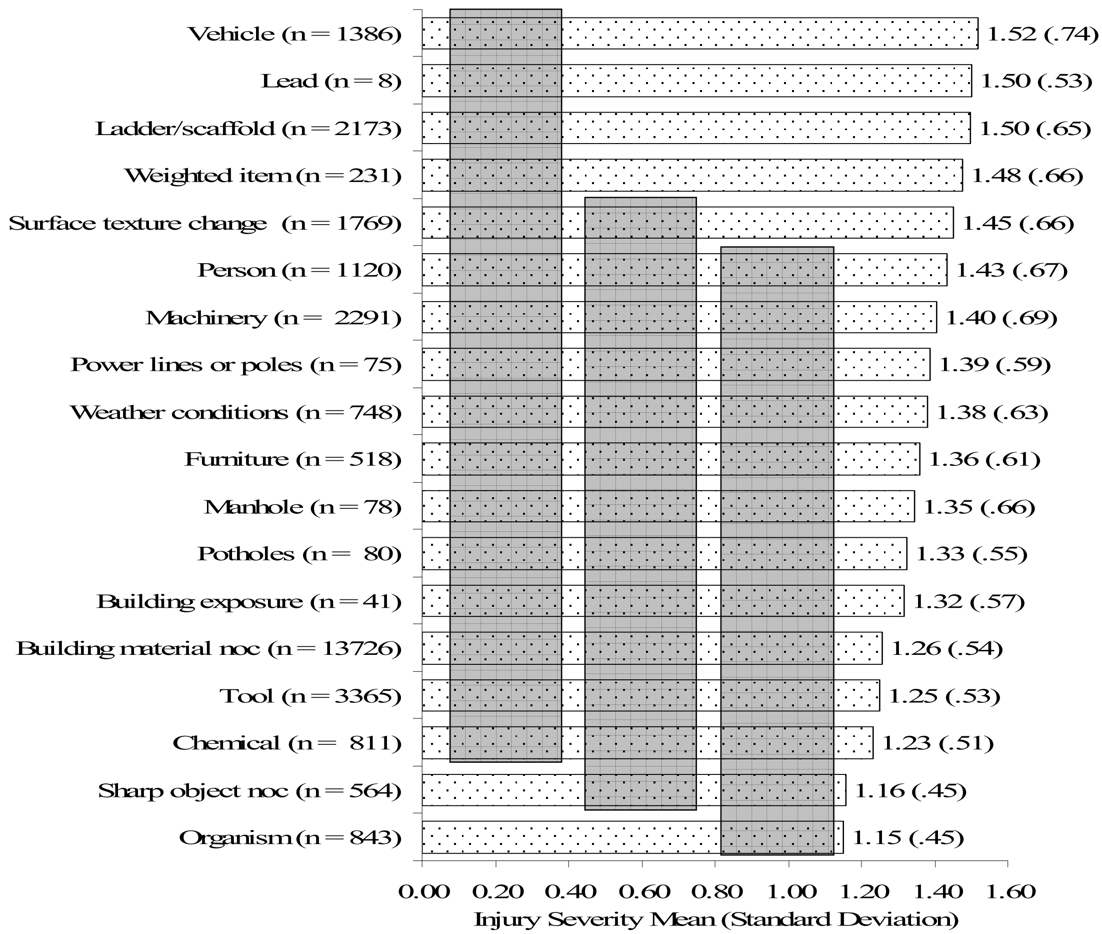

Figure 4- 53. Comparison of injury severity means by general agents of injury.

Specific injury severity mean differences, significant at $p \leq 0.05$, between the 'General Agent of injury" classifications were discerned from Figure 4- 53 and displayed in Figure 4- 54. Injuries for which the general agent of injury was identified as a vehicle, lead exposure, a ladder or scaffold, or a weighted item each had a significantly higher injury severity mean than injuries from sharp objects NOC and injuries from contact with some type of organism other than another person. Injuries involving a change in surface texture had a significantly greater injury severity mean, at $p \leq 0.05$, than injuries resulting from contact with an organism.

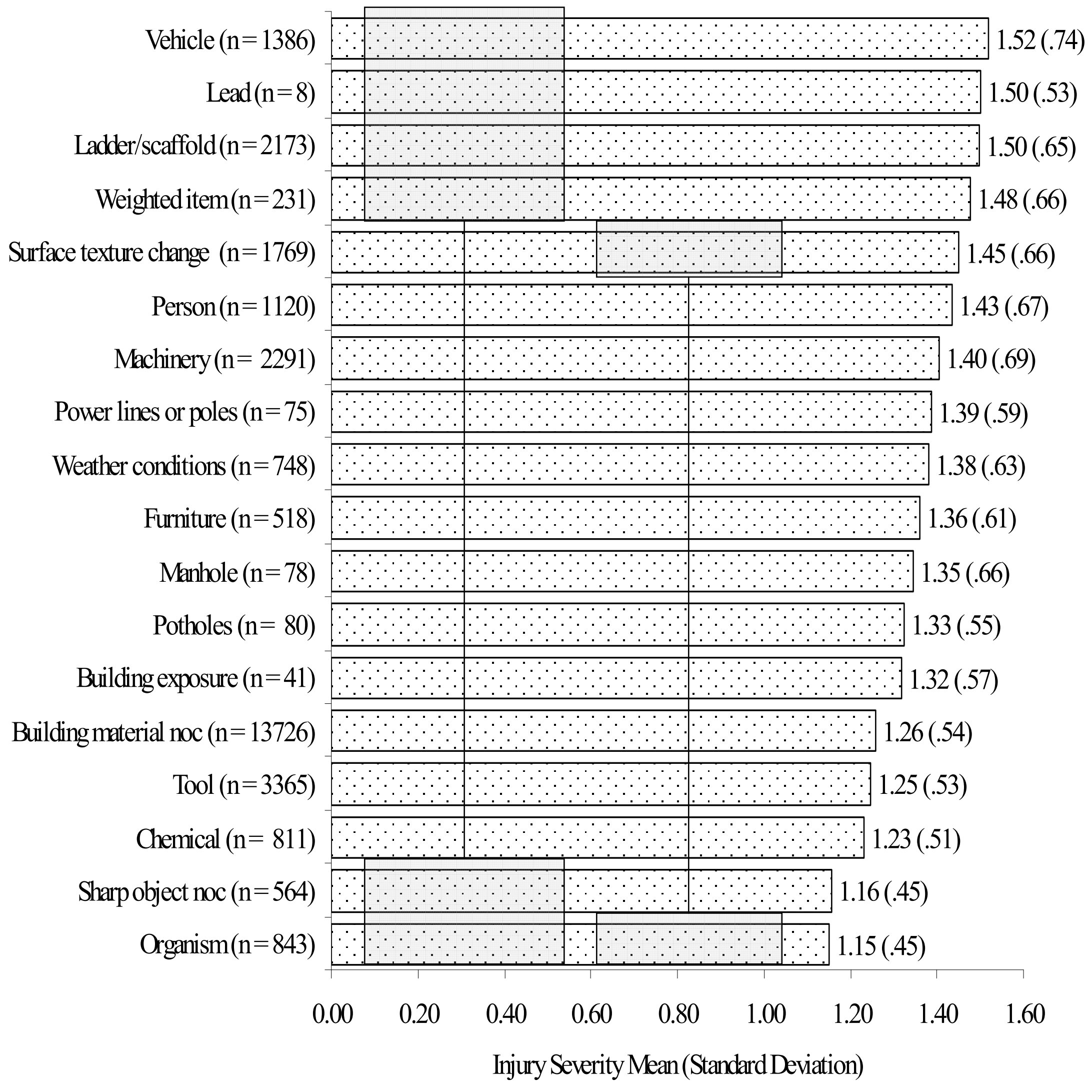

Figure 4- 54. Differences of injury severity means between general agents of injury.

Building Exposure

The specific agent leading to injuries from building exposures was identified for 46 such injuries. Table 4- 35 shows the distribution of “Building Exposure” injuries by specific “Agent of Injury” categories. Information regarding this category was provided for 46 workers. Over 90% (n = 43) of these injuries were attributed some kind of construction product as the specific building exposure agent of injury. Carbon monoxide emission from unidentified building components was attributed to two of the injuries. In one reported case, “Sick Building” was use to describe the specific agent of injury.

Table 4- 35. Agent of building exposure related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Construction products	43	93.48%	93.48%
Carbon monoxide	2	4.35%	97.83%
Sick building	1	2.17%	100.00%
Total	46	100.00%	

A comparison of injury severity means between each of these building exposure “Agent of injury” classifications showed construction products with the highest injury severity mean (μ = 1.34). However, due to the low frequencies for the remaining two “Agent of Injury’ classifications, statistically significant differences between the severity means could not be discerned. Collectively these three classifications had an injury severity mean of $\mu = 1.32$, ranking 12th out of the eighteen “General agent of injury” classifications.

Chemical

Information pertaining to chemical related injuries was provided for 826 worker injuries. Over 76% of the chemical related injuries were attributed to some kind of acid (n = 629) as the specific “Agent of Injury” (see Table 4- 36). Chemical agents attributable to the presence of some type of fume accounted for over 20% of the reported chemical related injuries. Chemical exposure of fumes was broken out into three “Agent of Injury” sub-classifications: fumes of hard metals (n = 45, 5.45%) including those produced by welding operations, fumes (unrelated to lead) of coatings, and paint products (n = 8, 0.97%). Smoke of a fire comprised almost 4% (n = 30) of the injuries associated with a chemical agent.

Possible differences of injury severity means between the five chemical agent of injury classifications were examined. A Levene test of homogeneity of variances of injury severity scores allowed for an assumption of equal variances of injury severity scores for the five “Agent of injury" classifications , L (4, 806) = .71, $p > 0.05$. Subsequently, the ANOVA test of equality of means was conducted and the results showed the lack of any significant differences between the injury severity means for the chemical agent of injury categories, F (4, 805) = 0.65, $p > 0.60$.

Table 4- 36. Agent of chemical related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Acid	629	76.15%	76.15%
Fumes NOC	114	13.80%	89.95%
Fumes from hard metals (incl. Welding)	45	5.45%	95.40%
Smoke of Fire	30	3.63%	99.03%
Fumes from coatings, paint (Not Lead)	8	0.97%	100.00%
Total	826	100.00%	

Even though no significant differences were found between the injury severity means among the chemical "Agent of Injury" classifications, the Tukey's b range test was still conducted in order to rank, in descending order of injury severity means, the five classifications (see Figure 4- 55). Chemical fumes from coatings or paint products showed the highest injury severity mean (μ = 1.25). Chemical injuries from acids (μ = 1.24) and smoke (μ = 1.23) ranked second and third, respectively. Chemical exposure from hard metal fumes (μ = 1.20) and from fumes not otherwise classified (μ =1.20) showed the lowest injury severity mean levels.

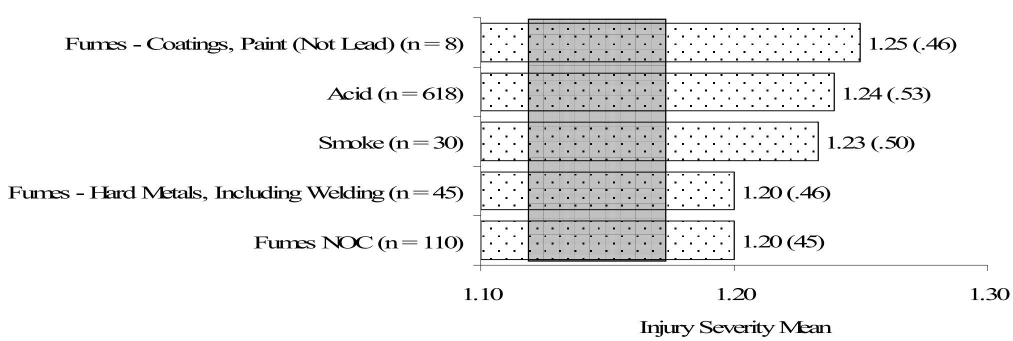

Figure 4- 55. Comparison of injury severity means by agent of chemical related injuries.

A comparison of the injury severity means was conducted for the "Agent of injury" categories for furniture related injuries (see Table 4- 37). The Levene test for homogeneity of variances allowed for the assumption of equal variances, L (2, 514) = 0.59, $p > .50$. Subsequently, the ANOVA test of injury severity means for the “Agent of Injury” categories for furniture related injuries showed a lack of significant difference of injury severity means between the three groups, F (2, 514) = 0.97, $p > 0.40$. This was confirmed by the results of the Tukey’s b range test.

Table 4- 37. Agent of furniture or furnishings related injuries

Agent of injury	Number of injuries	%	Cumulative %
Fixtures, furnishings	513	98.46%	98.46%
Commodes	4	0.77%	99.23%
Display items	4	0.77%	100.00%
Total	521	100.00%	

The Tukey’s b range test for means was performed in order to rank the three categories by their respective injury severity means. Figure 4- 56 shows that, among furniture related injuries, commodes had the highest injury severity means (μ = 1.75), followed by fixtures and furnishings (μ = 1.36). Display items showed the lowest injury severity mean level (μ = 1.25).

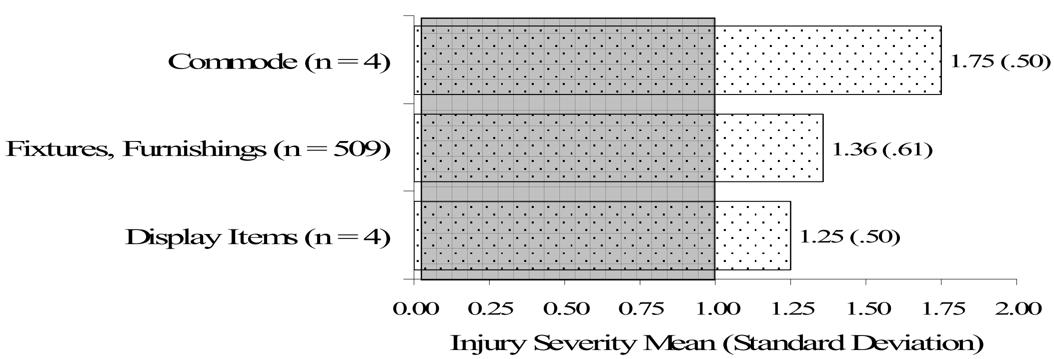

Figure 4- 56. Comparison of injury severity means by agent of furniture or furnishings related injuries.

Lead

Information regarding injuries related to lead containing products was provide for eight worker injuries. Five of the eight “Agent of Injury” categories associated with lead-related injuries involved the handling of some form type of paint product (see Table 4- 38).

Table 4- 38. Agent of lead related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Paint products	5	62.50%	62.50%
Other NOC	3	37.50%	100.00%
Total	8	100.00%	

To compare the injury severity means between the two lead categories an independent samples t-test was conducted (see Figure 4- 57). The results of the Levene test for equality of injury scores variances allowed for the assumption of equal variances, L (1, 6) = 0.74, $p > 0.70$. The results of the independent samples t-test showed that injuries associated with lead of paint products had a higher injury severity mean ($\mu = 1.60$) than lead in sources not otherwise classified ($\mu = 1.33$); this difference was not shown to be statistically significant, t (6) = 0.66, $p > .50$.

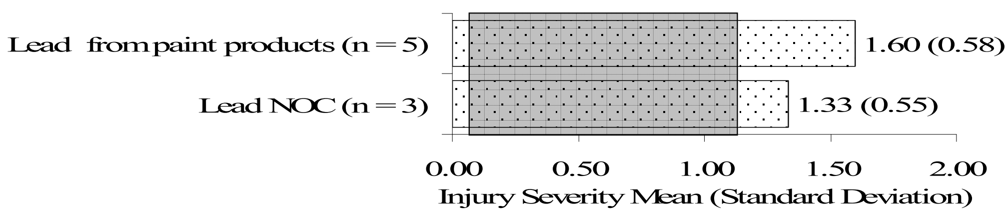

Figure 4- 57. Comparison of injury severity means by agent of lead related injuries.

Machinery

Information regarding machinery related injuries was provided for 2,326 workers injuries. Table 4- 39 shows, injuries for which “Machinery” was identified as the “General agent of Injury” as distributed over eleven “Agent of injury” categories. The majority of incidents for which a specific machinery item was identified were associated with some form of electrical apparatus (n = 333, 14.32%). Together, maintenance equipment (n = 122, 5.25%) and metal working machinery or equipment (n = 131, 5.63%) accounted for almost 11% of the machinery related injuries. Injuries involving turnstiles (n = 7, 0.03%), wood working equipment (n = 9, 0.39%), pumps (n = 19, 0.82%), conveyors (n = 27, 1.16%), belts, pulleys, gears or shafts (n =

27, 1.16%), hoisting equipment (n = 66, 2.84%) and furnace or heating equipment (69, 2.97%) accounted for less than 10 % of all the machinery related injuries.

The results of the Levene test for homogeneity of injury severity score variances did not allow the assumption equal variances between the 11 agents of injury for machinery related injuries. L (10, 2,280) = 6.16, $p < .001$. The subsequent Welch test for equality of injury severity means the results showed that at least one of these categories was significantly different from another, F (10, 83.47) = 2.94, $p < .01$. This result was not confirmed by the subsequent Tukey's b range test.

Table 4- 39. Agent of machinery related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Other NOC	1,516	65.18%	65.18%
Electrical apparatus	333	14.32%	79.50%
Metal working	131	5.63%	85.13%
Maintenance equipment	122	5.25%	90.37%
Furnace or heating equipment	69	2.97%	93.34%
Hoisting apparatus	66	2.84%	96.18%
Belts, pulleys, gears, shafts	27	1.16%	97.34%
Conveyors	27	1.16%	98.50%
Pumps	19	0.82%	99.32%
Wood working	9	0.39%	99.70%
Turnstile	7	0.30%	100.00%
Total	2,326	100.00%	

The Tukey's b range test was conducted to assess the severity of injuries of specific "Agent of Injury" categories for machinery related injuries. No significant difference of injury severity means, at $p \leq 0.05$, was detected between the "Agent of Injury" categories identified with machinery related injuries. The ranking of these categories (see Figure 4- 58) shows that injuries from conveyor type machinery generated the highest injury severity mean ($\mu = 1.67$) among the machinery related injuries, and injuries involving turnstiles were associated with the lowest injury severity mean ($\mu = 1.14$).

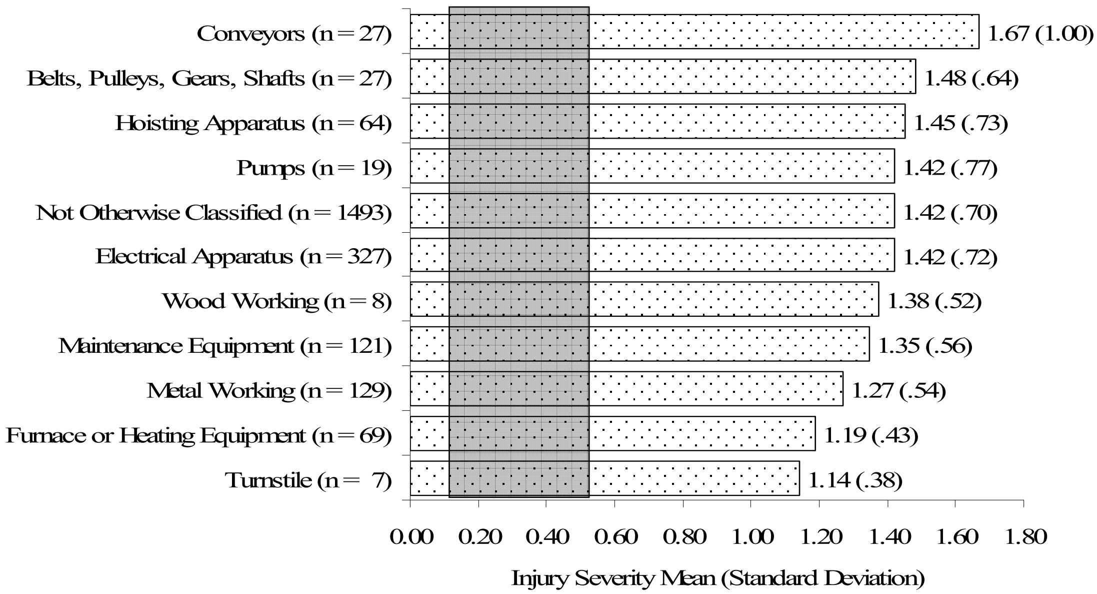

Figure 4- 58. Comparison of injury severity means by agent of machinery related injuries.

Manholes

Injuries associated with “Manholes” accounted for less than 1% (n = 78) of the injuries recorded for this “General Agent of Injury” variable. No “Agent of Injury” sub-classifications were identifiable from the data for manhole injuries. The injury severity mean ($\mu = 1.35$) for manhole injuries ranked eleventh among the “General Agent of injury” categories. It was not significantly different, at $p \leq 0.05$, than any of the other classifications.

Material

The distribution of injuries for material related injuries are displayed in Table 4- 40. Information was provided for 13,971 worker injuries. The majority of the material related injuries were directly associated with wire or metal material (n = 5,077, 36.34%). Piping (n = 1,867) and wood material (n = 1,673) each accounted for over 11% of the material related injuries. Rock or stone materials (n = 1,117) made up eight % of material related injuries. Nails (n = 896), boxes, barrels, and other containers or packages (n = 893), accounted for over 12 % of the material related injuries. The remaining 13 “Agent of Injury” categories for material related injuries accounted for less than 6 % of the injuries.

Table 4- 40. Agent of injury for material related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Wire or metal	5,077	36.34%	36.34%
Pipe	1,867	13.36%	49.70%
Wood	1,673	11.97%	61.68%
Rock or stone	1,117	8.00%	69.67%
Foreign matter	1,065	7.62%	77.30%
Nail	896	6.41%	83.71%
Boxes, barrells, containers, packages	893	6.39%	90.10%
Windows, doors	342	2.45%	92.55%
Scrap materials	270	1.93%	94.48%
Asbestos	179	1.28%	95.76%
Glass	155	1.11%	96.87%
Plastic	91	0.65%	97.52%
Fence	86	0.62%	98.14%
Automotive parts	72	0.52%	98.65%
Garbage cans, bags	72	0.52%	99.17%
Plumbing supplies	47	0.34%	99.51%
Shoes, clothing, apparel	22	0.16%	99.66%
Ceramic	19	0.14%	99.80%
Pulp or Paper	18	0.13%	99.93%
Coal & Petroleum Product(s)	10	0.07%	100.00%
Total	13,971	100.00%	

The Tukey’s b range test was conducted to evaluate possible differences in injury severity means between the “Agent of Injury” categories for materials related injuries. Figure 4- 59 shows the ranking, in descending order of the injury severity mean magnitude associated with the “Agent of Injury” classifications for materials related injuries. Injuries involving contact with coal or petroleum materials had the highest injury severity mean ($\mu = 1.60$) followed by contact with pulp or paper products ($\mu = 1.56$). Boxes, barrels, containers or packages had the third highest injury severity mean ($\mu = 1.40$), followed by fencing material ($\mu = 1.38$), automotive parts ($\mu = 1.33$), and rock or stone material ($\mu = 1.33$). Materials ranking between seventh and ninth, with an injury severity mean of $\mu = 1.31$, included windows and doors, wood material, and asbestos material. Plumbing materials ranked 10th (μ = 1.30), followed by shoes, clothing and apparel (μ = 1.30), and plastic materials (μ = 1.30). The bottom eight materials include ceramic materials (μ = 1.29), pipe (μ = 1.28), garbage cans or bags (μ = 1.27), glass materials (μ = 1.25), wire or metal materials (μ = 1.24), scrap materials (μ = 1.21), nails (μ = 1.11), and materials not otherwise classified (μ = 1.10).

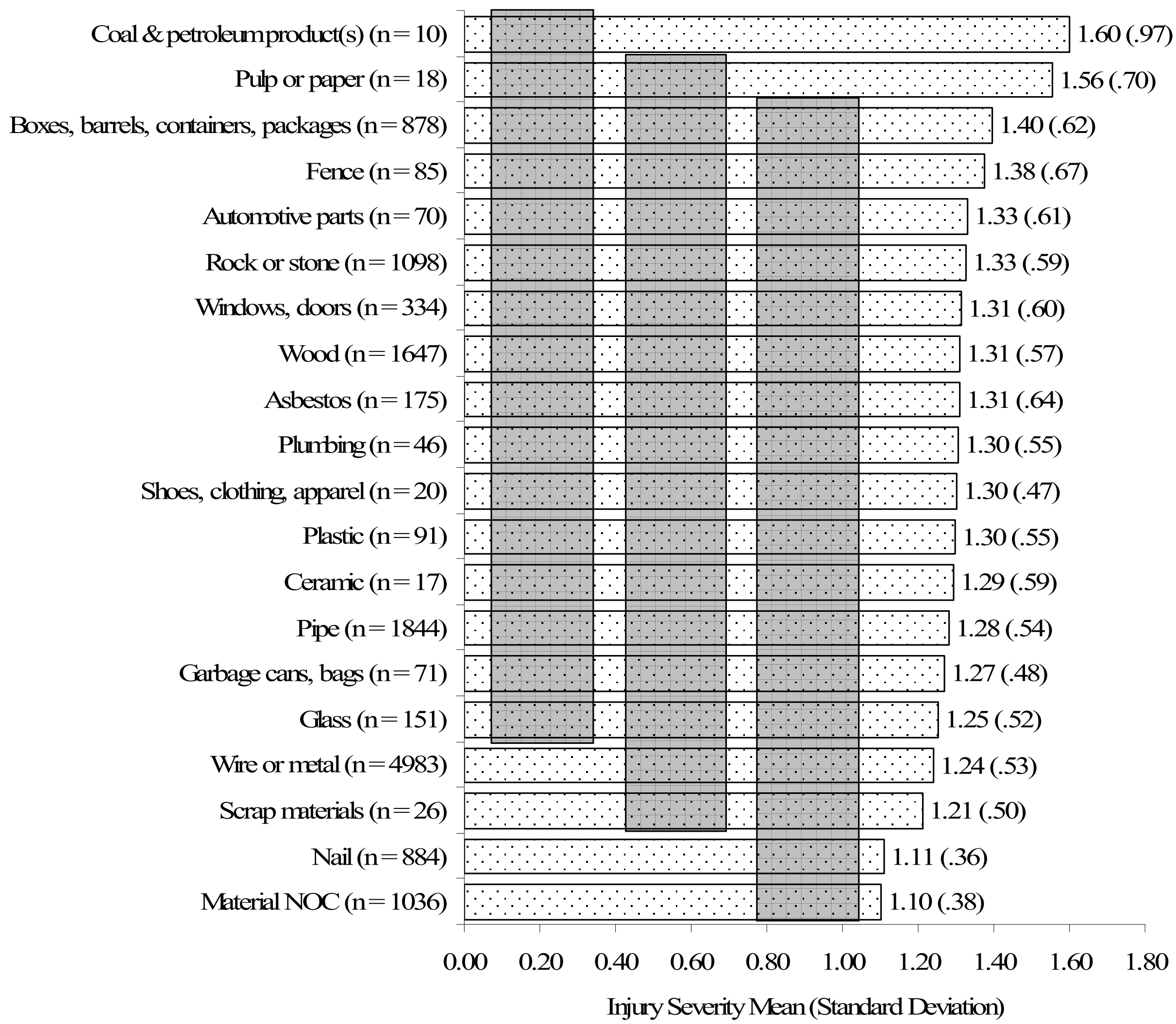

Figure 4- 59. Comparison injury severity means by agent of material related injuries.

Materials which had significantly different injury severity means, at $p \leq 0.05$, from other material categories were discerned from Figure 4- 59 and displayed in Figure 4- 60. Injuries involving coal and/or petroleum materials had a significantly greater injury severity mean (μ =

1.60), at $p \leq 0.05$, than injuries directly associated with wire or metal materials (μ = 1.24), scrap materials (μ = 1.21), nails (μ = 1.11), and other material not otherwise classified (μ = 1.10). Injuries from pulp or paper materials showed a significantly greater severity mean (μ = 1.56), at $p \leq 0.05$, than injuries from nails and other materials not otherwise classified. No other significant differences of injury severity means were detected, at $p \leq 0.05$, between the "Agent of injury" groups for materials related injuries

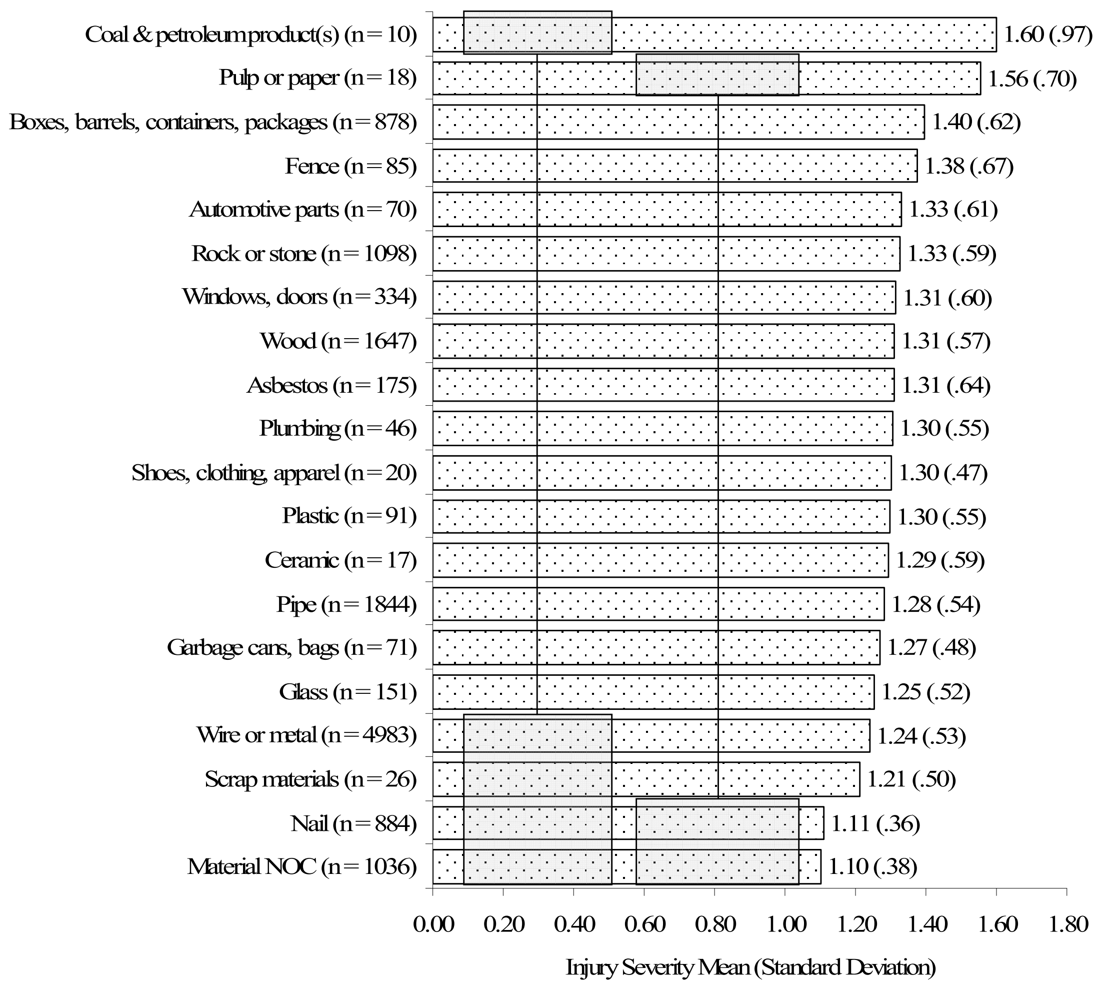

Figure 4- 60. Differences of injury severity means between agents of material related injuries.

Organism

Information regarding injuries directly associated with contact with an organism was provided for 854 workers. Injuries involving an insect comprised almost half (n = 424) of the injuries attributed to contact with some type of organism (see Table 4- 41). Over 23% of the organism related injuries were associated with contact with a plant (n = 200, 23.42%). Contact with either an animal (n = 149, 17.45%) or animal or insect not otherwise classified (n = 64, 7.49%) comprised almost 25% of injuries resulting from contact with an organism. The least common type of organism related injury organism was direct contact with bacteria (n = 17, 49.65%).

Table 4- 41. Agent of animal or insect related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Insect	424	49.65%	49.65%
Plant	200	23.42%	73.07%
Animal	149	17.45%	90.52%
Animal or insect NOC	64	7.49%	98.01%
Bacteria	17	1.99%	100.00%
Total	854	100.00%	

Equal variances of the injury severity means for the five "Agent of injury" classifications for organism related injuries could not be assumed, L (4, 838) = 12.21, $p < .001$. The results of a Welch test for equality of injury severity means suggested that at least one of the "Agent of Injury" groups had a significantly different severity mean than another classification, F (4, 95.35) = 3.19, $p < .02$. This was confirmed by the subsequent Tukey's b range test.

The results of the Tukey's b range test for injury severity means for the five "Organism" classifications are illustrated in Figure 4- 61. Despite being the least common of the injury classifications for injuries associated with exposure to an organism, bacteria related injuries showed the highest injury severity mean ($\mu = 1.35$). Injuries for which the agent of injury was specifically identified as an animal had the second highest injury severity mean ($\mu = 1.22$), followed by a plant ($\mu = 1.19$), and either an animal or an insect ($\mu = 1.11$). Injuries of contact with an insect had the lowest injury severity mean ($\mu = 1.10$) among injuries for which contact with an organism was identified as the general agent of injury.

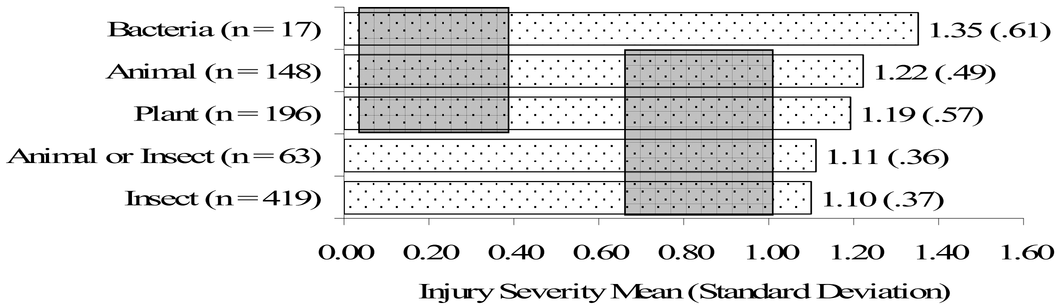

Figure 4- 61. Comparison of injury severity means by agent of organism related injuries.

The injury severity mean for bacteria related injuries was significantly greater, at $p \leq 0.05$, than injuries associated with either animal or insect ($\mu = 1.11$) and those injuries for which an insect ($\mu = 1.10$) was identified as the organism agent of injury (see Figure 4- 62).

Figure 4- 62. Differences of severity means between agents of organism related injuries.

Person

The distribution of injuries for the four agent of injury classifications associated with those injuries in which a "Person" was identified as the "General agent of injury" is displayed in Table 4- 42. Information regarding "Person" related injuries was provided for 1,136 worker injuries. Contact with a co-worker comprised over 80% (n = 948) of these injuries. Contact with maintenance personnel (n = 11, 0.97%), medical personnel (n = 42, 3.70%), and other persons not otherwise classified (n = 135, 11.88%), as an aggregate, accounted for less than 17% of the injuries associated with contact with another person.

The results of the Levene test for homogeneity of the injury severity scores for the four "Person" agent of injury categories allowed for the assumption of equal variances of injury severity scores for the four "Agent of injury" classifications for injuries associated with direct contact with another person, L (3, 1,116) = 2.41, $p > .06$. The results of the subsequent ANOVA did not show any significant difference between the four "Agent of Injury" groups, F (3, 1,116) = 1.41, $p > 0.60$. This result was confirmed by the Tukey's b range test.

Table 4- 42. Agent of injuries related to a person.

Agent of injury	Number of injuries	%	Cumulative %
Co-worker	948	83.45%	83.45%
Person NOC	135	11.88%	95.33%
Medical personnel	42	3.70%	99.03%
Maintenance personnel	11	0.97%	100.00%
Total	1,136	100.00%	

The Tukey's b range test was conducted to generate the rankings, in descending order of injury severity means, for the four "Agent of Injury" groups for injuries associated with contact with another person (see Figure 4- 63). Injuries resulting from contact with medical personnel (μ = 1.48) and co-workers (μ = 1.44) ranked first and second, respectively, in terms of their injury severity means. Contact with maintenance personnel showed the lowest injury severity mean (μ = 1.18), among the four categories.

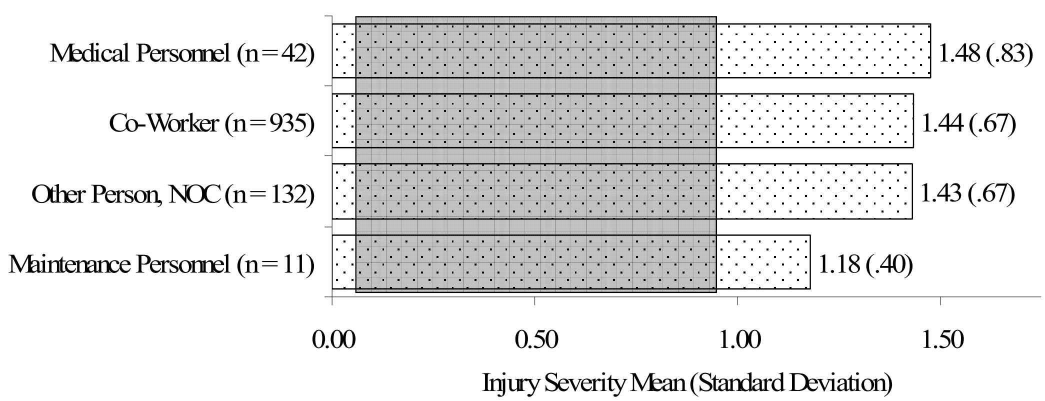

Figure 4- 63. Comparison of injury severity means by agent of person related injuries.

Potholes

Injuries associated with '"Potholes"" as the general agent of injury accounted for less than 1% (n = 84) of the injuries recorded for the "General agent of injury" variable. No "Agent of injury" classifications were identifiable from the data for injuries associated with "Potholes." The injury severity mean ($\mu = 1.33$) for potholes related injuries ranked twelfth among the "General Agent of injury" categories. It was not significantly different, at $p \leq 0.05$, than any of the other "General agent of injury."

Power Lines or Poles

Injuries associated with '"Power lines or poles" as the general agent of injury accounted for less than 1% (n = 75) of the injuries recorded for the "General Agent of Injury" variable. No "Agent of Injury" classifications were identified from the data for "Power lines or poles" injuries. The injury severity mean ($\mu = 1.39$) for "Power lines or poles" injuries ranked eighth among the "General agent of injury" categories. It was not significantly different, at $p \leq 0.05$, than any of the other "General Agent of Injury" classifications.

Sharp Object Not Otherwise Classified (NOC)

Injuries associated with '"Sharp object NOC" as the general agent of injury accounted for approximately 2 % (n = 570) of the injuries recorded for the "General Agent of Injury" variable. No "Agent of Injury" classifications were discernable from the data for "Sharp Object NOC" injuries. The injury severity mean ($\mu = 1.16$) for "Sharp Object NOC" injuries ranked seventeenth, out of eighteen, among the "General Agent of Injury" categories. It was not significantly, different, at $p \leq 0.05$, than any of the other "General Agent of injury" classifications.

Change in Surface Texture

Information regarding injuries resulting from a change in the surface texture of the worker's surroundings was provided for 1,790 worker injuries. Table 4- 43 shows the distribution of injuries for the four "Agent of Injury" categories for injuries associated with changes in surface texture. No specific contributing "Agent of Injury" could be identified for over 86% (n = 1,547) of the “change in surface texture” injuries. Spills from liquids, food or grease (n = 137, 7.65%) and wet floors from cleaning or waxing (n = 100, 5.59%) each comprised over five % of the total number of “Change in Surface Texture” injury cases. Six cases identified spills or leakage from a tank or vessel (0.34%) as the specific “Agent of Injury” which lead to the change in surface texture.

Table 4- 43. Agent of change in surface texture related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Change in surface texture NOC	1,547	86.42%	86.42%
Spills of liquid, food or grease	137	7.65%	94.07%
Wet floor from cleaning	100	5.59%	99.66%
Spills of a tank or vessel	6	0.34%	100.00%
Total	1,790	100.00%	

The Levene test for homogeneity of variances of injury severity scores among the four “Change in Surface Texture” classifications did not allow for the assumption of equal variances, L (3, 1,765) = 3.04, $p < 0.03$. Subsequent the results of the Welch test of equality of injury severity means for the four “Agent of Injury” classifications for injuries associated with a change in surface texture showed no significant difference between the severity means of the four “Agent of Injury” categories, F (3, 23.60) = 1.36, $p > 0.20$.

The injury severity means were ranked using the Tukey’s b range test (see Figure 4- 64). Among specific agents of loss associated with change in surface texture related injuries those not otherwise classified ($\mu = 1.46$), and thse due to a floors wet from cleaning or waxing had the second highest injury severity mean ($\mu = 1.44$). This was followed by spills from food, liquid or grease ($\mu = 1.39$). Change in surface texture due to spills or leakage from a tank or vessel showed the lowest severity mean level ($\mu = 1.17$) among the four “Change in Surface Texture” classifications. The results also confirmed the results of the ANOVA by showing no significant injury severity mean differences, at $p \leq 0.05$, between any of the four categories.

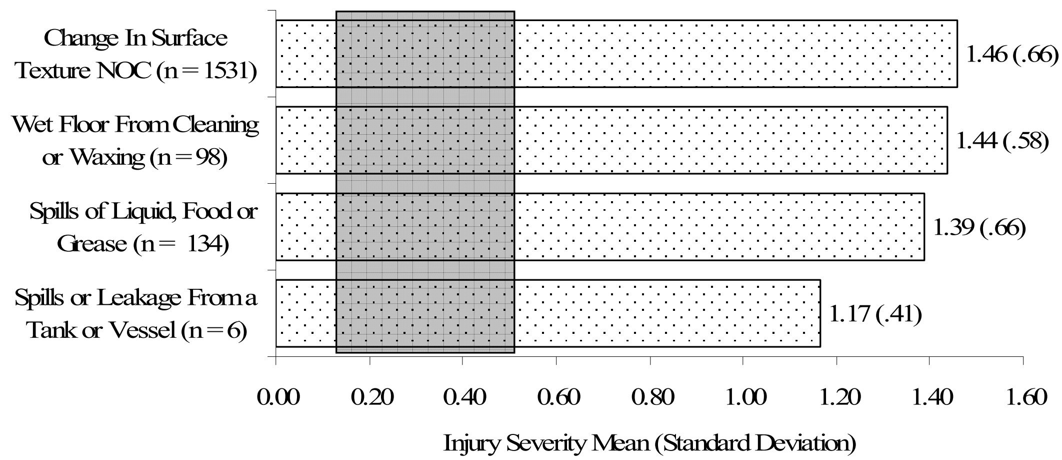

Figure 4- 64. Comparison of injury severity means by agent of change in surface texture related injuries.

Tool

Injuries from non-powered hand tools (n = 1,616) accounted for almost half of the reported injuries which involved tools (see Table 4- 44). Powered hand tools (n = 1,269) comprised over a third of the tool related injuries. Over 15% of the tool related injuries were directly associated with some type of non-powered knife (n = 536).

Table 4- 44. Agent of tool related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Non-powered hand tools	1,616	47.24%	47.24%
Powered hand tools	1,269	37.09%	84.33%
Non-powered knife	536	15.67%	100.00%
Total	3,421	100.00%	

The results of the Levene test for homogeneity of variances of injury severity scores for the three “Tool(s)” classifications did not allow for an assumption of equal variances of injury severity scores, L (2, 3,362) = 98.07, $p \leq .001$. The results of a subsequent Welch robust test of equality of injury severity means revealed a statistically significant difference among the severity means of the three “Agent of Injury” categories for tool related injuries, F (2, 1,604.67) = 32.66, $p \leq .001$.

The Tukey's b range test was conducted, and showed that the most severe of these injuries were attributable to an injury experienced while using a powered hand tool (μ = 1.30), followed by a non-powered hand tool (μ = 1.25). Use of a non-powered knife had the lowest injury severity mean (μ = 1.11) (see Figure 4- 65).

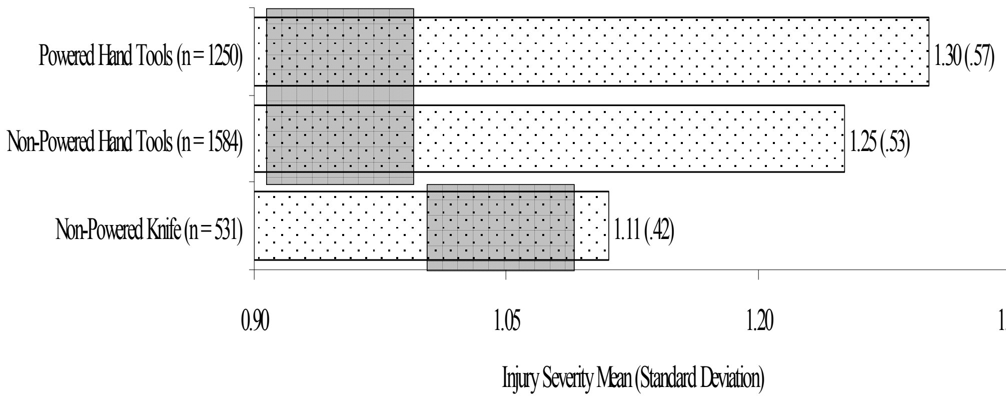

Figure 4- 65. Comparison of injury severity means by agent of tool related injuries.

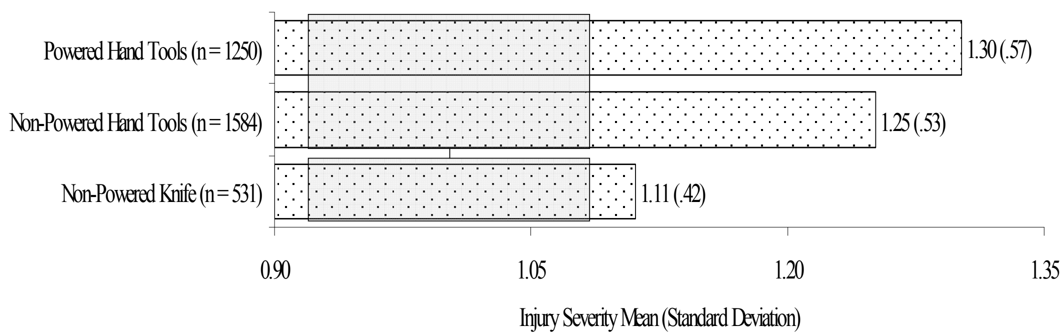

Figure 4- 66. Difference of injury severity means between agents of tool related injuries.

There was no significant difference, at $p \leq 0.05$, of injury severity means between injuries of powered hand tools and non-powered hand tools (see Figure 4- 66). Injuries associated with the use of a non-powered knife had a significantly lower injury severity mean, at $p \leq 0.05$, than injuries associated with the use of either powered or non-powered hand tools (see Figure 4- 66).

Vehicle

The distribution of injuries for the specific items associated with the "Vehicle" category of "General Agent of injury" is displayed in Table 4- 45. Vehicles not otherwise classified accounted for more than half of the reported injuries (n = 771) which involved a vehicle. Mobile machinery or equipment account for the largest number of distinguishable vehicle related injuries (n = 450). Delivery carts, wagons and bicycles (n = 188) accounted for over 13% of the vehicle related injuries. Eight (.56%) vehicle related injuries were directly associated with a golf cart.

Table 4- 45. Agent of vehicle related injuries.

Agent of injury	Number of injuries	%	Cumulative %
Vehicle NOC	771	54.41%	54.41%
Mobile machinery/equipment	450	31.76%	86.17%
Delivery cart. Wagon, or bicycle	188	13.27%	99.43%
Golf cart	8	0.56%	100.00%
Total	1,417	100.00%	

The injury severity means for the four "Vehicle" categories were compared. Equal variance of injury severity scores was assumed, L (3, 1,382) = 1.97, $p > 0.10$. This prompted the use of the ANOVA test of equality of injury severity means for the four "Agent of Injury" categories for vehicle related injuries. The results of this test indicated no significant means difference between the four "Vehicle" groups, F (3, 1,382) = 1.85, $p > 0.10$.

The results of the Tukey's b range test at $p \leq 0.05$are displayed in Figure 4- 67. Injuries involving some kind of mobile machinery or equipment showed the highest injury severity mean, ($\mu = 1.53$) and injuries involving a golf cart exhibited the lowest injury severity mean ($\mu = 1.38$) among vehicle related injuries. There were no significant differences of injury severity means between any of the four ''Agent of injury" classifications.

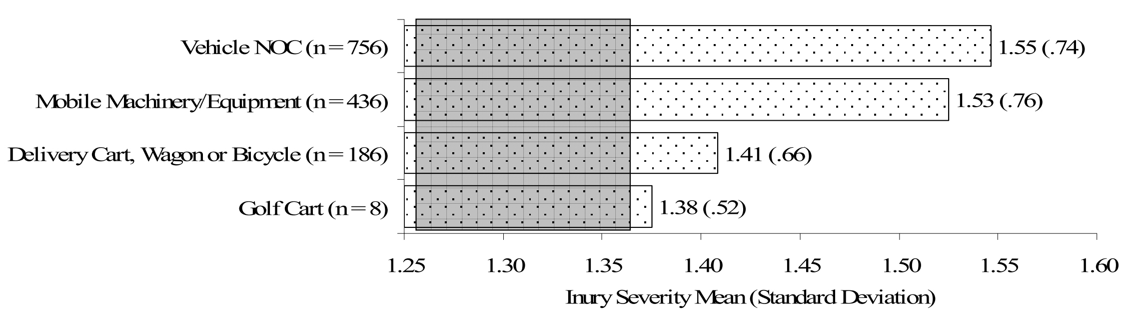

Figure 4- 67. Comparison injury severity means by agent of vehicle related injuries.

Weather Conditions

Weather related injuries accounted for 754 of the 30,307 injuries for which "General agent of injury" were recorded. No "Agent of injury" classifications were discernable of the data for weather related injuries. The injury severity mean (μ =1.38) for "Weather conditions" injuries ranked ninth, out of eighteen, among the "General agent of injury" categories. It was not significantly, different, at $p \leq 0.05$, from any of the other "General agent of injury" classifications.

Weighted Item

Information regarding the six "Agent of injury" categories for injuries involving a weighted item was provided for 234 worker injuries. Table 4- 46 shows that the most common injuries associated with a weighted item involved objects weighing over 150 pounds (n = 56, 23.93%), weighing from 26 to 50 pounds (n = 49, 20.94%), and those weighing up to 25 pounds (n = 45, 19.23%). Less than 25% of weighted item injuries weighed between 51 and 150 pounds.

As a whole, the injury severity mean for injuries associated with a weighted item ranked third (see Figure 4- 53). "Weighted item" injuries had a significantly higher, at $p \leq 0.05$, severity mean (μ = 1.48) than injuries associated with an exposure to an organism (μ = 1.15) and injuries from contact with a sharp object (μ = 1.16).

Table 4- 46. Agent of injuries related to weighted items.

Agent of injury	Number of injuries	%	Cumulative %
More than 150 Lbs.	56	23.93%	23.93%
Of 26 to 50 Lbs.	49	20.94%	44.87%
Up to 25 Lbs.	45	19.23%	64.10%
From 76 to 100 Lbs.	33	14.10%	78.20%
From 51 to 75 Lbs.	32	13.68%	91.88%
From 101 to 150 Lbs.	19	8.12%	100.00%
Total	234	100.00%	

An assumption of equal variances of injury severity scores was supported for the six "Agent of Injury' categories for injuries involving a weighted item, L (5,225) = 1.88, $p > 0.10$. An ANOVA revealed no statistically significant difference between the severity means of the six "Agent of Injury" injuries associated with weighted items, F (5, 225) = 1.44, $p >.60$). This was confirmed by the results of the Tukey's b range test for injury severity means, significant at $p \leq 0.05$.

The Tukey's b test also showed the ranking, in descending order of injury severity mean, of the six "Agent of injury" groups for injuries involving the handling of weighted items (see Figure 4- 68). Items weighing more than 150 pounds were associated with the most severe of these injuries (μ = 1.55), followed by items weighing between 76 and 100 pounds (μ = 1.54), 101 to 150 pounds (μ = 1.53), and items weighing less than 25 pounds (μ = 1.38) were associated with least severe weighted item injuries.

Figure 4- 68. Comparison of injury severity mean by agent of weighted item related injuries.

Date of Injury

Year of Occurrence of Injury

Information regarding the year in which the injury occurred was provided for 46,012 worker injuries. Injury frequency by the year of the injury is shown in Table 4- 47. Over 18% of the injuries (n = 8,499) were reported to have occurred during the year 2001. Over 15% of the injuries occurred in 2002 (n = 7,961) and 2000 (n = 7,223). Over 13% of the injuries occurred in 2003 (n = 6,159), and nearly 12% of the injuries occurred in 2004 (n = 5,501). Slightly less than

10% of the injuries occurred in 2005 (n = 4,532), and 1999 was associated with slightly over 8% of the injuries (n = 3,802). Almost 5% of the injuries were recorded for 1998 (n = 1,255), 1997 (n = 576), and 1996 (n = 282). For 2006, data were available only for the month of January. These accounted for less than one % of all the injuries (n = 222).

Table 4- 47. Year of injury.

Year of injury	Number of injuries	%	Cumulative %
2001	8,499	18.47%	18.47%
2002	7,961	17.30%	35.77%
2000	7,223	15.70%	51.47%
2003	6,159	13.39%	64.86%
2004	5,501	11.96%	76.81%
2005	4,532	9.85%	86.66%
1999	3,802	8.26%	94.92%
1998	1,255	2.73%	97.65%
1997	576	1.25%	98.90%
1996	282	0.61%	99.52%
*2006	222	0.48%	100.00%
Total	46,012	100.00%	

* For January only.

A comparison of the injury severity means was conducted for the reported years of injuries. The results of the Levene test of homogeneity of injury severity score variances for the years of the injury did not allow for the assumption of equal variances, L (10, 45,323) = 95.90, $p < .001$. Subsequently, the Welch robust test of equality of injury severity means was conducted to detect possible differences of injury severity means, significant at $p \leq 0.05$, by year of occurrence. The results of this test did show that any year had a significantly different injury severity mean than one of the other years, F (10, 3,298.66) = 30.56, $p < .001$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 69).

The results of the Tukey's b range test are displayed in Figure 4- 70. It shows that the injury severity means associated with injuries sustained during 2001 ($\mu = 1.38$) and 2002 ($\mu = 1.38$) had significantly greater injury severity means, at $p \leq 0.05$, than injury severity means for the years of 2004 (μ = 1.29), 2005 (μ = 1.24), and 2006 (μ = 1.15). Injury severity means for the years of 1996 (μ = 1.35), 1997 (μ = 1.35), 2003 (μ = 1.34) and 2000 (μ = 1.33) were significantly greater, at p ≤ 0.05, than the injury severity means associated with the years of 2005 and 2006. The years of 1998 (μ = 1.32), 1999 (μ = 1.30), 2004, and 2005each had a significantly greater injury severity mean than that for 2006.

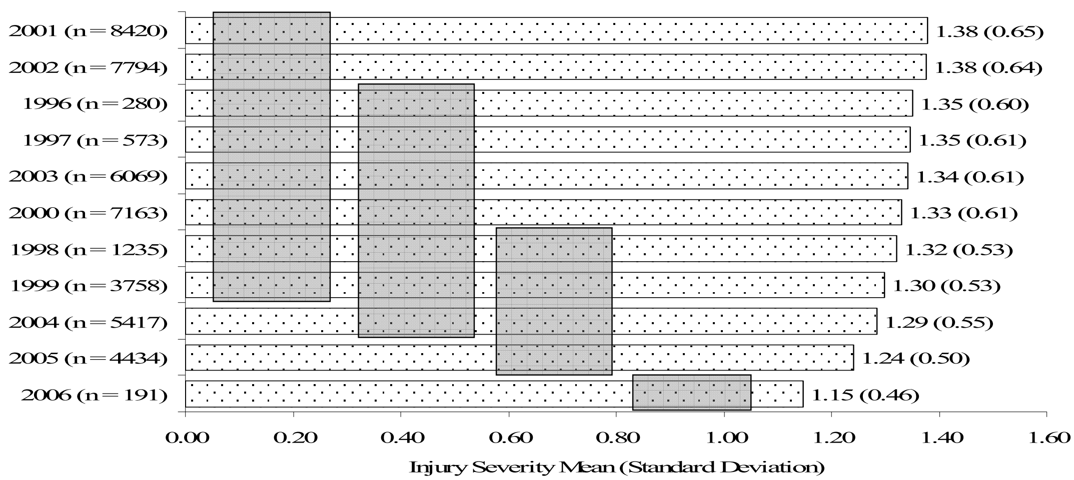

Figure 4- 69. Comparison of injury severity means by year of occurrence.

Between the years of 2001 and 2006 there appeared to be a downward trend in the severity of injuries. The results of a Kendall's *tau* test for correlation between injury severity and the year of the injury of 2001 through 2005 indicated a slight, though significant, at $p \leq 0.01$, correlation of -0.04.

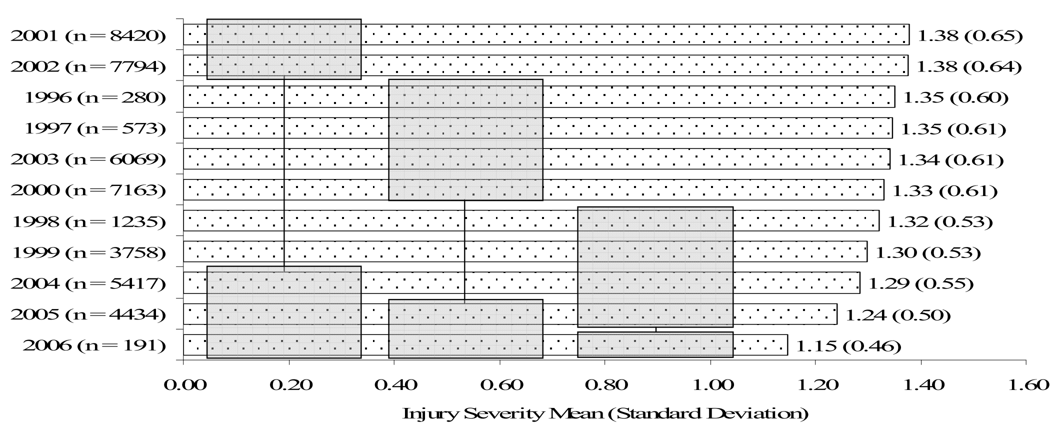

Figure 4- 70. Differences of injury severity means between years of occurrence.

Month of Occurrence of Injury

The month the injured occurred on was made available for 46,056 workers. Table 4- 48 displays the distribution of the injuries by month of the year in which the injury occurred. Information regarding the month of the injury was provided for 46,056 worker injuries. Between eight and 10 % of the injuries occurred in each of the months of August (n = 4,473), October (n = 4,421), July (n = 4,330), September (n = 4,080), June (n = 3,983), May (n = 3,824), March (n = 3,778), and April (n = 3,701). Less than eight % of the injuries were represented within the coldest months of November (n = 3,577), January (n = 3,516), December (n = 3,208), and February (n = 3,165).

Table 4- 48. Month of injury.

Month of injury	Number of injuries	%	Cumulative %
August	4,473	9.71%	9.71%
October	4,421	9.60%	19.31%
July	4,330	9.40%	28.71%
September	4,080	8.86%	37.57%
June	3,983	8.65%	46.22%
May	3,824	8.30%	54.52%
March	3,778	8.20%	62.72%
April	3,701	8.04%	70.76%
November	3,577	7.77%	78.53%
January	3,516	7.63%	86.16%
December	3,208	6.97%	93.13%
February	3,165	6.87%	100.00%
Total	46,056	100.00%	

A comparison of the injury severity means was conducted for the months of injury occurrence. The results of the Levene test of homogeneity of injury severity score variances for the years of injury did not allow for the assumption of equal variances, L (10, 45,364) = 3.43, $p < .001$. Subsequently, the Welch robust test of equality of injury severity means was conducted to detect possible differences of injury severity means, significant at $p \leq 0.05$, for the months of injury occurrence. The results of this test did not show any significant difference of injury severity means between the months, F (11, 17,594.90) = 1.41, $p > 0.10$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 71).

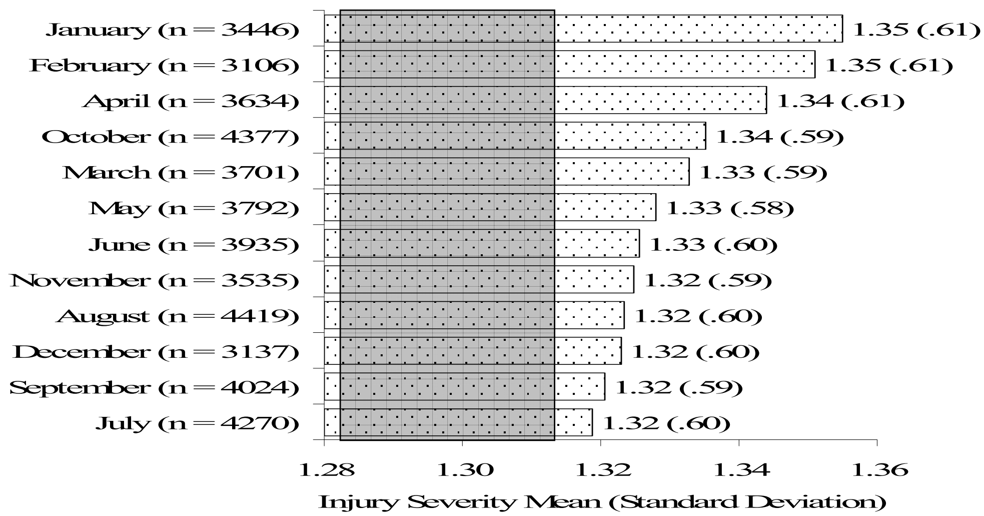

Figure 4- 71. Comparison of injury severity means by month of injury occurrence.

Day of the Week of Occurrence of Injury

The day of the week on which the injury was recorded to have occurred was provided for 46,056 workers. Table 4- 49 displays the distribution of injuries for the days of the week in which the injury occurred. Information regarding the day of the week of injury occurrence was provided for 46,056 worker injuries. Almost 19% of the injuries occurred on Tuesdays (n = 8,885), Wednesdays (n = 8,745), Mondays (n = 8,693), and Thursdays (n = 8,678). Less than 17% of the injuries occurred on Fridays (n = 7,740). Just over 5% of the injuries occurred on Saturdays (n = 2,440) while Sundays (n = 875) were associated with less than 2% of the injuries.

A comparison of the injury severity means was conducted for the reported days of the week on which the injuries occurred. The results of the Levene test of homogeneity of injury score variances between the years of the injury did not allow for the assumption of equal variances, L (6, 45,369) = 12.33, $p < .001$. Subsequently, the Welch robust test of equality of injury severity means was conducted to detect possible differences of injury severity means, significant at $p \leq 0.05$, between the days of the week. The results of this test showed that at least one of the days of the week had a significantly different injury severity mean than one or more of the other days, F (6, 8,474.06) = 4.013, $p \leq .001$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 72).

Table 4- 49. Day of the week of injury.

Day of the week of injury	Number of injuries	%	Cumulative %
Tuesday	8,885	19.29%	19.29%
Wednesday	8,745	18.99%	38.28%
Monday	8,693	18.87%	57.15%
Thursday	8,678	18.84%	75.99%
Friday	7,740	16.81%	92.80%
Saturday	2,440	5.30%	98.10%
Sunday	875	1.90%	100.00%
Total	46,056	100.00%	

Injuries occurring on Saturdays ($\mu = 1.37$) or Sundays ($\mu = 1.37$) had the highest injury severity mean ($\mu = 1.37$). These were followed by injuries on Fridays or Mondays ($\mu = 1.34$). Injuries occurring on Tuesdays, Thursdays and Wednesdays had the lowest injury severity means, $\mu = 1.32$).

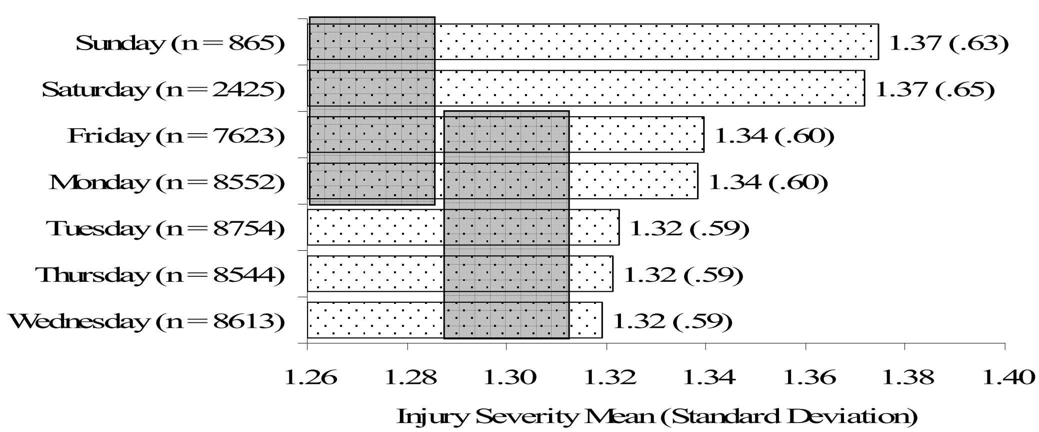

Figure 4- 72. Comparison of injury severity means by day of the week of injury occurrence.

Results for significant injury severity mean differences, at $p \leq 0.05$, by "Day of the week of occurrence" the results were discerned and are dislpayed in Figure 4- 73. The injury severity means associated with injuries occurring on Sundays ($\mu = 1.37$) or Saturdays ($\mu = 1.37$) had significantly greater injury severity means, at $p \leq 0.05$, than injury severity means for injuries occurring on Tuesdays (μ = 1.32), Thursdays (μ = 1.32), or Wednesdays (μ = 1.32).

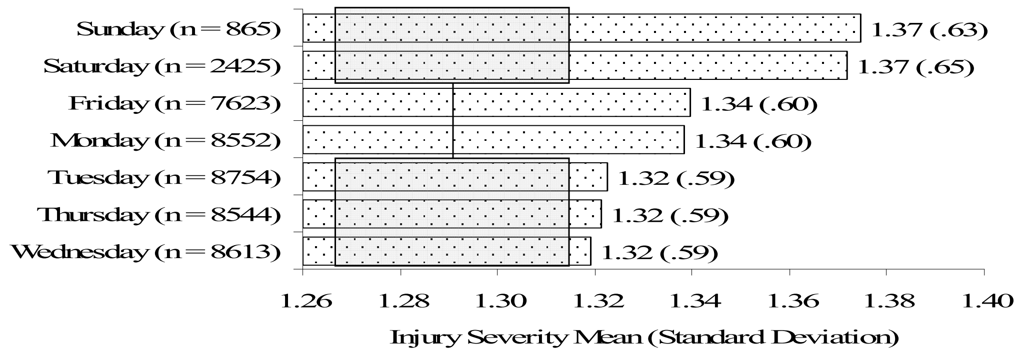

Figure 4- 73. Differences of injury severity means between days of the week of injury occurrence.

Injury Profiles by Body Region

Body Region

Information regarding the "Body region" directly impacted by the loss event was provided for 45,966 worker injuries. Table 4- 50 shows the distribution of injuries for the six body regions directly impacted by injuries. Upper extremity injuries (n = 13,152, 28.61%), injuries to the trunk (n = 11,646, 25.34%) and injuries to the lower extremities (n = 9,196, σ = 20.01%) accounted for over 70% of the total number of injuries. As an aggregate, injuries to the head (n = 7,539), neck (n = 985), and to multiple body parts or body systems (n = 3,448) were just over 25% of the injuries.

Table 4- 50. Body region injured.

Body region	Number of injuries	%	Cumulative %
Upper extremities	13,152	28.61%	28.61%
Trunk	11,646	25.34%	53.95%
Lower extremities	9,196	20.01%	73.95%
Head	7,539	16.40%	90.35%
MBRBS*	3,448	7.50%	97.85%
Neck	985	2.14%	100.00%
Total	45,966	100.00%	

*Multiple body regions or body systems

The severity of injuries associated with each of the body regions was examined by comparing injury severity means between the six categories. The results of the Levene test for homogeneity of variances did not allow for the assumption of equal variances of injury severity scores for the six body regions, L (5, 45,285) = 1257.86, $p < 0.001$. The results of the subsequent Welch test showed that at least one of the body regions had a significantly different injury severity mean than one or more of the other five regions, F (5, 7,664.22) = 531.46, $p < 0.001$. This was confirmed by the results of Tukey's b range test (see Figure 4- 74).

Neck injuries had the highest injury severity mean (μ = 1.48). Multiple body part injuries or injuries to body systems ranked second (μ = 1.47). This was followed by trunk injuries (μ = 1.44), injuries to the lower extremities (μ = 1.40), and upper extremities (μ = 1.26). Head injuries reflected the lowest injury severity mean, μ = 1.11. Specific significantly different injury severity means, at $p \leq 0.05$, were discerned from Figure 4- and displayed in Figure 4- 75.

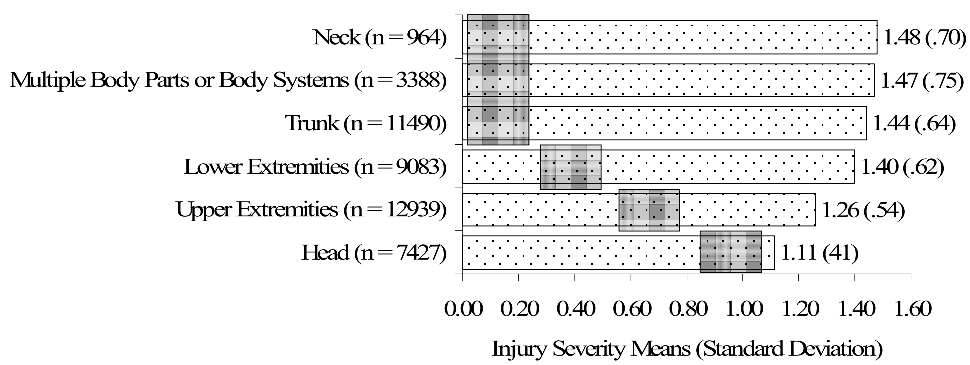

Figure 4- 74. Comparison of injury severity means by body region..

At the significance level of $p \leq 0.05$, injuries to the neck, multiple body parts or body systems, and to the trunk had significantly higher injury severity means than injuries to the lower and upper extremities and injuries to the head (see Figure 4- 75). Injuries to the lower extremities had a significantly greater injury severity mean, at $p \leq 0.05$, than injuries to the upper extremities and head injuries. Injuries to the lower extremities were significantly more severe, at $p \leq 0.05$, than head injuries.

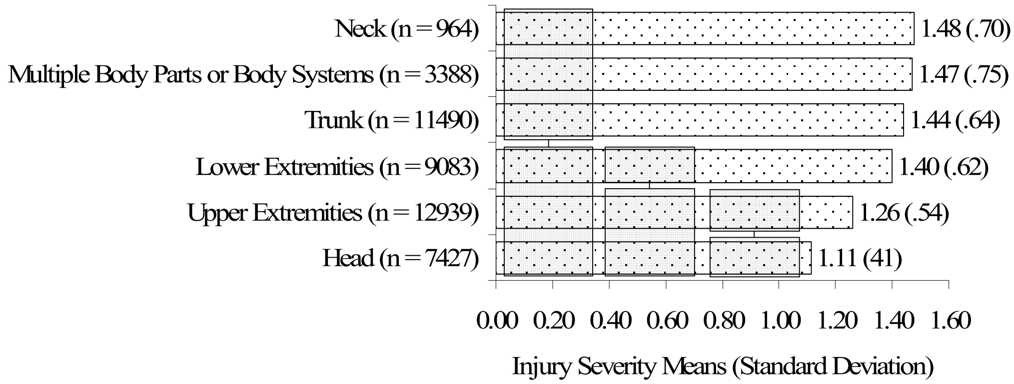

Figure 4- 75. Differences of injury severity means between body regions.

Body Region and Age

Even though age is not a cause of injury, it can be used as an approximate measure of human limitations and behaviors, including exposure to more or less risky activities that result in conditions that affect vulnerability of various body regions and body parts. Age often indicates differential risk that can be used to target injury control efforts. Possible associations of age with the body regions that were injured were examined. Information regarding age and the body region affected by the injury was provided for 14,909 worker injuries. Since equal variances of injury severity scores could not be assumed, L (5, 14,903) = 2.55, $p < 0.03$, a Welch robust test of the equality was conducted of mean age for the six body region groups. The results of this test showed that at least one of the body regions displayed a mean age that was significantly different from one or more of the other groups, F (5, 2,576.46) = 10.97, $p < 0.001$.This was confirmed by the results of the Tukey's range test which were significant at $p \leq 0.05$ (see Figure 4- 76).

Neck injuries reflected the highest mean age (μ = 38.56), followed by injuries to the trunk (μ = 38.30), multiple body part or body system injuries (μ = 38.22), injuries to the lower extremities (μ = 38.04), and upper extremities (μ = 37.00). Head injuries were associated with the lowest mea age, μ = 36.67).

From the Tukey's b test it was determined that, as a group, individuals who experienced either neck injuries and injuries to the trunk had significantly greater, at $p \leq 0.05$, mean ages than did workers who had injuries to either the upper extremities and to the head. Injuries to the lower extremities had a significantly lower, at $p \leq 0.05$, mean age than those with head injuries (see Figure 4– 77).

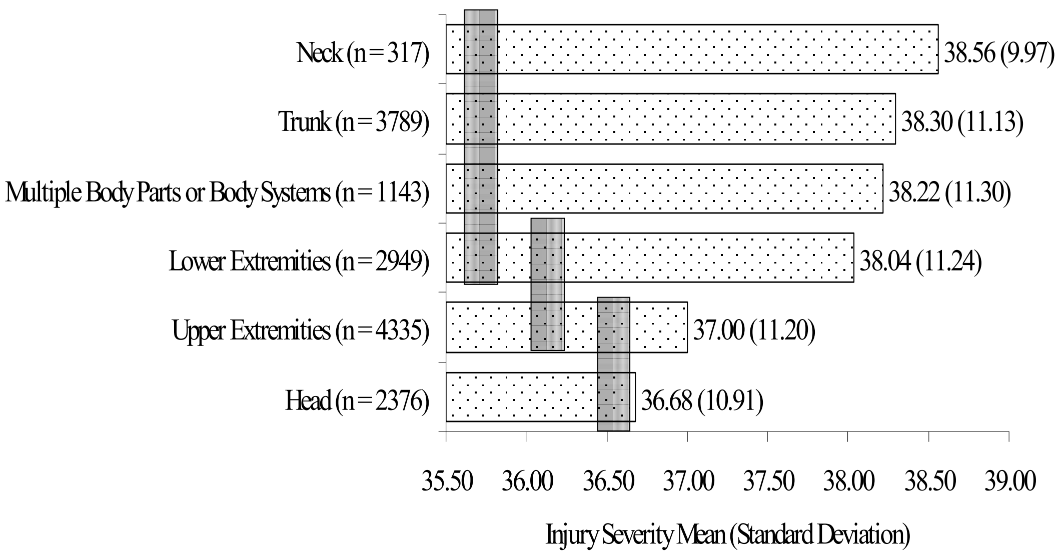

Figure 4- 76. Mean age by injured body region.

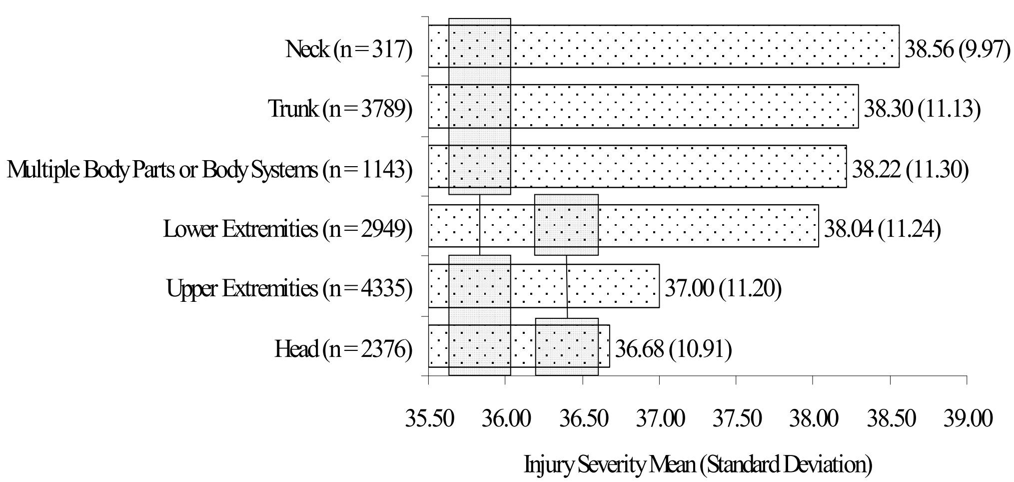

Figure 4- 77. Difference of mean ages between injured body regions.

Experience Level

Information pertaining to the occupational experience level of the injured worker by body region was made available for 14,374 injuries. Table 4- 51 and Table 4- 52 display the ranking of the body regions, according to relative frequency within their "General Occupational Experience" groups, for both field based personnel and administrative based personnel, respectively. Laborers, apprentices, journeymen, and foremen have similar ranking profiles among the field based personnel. Each show injuries to the upper extremities as the most frequent within their respective occupational level, followed by injuries to the trunk, lower extremities, head injuries, injuries to multiple body parts or body systems, and finally, neck injuries (see Table 4- 51). Among helper or assistant level workers, head injuries ranked third, followed by injuries to the lower extremities and neck injuries. Field supervisory personnel showed injuries to the lower extremities as ranking second, behind upper extremities, in frequency of injury and trunk injuries ranked third.

Table 4- 52 shows that among administrative workers, injuries to the trunk, upper extremities, and lower extremities ranked closely in first, second, and third positions. Professional level workers, such as professional engineers and project managers, showed injuries to lower extremities, trunk, and upper extremities as ranking first, second, and third, respectively. For both administrative based personnel groups, head injuries, injuries to multiple body parts or body systems, and neck injuries, ranked fourth, fifth, and sixth, respectively.

Laborers

Information regarding the injury distribution by body region was provided for 7,913 in injured laborers (see Table 4- 53). Among laborers, injuries to the upper extremities (n = 2,240, 28.31%), trunk (n = 2,147, 27.13%), and lower extremities (n = 1,784, 22.55%) clearly exceeded

Table 4- 51. Ranking of injured body regions by injury distribution for occupational experience level among field based personnel.

Overall	Rank	Field Personnel					
		Laborers N = 7913	Helpers/ assistants N = 752	Apprentices N = 1,576	Journeymen N = 1,538	Foremen N = 1,449	Field Supervisors N = 612
UE* n = 4,182 29.09%	1	UE n = 2,246 28.31%	UE n = 216 28.72%	UE n = 560 35.53%	UE n = 426 31.37%	UE n = 416 28.71%	UE n = 166 27.12%
T n = 3,823 26.60%	2	T n = 2,147 27.13%	T n = 194 25.80%	T n = 365 23.16%	T n = 377 27.76%	T n = 407 28.09%	LE n = 163 26.63%
LE n = 3,169 22.05%	3	LE n = 1784 22.55%	H n = 142 18.88%	LE n = 299 18.97%	LE n = 272 20.03%	LE n = 337 23.26%	T n = 149 24.35%
H n = 1,996 13.89%	4	H n = 1,044 13.19%	LE n = 138 18.35%	H n = 259 16.43%	H n = 187 13.77%	H n = 181 12.49%	H n = 78 12.75%
MBP/BS n = 897 6.24%	5	MBP/BS n = 541 6.84%	MBP/BS n = 48 6.38%	MBP/BS n = 57 3.62%	MBP/BS n = 59 4.34%	MBP/BS n = 79 5.45%	MBP/BS n = 39 6.37%
NK n = 307 2.14%	6	NK n = 157 1.98%	NK n = 14 1.86%	NK n = 365 2.28%	NK n = 37 2.72%	NK n = 29 2.00%	NK n = 17 2.78%

*NK = Neck, UE = Upper Extremities, T = Trunk, LE = Lower Extremities, H = Head, MBPS/BS = Multiple Body Systems, Parts/Body

Table 4- 52. Ranking of injured body regions by injury distribution for occupational experience level among administrative based personnel.

Overall	Rank	Administrative & Professional Personnel	
		Administrative N = 448	Professional N = 752
UE* n = 4,182 29.09%	1	T n = 114 25.45%	LE n = 71 26.69%
T n = 3,823 26.60%	2	UE n = 108 24.11%	T n = 70 26.32%
LE n = 3,169 22.05%	3	LE n = 105 23.44%	UE n = 50 18.80%
H n = 1,996 13.89%	4	H n = 69 15.40%	H n = 36 13.53%
MBP/BS n = 897 6.24%	5	MBP/BS n = 44 9.82%	MBP/BS n = 30 11.28%
NK n = 307 2.14%	6	NK n = 8 1.79%	NK n = 9 3.38%

*NK = Neck, UE = Upper Extremities, T = Trunk, LE = Lower Extremities, H = Head, MBPS/BS = Multiple Body Systems, Parts/Body injuries to the head (n = 1,044, 1,044, 13.19%), multiple body parts or body systems (n = 541, 6.84%), and neck (n = 157, 1.98%).

The injury severity was examined for the six body regions for laborers. The results of the Levene test for homogeneity of variances of the injury severity scores did not allow for the assumption of equal injury severity score variances for the six body regions for laborers, L (5, 7,829) = 188.07, $p < 0.001$. The Welch test statistic subsequently showed that, among laborers, at least one of the body regions had a significantly different injury severity mean of one or more of the other body regions, F (5, 1,237.04) = 63.93, $p < 0.001$. This was confirmed by the Tukey's b range test which compared individual injury severity means, for each of the body regions.

The results of the Tukey's b range test are reflected in Figure 4- 78 and Figure 4- 79. Figure 4- 78 shows the homogeneous groupings of injury severity means for the six body regions. Among laborers, injuries to the neck had the highest injury severity mean ($\mu = 1.57$), followed by multiple body parts or body systems injuries ($\mu = 1.57$), injuries to the trunk region ($\mu = 1.50$), lower extremities ($\mu = 1.45$), and upper extremities ($\mu = 1.27$). Head injuries among laborers showed the lowest injury severity mean ($\mu = 1.13$).

Table 4- 53. Injuries to laborers by body region.

Body region	Number of injuries	%	Cumulative %
Upper extremities	2,240	28.31%	28.31%
Trunk	2,147	27.13%	55.44%
Lower extremities	1,784	22.55%	77.99%
Head	1,044	13.19%	91.18%
MBRBS*	541	6.84%	98.02%
Neck	157	1.98%	100.00%
Total	7,913	100.00%	

* MBRBS = Multiple body regions or body systems.

Figure 4- 79 shows the means that are significantly different, at $p \leq 0.05$, of each other. Among laborers, injuries to the neck had a significantly higher, at $p \leq 0.05$, injury severity mean (μ =

1.57) than all of the other body regions, except that of multiple body injuries (μ = 1.50). Multiple body part injuries showed a significantly greater injury severity mean, at $p \leq 0.05$, than

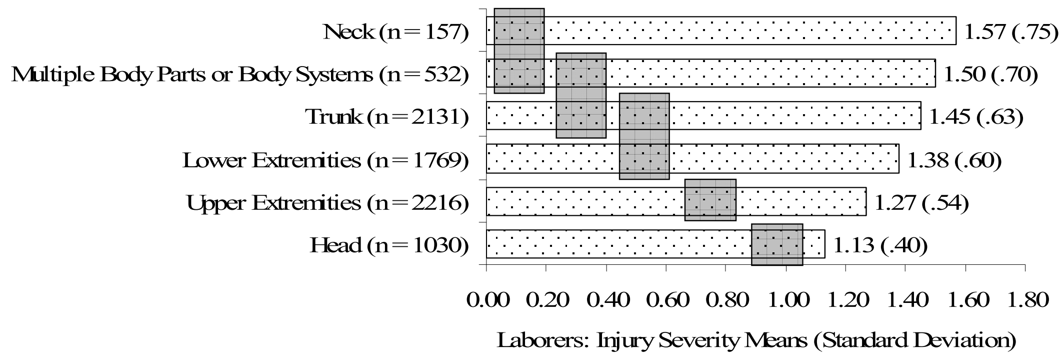

Figure 4- 78. Comparison of injury severity means by body region for laborers.

injuries to lower extremities (μ = 1.38), upper extremities (μ = 1.27) and head injuries (μ = 1.13). Injuries to the trunk (μ = 1.45) and lower extremities each had a significantly greater injury severity mean, at $p \leq 0.05$, than injuries to the upper extremities, and head injuries. Injuries to the upper extremities of laborers had a significantly greater injury severity mean, $p \leq 0.05$, than head injuries among laborers.

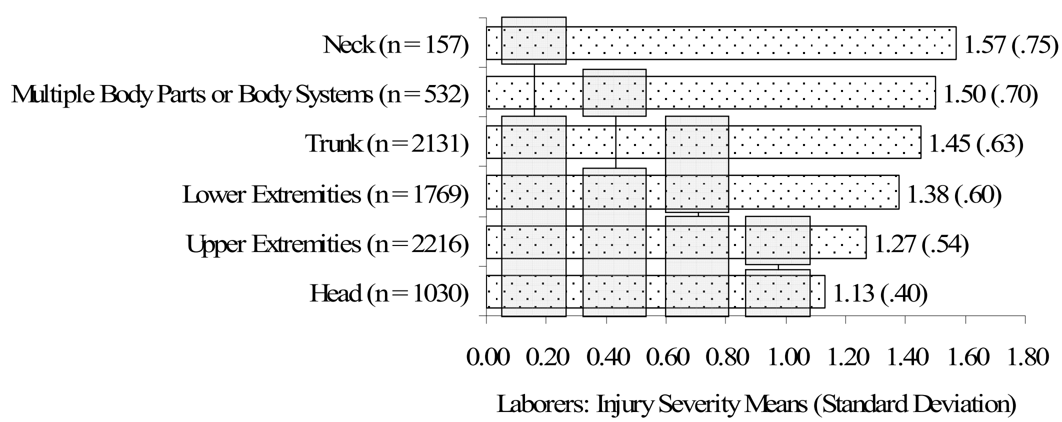

Figure 4- 79. Differences of mean ages between body regions for laborers.

Helpers/Assistants

Information regarding the body region affected by the injury was provided for 752 workers identified at the helper or assistant “Experience Level.” As shown in Table 4- 54, helpers and assistants had a similar to injury profile to that of laborers. Among helpers and assistants, injuries to the upper extremities (n = 215, 28.72%) and trunk (n = 194, 25.80%) comprised over 50% of the total number of injuries experienced by helpers or assistants. However, head injuries comprised a greater proportion of the injuries to helpers or assistants than to laborers. Head injuries (n = 142, 18.88%) and injuries to lower extremities (n = 138, 18.35%), ranked a virtual tie for the third most injured body region experienced by helpers or assistants. Injuries to multiple body or body systems accounted for 6.38% (n = 48) of the injuries recorded for workers at the helper or assistant experience level. Neck injuries accounted for less 2% (n = 14) of injuries to helpers or assistants.

Table 4- 54. Injuries to helpers and assistants by body region.

Body region	Number of injuries	%	Cumulative %
Upper extremities	216	28.72%	28.72%
Trunk	194	25.80%	54.52%
Head	142	18.88%	73.40%
Lower extremities	138	18.35%	91.75%
MBRBS*	48	6.38%	98.13%
Neck	14	1.86%	100.00%
Total	752	100.00%	

* MBRBS = Multiple body regions or body systems.

The injury severity was examined for the six body regions among injuries to helper/assistants. The results of the Levene test for homogeneity of variances of the injury severity scores did not allow for the assumption of equal variances, L (5, 732) = 24.40, $p <$ 0.001. Subsequently, the results of a Welch test of the equality of the injury severity means for the body regions for helpers or assistants showed that at least one of the body region categories had a significantly different injury severity mean than one or more of the other body regions, F (5, 100.31) = 11.33, $p < .001$. Figure 4 – 80 shows the results of the Tukey’s b range test and confirms the results of the Welch test. The two homogeneous groupings of injury severity means for body regions suggests that for helpers or assistants a statistically significant difference, at $p \leq 0.05$, of injury severity means exists between these groups.

The results of the Tukey's b range test (see Figure 4- 80) shows that the most severe injuries among helpers or assistants were injuries sustained by multiple body parts or upon body systems (μ = 1.50). This was followed by, as a homogeneous subset in descending order of severity, injuries to the trunk (μ = 1.41), lower extremities (μ = 1.39), neck (μ = 1.31), upper extremities (μ = 1.22), and head (μ = 1.10).

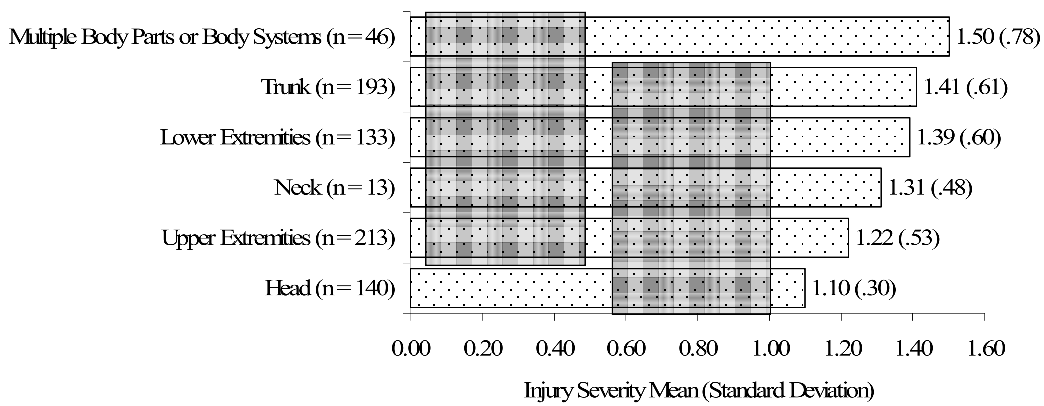

Figure 4- 80. Comparison of injury severity means by body region injuries to helpers and assistants.

Figure 4- 81 shows that, among helpers or assistants, injuries to multiple body parts or body regions had a significantly greater, at $p \leq 0.05$, injury severity mean than head injuries.

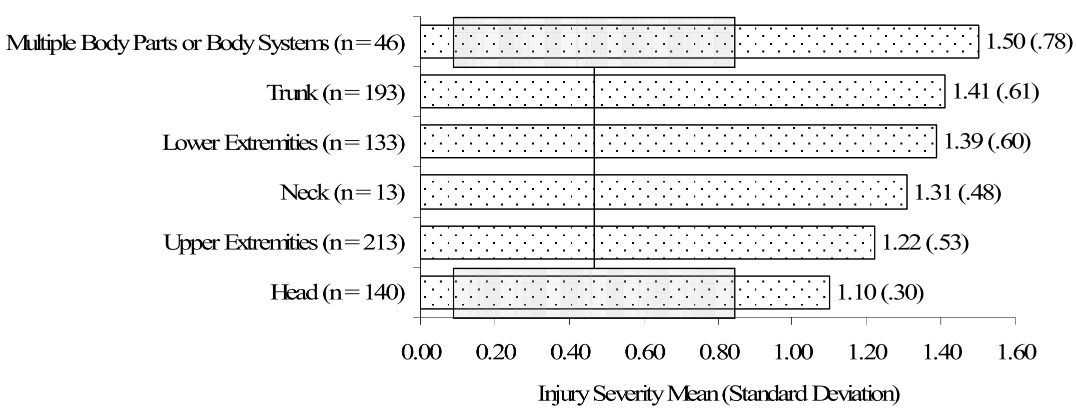

Figure 4- 81. Differences of injury severity means between body regions injured among helpers and assistants.

Apprentice

Among apprentice level workers, information regarding injuries to the six body regions was provided for 1,576 worker injuries. As a group, apprentices experienced a higher proportion of injuries to the upper extremities (n = 560, 35.53%) than any of the other general occupational experience groups. Injuries to the upper extremities comprised over 35% of the injuries to apprentices (see Table 4- 55). In descending percentages, over 58% of the injuries to apprentices were comprised of injuries to the trunk (n = 365, 23.16%), lower extremities (n = 299, 18.97%) and to the head (n = 259, 16.43%). Less than 4% of the injuries to apprentice level workers were injuries to multiple body parts or body systems (n = 57, 3.62%), while just over 2% of the injuries were to the neck (n = 36, 2.28%).

Table 4- 55. Injuries to body regions among apprentices.

Body region	Number of injuries	%	Cumulative %
Upper extremities	560	35.53%	35.53%
Trunk	365	23.16%	58.69%
Lower extremities	299	18.97%	77.66%
Head	259	16.43%	94.10%
MBRBS	57	3.62%	97.71%
Neck	36	2.28%	100.00%
Total	1,576	100.00%	

* MBRBS = Multiple body regions or body systems.

The injury severity was examined for the six body regions among apprentices. The results of the Levene test for homogeneity of variances of the injury severity scores did not allow for the assumption of equal variances, L (5, 1,559) = 43.85, $p < 0.001$. The results of the subsequent Welch test for the equality of injury severity means showed a greater between body region difference than within body region difference for apprentices, F (5, 220.07) = 16.24, $p < 0.001$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 82).

The Tukey's b range test was conducted to examine the specific distribution of injury severity means for the six body region groups for apprentice level workers. Figure 4- 82 identifies homogeneous groups, whose injury severity means are not different at a statistically significant level of $p \leq 0.05$. Three discreet homogeneous groups suggest that several of the body regions among apprentice level workers have significantly different injury severity means, at $p \leq 0.05$, than one of the other body regions. Among apprentices injuries to multiple body parts or body systems had the highest injury severity mean ($\mu = 1.64$). This was followed by trunk injuries ($\mu = 1.43$), neck injuries ($\mu = 1.37$), injuries to the lower extremities ($\mu = 1.37$), and injuries to the upper extremities ($\mu = 1.25$). Head injuries among apprentices had the lowest injury severity mean ($\mu = 1.11$).

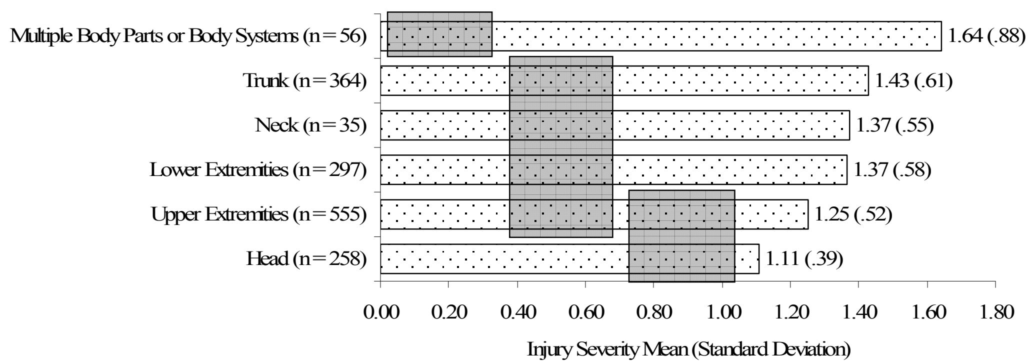

Figure 4- 82. Comparison of injury severity means by body regions injured among apprentices.

Among apprentice level workers, injuries to multiple body parts or body systems had a significantly greater injury severity mean, at $p \leq 0.05$, than injuries to all the remaining body regions (see Figure 4- 83). Injuries to the trunk, neck, and the lower extremities, showed a significantly greater injury severity mean, at $p \leq 0.05$, than that for injuries to the head.

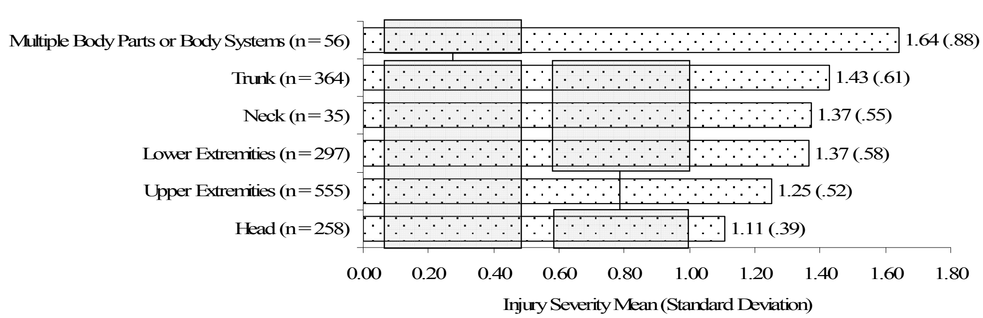

Figure 4- 83. Differences of injury severity means between body regions among apprentices.

Journeymen

Information for journeyman level workers regarding injuries for the six body regions was provided for 1,358 workers (see Table 4- 56). Over 30% of the injuries to journeymen were injuries to the upper extremities (n = 426, 31.37%). Injuries to the trunk (n = 377, 27.76%) and lower extremities (n = 272, 20.03%) combined to account for over 47% of the total number of injuries to journeymen. Injuries to neck comprised the lowest percentage (n = 37, 2.72%) of injuries to journeymen. Head injuries accounted for just over 13% (n = 187) of the injuries to journeymen. Slightly more than four % of the injuries to journeymen were multiple body part or body systems injuries (n = 59).

Table 4- 56. Injuries to journeymen by body region.

Body region	Number of injuries	%	Cumulative %
Upper extremities	426	31.37%	31.37%
Trunk	377	27.76%	59.13%
Lower extremities	272	20.03%	79.16%
Head	187	13.77%	92.93%
MBRBS*	59	4.34%	97.28%
Neck	37	2.72%	100.00%
Total	1,358	100.00%	

* MBRBS = Multiple body regions or body systems.

Injury severity was examined for the six body regions among journeymen. The results of the Levene test for homogeneity of variances of the injury severity scores would not allow for the assumption of equal variances, L (5, 1,344) = 54.61, $p \leq 0.001$. The results of the Welch robust test of equality of injury severity means for the six regions showed a greater between body region difference than within body region difference in injury severity means for journeymen, F (5, 226.63) = 21.09, $p \leq 0.001$. This was confirmed by the results of the Tukey's b range test.

The Tukey's b range test was conducted to examine the specific distribution of injury severity means for the six body region groups for journeymen. Figure 4- 84 identifies the Tukey's b homogeneous subsets, in which injury severity means are not significantly different at

$p \leq .0.05$. Figure 4 – 84 shows the groupings which showed significantly different injury severity means, at $p \leq 0.05$. Among journeymen, injuries to multiple body parts had the highest injury severity mean ($\mu = 1.79$). Trunk injuries constituted the second highest injury severity mean ($\mu = 1.50$), followed by injuries to the lower extremities ($\mu = 1.49$), neck ($\mu = 1.38$), and upper extremities ($\mu = 1.30$). Head injuries had the lowest injury severity mean among journeymen, $\mu = 1.09$).

Among journeymen, injuries to multiple body parts or body systems had a significantly greater, at $p \leq 0.05$, injury severity mean, than injuries to the trunk, lower extremities, neck, upper extremities, and head injuries (see Figure 4- 85). Injuries to the trunk, lower extremities, neck, and upper extremities showed significantly greater injury severity means, at $p \leq 0.05$, than head injuries among journeymen

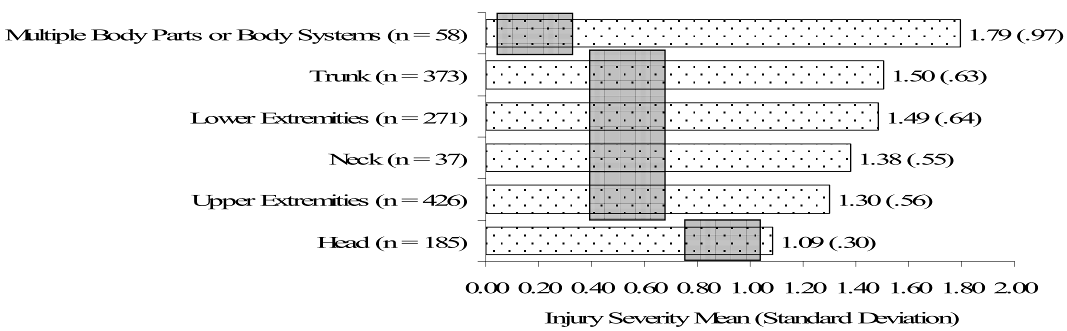

Figure 4- 84. Comparison of injury severity means by body region among journeymen.).

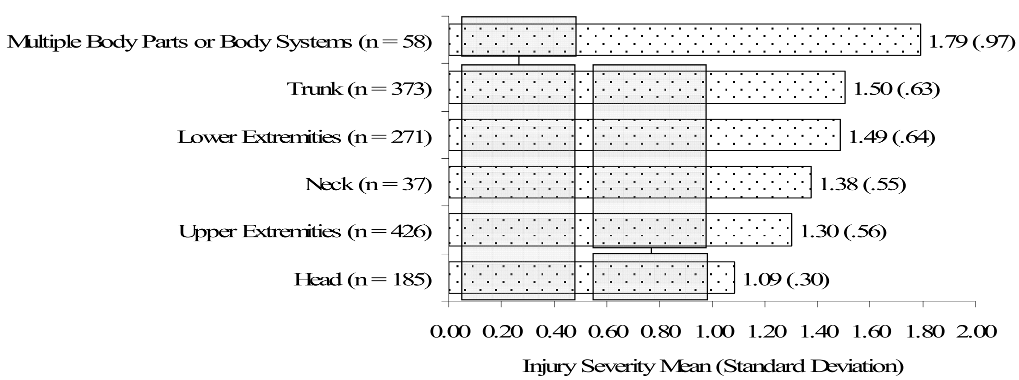

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Figure 4- 85. Differences of injury severity means between body regions among journeymen.

Foreman

Information pertaining to injuries associated with the body regions affected by the injury was provided for 1,449 foreman level workers (see Table 4- 57). Among foremen, injuries to the upper extremities (n = 416) and to the trunk (n = 407) accounted for over 28% of the injuries, each. Injuries to the lower extremities accounted for just over 23% (n = 337) of the injuries to foremen. Slightly over 12% of the injuries to foremen were head injuries. Injuries to multiple body parts or body systems (n = 79) and neck injuries (n = 29) combined to account for slightly less than eight % of the injuries to foremen.

Table 4- 57. Injuries to foremen by body region.

Body region	Number of injuries	%	Cumulative %
Upper extremities	416	28.71%	28.71%
Trunk	407	28.09%	56.80%
Lower extremities	337	23.26%	80.06%
Head	181	12.49%	92.55%
MBRBS*	79	5.45%	98.00%
Neck	29	2.00%	100.00%
Total	1,449	100.00%	

* MBRBS = Multiple body regions or body systems.

Injury severity relative to the six body regions was examined by using statistics which compared injury severity means for the body regions among foremen. The results of the Levene test of homogeneity of variances of injury severity scores for the six body regions did not allow for an assumption of equal variances, L (5, 1,428) = 32.76, $p < 0.001$. The results of the subsequent Welch test of equality of injury severity means indicated that, among foremen, at least one of the body regions had a significantly different injury severity mean than one of the other regions, F (5, 211.14) = 13.69, $p < 0.001$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 86 and Figure 4- 87).

The results of the Tukey's b range test are shown in Figure 4- 86. Two homogeneous subsets of injury severity means were identified. Among foremen, injuries to lower extremities had the highest injury severity mean (μ = 1.48) followed by injuries to the neck (μ = 1.45), multiple body parts or body systems injuries (μ = 1.43), injuries to the trunk (μ = 1.41), and upper extremities (μ = 1.26). Head injuries showed the lowest injury severity mean (μ = 1.12) among foremen

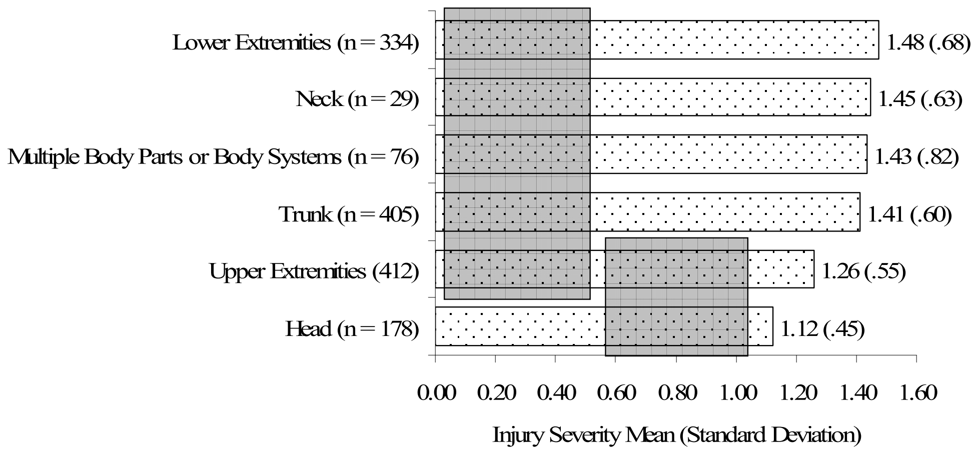

Figure 4- 86. Comparison of injury severity means by body region among foremen.

From the arrangement of the homogeneous subsets in Figure 4- 86, it was discerned that, among foremen, injuries to the lower extremities, neck, multiple body parts or body regions, and trunk each had a significantly greater injury severity mean, at $p \leq 0.05$, than that of head injuries (see Figure 4- 87).

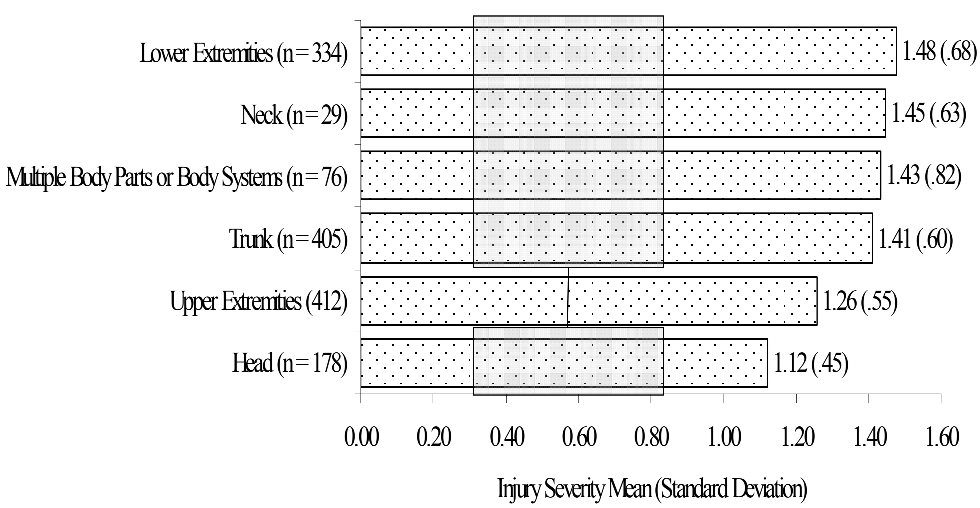

Figure 4- 87. Differences of injury severity means between body region injuries to foremen.

Field Supervision

Field supervision level workers were those who were not specifically identified as foremen, but could be identified as acting in a supervisory capacity on the jobsite. This group included superintendents, assistant superintendents, project managers, and field engineers. Table 4- 58 shows that injuries to the upper extremities (n = 166), lower extremities (n = 163), and trunk (n = 149) each accounted for around 25% of the injuries to field supervisors. Head injuries (n = 78) occurred to almost 13% of field supervisors, neck injuries (n = 17), and injuries to multiple body parts or body systems combined for less than ten % of the injuries.

Table 4- 58. Injuries to field supervisors by body region.

Body region	Number of injuries	%	Cumulative %
Upper extremities	166	27.12%	27.12%
Lower extremities	163	26.63%	53.75%
Trunk	149	24.35%	78.10%
Head	78	12.75%	90.85%
MBRBS*	39	6.37%	97.22%
Neck	17	2.78%	100.00%
Total	612	100.00%	

* MBRBS = Multiple body regions or body systems.

Injury severity was examined for the six body regions for field supervisory level workers. The results of the Levene test for homogeneity of variances of the injury severity scores did not allow for the assumption of equal variances, L (5, 595) = 5.30, $p < 0.001$. The results of the Welch test of equality of injury severity means for the body regions showed that at least one of the body regions had a significantly different injury severity mean than one or more of the other body regions among field supervisors, F (5, 110.25) = 2.50, $p < .04$. This result was not confirmed by the Tukey's range test, significant at $p \leq 0.05$.

The homogeneous subsets generated by the Tukey's b range test are displayed in Figure 4- 88. The results showed that none of the body regions had a significantly different injury severity mean, at $p \leq 0.05$, than any of the other body regions. For field supervisors, injuries to multiple body parts showed the highest injury severity mean (μ = 1.49), followed by injuries to lower extremities (μ = 1.36), head injuries (μ = 1.32), injuries to the trunk (μ = 1.30), and upper extremities injuries (μ = 1.20, and neck injuries (μ = 1.19).

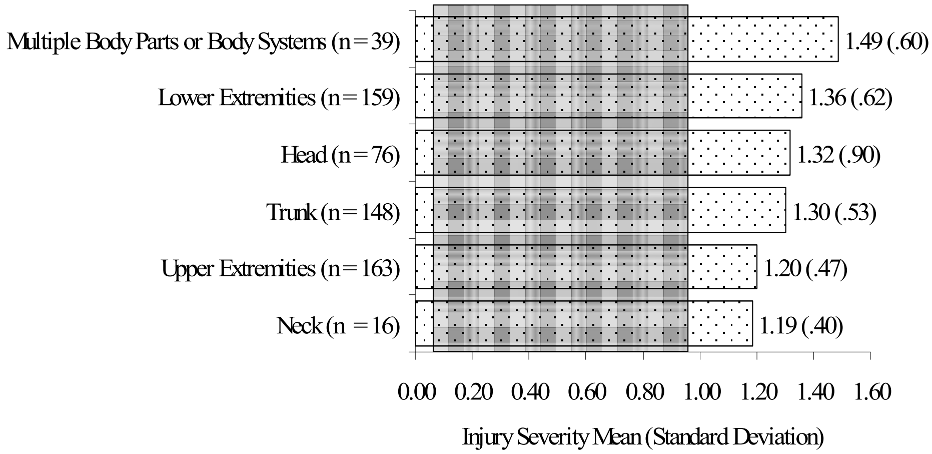

Figure 4- 88. Comparison of injury severity means by body region among field supervisors.

Professional

Professional level workers included professional engineers (n = 121) and inspectors (n = 144). Among 266 injured professional level workers, injuries to the lower extremities and to the trunk, each accounted for over 26% of the injuries to professional level workers (see Table 4-59). Upper extremities injuries accounted for over 18% of the injuries, and injuries to head comprised over 13% of the injuries to professional level workers. Over 11% of the injuries to professionals were to multiple body parts or body systems, with less than 4% being neck injuries.

Table 4- 59. Injuries to professionals by body region.

Body region	Number of injuries	%	Cumulative %
Lower extremities	71	26.69%	26.69%
Trunk	70	26.32%	53.01%
Upper extremities	50	18.80%	71.80%
Head	36	13.53%	85.34%
MBRBS*	30	11.28%	96.61%
Neck	9	3.38%	100.00%
Total	266	100.00%	

* MBRBS = Multiple body regions or body systems.

The results of the Levene test for homogeneity of variances of the injury severity scores did not allow for the assumption of equal variances, L (5, 258) = 8.14, $p < 0.01$. The results of the subsequent Welch robust test of equality of injury severity means showed a greater between body region group difference than within body region group difference in injury severity means among professional level workers, F (5, 54.34) = 3.41, $p < 0.01$.

The Tukey's b range test was conducted to rank the six body regions injured among professionals according to their respective injury severity means. Figure 4- 89 shows that among professionals neck injuries had the highest injury severity mean ($\mu = 1.63$). With an injury severity mean of $\mu = 1.53$, injuries to multiple body parts or body regions ranked second among injuries to professionals. This was followed by injuries to the lower extremities ($\mu = 1.35$), trunk ($\mu = 1.35$), upper extremities ($\mu = 1.18$), and head injuries ($\mu = 1.11$).

From the arrangement of the homogeneous subsets shown in Figure 4- 89, it was determined that there were significantly different injury severity means between the six body region groups, at $p \leq 0.05$ (see Figure 4- 90). Neck injuries had a significantly greater injury severity mean, at $p \leq 0.05$, than injuries to the upper extremities and head.

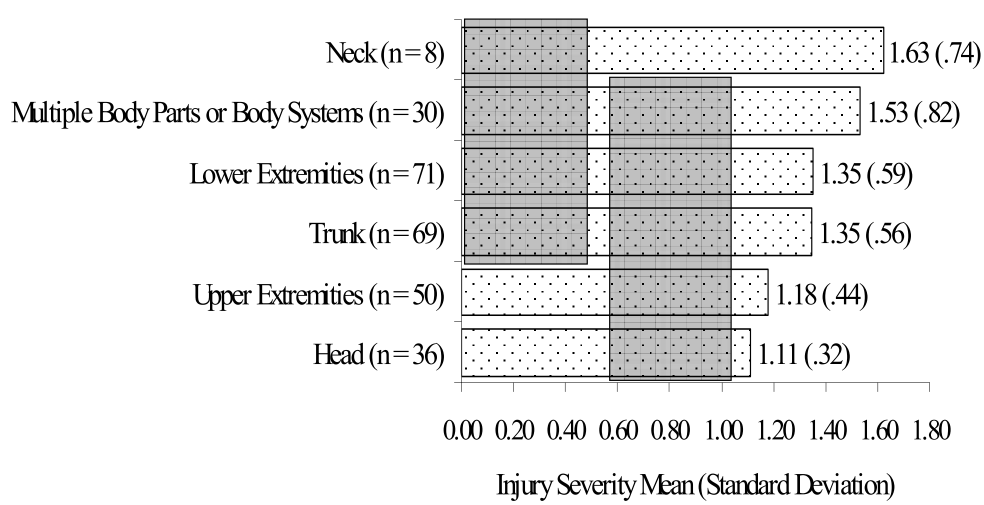

Figure 4- 89. Comparison of injury severity means by body region among professionals.

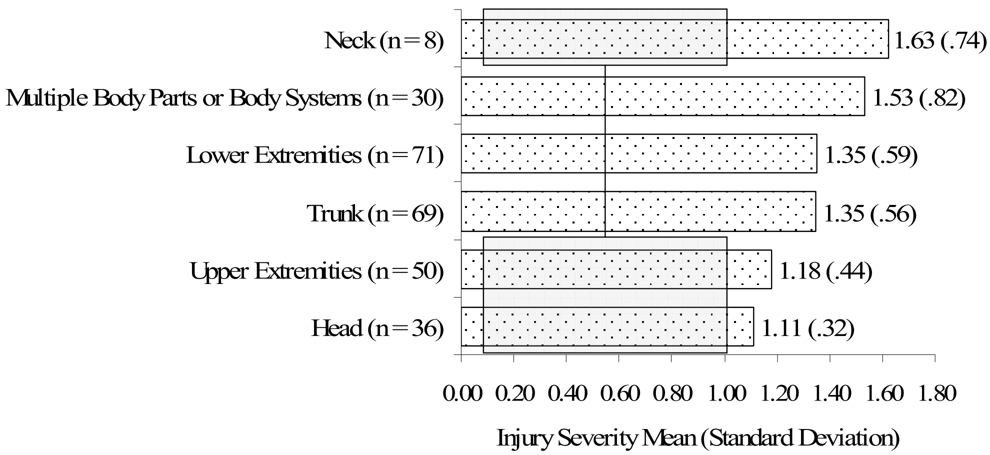

Figure 4- 90. Differences of injury severity means between body regions among professionals.

Administrative

Administrative level workers (n = 448) included clerical workers (n = 253) and managers (n = 195). Table 4- 60 shows slightly over 25% (n = 114) of the injuries to administrative level workers were to the trunk. Injuries to lower extremities accounted for over 24% (n = 108) of the injuries, followed by 23% (n = 105) injuries to the lower extremities, and 15% (n = 69) of the injuries to the head. Injuries to multiple body parts (n = 44) and neck injuries (n = 4) accounted for slightly more than 11% of the injuries to administrative level workers.

Table 4- 60. Injuries to field administrative level workers by body region.

Body region	Number of injuries	%	Cumulative %
Trunk	114	25.45%	25.45%
Upper extremities	108	24.11%	49.56%
Lower extremities	105	23.44%	72.99%
Head	69	15.40%	88.40%
MBRBS*	44	9.82%	98.22%
Neck	8	1.79%	100.00%
Total	448	100.00%	

* MBRBS = Multiple body regions or body systems.

The results of the Levene test for homogeneity of variances of the injury severity scores did not allow for the assumption of equal variances, L (5, 436) = 7.13, $p < 0.01$. The Welch test was conducted to examine if there was a statistically significant difference in injury severity means between the six body regions for injuries to administrative level workers. The results of this test showed at least one of the body regions displayed an injury severity mean that was significantly different from another body region for administrative level workers, $F(5, 54.75) = 2.90$, $p < 0.03$.

The Tukey's b range test was conducted to identify the specific distribution of injury severity means between the six body region groups for administrative level workers (see Figure 4- 91). Injuries to the neck had the highest injury severity mean ($\mu = 1.57$), followed by injuries to multiple body parts or body systems ($\mu = 1.41$), trunk ($\mu = 1.35$), head ($\mu = 1.28$), lower extremities ($\mu = 1.20$), and upper extremities ($\mu = 1.12$). No specific differences, significant at $p \leq 0.05$, in injury severity means between the body regions among administrative level workers were found.

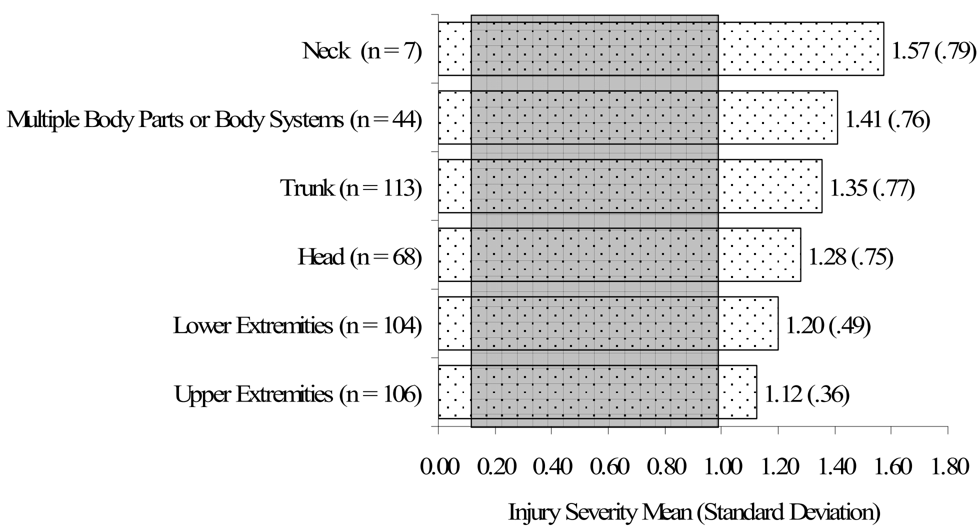

Figure 4- 91. Comparison of injury severity means by body region among administrative workers.

Head Injuries

Body Part

Information regarding head injuries by specific body parts injured was provided for 7,539 worker injuries. Table 4- 61shows that eye injuries constituted over 60% (n = 4,776) of all head injuries. Soft tissue injuries, which pertain primarily to cuts or bruises to areas such as the check, scalp, eyebrows and forehead, accounted for almost 18% of the head injuries (n = 1,342). Injuries to the mouth (n = 327) accounted for slightly less than five % of the head injuries while injuries to the teeth (n = 279), ears (n = 252), and nose (n = 199) each comprised around three % of all the head injuries. Facial bone injuries (n = 145), multiple head injuries (n = 91), skull injuries (n = 91), and injuries to the brain (n = 37) combined to account for less than five % of the head injuries.

A comparison of injury means was conducted between the ten body parts. An assumption of equal variances of injury scores could not be made for the ten body parts for head injuries, L (9, 7,417) = 187.27, $p < 0.001$. The results of the subsequent Welch test of equality of injury severity means showed that, among head injuries, at least one of the body parts had a significantly different injury severity mean than one of the other body parts, F (9, 451.63) = 32.41, $p < 0.001$. This was confirmed by the results of the Tukey's b range test (see Figure 4-92).

Table 4- 61. Head injuries by body part.

Body region	Number of injuries	%	Cumulative %
Eye	4,776	63.35%	63.35%
Soft tissue	1,342	17.80%	81.15%
Mouth	327	4.34%	85.49%
Teeth	279	3.70%	89.19%
Ear	252	3.34%	92.53%
Nose	199	2.64%	95.17%
Facial bones	145	1.92%	97.09%
Multiple injuries	91	1.21%	98.30%
Skull	91	1.21%	99.51%
Brain	37	0.49%	100.00%
Total	7,539	100.00%	

The rankings of body parts for head injuries by their descending injury severity mean magnitudes are shown in Figure 4- 92. Brain injuries had the highest injury severity mean (μ =

2.22), followed by multiple head injuries (μ = 1.64), injuries to the skull (μ = 1.33), facial bones (μ = 1.28), ears (μ = 1.24), and soft tissue injuries (μ = 1.22). Injuries to the nose had the seventh largest injury severity mean (μ = 1.18), followed by injuries directly impacting the teeth (μ = 1.11), and mouth (μ = 1.11). Eye injuries showed the lowest injury severity mean (μ = 1.05).

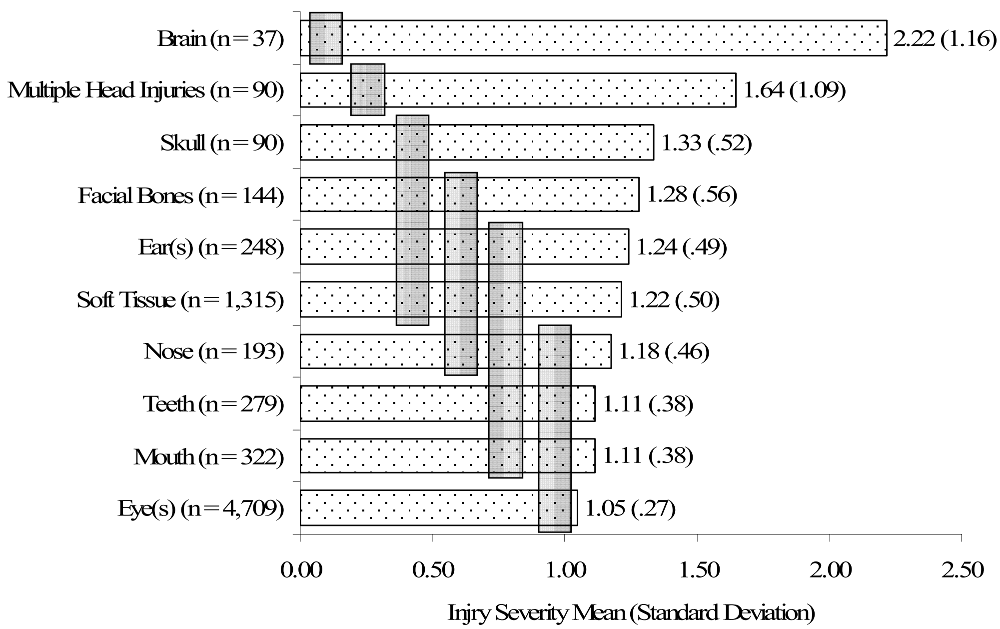

Figure 4- 92. Comparison of injury severity means by body part of head.

From the homogeneous subsets of injury severity means for each of the body parts for head injuries, specific differences in injury severity means, significant at $p \leq 0.05$, were discerned between the body parts among head injuries (seeFigure 4- 93). Among head injuries, brain injuries showed a significantly greater injury severity mean, at $p \leq 0.05$, than all of the remaining nine body parts. Multiple head injuries had a significantly greater injury severity mean, at $p \leq 0.05$, than skull injuries, injuries to the facial bones, ears, soft tissue, nose, teeth, mouth, and eyes. Skull injuries had a greater injury severity mean than injuries to the nose, teeth, mouth and eyes. Facial bone injuries showed a significantly higher injury severity mean, $p \leq 0.05$, than injuries directly impacting the teeth, eyes, and mouth. Ear injuries and soft tissue injuries each had significantly greater injury severity means, $p \leq 0.05$, than eye injuries.

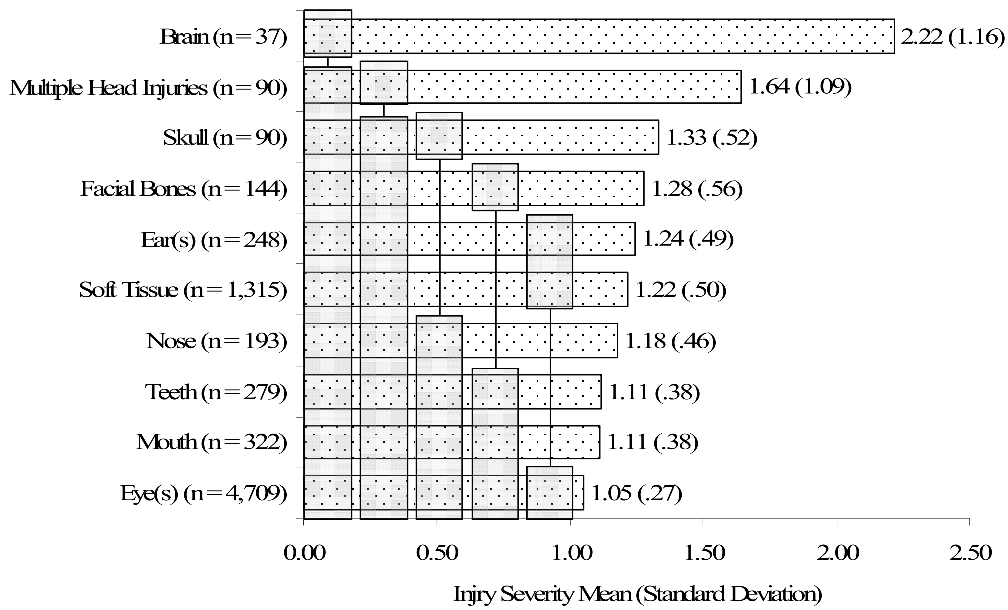

Figure 4- 93. Differences of injury severity means between injured body parts of the head.

Nature of Injury

Information regarding the nature of head injuries was provided for 7,010 worker injuries. As Table 4- 62 shows, a Foreign body was the nature of the head injury for almost 54% (n = 3,781) of these cases. Lacerations (n = 1,259) accounted for just under 18% of the head injuries. Contusion (n = 623) accounted for almost nine % of the head injury cases. Inflammations (n = 329), burns (n = 310), and fractures (n = 299), accounted for nearly 5 % of the injuries to the head. Injury frequencies among the 21 remaining nature of injury categories combined to represent slightly more than five % of the head injuries. These included the following: punctures (n = 79), concussions (n = 60), hearing loss or impairment (n = 55), infections (n = 45), strains (n = 36), enucleations (n = 28), multiple head injuries (n = 25), dermatitis (n = 15), other occupational diseases not otherwise classified (NOC) (n= 13), respiratory disorders (n= 11), crushing (n = 7), dislocations (n = 7), mental stress or mental disorders (n = 7), sprains (n = 5), electric shocks (n = 4), general poisoning (n = 3), ruptures (n = 3), heat prostration (n = 2), chemical poisoning (n = 2), severance (n = 1), and syncope (n = 1).

Table 4- 62. Nature of head injuries.

Nature of injury	Number of injuries	%	Cumulative %
Foreign body	3,781	53.94%	53.94%
Laceration	1,259	17.96%	71.90%
Contusion	623	8.89%	80.79%
Inflammation	329	4.69%	85.48%
Burn	310	4.42%	89.90%
Fracture	299	4.27%	94.17%
Puncture	79	1.13%	95.30%
Concussion	60	0.86%	96.15%
Hearing loss or impairment	55	0.78%	96.94%
Infection	45	0.64%	97.58%
Strain	36	0.51%	98.09%
Enucleation	28	0.40%	98.49%
Multiple Injuries	25	0.36%	98.85%
Dermatitis	15	0.21%	99.06%
Occupational disease NOC	13	0.19%	99.25%
Respiratory disorder	11	0.16%	99.40%
Crushing	7	0.10%	99.50%
Dislocation	7	0.10%	99.60%
Mental stress/disorder	7	0.10%	99.70%
Sprain	5	0.07%	99.77%
Electric Shock	4	0.06%	99.83%
Poisoning NOC	3	0.04%	99.87%
Rupture	3	0.04%	99.92%
Heat prostration	2	0.03%	99.95%
Chemical poisoning	2	0.03%	99.97%
Severance	1	0.01%	99.99%
Syncope	1	0.01%	100.00%
Total	7,010	100.00%	

A comparison of the injury severity means for head injuries was made between the "Nature of Injury" classifications. The results of Levene test of homogeneity of severity scores between the nature of injury for head injuries did not allow for an assumption of equal variances, L (24, 6,883) = 66.44, $p < 0.001$. Because syncope injuries and severance injuries to the head had only one case each and each had a zero injury severity score variance, the Welch robust test of equality of injury severity means for head injuries between "Nature of Injury" groups could not be performed. The results of an ANOVA test did suggest that at least one of the "Nature of Injury" groups had a significantly different severity mean than one of the other classifications, $F(24, 6{,}883) = 31.90$, $p < 0.001$. When syncope and severance injuries were excluded, because of the inability to analyze frequencies fewer than two cases, the results of the Tukey's b range test confirmed the results of the ANOVA test.

The results of the Tukey's b range test are shown in Figure 4- 94. Crushing head injuries had the highest injury severity mean ($\mu = 2.86$) among the head injuries. This was followed by mental stress and mental disorders ($\mu = 1.86$), sprains ($\mu = 1.80$), ruptures ($\mu = 1.67$), hearing loss or impairment ($\mu = 1.64$), concussions ($\mu = 1.61$), multiple injuries ($\mu = 1.54$), chemical poisoning ($\mu = 1.50$), heat prostration ($\mu = 1.50$), and strains ($\mu = 1.31$). The injury severity means declined steadily among the remaining nature of injury categories, ending with a severity of 1.00 for general poisoning.

Severance and syncope injuries to the head each had a single case, thus were not included in the Tukey's range test. The severance injury had a severity score of two, equivalent to a temporary injury, while the case of syncope was reported at level three, corresponding to a permanent partial disability of some type. The remaining 25 "Nature of Injury" groups were compared using the Tukey's b range test (see Figure 4- 95). Among the head injuries, crushing injuries had a significantly higher severity mean, at $p \leq 0.05$, than all of the other "Nature of Injury" groups. Mental stress or mental disorders showed a significantly greater injury severity mean, at $p \leq 0.05$, than head injuries from electric shock, fractures, contusions, punctures, respiratory disorders, lacerations, burns, infections, other occupational diseases NOC, inflammation, dermatitis, foreign body, and general poisoning. Sprains had significantly greater injury severity mean, at $p \leq 0.05$, than the same classifications as mental stress and mental disorders, except electric shocks and fractures. Rupture injuries to the head had a significantly greater severity mean, at $p \leq 0.05$, than head injuries involving a Foreign body and general poisoning. Hearing loss or impairments showed a significantly greater severity mean, at $p \leq 0.05$, than head injuries of general poisoning.

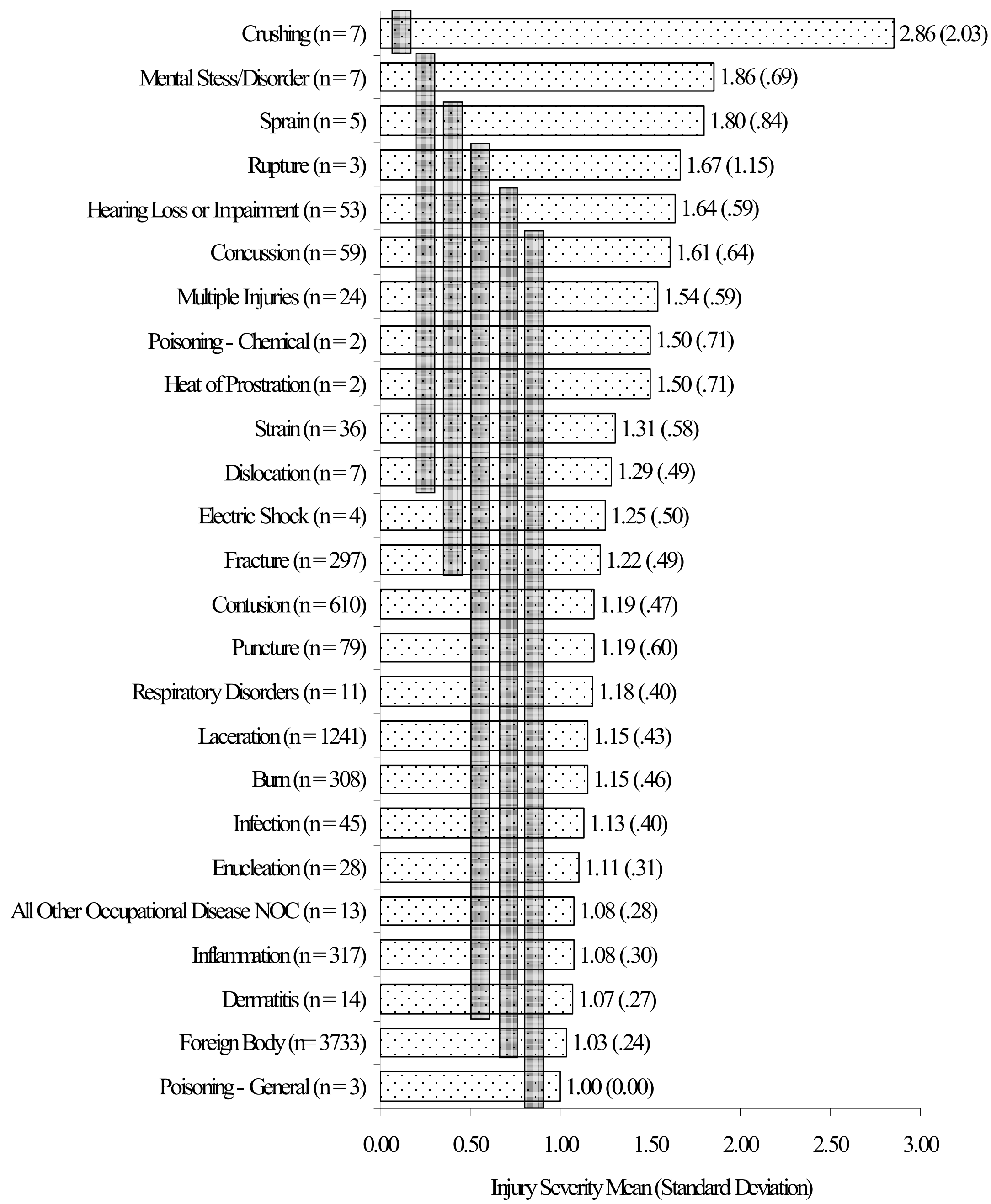

Figure 4- 94. Comparison of injury severity means by nature of injury to the head.

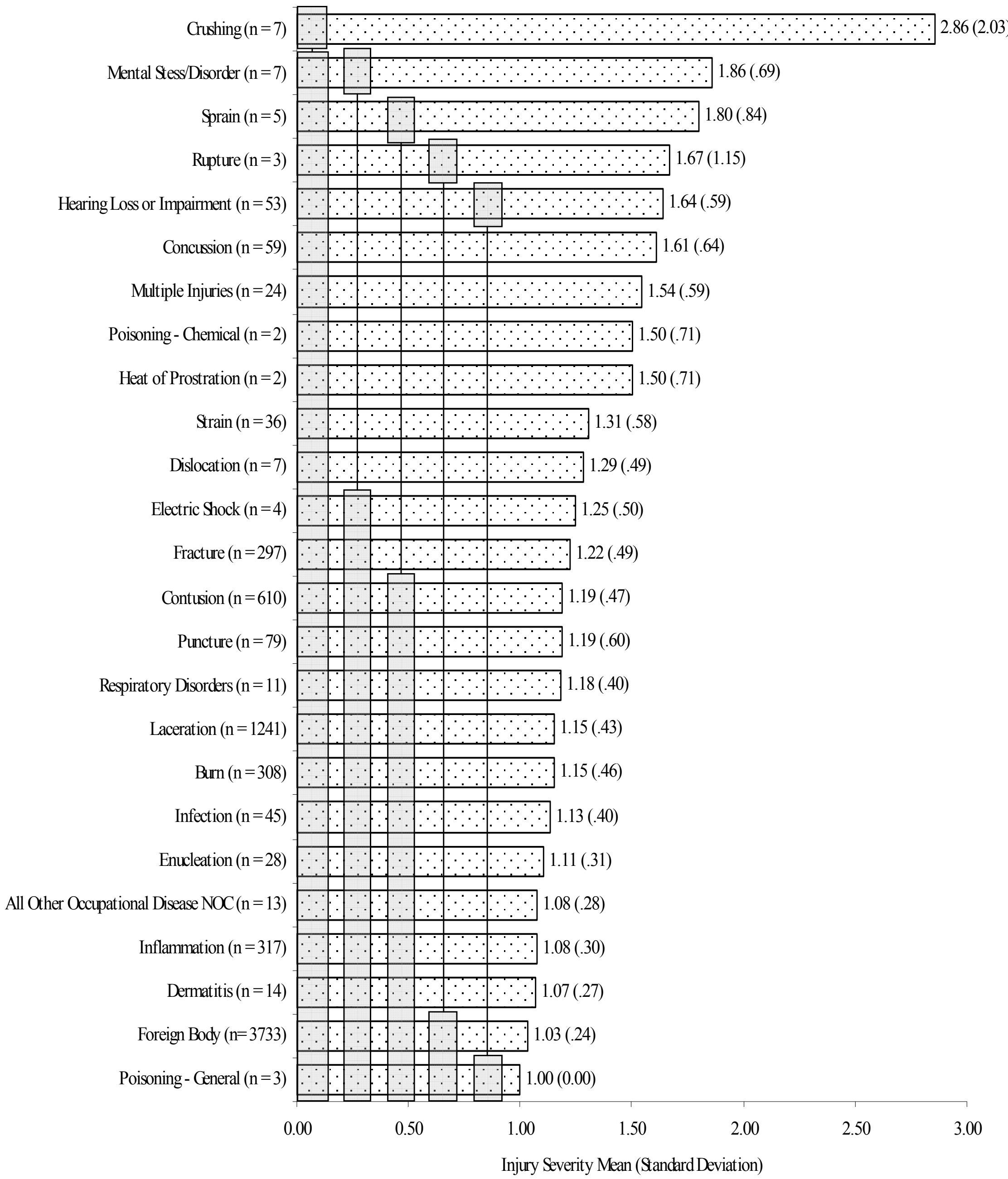

Figure 4- 95. Differences of injury severity by nature of head injury.

General Cause of Injury

Information regarding the general cause of head injuries was provided for 7,226 worker injuries. Table 4- 62 shows that foreign matter in the eyes (n = 4,064) was attributed as the general cause of the injury for over 56% of the head injuries. Being struck by an object (n =

1,433) was sited as the general cause of nearly 20% of the head injuries, while striking against or stepping on an object accounted for 6% of the injuries. Each of the remaining eight causes of injuries accounted for less than 5% of the head injuries.

Table 4- 62. Head injuries by general cause of injury.

General cause of injury	Number of injuries	%	Cumulative %
Foreign matter	4,064	56.24%	56.24%
Struck by	1,433	19.83%	76.07%
Striling against or stepping on	467	6.46%	82.53%
Fall or slip	357	4.94%	87.47%
Cut, puncture, or scrape	279	3.86%	91.34%
Burn or Scald	277	3.83%	95.17%
Absorption, ingestion or inhalation	123	1.70%	96.87%
Strain	76	1.05%	97.92%
Animal or insect bite or sting	76	1.05%	98.97%
Motor vehicle	42	0.58%	99.56%
Caught in or between	32	0.44%	100.00%
Total	7,226	100.00%	

The results following tests conducted to compare the head injury severity means for the different general causes of injury are shown in Figure 4- 96 and Figure 4- 97. The results of the Levene test of homogeneity of head injury score variances between the general causes of injury did not allow an assumption of equal variances, L (10, 7,110) = 152.60, $p < 0.001$. Subsequently, the Welch test was performed to examine the equality of head injury severity means between general causes of injury. The results of this test showed that at least one of the general causes of injury had a significantly different severity mean than one of the other general causes of injury, F (10, 382.41) = 27.51, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

Rankings of the general causes of head injury by their respective severity means generated of the Tukey's b range test are displayed in Figure 4- 96. Head injuries of being Caught in or between an object or objects had the highest severity mean ($\mu = 1.41$), followed falls or slips ($\mu = 1.38$), and events involving a motor vehicle ($\mu = 1.37$). Among the eleven causes of head injuries, head injuries involving strains had the fourth highest severity mean ($\mu = 1.22$), followed by being struck by an object (μ = 1.19), having struck against or stepped on an object (μ = 1.18), and being burned or scalded (μ = 1.16), cut, punctured or scraped (μ = 1.09), and being bitten by an animal or insect (μ = 1.08). The remaining causes were associated with injury severity means of less than 1.10.

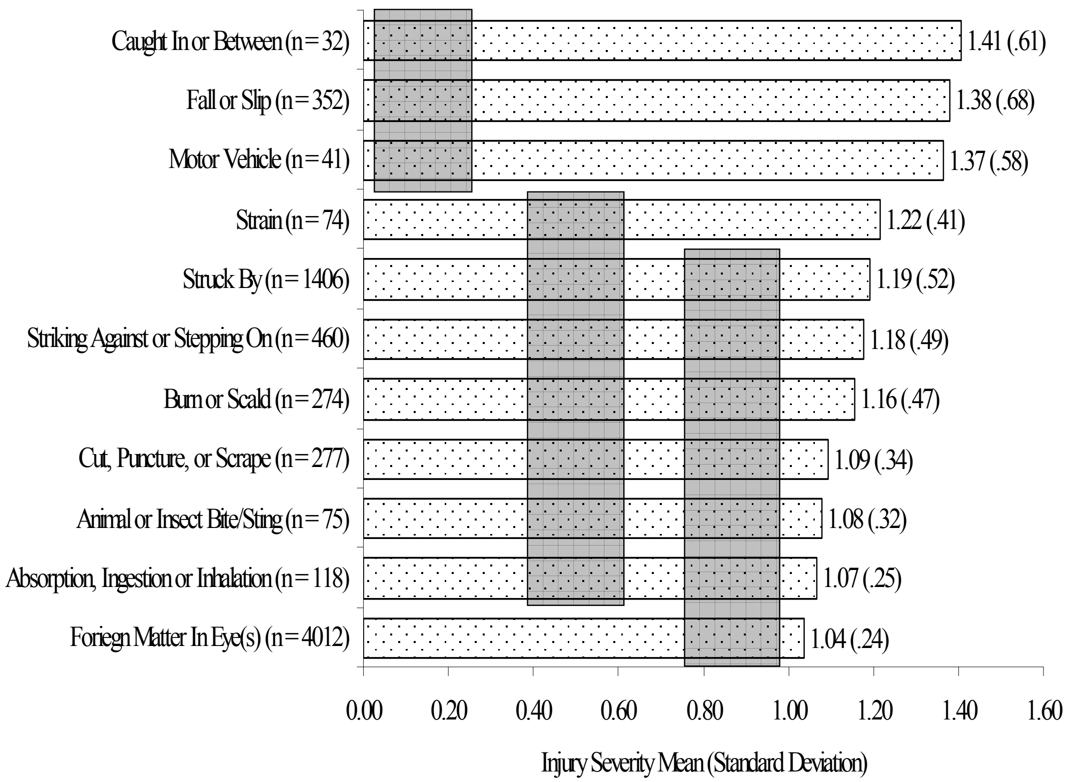

Figure 4- 96. Comparison of injury severity means by general cause of head injury.

A further examination of the homogeneous severity mean groupings of head injuries by general causes of injuries identified the specific difference of severity means, significant at $p \leq 0.05$, between the twelve general causes of injury. The results of the assessment are displayed in Figure 4- 97. Head injuries caused by being Caught in or between an object, falling or slipping, and a motor vehicle had a significantly greater, at $p \leq 0.05$, severity mean for head injuries than all of the remaining causes of injury. Head injuries caused by some type of straining activity had a significantly higher injury severity mean, at $p \leq 0.05$, than head injuries caused by foreign matter in the eyes.

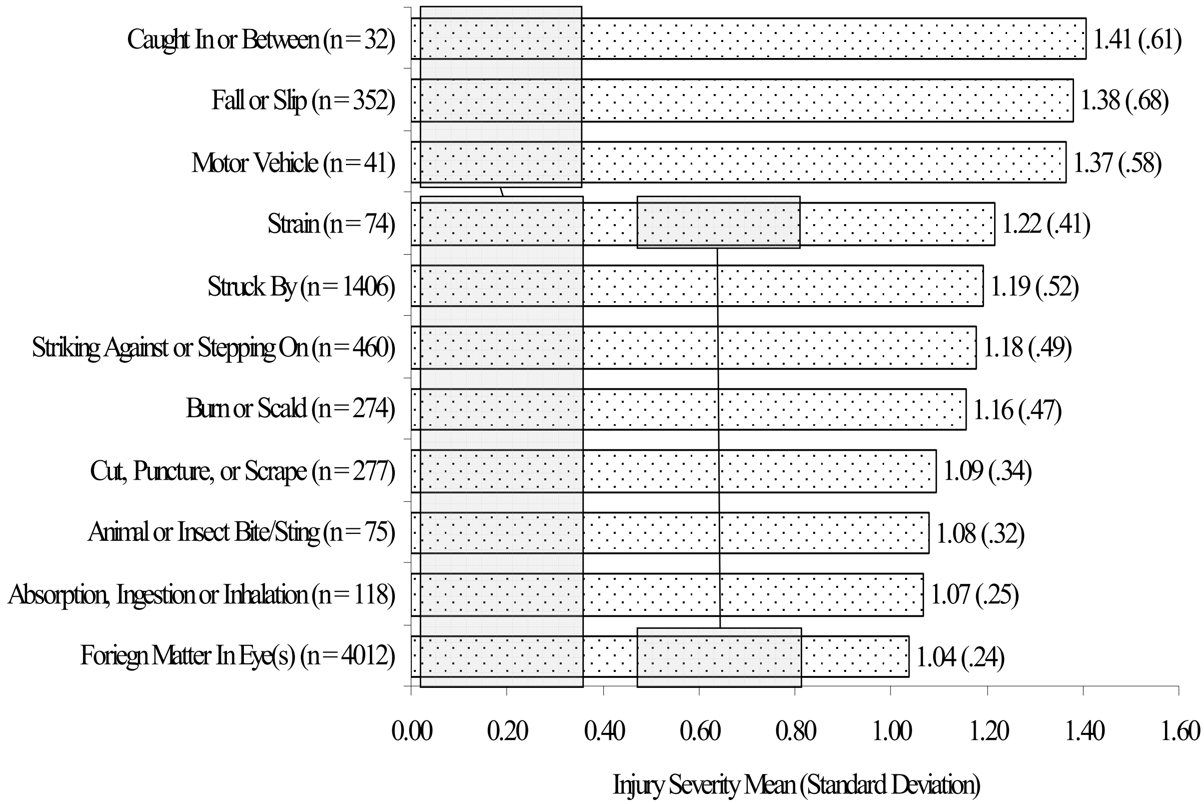

Figure 4- 97. Differences of injury severity means between the general causes of head injury.

Occupational Work Area

Head injuries were examined by the workers' occupational work areas at the time of the injury. Head injury by occupational work area information was provided for 6,019 injuries (see Table 4- 63). Over 30% of the head injuries were reported for workers working in the area of carpentry (n = 932, 15.48%) and in iron and steel work (n = 930, 15.45%). Slightly over 12% of the head injuries were among electrical workers (n = 753). Each of the following work areas were associated with five and eight % of the head injuries: pipe fitting or pipe laying (n = 478, 7.94%), boilermakers (n = 367, 6.10%), and concrete work (n = 308, 5.12%). The remaining 35 occupational work areas (see Table 4-63) were each accountable for less than 5% of the injuries.

Table 4- 63. Head injuries by occupational work area.

Occupational work area	Number of injuries	%	Cumulative %
Carpentry	932	15.48%	15.48%
Iron/Steel	930	15.45%	30.93%
Electrical	753	12.51%	43.44%
Pipe fitting/laying	478	7.94%	51.38%
Boilermaker	367	6.10%	57.48%
Concrete	308	5.12%	62.60%
Welding	283	4.70%	67.30%
Plumbing	275	4.57%	71.87%
Technical repair and maintenance	255	4.24%	76.10%
Sheet metal	253	4.20%	80.31%
Equipment/machinery operation	187	3.11%	83.41%
Masonry	147	2.44%	85.86%
Millwright work	129	2.14%	88.00%
Painting	91	1.51%	89.51%
Supervision	76	1.26%	90.77%
Steam fitting	70	1.16%	91.94%
Insulation	54	0.90%	92.84%
Drywall Installation	50	0.83%	93.67%
Driving	45	0.75%	94.41%
Glazing	38	0.63%	95.04%
Lineman	38	0.63%	95.68%
Clerical	36	0.60%	96.27%
Managing	33	0.55%	96.82%
Sprinkler fitting	28	0.47%	97.29%
Roofing	22	0.37%	97.65%
Inspection	20	0.33%	97.99%
Scaffold erection	18	0.30%	98.28%
Engineering	16	0.27%	98.55%
Conveyor systems work	13	0.22%	98.77%
Security	13	0.22%	98.98%
Lathing	12	0.20%	99.18%
Material handling	9	0.15%	99.33%
Waterproofing	9	0.15%	99.48%
Flooring, tile, carpeting	7	0.12%	99.60%
HVAC/refrigeration	6	0.10%	99.70%
Rigging	5	0.08%	99.78%
Landscaping	4	0.07%	99.85%
Acoustic ceiling	3	0.05%	99.90%
Surveying	3	0.05%	99.95%
Field engineering	2	0.03%	99.98%
Hod carrying	1	0.02%	100.00%
Total	6,019	100.00%	

Head injury severity means were compared between occupational work areas for which frequencies exceeded two injuries. The Welch robust test of equality of head injury severity means could not be performed over all of the occupational areas because at least one of the work areas had a head injury severity score variance of zero. In lieu of the Welch test, the ANOVA test was performed. The results of an ANOVA indicated that at least one of the general occupational work areas could have had a significantly different head injury severity mean of one of the other occupational areas, $F\ (38, 5{,}919) = 12.75$, $p < 0.001$. This was not confirmed by the results of the Tukey's b range test. Figure 4- 98 shows the rankings of the occupational work areas, by descending magnitudes of severity means for head injuries, generated by the Tukey's b test. The results of this did not indicate that any of the occupational work areas had a significantly different head injury severity mean, at $p \leq 0.05$, than any of the other work areas.

Occupational work areas were ranked by head injury severity means (see Figure 4- 98). Among the occupational work areas, injuries to workers in security showed had the highest severity mean ($\mu = 1.38$) for head injuries. This was followed by supervision ($\mu = 1.32$), managing ($\mu = 1.31$), roofing ($\mu = 1.29$), and flooring, tile, or carpeting work ($\mu = 1.29$). Occupational work areas associated with head injuries with the lowest five severity means included material handling, acoustic ceiling work, landscaping, HVAC and refrigeration work, and working with conveyor systems, each with injury severity means of $\mu = 1.00$.

Occupational Experience Level

Head injuries were examined by workers' general occupational experience level. Information regarding this relationship was provided for 1,996 work injuries (see Table 4- 64). Laborers had the highest frequency of head injuries (n = 1,044) comprising over 50% of all of the head injuries. Apprentice level workers accounted for almost 13% of the head injuries (n = 259), while both journeymen level workers (n = 187) and foremen (n = 181) each accounted for over nine % of the injuries to the head. Injuries to helper or assistant level workers (n = 142) accounted for seven % of the head injuries, followed by field supervisory level workers (n = 78, 3.91%), administrative level workers (n = 69, 3.46%), and professional workers. (n = 36, 1.80%).

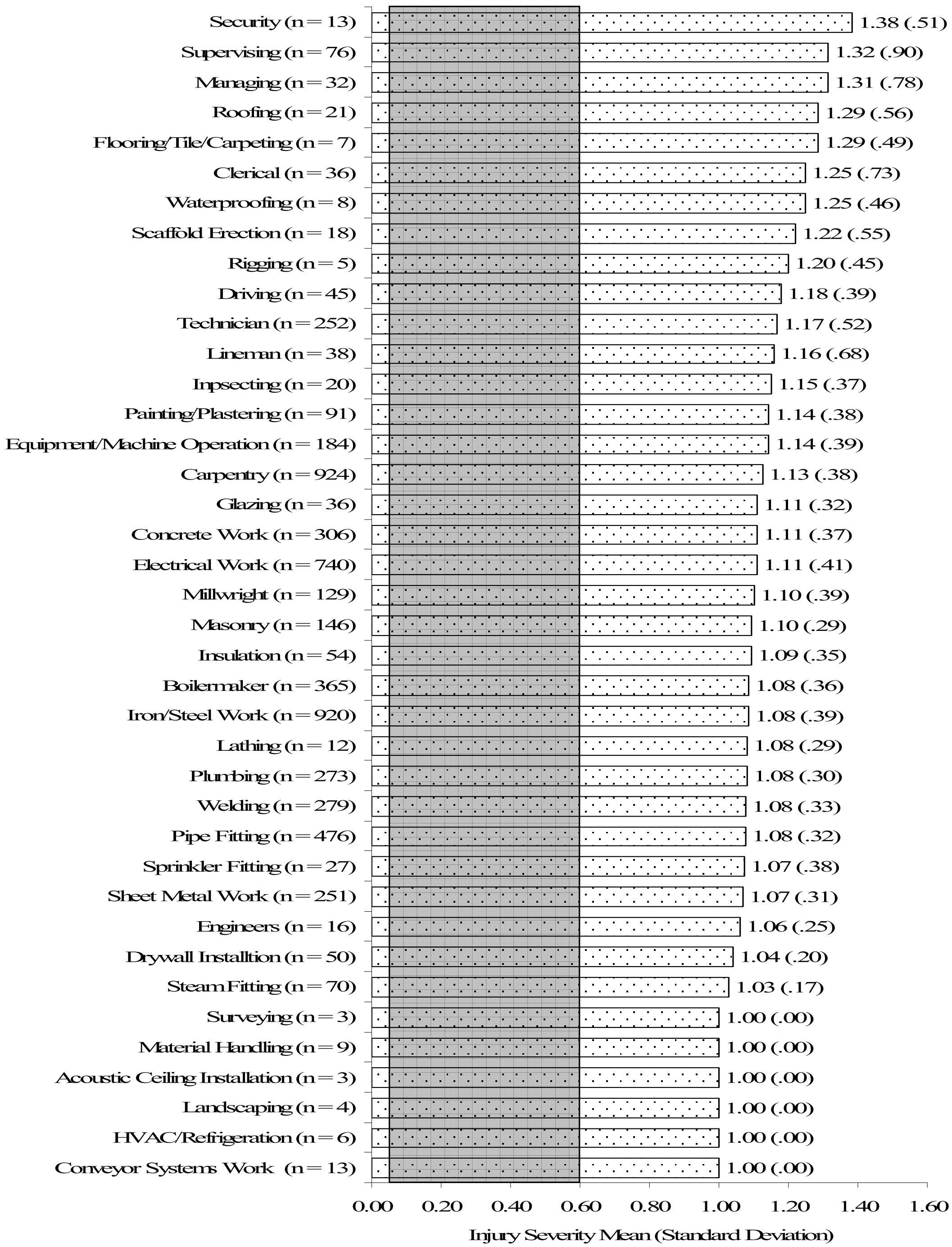

Figure 4- 98. Comparison of injury severity means by occupational work area of workers with a head injury.

Table 4- 64. Head injuries by occupational experience level.

Occupational experience level	Number of injuries	%	Cumulative %
Laborer	1,044	52.30%	52.30%
Apprentice	259	12.98%	65.28%
Journeyman	187	9.37%	74.64%
Foreman	181	9.07%	83.71%
Helper/assistant	142	7.11%	90.83%
Field supervisor	78	3.91%	94.73%
Administrative	69	3.46%	98.19%
Professional	36	1.80%	100.00%
Total	1,996	100.00%	

The severity means of head injuries was compared between occupational experience levels. The result of the Levene test did not permit the assumption of equal severity score variances between the eight occupational levels, L (7, 1,963) = 13.34, $p < 0.001$. Subsequently, the results of the Welch test of equality of head injury severity means between the eight experience level groups showed that at least one of the experience levels had a significantly different head injury severity mean than one of the other experience levels, F (7, 289.66) = 3.64, $p < 0.01$. This was confirmed by the results of the Tukey's range test as illustrated in Figure 4- 99.

The Tukey's b test's the ranking of occupational experience levels by their descending head injury severity mean magnitudes, along with the homogeneous subsets of severity means, are shown in Figure 4- 99. Among general occupational experience levels, the most severe head injuries were to field supervisors ($\mu = 1.32$) and administrative personnel ($\mu = 1.28$). With an injury severity mean of 1.13, laborers showed the third most severe experience level for head injuries. This was followed by head injuries to foremen ($\mu = 1.12$), professionals ($\mu = 1.11$), apprentices ($\mu = 1.11$), helpers or assistants ($\mu = 1.10$), and journeymen ($\mu = 1.09$). Figure 4- 100 shows the occupational experience levels that had significantly different severity means, at $p \leq 0.05$, for head injuries.

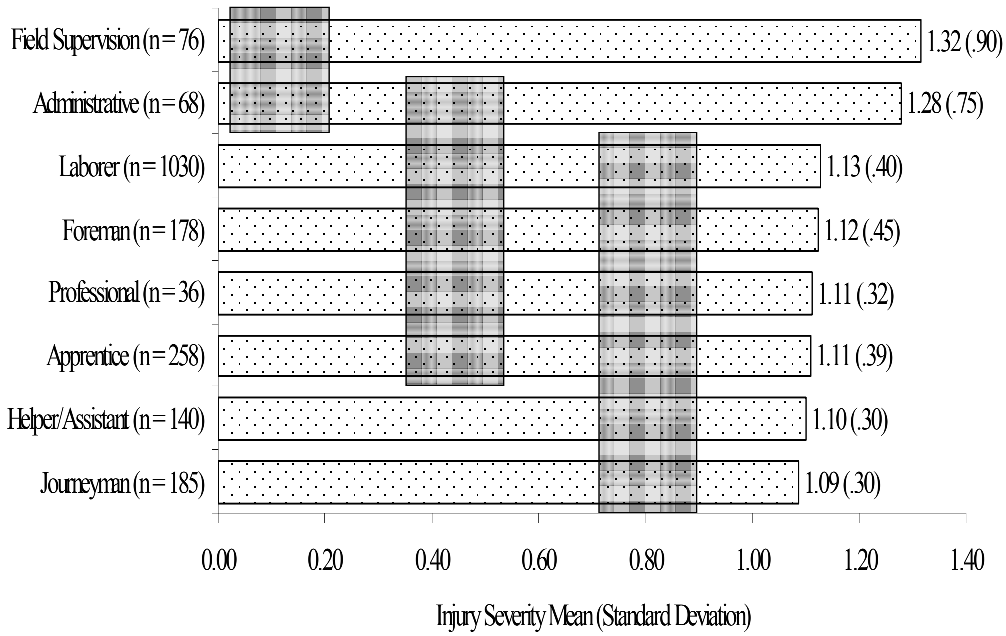

Figure 4- 99. Comparison of injury severity means by occupational experience level of workers with head injuries.

Head injuries to field supervisors showed a significantly greater severity mean, at $p \leq 0.05$, than all of the other occupational experience levels, except administrators. Head injuries to administrative personnel showed a significantly higher severity means, at $p \leq 0.05$, than head injuries to helpers or assistants and journeymen (see Figure 4- 100).

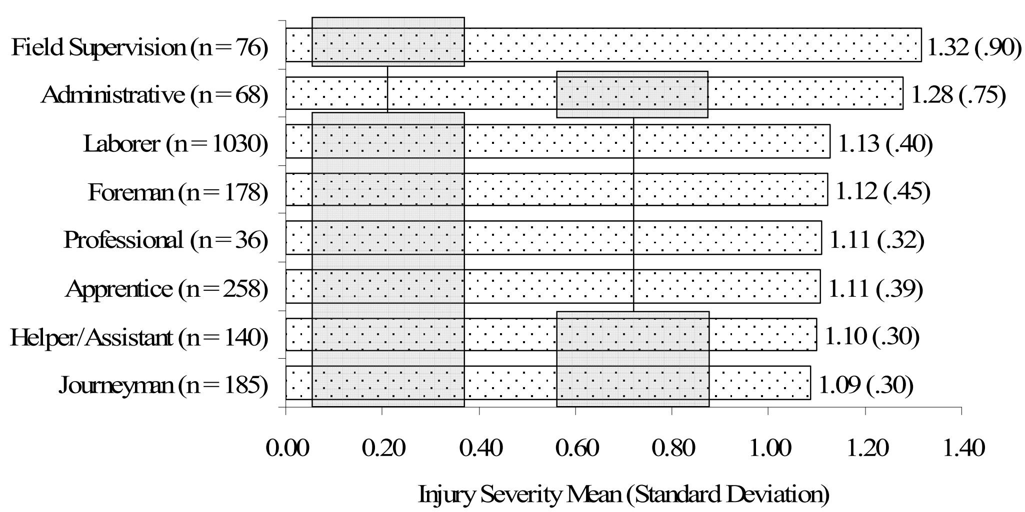

Figure 4- 100. Differences of injury severity between occupational experience levels of workers with head injuries.

Age

Age often indicates differential risk that can be used to target injury control efforts. An examination of the influence of the age of workers on head injuries was conducted. The results of the Levene test for homogeneity of variances of the ages did not allow for the assumption of equal variances, L (9, 2,366) = 2.37, $p \leq 0.01$. The results of the subsequent Welch test of the homogeneity of variances of ages by the 10 body region categories for head injuries showed that at least one of the specific body parts displayed a mean age that was significantly different than one of the body parts, F (5, 77.98) = 5.43, $p < 0.01$. This was confirmed by the results of the Tukey's b range test.

The Tukey's b range test was conducted to identify the specific distribution of age means between the ten body parts for head injuries (see Figure 4- 101). Injuries to the ears showed the highest mean age, 42.86 years. This was followed by multiple head injuries (μ = 39.61), injuries to the nose (μ = 38.84), brain (μ = 38.50), soft tissue (μ = 37.05), facial bones (μ = 36.91), eyes (μ = 36.51), skull (μ = 35.50), mouth (μ = 34.02), and teeth (μ = 32.88).

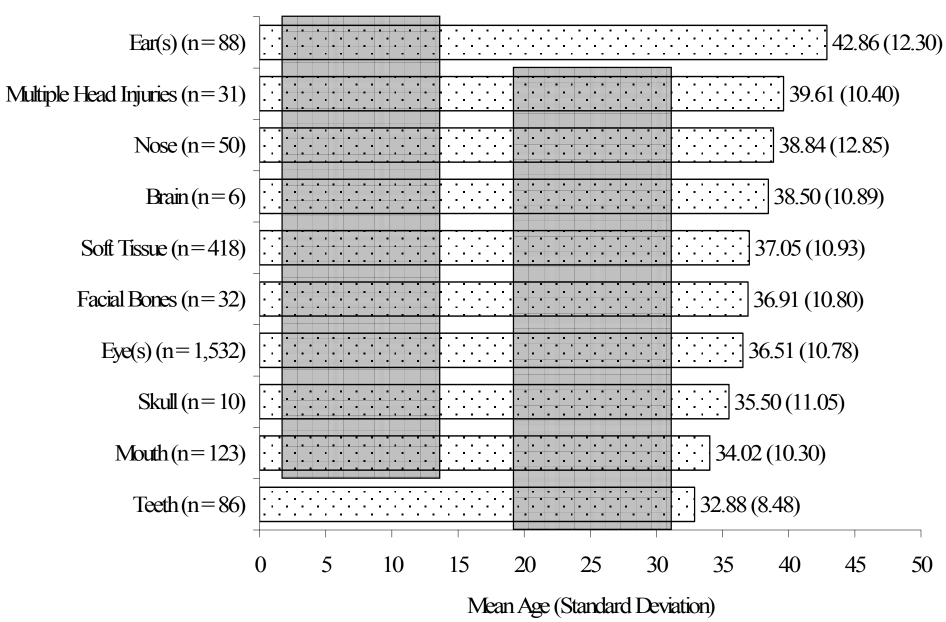

Figure 4- 101. Comparison of mean ages by body part of the head injured.

A further examination of the arrangement of the homogeneous subsets of the age means showed that, among head injuries, injuries to the ears had a significantly higher mean age, at $p \leq 0.05$, than injuries that directly impacted the teeth. No other significantly different means, at $p \leq 0.05$, were displayed between the body parts among head injuries (see Figure 4- 102).

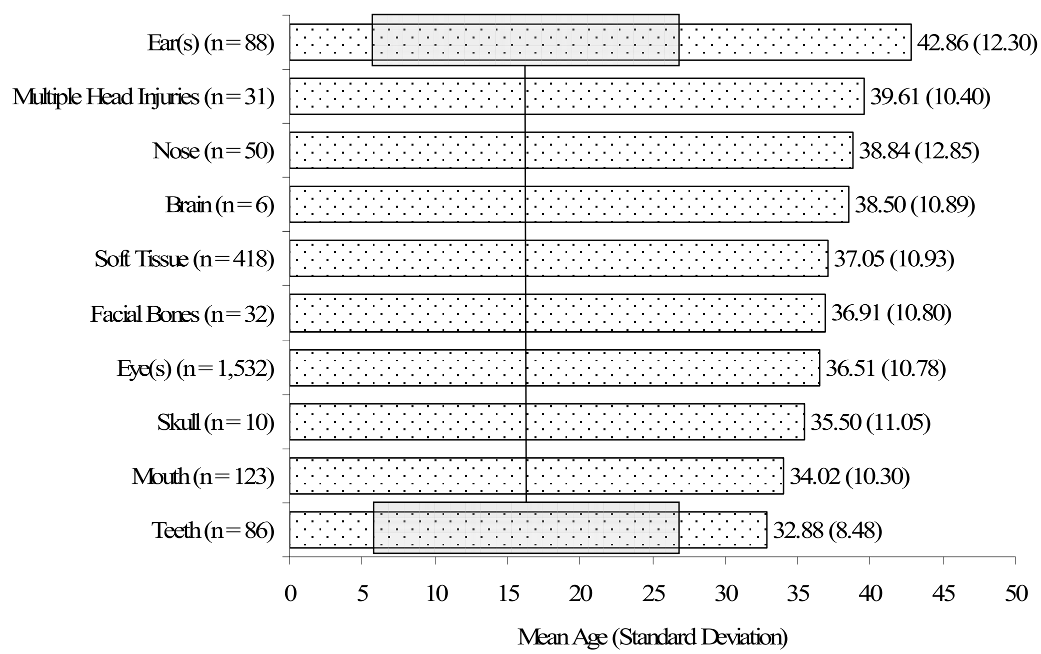

Figure 4- 102. Differences of mean ages by body parts of the head injured.

Injury severity means for head injuries were examined by age. The results of the Levene test of homogeneity of injury score variances for the six age groups did not allow for an assumption of equal variances, L (5, 2,334) = 6.89, $p < 0.001$. The results of the Welch test showed that none of the age groups had a significantly different injury severity mean than any of the other age groups, F (5, 254.66) = 1.48, $p > 0.19$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 103).

At $p \leq 0.05$, the results of the Tukey's b test did not show significantly different injury severity means between the age groups for head injuries. As Figure 4- 103 shows, workers between the ages of 60 to 69 years had the highest injury severity mean ($\mu = 1.17$), followed by workers between 50 and 59 years of age (μ = 1.14), 40 and 49 years of age (μ = 1.11), under 20 years old (μ = 1.10), and workers between 30 and 39 years of age (μ = 1.09). Workers between 20 and 29 years old had the lowest injury severity mean, μ = 1.08.

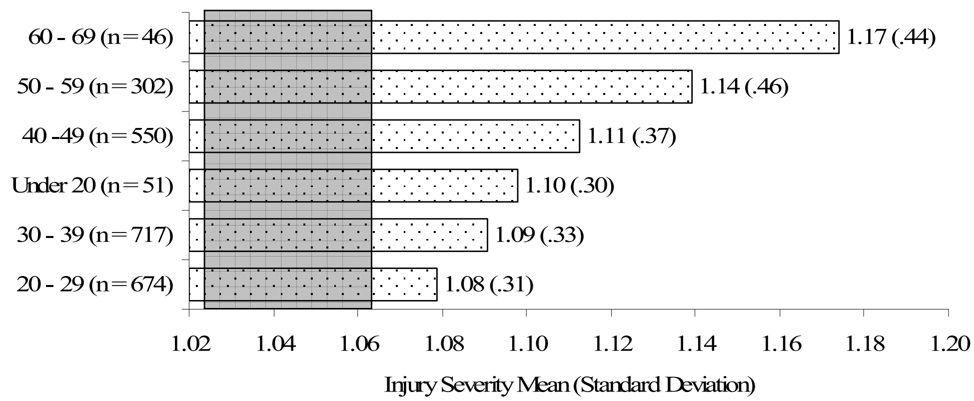

Figure 4- 103. Comparison of injury severity means by age of workers with head injuries.

Month of Occurrence of Injury

Head injuries were examined relative to the month of the year during which the injury occurred. Information regarding the month in which head injuries occurred were provided for 7,539 worker injuries. Table 4- 65 shows that head injuries occurred in October for slightly over 10% (n = 764) of all the head injuries. August had the second highest relative frequency of head injuries (n = 682, 9.05%). With between 612 and 662 reported head injuries, the months of January, March, April, May, July, September, and November each accounted for slightly over eight % of the head injuries. Around seven % of the head injuries occurred in either June (n = 556), December (n = 550), or February (n = 511).

Following the results of the Levene test, L (11, 5,442) = 18.7, $p < 0.05$, no assumption of equal variances of head injury severity scores could be made among the twelve months. The Welch test of equality of severity means for head injuries showed that none of the months of the year had a significantly different head injury severity mean with any of the other months, F (11, 1,893.46) = 0.54, $p > 0.80$. This observation was further confirmed by the results of the Tukey's b range test.

Table 4- 65. Head injuries by month of occurrence.

Month of injury	Number of injuries	%	Cumulative %
October	764	10.13%	10.13%
August	682	9.05%	19.18%
November	662	8.78%	27.96%
September	657	8.71%	36.67%
July	652	8.65%	45.32%
March	642	8.52%	53.84%
May	630	8.36%	62.19%
January	621	8.24%	70.43%
April	612	8.12%	78.55%
June	556	7.37%	85.92%
December	550	7.30%	93.22%
February	511	6.78%	100.00%
Total	7,539	100.00%	

Rankings of the months of the year by their respective head injury severity means were generated by the Tukey's b range and are illustrated in Figure 4- 104. Head injuries occurring during December had the highest severity mean ($\mu = 1.15$), followed by the months of November ($\mu = 1.13$), September ($\mu = 1.13$), June ($\mu = 1.13$), February ($\mu = 1.13$), July ($\mu = 1.13$), and May ($\mu = 1.13$). Head injuries which occurred within the months of March ($\mu = 1.12$), January ($\mu = 1.12$), August ($\mu = 1.11$), October ($\mu = 1.10$) and April ($\mu = 1.10$) were associated with the five lowest severity means. All months were found to constitute a single homogeneous group which indicates that, at $p \leq 0.05$, no specific significant head injury severity mean differences were found between any of the months.

Day of the Week of Occurrence of Injury

Head injuries were examined relative to the day of the week during which the injury occurred. Information regarding the month in which head injuries occurred were provided for

7,539 worker injuries. Table 4- 66 shows that head injuries occurred most frequently on Wednesdays (21% of all injuries, n = 1,592). This was followed closely by Tuesdays (n = 1,536) with slightly over 20% of the head injuries. Thursdays (n = 1,470) and Mondays (n = 1,449) each were associated with just under 20% of the head injuries. Among the days within a business week, the day attributed to having the least amount of head injuries was Friday (n = 1,333, 17.68%). Among the seven calendar days of the week, Saturdays (n = 124, 1.64%) and Sundays (n = 35, 0.46%) showed the smallest number of head injury occurrences.

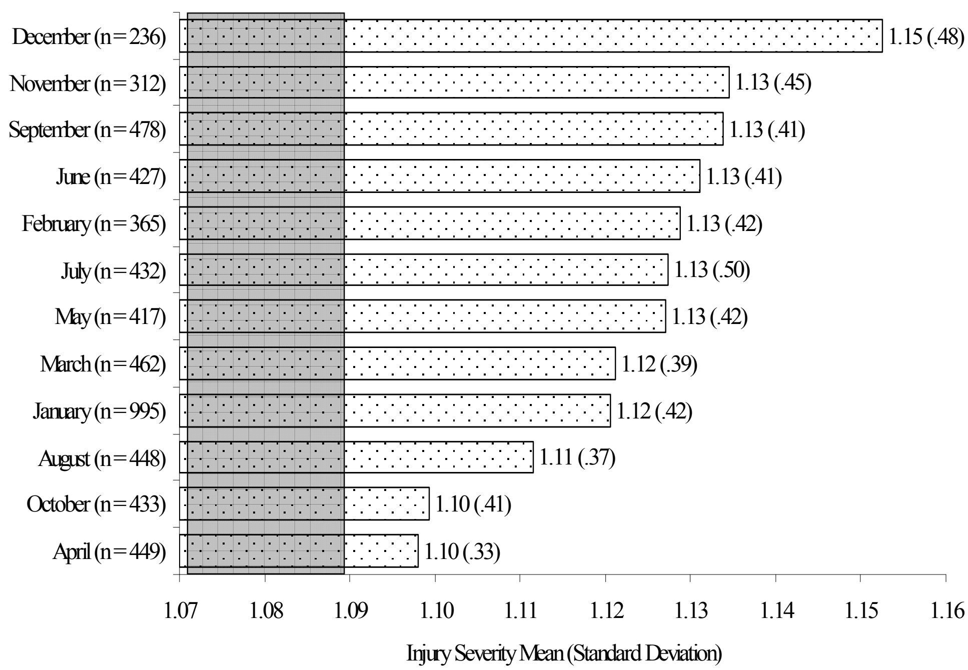

Figure 4- 104. Comparison of injury severity means by month of occurrence of head injuries.

Table 4- 66. Head injuries by the day of the week of occurrence.

Day of the week	Number of injuries	%	Cumulative %
Wednesday	1,592	21.12%	21.12%
Tuesday	1,536	20.37%	41.49%
Thursday	1,470	19.50%	60.99%
Monday	1,449	19.22%	80.21%
Friday	1,333	17.68%	97.89%
Saturday	124	1.64%	99.54%
Sunday	35	0.46%	100.00%
Total	7,539	100.00%	

Head injury severity means for each day of the week were compared. The results of the Levene test did not allow for an assumption of equal head injury severity scores variances, among the seven days of the week, L (6, 5,447) = 2.34, $p < 0.03$. The results of the Welch test of equality of head injury severity means showed that there was greater within days of week differences of severity means than between days of week differences of injury severity, F (6, 1,587.43) = 0.54, $p > 0.70$.

The Tukey's b range test was conducted in order to both rank the days of week by their respective head injury severity means and to detect any specific significant differences of head injury severity means, at $p \leq 0.05$, between the days of the week. Figure 4- 105 shows that head injuries which were reported to have occurred on Saturdays had the highest severity means for head injuries ($\mu = 1.14$). Among typical workweek days, injuries on Fridays had the highest injury severity mean ($\mu = 1.14$). Among all the days of the week, Mondays ($\mu = 1.12$), Wednesdays ($\mu = 1.12$), and Tuesdays ($\mu = 1.12$), were associated with third, fourth, and fifth highest, respectively, severity means for head injuries. Thursdays ($\mu = 1.11$) and Sundays ($\mu = 1.11$) showed the lowest head injury severity means. The results of the Tukey's range test also showed that there were no significantly different injuries severity means, at $p \leq 0.05$, for head injuries between any of the days of the week. This confirmed by the results of the Welch test.

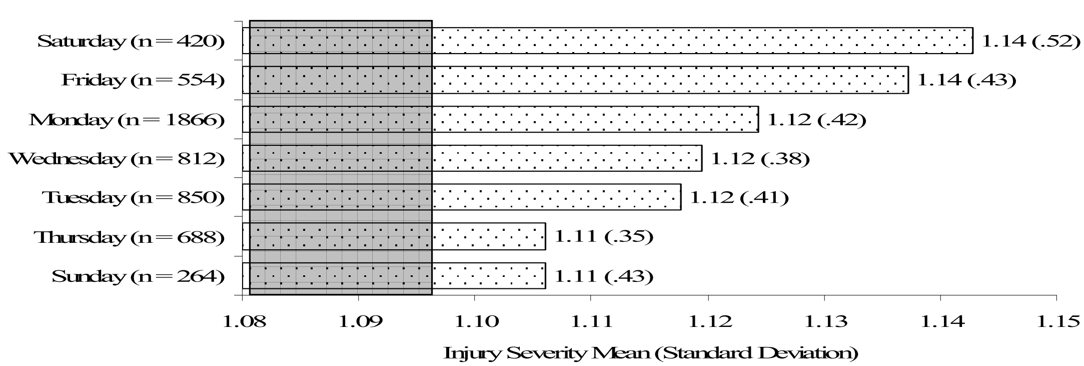

Figure 4- 105. Comparison of injury severity means by the day of the week of occurrence of head injuries.

Neck Injuries

The frequency and severity of neck injuries were examined in relation to the demographic variables of age, job tenure prior to the injury event, month of the injury, and day of the week during which the injury occurred. Similar examinations were conducted for the specific body part of the neck that was injured, the nature of the injury, and the general cause of the injury, the general occupational experience level of the injured worker at the time of the injury, and the specific occupational work area in which the injured worker was working at the time of the neck injury.

Body Part

Frequency **i**nformation regarding the specific body part affected by the neck injury was provided for 985 workers and is displayed in Table 4- 67. Over 65% of these neck injuries affected the soft tissue (n = 648). Some type of injury to the discs within the neck region were associated with nearly 19% (n = 187) of the neck injuries. An injury to multiple parts of the neck accounted for almost eight % (n = 78) of the neck injuries. Spinal chord (n = 40, 4.06%) and vertebrae (n = 29, 2.94%) neck injuries combined for seven % of all the neck injuries. Less than one % of the neck injuries affected the larynx (n = 3).

Table 4- 67. Neck injuries by body part injured.

Body part	Number of injuries	%	Cumulative %
Soft tissue	648	65.79%	65.79%
Disc	187	18.98%	84.77%
Multiple injuries	78	7.92%	92.69%
Spinal cord	40	4.06%	96.75%
Vertebrae	29	2.94%	99.70%
Larynx	3	0.30%	100.00%
Total	985	100.00%	

Neck injury severity means were compared between the six body parts. The results of the Levene test of equal severity score variances between the six body parts of the neck indicated that the assumption of equal variance could not be assumed, L (5, 958) = 6.59, $p < 0.001$. Subsequently, the results of the Welch test indicated that at least one of the body parts of the neck had a significantly different injury severity mean than one of the other body parts, F (5, 20.47) = 14.88, $p < 0.001$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 103and Figure 4- 107).

Using the Tukey's b range test, the six body parts of the neck were ranked by their respective injury severity means (see Figure 4- 106). Injury to the neck vertebrae had the highest injury severity mean (μ = 2.07), followed by disc injuries (μ = 1.87), injuries to the larynx (μ = 1.67), injury to spinal chord area of the neck (μ = 1.53), and multiple neck injuries (μ = 1.38). Injuries to the soft tissue of the neck had the lowest severity mean (μ = 1.34).

The Tukey's b range test identified homogeneous subsets of injury severity means among the six neck body parts. Significantly different severity means, at $p \leq 0.05$, were discerned between the six body parts of the neck (see Figure 4- 107). Among neck injuries, vertebral injuries had a significantly greater injury severity mean, at $p \leq 0.05$, than soft tissue injuries of the neck.

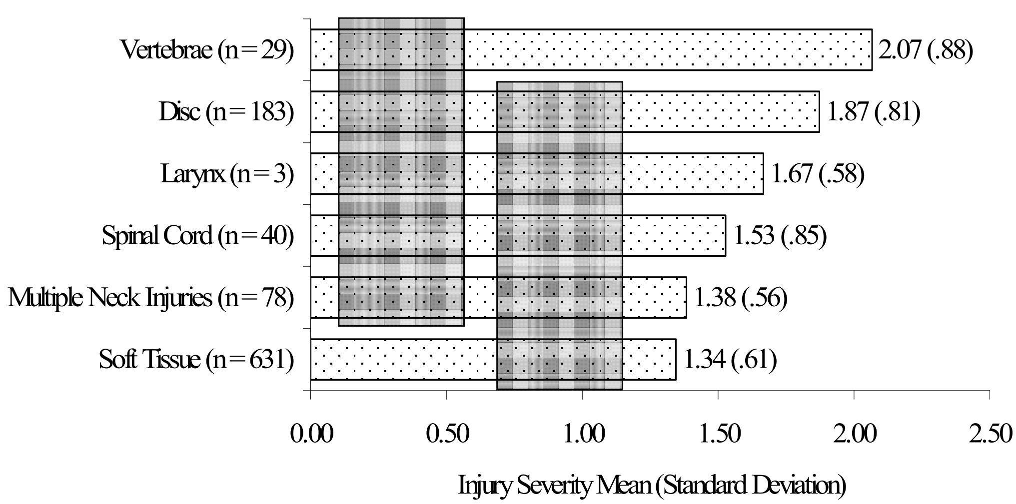

Figure 4- 106. Comparison of injury severity means by body part of the neck injured.

Figure 4- 107. Differences of injury severity means between injured body parts of the neck.

Nature of Injury

Based on information provided for 893 neck injuries, the distribution of injuries was assessed for each of the 21 nature of injury categories (see Table 4- 68). Almost 61% of the all neck injuries were strains (n = 542). Ruptures accounted for slightly under nine % (n = 79) of the injuries to the neck, and 66 contusions accounted for seven %. This was followed by neck sprains (n = 56, 6.27%), inflammations (n = 35, 3.92%), punctures (n = 24, 2.69%), fractures (n = 22, 2.46%), burns (n = 20, and lacerations of the neck (n = 18, 2.02%). The relative frequencies of the remaining 13 nature of injury classifications combined to account for slightly more than three % of all the neck injuries. These included multiple neck injuries (n = 7), hernia (n = 6), dislocations (n = 4), infections (n = 2), severances (n = 2), asphyxiation (n = 2), other occupational diseases NOC (n = 2), a concussion, one crushing, one electric shock injury, a single Foreign body case, a general poisoning, and a single case of dermatitis of the neck.

Neck injury severity means were compared between the nature of injury classifications. Nature of injury groups with a frequency of one were excluded from this comparison. In addition dislocations and occupational diseases NOC each had a zero severity score variance the Welch robust test of equality of means could not be performed. The results of the ANOVA test suggested that at least one of the nature of injury groups had a neck injury severity mean that was significantly different from one of the other categories, F (15, 852) = 126.94, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

Table 4- 68. Neck injuries by nature of injury

Nature of injury	Number of injuries	%	Cumulative %
Strain	542	60.69%	60.69%
Rupture	79	8.85%	69.54%
Contusion	66	7.39%	76.93%
Sprain	56	6.27%	83.20%
Inflammation	35	3.92%	87.12%
Puncture	24	2.69%	89.81%
Fracture	22	2.46%	92.27%
Burn	20	2.24%	94.51%
Laceration	18	2.02%	96.53%
Multiple injuries	7	0.78%	97.31%
Hernia	6	0.67%	97.98%
Dislocation	4	0.45%	98.43%
Infection	2	0.22%	98.66%
Severance	2	0.22%	98.88%
Asphyxiation	2	0.22%	99.10%
Occupational disease NOC	2	0.22%	99.33%
Concussion	1	0.11%	99.44%
Crushing	1	0.11%	99.55%
Electric shock	1	0.11%	99.66%
Foreign body	1	0.11%	99.78%
Poisoning NOC	1	0.11%	99.89%
Dermatitis	1	0.11%	100.00%
Total	893	100.00%	

The results of the Tukey's b range test for equality of severity means for neck injuries between the nature of injury categories are shown in Figure 4- 108. Ruptures resulted in neck injuries with the highest injury severity mean ($\mu = 2.51$), followed closely by severances ($\mu = 2.50$), and neck fractures ($\mu = 2.41$). Occupational diseases NOC and dislocations each had neck injury severity means of $\mu = 2.00$, but with no variance. Neck injuries of asphyxiation ($\mu = 1.50$), infections ($\mu = 1.50$), and hernias ($\mu = 1.50$) had the sixth, seventh, and eighth, respectively, highest severity means for neck injuries among the nature of injury groups. The nature of injury categories associated with the lowest eight neck injury severity means included sprains (μ = 1.47), contusions (μ = 1.44), multiple neck injuries (μ = 1.43), strains (μ = 1.37), inflammation (μ = 1.12), lacerations (μ = 1.11), punctures (μ = 1.08), and burns (μ = 1.05). Two homogeneous subsets of neck injury severity means by nature of injury categories were detected with the Tukey's b test. Nature of injury categories within each subset had neck injury severity means that did not significantly differ, at $p \leq 0.05$, from one of the other categories within the subset.

From the arrangement of the two subsets shown in Figure 4- 108 it was determined that ruptures, severances, and fractures of the neck had significantly higher injury severity means, at $p \leq 0.05$, than inflammations, lacerations, punctures, and burns to the neck (see Figure 4- 109).

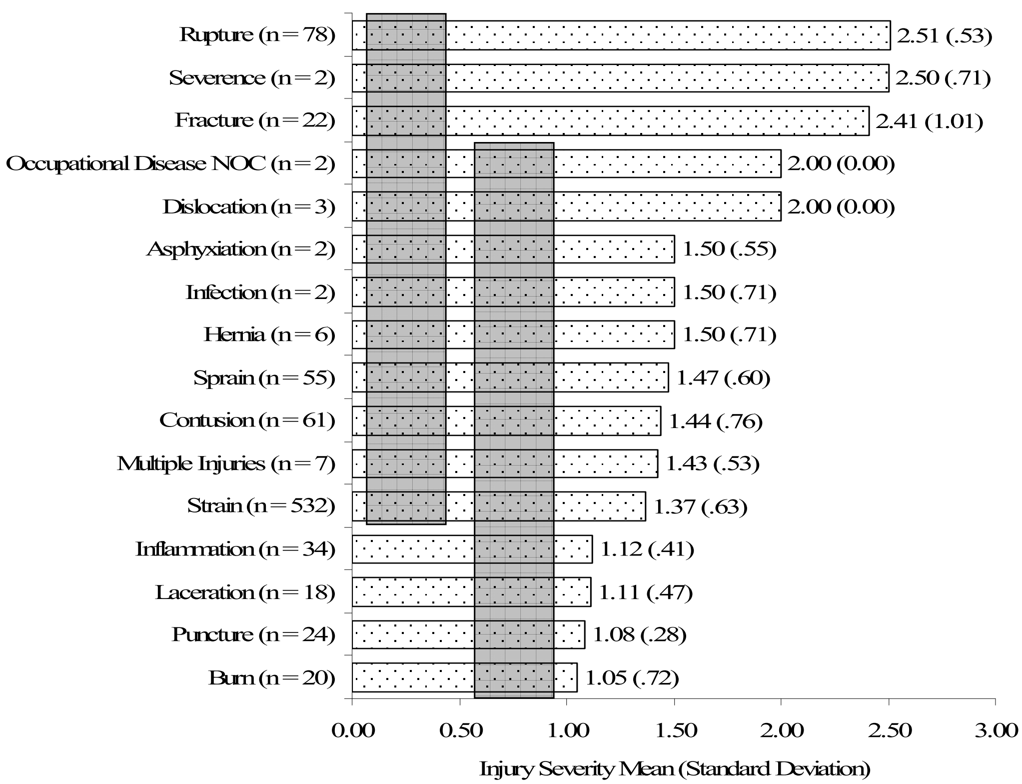

Figure 4- 108. Comparison of injury severity means by nature of neck injury. .

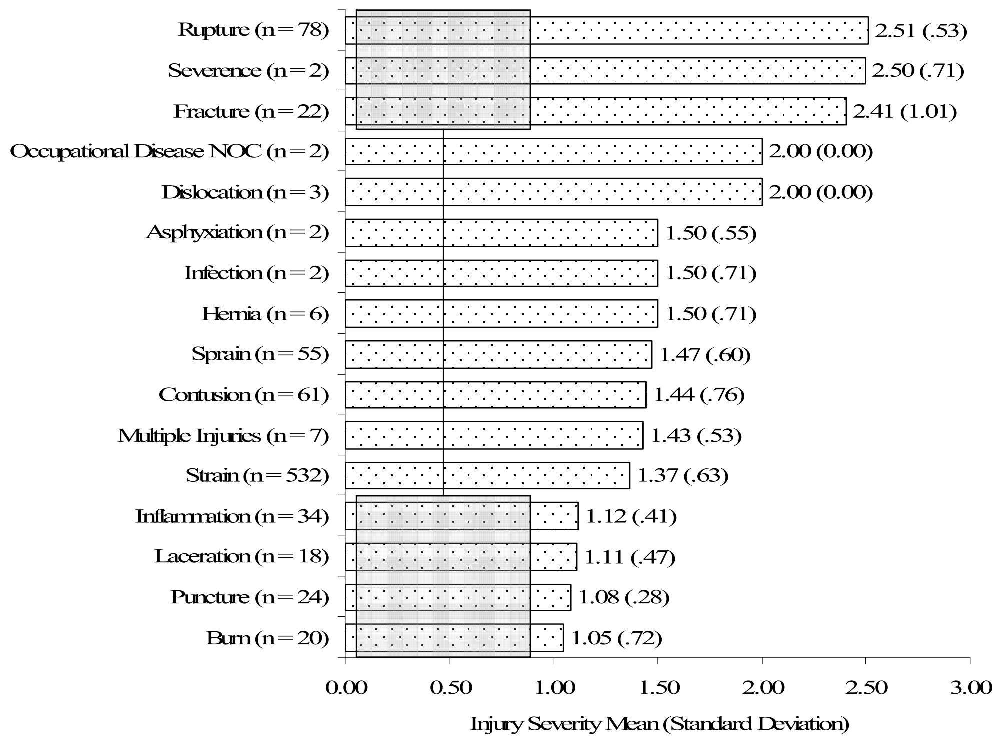

Figure 4- 109. Differences of injury severity means by nature of neck injuries.

General Cause of Injury

Nine general causes of neck injuries were determined based on information provided for 985 worker injuries. Table 4- 69 shows the distribution of neck injury frequencies by the general cause of the injury. Straining was the leading cause of neck injuries (n = 347, 36.22%), followed by struck by injuries (n = 183, 19.10%). Slightly more than 15% (n = 148) of the neck injuries were caused by the worker striking against or stepping on an object or objects. Just over ten % of the neck injuries were caused by a slip or fall (n = 99). Some kind of involvement with a motor vehicle was cited as the cause of injury for around eight % (n = 77) of the neck injuries. Just over three % (n = 32) of the neck injuries were caused by a bite or sting of an animal or insect. Absorption, inhalation, or ingestion of a substance (n = 26) along with being cut, punctured or scraped by an object (n = 20), and being burned (n = 19) accounted for around 2 % eah, of the neck injuries. Less than one % of neck injuries (n = 7) were caused by the worker being Caught in or between an object or objects.

Table 4- 69. General cause of neck injuries.

General cause of injury	Number of injuries	%	Cumulative %
Strain	347	36.22%	36.22%
Struck by	183	19.10%	55.32%
Striling against or stepping on	148	15.45%	70.77%
Fall or slip	99	10.33%	81.11%
Motor vehicle	77	8.04%	89.14%
Animal or insected bite or sting	32	3.34%	92.48%
Absorption, ingestion or inhalation	26	2.71%	95.20%
Cut, puncture, or scrape	20	2.09%	97.28%
Burn	19	1.98%	99.27%
Caught in or between	7	0.73%	100.00%
Total	958	100.00%	

Despite the results of the Levene test of homogeneity of neck injury severity scores between the cause of injury groups (L (9, 927) = 20.71, $p < 0.001$), the Welch test of equality of means could not be performed because neck injuries caused by Absorption, ingestion or inhalation of a substance showed zero variance of the severity score. Consequently, the ANOVA test was used in lieu of the Welch test to assess differences of severity mean between the general causes of neck injuries. The results of the ANOVA test showed that at least one of the causes of neck injuries might have a neck injury severity mean significantly different than one of the other general cause of injury categories, F (9, 927) = 6.08, $p < 0.001$. As Figure 4- 110 and Figure 4- 111 illustrate, this result was confirmed by the results of the Tukey's b range test.

The results of the Tukey's b range test demonstrated that neck injuries from falls or slips are associated with the highest injury severity mean ($\mu = 1.61$). Falls and slips, as a general cause of injury, was followed by straining as causing neck injuries with the second highest severity mean ($\mu = 1.59$). This was followed by neck injuries caused by involvement with a motor vehicle ($\mu = 1.51$), being struck by an object ($\mu = 1.47$), having struck against or stepped on an object (μ

= 1.35), having been cut, punctured or scraped by an object (μ = 1.25), Caught in or between an object or objects (μ = 1.14), burned (μ = 1.11), and having been bitten or stung by an animal or insect (μ = 1.03). Neck injuries caused by the absorption, ingestion, or inhalation of a substance had the lowest severity mean (μ = 1.00).

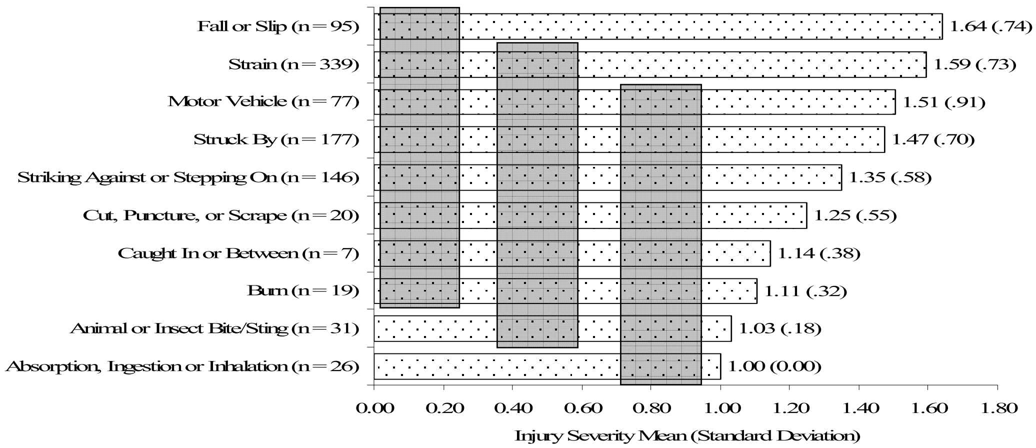

Figure 4- 110. Comparison of injury severity means by general cause of neck injuries.

Specific neck injury severity mean differences between the nine general causes of injury were discerned for the homogeneous subsets shown in Figure 4- 110. As Figure 4- 111 illustrates, neck injuries from falls or slips had a significantly higher severity mean, at $p \leq 0.05$, than neck injuries from either being bitten or stung by an animal or insect or from the absorption, ingestion or inhalation of a substance. In addition, neck injuries caused by straining had a significantly greater injury severity mean, at $p \leq 0.05$, than neck injuries from the absorption, inhalation, or ingestion of a substance.

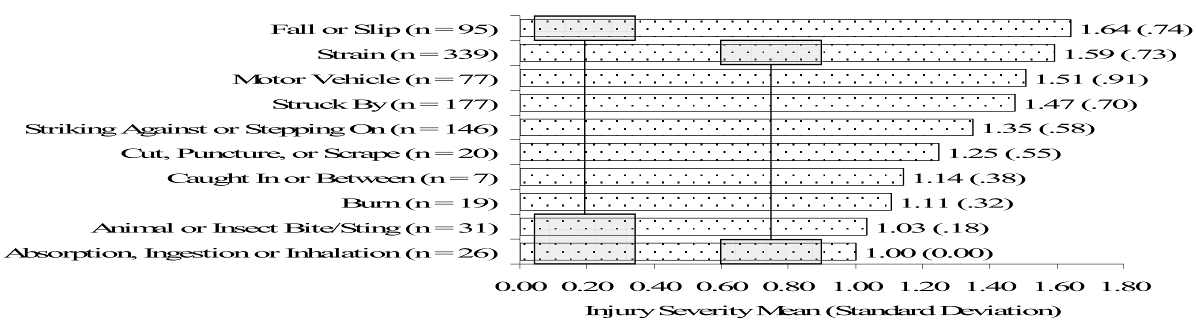

Figure 4- 111. Differences of injury severity means between general causes of neck injury.

Occupational Work Area

Neck injury frequency information regarding the occupational work area in which the injured worker was working at the time of the neck injury was provided for 743 worker injuries. These frequencies are displayed in Table 4 – 70. Carpentry workers experienced over 15% (n = 118) of the neck injuries, followed by electrical workers (n = 99, 13.32%), and workers involved in iron and steel work (n = 93, 12.52%). Technicians experienced around nine % (n = 65) of the injuries to the neck, while pipe fitting (n = 48) and concrete workers (n = 43) each accounted for around six % of the neck injuries. Around three % of the neck injuries were to workers working in either plumbing (n = 29), equipment or machinery operation (n = 28), or masonry (n = 22). Workers working as or with a boilermaker (n = 19), in painting or plastering (n = 17), sheet metal work (n = 17), welding (n = 16), or supervisory work (n = 16) accounted for slightly more than 2 % each of the neck injuries. Drivers had nearly two % (n = 14) of the neck injuries, while workers conducting some type of inspection work had just above one % (n = 8) of the neck injuries. The remaining work areas shown Table 4- 70 were associated with less than one % of the neck injuries.

Among neck injuries, injury severity means were compared between each of the workers' general occupational work areas. The results of the Leven test of homogeneity of neck injury severity scores by the general occupational work area did not support an assumption of equal variances, L (29, 695) = 2.57, $p < 0.001$. However, The Welch test of equality of neck injury severity means between the work areas could not be performed because the following work areas had a variance of injury severity scores equal to zero: Flooring, tile, or carpeting, rigging, Acoustic ceiling work, flagging, security, material handling, surveying, field engineering, managing, engineering, landscaping, and glazing. Consequently, the ANOVA test was performed to assess possible differences of neck injury severity means between the work areas.

The results of the ANOVA test did not show a significant between work areas severity mean difference than within work areas differences, F (29, 695) = 18.27, $p > 0.18$. The Tukey's b range test was conducted in order to rank the occupational work areas by their respective neck injury severity means (see Figure 4 – 112). The results of the Tukey's also confirmed the ANOVA the results. None of the work areas had a significantly different neck injury severity

Table 4- 70. Neck injuries by occupational work area of injured workers.

Occupational work area	Number of injuries	%	Cumulative %
Carpentry	118	15.88%	15.88%
Electrical	99	13.32%	29.20%
Iron/Steel	93	12.52%	41.72%
Technical repair and maintenance	65	8.75%	50.47%
Pipe Fitting/laying	48	6.46%	56.93%
Concrete	43	5.79%	62.72%
Plumbing	29	3.90%	66.62%
Equipment/machinery operation	28	3.77%	70.39%
Masonry	22	2.96%	73.35%
Boilermaker	19	2.56%	75.91%
Painting and plastering	17	2.29%	78.19%
Sheet metal	17	2.29%	80.48%
Welding	16	2.15%	82.64%
Supervision	16	2.15%	84.79%
Driving	14	1.88%	86.67%
Millwright work	13	1.75%	88.42%
Lineman	11	1.48%	89.90%
Drywall Work	10	1.35%	91.25%
Inspecting	8	1.08%	92.33%
Steam fitting	7	0.94%	93.27%
Clerical	7	0.94%	94.21%
Roofing	6	0.81%	95.02%
Insulation	5	0.67%	95.69%
Scaffold erection	5	0.67%	96.36%
HVAC/Refrigeration	4	0.54%	96.90%
Glazing	3	0.40%	97.31%
Sprinkler fitting	3	0.40%	97.71%
Landscaping	3	0.40%	98.11%
Conveying systems	2	0.27%	98.38%
Lathing	2	0.27%	98.65%
Flooring, tile, or carpeting	1	0.13%	98.79%
Rigging	1	0.13%	98.92%
Acoustic ceiling work	1	0.13%	99.06%
Flagging Traffic	1	0.13%	99.19%
Security	1	0.13%	99.33%
Material handling	1	0.13%	99.46%
Surveying	1	0.13%	99.59%
Field engineering	1	0.13%	99.73%
Managing	1	0.13%	99.86%
Engineering	1	0.13%	100.00%
Total	743	100.00%	

mean, at $p \leq 0.05$, than any of the other work areas. In order to conduct the Tukey's any work area with a neck injury frequency of less than two was excluded.

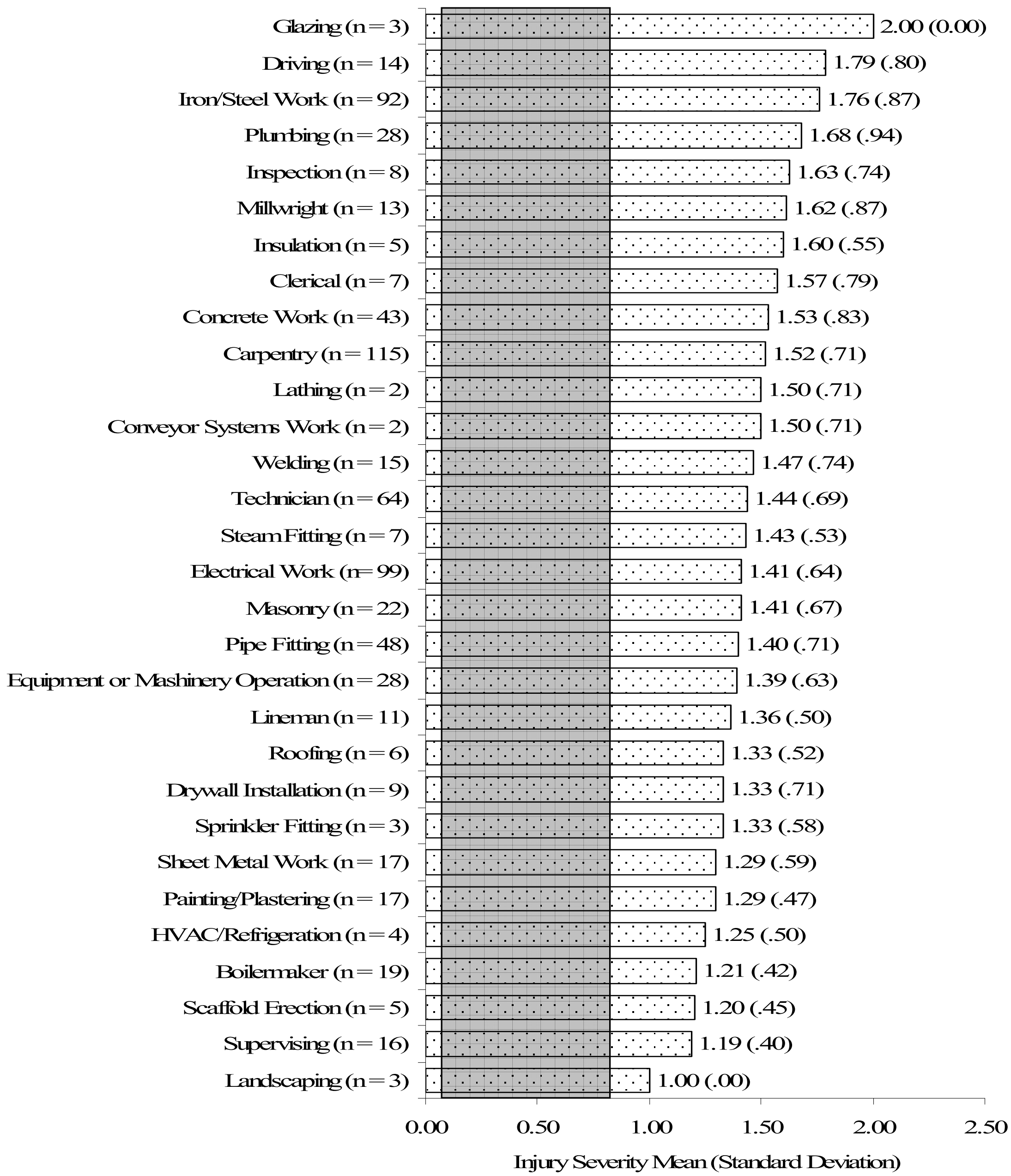

Figure 4- 112. Comparison of injury severity means by occupational work area of workers with neck injuries.

Of all the work areas which had two or more cases, workers performing a glazing activity at the time of injury had the highest neck injury severity mean ($\mu = 2.00$). This was followed by driving (μ = 1.79), iron and steel work (μ = 1.76), plumbing (μ = 1.68), inspecting (μ = 1.63), and working with or as a millwright (μ = 1.62). Insulation workers had the seventh highest neck injury severity mean (μ = 1.60), followed by clerical work (μ = 1.57), concrete work (μ = 1.53) carpentry (μ = 1.52). The remaining twenty occupational work areas, and their respective neck injury severity means, are found in Figure 4- 112, which shows a single homogeneous subset identified from the Tukey's b test. This indicates no significant neck injury severity mean difference, at $p \leq 0.05$, between the general occupational work areas.

Occupational Experience Level

Neck injury distributions by the workers' level of occupational experience are displayed in Table 4- 71. Information regarding neck injuries among occupational experience levels was provided for 307 worker injuries. Laborers experienced just over 50% (n = 157) of the neck injuries. Journeymen (n = 37) and apprentice level workers (n = 36) each represented nearly 12% of the 307 neck injuries. Foremen experienced just under 10% (n = 9.45%) of the neck injuries, followed by field supervisors not otherwise classified (n = 17) and helpers or assistants (n = 14). Professionals (n = 9) and administrative personnel (n = 8) had less than 3 % each of the neck injuries.

The eight occupational experience levels were compared by their respective neck injury severity means. The results of the Levene test did not allow for an assumption of equal variances of neck injury severity scores between the occupational experience levels, L (7, 294) = 3.60, $p <$ 0.002. Subsequently, the Welch robust test of equality of neck injury severity means between the eight experience levels was performed. The results for this test indicated that none of the occupational experience levels had a significantly different severity mean for neck injuries from any of the other experience levels, F (7, 42.48) = 1.743, $p > 0.10$. This was confirmed by the results of the Tukey's b range test (see Figure 4- 113).

Table 4- 71. Neck injuries by occupational experience level.

Experience Level	Number of injuries	%	Cumulative %
Laborer	157	51.14%	51.14%
Journeyman	37	12.05%	63.19%
Apprentice	36	11.73%	74.92%
Foreman	29	9.45%	84.36%
Field supervision	17	5.54%	89.90%
Helper/assistant	14	4.56%	94.46%
Professional	9	2.93%	97.39%
Administrative	8	2.61%	100.00%
Total	307	100.00%	

Figure 4- 113 shows the rankings, by neck injury severity mean, for each of the eight occupational experience levels. Homogenous groupings of experience levels in which no significant difference of neck injury severity mean, at $p \leq 0.05$, is shown between any group members is depicted by the single transparent rectangular box. Professionals had the highest severity mean of neck injuries (μ = 1.63), followed by neck injuries to administrative level workers (μ = 1.57), laborers (μ = 1.57), foremen (μ = 1.45), journeymen (μ = 1.38), apprentices (μ = 1.37),and helpers and assistants (μ = 1.31), Field supervisors not otherwise classified had the lowest neck injury severity mean (μ = 1.19). Despite these rankings, the Tukey's b range test did not detect significantly different neck injury severity means, at $p \leq 0.05$, between any of the occupational experience levels.

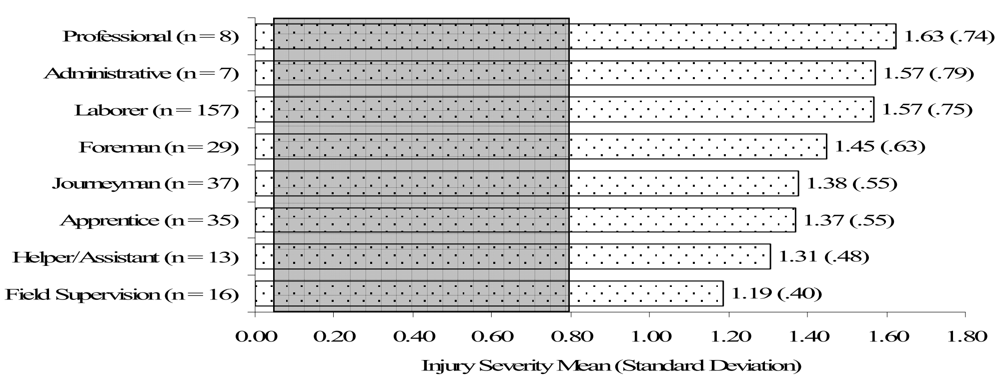

Figure 4- 113. Comparison of injury severity means by occupational experience levels of workers with neck injuries.

Age

From a previous analysis, the mean age of workers with neck injuries ($\mu = 38.56$) was significantly greater, at $p \leq 0.05$, than that for workers with lower extremity injuries ($\mu = 37.00$) and head injuries ($\mu = 36.68$). Information regarding neck injuries and the respective age, by age group, was provided for 317 worker injuries. Table 4- 72 shows workers' neck injury frequencies by four age groups. Workers between the ages of 30 and 39 years (n = 97) and 40 through 49 years (n = 97) represented just over 30% each of the neck injuries. Workers between 20 and 29 years of age had almost 23% (n = 72) of the neck injuries, and 16% of the neck injuries were to workers between the ages of 50 and 59 years.

Table 4- 72. Neck injuries by age.

Age (year)	Number of injuries	%	Cumulative %
30 - 39	97	30.60%	30.60%
40 - 49	97	30.60%	61.20%
20 - 29	72	22.71%	83.91%
50 - 59	51	16.09%	100.00%
Total	317	100.00%	

Injury severity means for neck injuries were compared by age groups in which workers with neck injuries were assigned. The results of the Levene test did not allow for an assumption of equal neck injury severity score variances between the four age groups, L (3, 307) = 12.74, $p < 0.001$. The Welch test was subsequently performed in order to detect any significant neck injury severity mean differences between the age groups. The results of this test indicated that at least one of the age groups had a significantly different neck injury severity mean than one of the other age groups, F (3, 151.73) = 6.17, $p < 0.002$. The results of the Tukey's b range confirmed this result.

The results of the Tukey's b range test enabled the ranking of age groups by neck injury severity mean (see Figure 4- 114). Workers between 50 and 59 years of age had the highest severity mean for neck injuries (μ = 1.55), followed by workers 40 through 49 years old (μ = 1.48), and between 30 and 39 years of age (μ = 1.43). Workers 20 through 29 years of age had the lowest neck injury severity mean (μ = 1.17). Figure 4– 114 also shows the grouping of age groups by the homogeneity of their respective neck injury severity means, at $p \leq 0.05$.

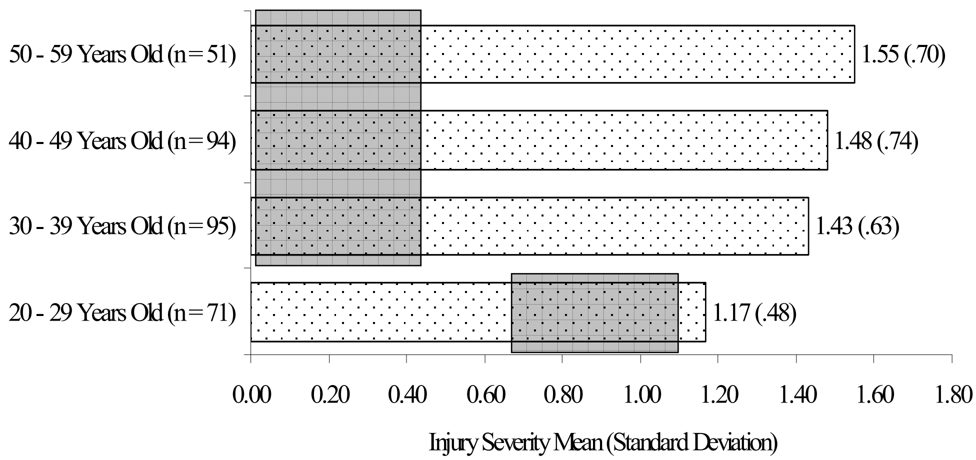

Figure 4- 114. Comparison of injury severity means by age of workers with neck injuries. .

From the arrangement of the two homogeneous subsets of the neck injury severity means among the four age groups, it was determined that the neck injury severity means for the 30 through 39, 40 through 49, and 50 through 59 years old workers were significantly greater, at $p \leq 0.05$, than the neck injury severity mean for workers within the 20 to 29 years of age group. This is illustrated in Figure 4- 115.

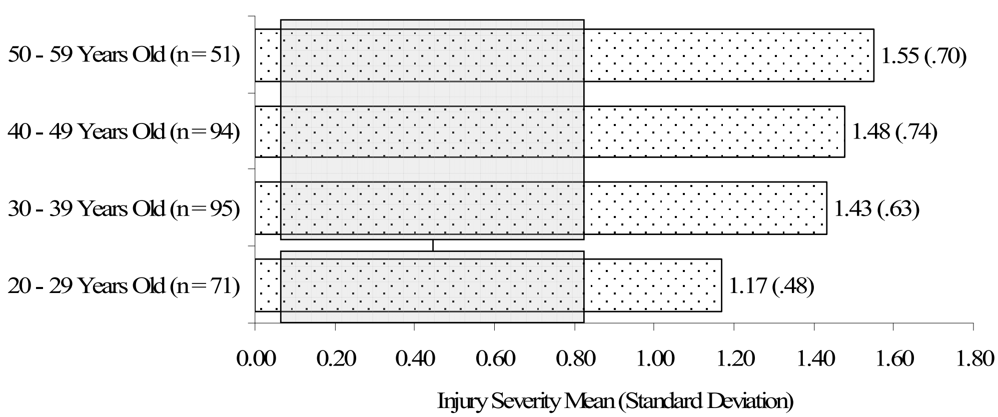

Figure 4- 115. Differences between injury severity means by age of workers with neck injuries.

A comparison of age means, by specific body part injured, was conducted for neck injuries. There was only a single case where age (age = 38) was reported for neck injuries to the larynx. Groups with only one case were ignored in computing the Levene test of homogeneity of variance for age between the specific neck body parts. The results of the Levene test allowed for an assumption of equal variances, L (4, 311) = 0.65, $p > 0.60$. The results of the subsequent ANOVA test showed that there were no significant differences of mean age between the specific body parts for neck injuries, F (5, 311) = 1.71, $p > 0.10$. Figure 4- 116 shows the rankings, by mean age, of the specific body parts injured among neck injuries. Injuries to disc of the neck showed the highest mean age (μ = 40.79), followed by neck injuries to the soft tissue (μ = 38.63), multiple neck injuries (μ = 37.00), and spinal chord injuries (μ = 35.60). Injuries to the vertebrae of the neck displayed the lowest mean age (μ = 27.75).

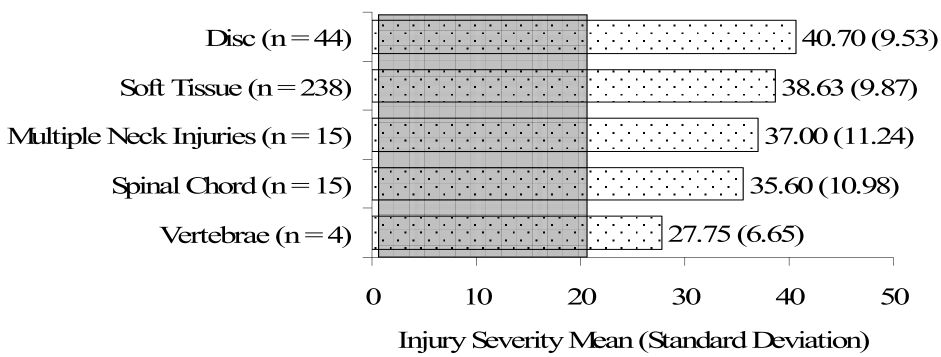

Figure 4- 116. Comparison of mean ages by body part of neck injuries.

Job Tenure

Job tenure was examined for data on neck injuries. Information regarding these two dimensions was provided for 777 worker injuries. Table 4- 73shows the distribution of neck injuries by job tenure. Just over 18% (n = 141) of these cases occurred to workers who had been working 91 to 180 days prior to experiencing their neck injuries. Around 15% (n = 120) of the neck injuries were experienced between the 81^{st} and 365^{th} day of employment. Neck injuries occurring within the first 90 days employment combined to account for nearly 46% (n = 354) of the neck injuries. Around 21% of the neck injuries occurred after the first year of employment.

Table 4- 73. Injury frequency by job tenure of workers with neck injuries.

Job tenure	Number of injuries	%	Cumulative %
91 to 180 days	141	18.15%	18.15%
81 to 365 days	120	15.44%	33.59%
31 to 60 days	105	13.51%	47.11%
0 to 15 days	88	11.33%	58.43%
16 to 30 days	82	10.55%	68.99%
61 to 90 days	79	10.17%	79.15%
366 to 730 days (1 to 2 years)	78	10.04%	89.19%
731 to 1,460 days (2 to 4 years)	44	5.66%	94.86%
> 1,461 days (> 4 years)	40	5.15%	100.00%
total	777	100.00%	

Injury severity for neck injuries was explored by workers' job tenure on the date of the injury. The results of the Levene test of homogeneity of neck injury severity score variances between nine job tenure categories allowed for the assumption of equal variances, L (8, 752) = 1.03, $p > 0.40$. Subsequently, the results of the ANOVA did not show any significant difference of neck injury severity means between the nine job tenure categories, F (8, 752) = 0.36, $p > 0.90$. This was confirmed by the results of the Tukey's b range test (see Figure 4 – 117).

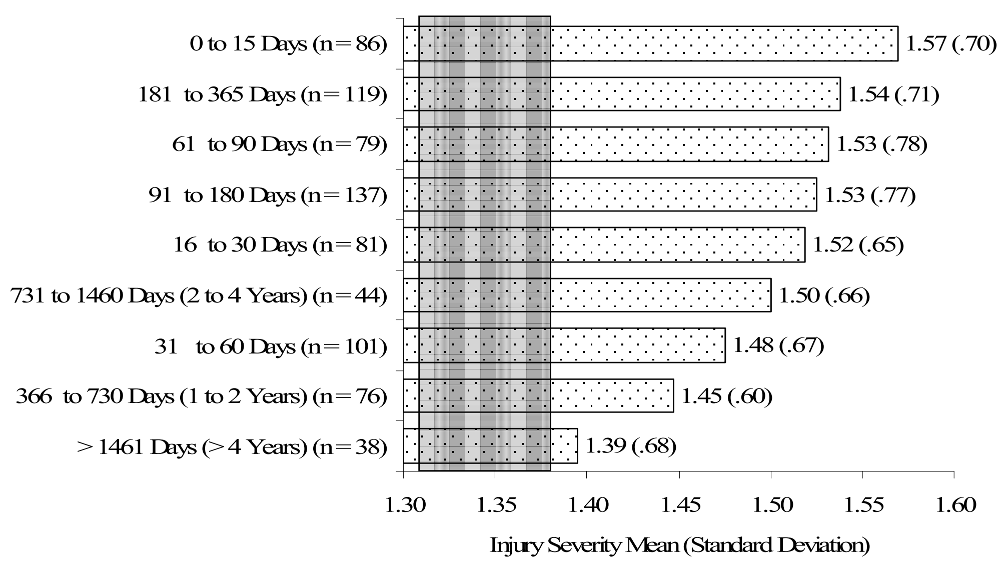

Figure 4- 117. Comparison of injury severity means by job tenure of workers with neck injuries.

The results of the Tukey's b range test indicated that all of the neck injury severity means for the nine job tenure groups were homogeneous, th

us showing no significantly different neck injury severity means, at $p \leq 0.05$, between any of the job tenure categories. Despite the lack of any significant difference of neck injury severity means between the job tenure periods, each of these were ranked by their respective neck injury severity mean (see Figure 4- 117). Neck injuries occurring within the first 15 days of employment had the highest severity mean ($\mu = 1.57$). This was followed closely by workers with neck injuries occurring between the 181st and 365th day of employment ($\mu = 1.54$), the 61st and 90th day ($\mu = 1.53$), the 91st and 180th day ($\mu = 1.53$), and the 6th and 30th day of employment ($\mu = 1.52$). Workers who had been working two to four years prior to experiencing a neck injury had the fourth lowest injury severity mean ($\mu = 1.50$), followed by job tenure periods of 31 to 60 days ($\mu = 1.48$), and one to two years ($\mu = 1.45$). Workers with over four years job tenure prior to reporting a neck injury had the lowest severity mean ($\mu = 1.39$) associated with those neck injuries.

Month of Occurrence of Injury

The month of the year during which neck injuries occurred was examined, based on information provided for 985 worker injuries. Table 4- 74 shows that over ten % (n = 101) of the neck injuries occurred during the month of August. During each of the months of September (n = 94), November (n = 94), and June (n = 91), slightly over nine % of the neck injuries occurred. Around 17% of these neck injuries were reported to have occurred during the months of July (n = 87) and May (n = 82). Each of the following months were associated with slightly over seven % of the neck injuries: namely, January (n = 77), October (n = 77), February (n = 76), March (n = 75), and April (n = 74). December was associated with the least amount of neck injuries (n = 57, 5.79%).

Table 4- 74. Neck injuries by month of occurrence.

Month of occurrence	Number of injuries	%	Cumulative %
August	101	10.25%	10.25%
September	94	9.54%	19.79%
November	94	9.54%	29.34%
June	91	9.24%	38.57%
July	87	8.83%	47.41%
May	82	8.32%	55.73%
January	77	7.82%	63.55%
October	77	7.82%	71.37%
February	76	7.72%	79.08%
March	75	7.61%	86.70%
April	74	7.51%	94.21%
December	57	5.79%	100.00%
Total	985	100.00%	

Injury severity means were compared for neck injuries occurring in the twelve months of the year. Injury severity scores were provided for 964 of the 985 neck injuries. The results of the Levene test of homogeneity of variances between the twelve months did not allow for an assumption of equal variances, L (11, 952) = 3.11, $p < 0.001$. The subsequent results of the Welch test of equality of neck injury severity means between the months of the year did not indicate any significant differences, at $p \leq 0.05$, of neck injury severity means between any of the months, F (11, 364.87) = 1.76, $p > 0.05$; however, this was not confirmed by the results of the Tukey's b range test.

The results of the Tukey's b range test are illustrated in Figure 4- 118. Neck injuries occurring within the month of April had the highest severity mean ($\mu = 1.67$). April was followed by February ($\mu = 1.59$), October ($\mu = 1.54$), and January ($\mu = 1.53$) as having the second, third, and fourth highest neck injury severity means. The injury severity means for the months of May, June, September, November, August, and March showed a steady decline, with December having the lowest injury severity mean of $\mu = 1.25$.

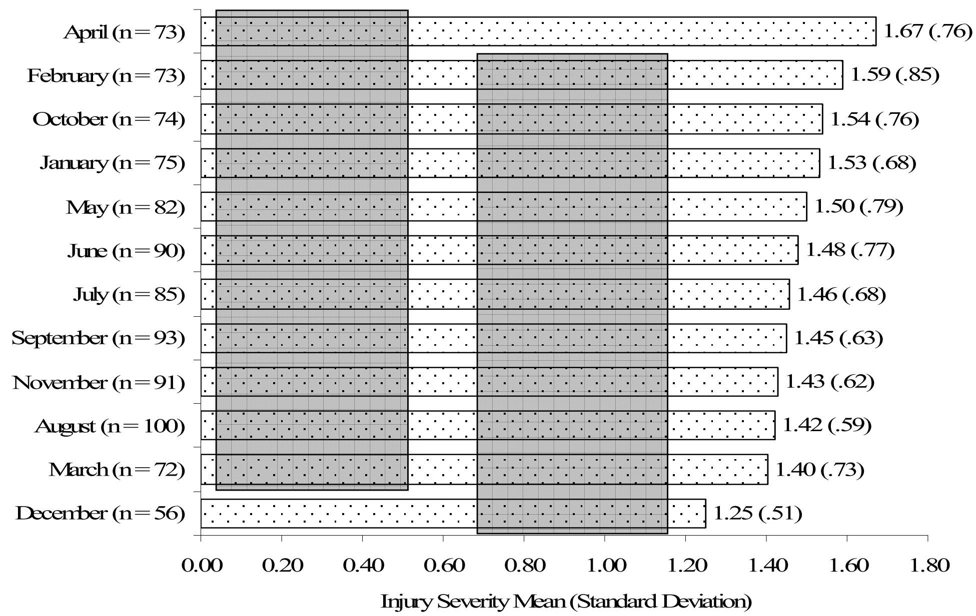

Figure 4- 118. Comparison of injury severity means by month of occurrence of neck injuries. .

From the two homogeneous groupings of the months by neck injury severity means, it was determined that, at $p \leq 0.05$, neck injuries that occurred during the month April had a significantly greater severity mean than those which happened during December (see Figure 4-119).

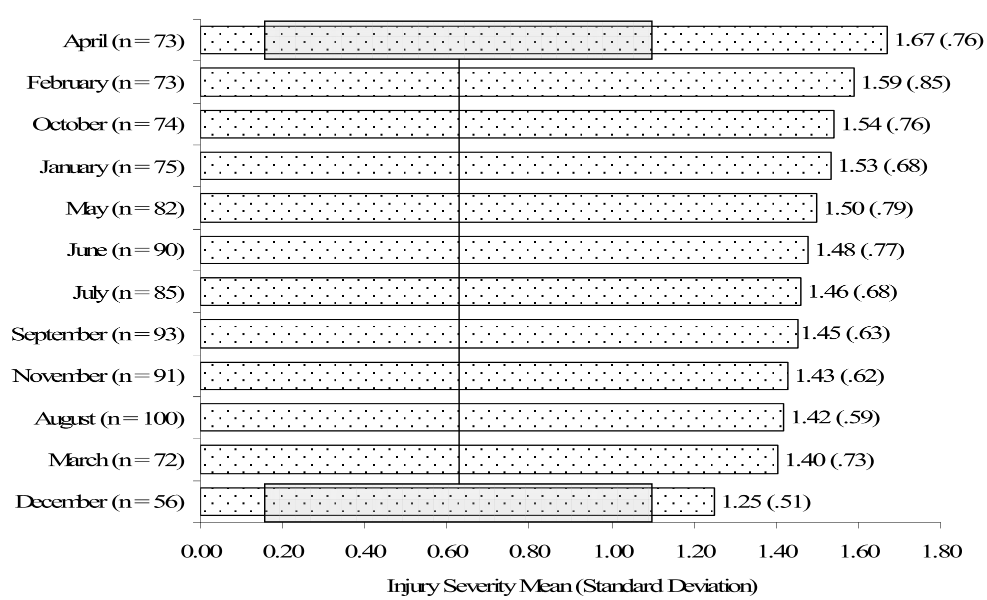

Figure 4- 119. Differences between injury severity means by month of occurrence of neck injuries.

Day of the Week of Occurrence of Injury

A similar investigation as the one conducted for month of occurrence of the neck injuries was performed regarding the relationship between neck injuries and the day of week on which injuries occurred. Information regarding the distribution of neck injuries relative to the day of the week of injury occurrence was provided for 985 worker injuries. As Table 4- 75 shows, nearly 60% of the 985 neck injuries occurred on Wednesdays (n = 200), Thursdays (n = 196) and Tuesdays (n = 192). Slightly over 16% of the neck injuries were experienced on either Mondays (n = 166) or Fridays (n = 163). Slightly less than 5% of the neck injuries occurred on Saturdays (n = 44), and less than 3% occurred on Sunday (n = 24).

Injury severity scores were provided for 964 neck injuries. Prior to comparing the neck injury severity means between the days of the week, the Leven test of homogeneity of severity score variances for the days of the week was performed. The results of this test allowed for an assumption of equal variances (L (6, 957) =1.64, $p > 0.10$), thus prompting the use of an ANOVA to assess the possibility that any of the days of the week could have a significantly different neck injury severity mean from one of the other days. The results of the ANOVA indicated that none of the days of the week had a significantly different neck injury severity mean than any of the other days of the week, F (6, 957) = 0.33, $p > 0.90$. This was confirmed by the results of the Tukey's b range test.

Table 4- 75. Neck injuries by day of the week of occurrence.

Day of the week of occurrence	Number of injuries	%	Cumulative %
Wednesday	200	20.30%	20.30%
Thursday	196	19.90%	40.20%
Tuesday	192	19.49%	59.70%
Monday	166	16.85%	76.55%
Friday	163	16.55%	93.10%
Saturday	44	4.47%	97.56%
Sunday	24	2.44%	100.00%
Total	985	100.00%	

Figure 4- 120 was derived from the results of the Tukey's b range test for homogeneity of neck injury severity means by days of the week. The results of this test showed that the neck injury severity means for each day of the week were identified as a single homogeneous group, thus indicating that none of the days of the week had a neck injury severity mean that was significantly different, at $p \leq 0.05$, from any of the other days of the week. Despite the outcome, the results also allowed for the ranking of the days of week by their respective severity mean for neck injuries. Neck injuries occurring on Saturdays (μ = 1.52) and Fridays (μ = 1.52) had the highest severity means. These were followed by Tuesdays (μ = 1.49), Mondays (μ = 1.49), Thursdays (μ = 1.47), and Wednesdays (μ = 1.44). Neck injuries occurring on a Sunday had the lowest injury severity mean.

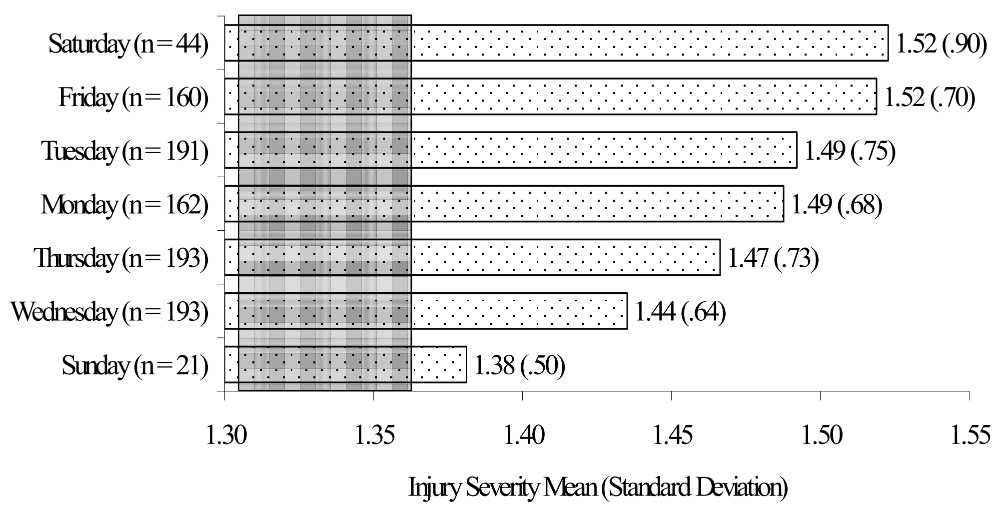

Figure 4- 120. Comparison of injury severity means by day of the week of occurrence of neck injury.

Trunk

Injuries to the trunk region made up just over 25% (n = 11,646) of the injuries to the six body regions. Injuries to the trunk had a significantly greater injury severity mean (μ = 1.44), at

$p \leq 0.05$, than injuries to the lower extremities (μ = 1.40), lower extremities (μ = 1.26), and head injuries (μ = 1.11).

Body Part

Information on trunk injuries by the specific body part injured was provided for 11, 646 worker injuries. The distribution of trunk injuries by specific body part is displayed in Table 4-76. Just over 48% (n = 5,611) of the trunk injuries were injuries to the lower back. Around 18% (n = 2,115) of the trunk injuries were to the shoulders. Injuries to the abdomen or groin (n = 1,144), chest (n = 882), lower back (n = 528), and lumbar or sacral vertebrae (n = 431) combined to constitute almost 26% of the injuries to the trunk. Injuries to internal organs not otherwise classified (n = 328) and the lungs (n = 324) accounted for nearly three % each of the 11,646 trunk injuries. The remaining five trunk body part injuries constituted less than 3 % of the trunk injuries.

Table 4- 76. Trunk injuries by body part.

Body part	Number of injuries	%	Cumulative %
Lower back	5,611	48.18%	48.18%
Shoulder	2,115	18.16%	66.34%
Abdomen (includes groin	1,144	9.82%	76.16%
Chest	882	7.57%	83.74%
Upper back	528	4.53%	88.27%
Lumbar and/or sacral Vertebrae	431	3.70%	91.97%
Internal organs NOC	328	2.82%	94.79%
Lungs	324	2.78%	97.57%
Multiple injuries	92	0.79%	98.36%
Buttocks	69	0.59%	98.95%
Heart	61	0.52%	99.48%
Pelvis	33	0.28%	99.76%
Sacrum and coccyx	28	0.24%	100.00%
Total	11,646	100.00%	

A comparison of the severity means was conducted between each of the thirteen body parts for trunk injuries. Injury severity scores, by body part, were provided for 11,490 of these trunk injuries. The results of the Levene test of homogeneity of trunk injury severity scores between the body parts did not allow for an assumption of equal variances, L (12, 11,477) = 23.89, $p >$ 0.001. The results of the subsequent Welch test of equality of trunk injury severity means between the body parts indicated that at least one of the trunk body parts displayed a trunk injury severity mean that were different from one of the other body parts, F (12, 454.74) = 13.76, $p <$ 0.001. This was not confirmed by the results of the Tukey's b range test for injury severity means between specific body parts of the trunk.

The results of the Tukey's b test allowed the specific body parts of the trunk to be ranked according to their respective injury severity means (see Figure 4- 121). Along with these rankings, Figure 4- 121 displays the five subsets of body parts by homogeneous trunk injury severity means. Heart injuries had the highest injury severity mean ($\mu = 2.19$) among trunk injuries. Pelvis injuries showed the second highest severity mean ($\mu = 1.82$) for trunk injuries. This was followed by multiple trunk injuries ($\mu = 1.57$), injuries to the abdomen (including the groin) ($\mu = 1.54$), shoulder injuries ($\mu = 1.48$), and injuries to the lower back ($\mu = 1.44$). Injuries or occupational diseases of the lungs ($\mu = 1.44$) had the seventh highest severity mean among the trunk injuries. This was followed by injuries to the lumbar or sacral vertebrae ($\mu = 1.40$), internal organs not otherwise classified ($\mu = 1.35$), lower back ($\mu = 1.34$), chest ($\mu = 1.28$), and buttocks ($\mu = 1.28$). Among trunk injuries, those to the sacrum and/or coccyx had the lowest severity mean ($\mu = 1.25$).

Significantly different trunk injury severity means, at $p \leq 0.05$, between body parts were discerned from the homogeneous subsets shown in Figure 4- 121. These are displayed in Figure 4- 122. Among injuries to the trunk, heart injuries had a significantly greater severity mean, at $p \leq 0.05$, than injuries to all of the other body parts. Injuries to the pelvis had a severity mean that was significantly greater, at $p \leq 0.05$, than all of the other body parts, except the heart. Injuries to the chest, buttocks, and sacrum or coccyx displayed a trunk injury severity mean significantly lower, at $p \leq 0.05$, than that of multiple injuries to the trunk. Abdomen (including groin) injuries had a significantly greater severity mean, at $p \leq 0.05$, than injuries to the sacrum or coccyx

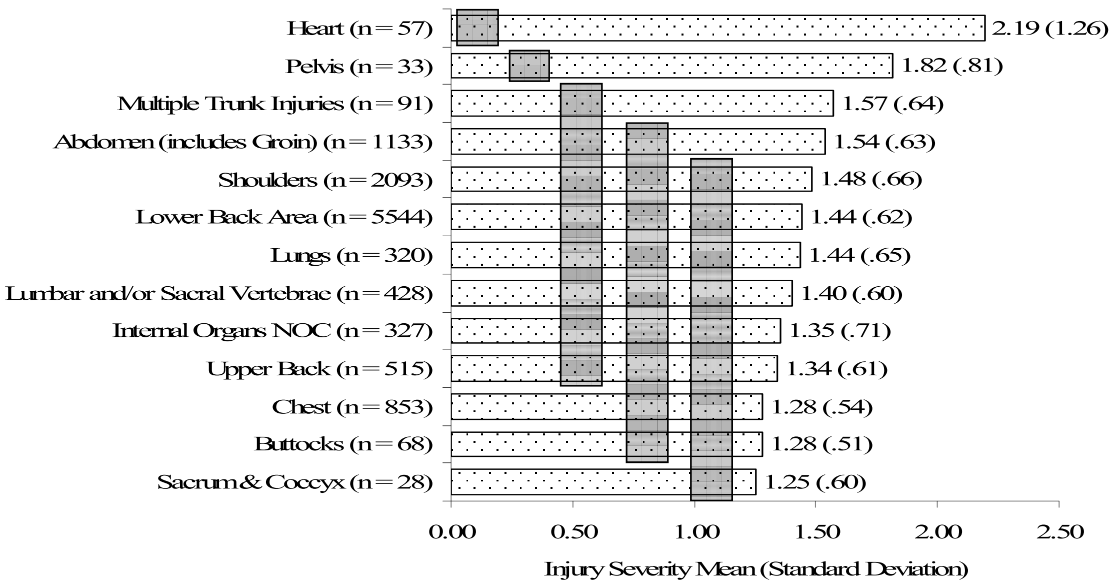

Figure 4- 121. Comparison of injury severity means by injured body parts of the trunk.

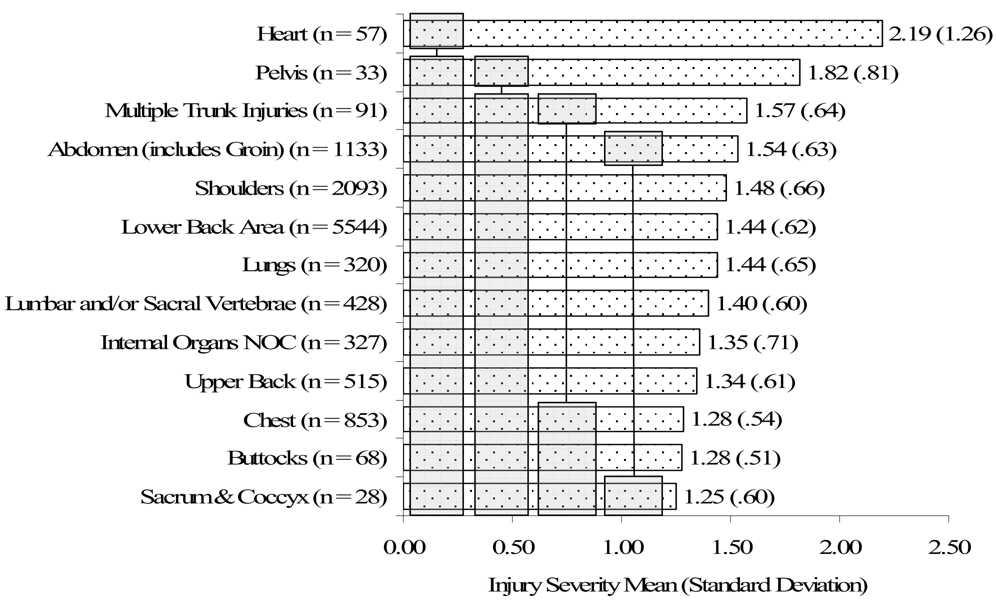

Figure 4- 122. Differences of injury severity means by injured body parts of the trunk.

General Nature of Injury

Information regarding the general nature of trunk injuries was provided for 11,646 worker injuries. Over 95% (n = 11,118) of the injuries to the trunk were specific injuries. Around four % (n = 456) of the trunk injuries were either an occupational disease or a cumulative disorder. Multiple injuries to the trunk constituted less than one % (n = 72) of the trunk injuries (see Table 4- 77).

Table 4- 77. Trunk injuries by general nature of injury.

General nature of injury	Number of injuries	%	Cumulative %
Specific injury	11,118	95.47%	95.47%
Occupational disease or cumulative injury	456	3.92%	99.39%
Multiple injuries	72	0.62%	100.00%
Total	11,646	100.00%	

From the 11,646 trunk injury cases, information regarding the injury severity relative to general nature of the trunk injury was provided for 11,490 worker injuries. The results of the Levene test of homogeneity of trunk injury severity scores between the three general nature of injury categories did not allow for the assumption of equal variances, L (2, 16.06, $p < 0.001$. Subsequently, the results of the Welch robust test of equality of trunk injury severity means indicated that at least one of the general nature of injury groups had a significantly greater trunk injury severity mean than one of the other categories, F (2, 166.44) = 12.62, $p < 0.001$. This was confirmed by the results of the Tukey's b range test of trunk injury severity means between the three general nature of injury groups.

From the results of the Tukey's b test, each of the general nature of injury classifications for trunk injuries was ranked by their respective injury severity means (see Figure 4- 123). Among trunk injuries, multiple injuries to the trunk had the highest severity mean ($\mu = 1.65$), followed by specific injuries to the trunk ($\mu = 1.45$). Occupational diseases or cumulative injuries to the trunk had the lowest severity mean ($\mu = 1.32$).

From the two groupings of general nature of injury classifications by homogeneous severity means, it was determined that multiple trunk injuries had a significantly greater injury severity mean, at $p \leq 0.05$ than that for both specific trunk injuries and injuries to the trunk resulting from an occupational disease or cumulative injury. This is illustrated in Figure 4- 124.

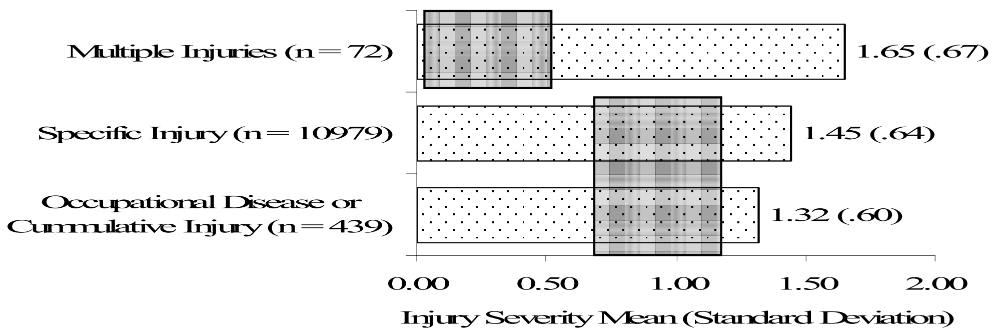

Figure 4- 123. Comparison of injury severity means by general nature of trunk injuries.

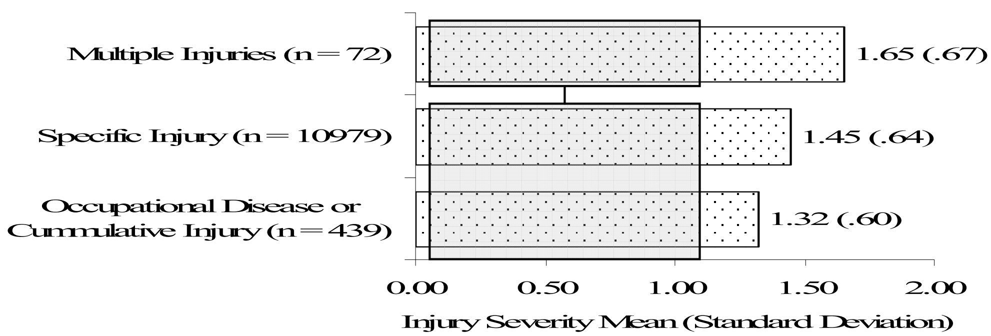

Figure 4- 124. Differences of injury severity means by general nature of trunk injuries.

Nature of Injury

Within each of the general nature of injury categories, specific “Nature of Injury” categories were identified. Information about the distribution of nature of trunk injuries was provided for 10,820 worker injuries (see Table 4- 78). Strains comprised just over 69% (n = 7,503) of the injuries to the trunk. Contusions (n = 1,031) had the second highest frequency among trunk injuries (9.53%). Sprains (n = 457) and hernias (n = 374) accounted for around 4 % each, of the trunk injuries. The remaining 29 nature of injury categories accounted for less than 14% of the injuries.

Nature of injury classifications of trunk injuries with of less than two cases were excluded from subsequent trunk injury severity means comparisons between the nature of injury groups. The single amputation among the trunk injuries had an injury severity score of two (i.e., temporary injury), while both the concussion, and carpal tunnel cases each had a severity score of one (i.e., medical only). The implausibility of a, concussion and carpal tunnel syndrome being associated with a trunk injury suggests the likelihood of a miscode for each these respective cases.

With the exception of the single cases of amputation, carpal tunnel syndrome, and concussion, the trunk injury severity means were generated for each of the nature of injury classifications. Comparisons between these means were subsequently conducted. The results of the Levene test did not allow for an assumption of equal trunk injury severity score variances between the nature of injury groups. The Welch test of equality of means could not be conducted because there was a zero variance of severity scores for the Foreign body ($\mu = 1.00$), syncope ($\mu = 1.00$) and dermatitis ($\mu = 1.00$) nature of injury groups for trunk injuries. In lieu of the Welch test, an ANOVA test was performed to initially assess possible trunk injury severity mean differences between the nature of injury categories with a frequency of two or more.

The results of the ANOVA indicated that at least one of the nature of injury groups had a trunk injury severity mean that was significantly different from one of the other nature of injury groups, $F\ (15, 852) = 22.40$, $p < 0.001$. This was confirmed by the results of the Tukey's b range test of trunk injury severity means between the nature of injury groups.

Using the results of the Tukey's b test each of the nature of injury groups was ranked by their severity means for trunk injuries (see Figure 4- 125). Amputation, carpal tunnel syndrome, and concussion were excluded because the Tukey's b range test could not accommodate categories with less than two cases. Among the nature of injury categories for trunk injuries, myocardial infarction had the highest injury severity mean (μ = 2.60). Silicosis was associated with trunk injuries with the second highest injury severity mean (μ = 2.50). The results of the Tukey's b test also generated homogeneous subsets of the nature of injury groups (see Figure 4- 125). Each column represents a set of nature of injury groups which have similar means. From this, specific differences between groups were inferred, as displayed in Figure 4- 126.

Table 4- 78. Injury frequency by nature of trunk injury.

Nature of injury	Number of injuries	%	Cumulative %
Strain	7,503	69.34%	69.34%
Contusion	1,031	9.53%	78.87%
Sprain	457	4.22%	83.10%
Hernia	374	3.46%	86.55%
Fracture	171	1.58%	88.13%
Asbestosis	169	1.56%	89.70%
Respiratory disorder	162	1.50%	91.19%
Rupture	156	1.44%	92.63%
Inflammation	114	1.05%	93.69%
Dislocation	100	0.92%	94.61%
Laceration	91	0.84%	95.45%
Multiple Injuries	72	0.67%	96.12%
Puncture	68	0.63%	96.75%
Chemical poisoning	65	0.60%	97.35%
Heat prostration	45	0.42%	97.76%
Myocardial infarction	44	0.41%	98.17%
Burn	43	0.40%	98.57%
Occupational disease NOC	25	0.23%	98.80%
Infection	21	0.19%	98.99%
Poisoning NOC	16	0.15%	99.14%
Asphyxiation	15	0.14%	99.28%
Electric shock	14	0.13%	99.41%
Crushing	13	0.12%	99.53%
Dermatitis	11	0.10%	99.63%
Angina pectoris	9	0.08%	99.71%
Mental stress/disorder	8	0.07%	99.79%
Severance	6	0.06%	99.84%
Silicosis	6	0.06%	99.90%
Foreign body	5	0.05%	99.94%
Syncope	3	0.03%	99.97%
Amputation	1	0.01%	99.98%
Concussion	1	0.01%	99.99%
Carpal tunnel syndrome	1	0.01%	100.00%
Total	10,820	100.00%	

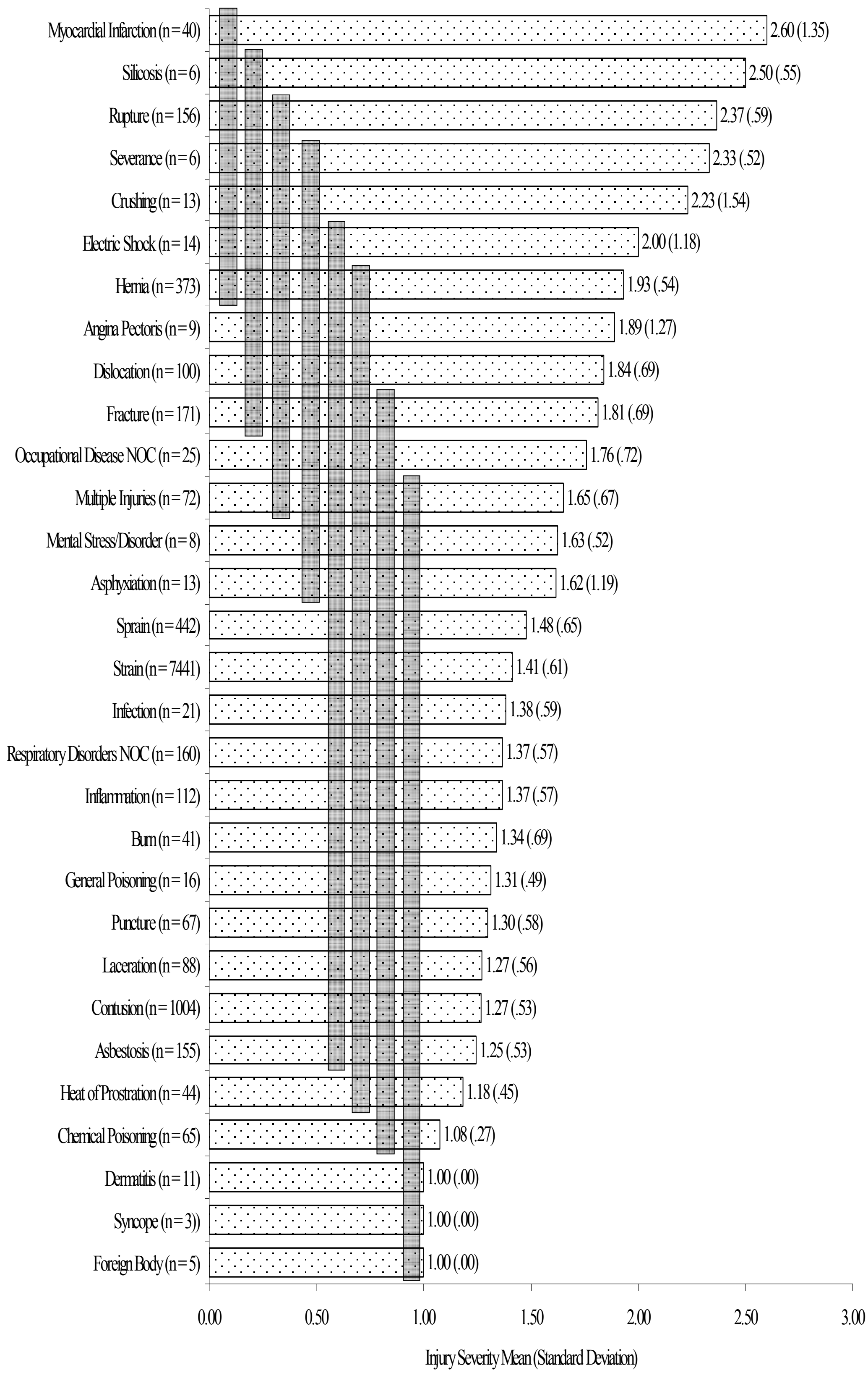

Figure 4- 125. Comparison of injury severity means by nature of trunk injuries.

Among the trunk injuries, myocardial infarctions had a significantly greater, at $p \leq 0.05$, injury severity mean than all of the other nature of injury categories, except silicosis, rupture, severance, crushing, electric shock, and hernia (see Figure 4- 126). Silicosis showed a similar difference as myocardial infarction, with the exception of angina pectoris, dislocation, and fracture. Ruptures displayed a similar set of differences to silicosis, with the exception of occupational diseases not otherwise classified (NOC) and multiple trunk injuries. Among trunk injuries, both severances and crushing had a significantly greater injury severity mean than that for sprains, strains, infections, respiratory disorders NOC, inflammations, burns, general poisoning, punctures, lacerations, contusions, asbestosis, heat prostration, chemical poisoning, dermatitis, syncope, and a Foreign body. Electric shock injuries to the trunk had a significantly greater severity mean, $p \leq 0.05$, heat prostration, chemical poisoning, dermatitis, syncope, and Foreign body injuries to the trunk. Hernias displayed a significantly higher injury severity mean, at $p \leq 0.05$, than chemical poisoning, dermatitis related, syncope, and foreign body injuries to the trunk region. Fractures to body parts of the trunk had a significantly greater injury severity mean, at $p \leq 0.05$, than dermatitis, syncope, and foreign body related injuries to the trunk region.

General Cause of Injury

The general cause of injury was examined for injuries of the trunk region. Information regarding the distribution of injury by general cause of injury categories was provided for 11,201 worker injuries. Table 4- 79 shows the trunk injury distribution for each of the general cause of injury classifications. Straining was the leading cause of injuries to the trunk, comprising over64% (n = 7,190) of the injuries. Around 18% (n = 2,025) of the trunk injuries were caused by a fall or slip. Over 14% of the trunk injuries were caused by the combination of being struck by an object (n = 752), the absorption, ingestion, or inhalation of a substance (n = 505), and having struck against or stepped on an object (n = 331). Slightly more than one % (n = 124) of

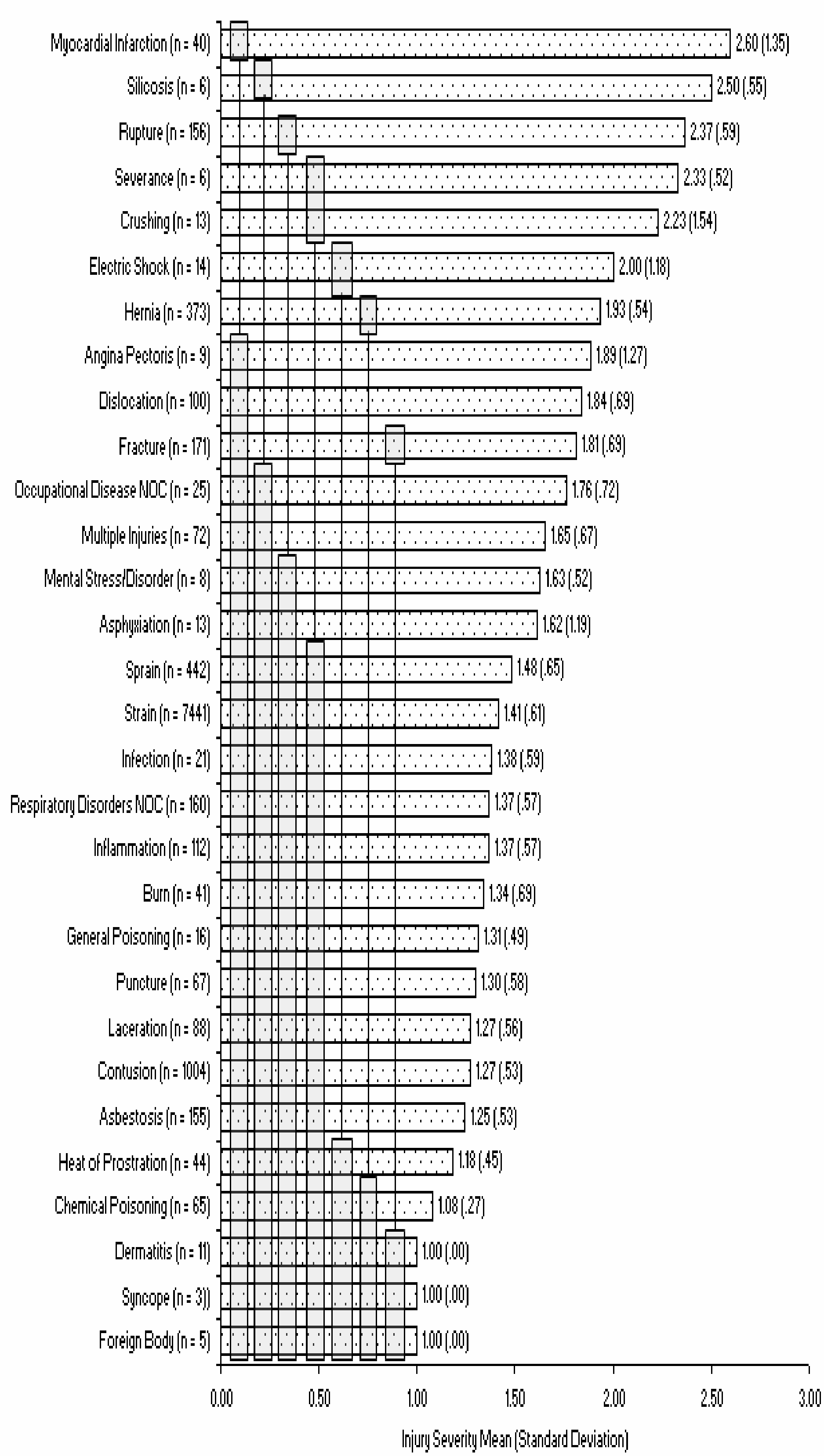

Figure 4- 126. Differences of injury severity means between nature of trunk injuries.

the trunk injuries were caused by some kind of involvement with a motor vehicle. Having been Caught in or between an object or objects (n = 84), cut, punctured, or scraped (n = 84), burned (n = 64), and bitten or stung by animal or insect (n = 42) accounted for around three % of the trunk injuries.

Table 4- 79. General cause of trunk injury.

General cause of injury	Nature of Injury	%	Cumulative %
Strain	7,190	64.19%	64.19%
Fall or slip	2,025	18.08%	82.27%
Struck by	752	6.71%	88.98%
Absorption, ingestion, or inhalation	505	4.51%	93.49%
Striking against or stepping on	331	2.96%	96.45%
Motor vehicle	124	1.11%	97.55%
Caught in or between	84	0.75%	98.30%
Cut, puncture, or scrape	84	0.75%	99.05%
Burn	64	0.57%	99.63%
Animal or insect bite or sting	42	0.37%	100.00%
Total	11,201	100.00%	

Injury severity means were compared among the ten general causes of injury for trunk injuries. Injury severity scores by general cause of injury were provided for 11,054 workers with trunk injuries. The results of the Levene test of homogeneity of injury severity score variances, for the ten general cause of injury groups, did not allow for an assumption of equal variances, L (9, 11,044) = 25.63, $p < 0.001$. The results of the subsequent Welch test of equality of trunk injury severity means indicated that at least one general cause of injury group was significantly different of another group, F (9, 419.53) = 15.32, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

Output of the Tukey's b test provided a ranking of the general cause of injury groups by their respective trunk injury severity means (see Figure 4- 127). Trunk injuries caused by being Caught in or between an object or objects had the highest injury severity mean ($\mu = 1.50$), followed by trunk injuries of a fall or slip ($\mu = 1.50$), involvement with some type of motor vehicle (μ = 1.46), straining (μ = 1.44), and being struck by an object (μ = 1.41). General causes of trunk injuries with the lowest injury severity means include having struck up against or stepped on an object (μ = 1.40), absorption, ingestion, or inhalation of a substance (μ = 1.30), having been cut, punctured, or scraped (μ = 1.16), and having been bitten or stung by an animal or insect (μ = 1.10). The Tukey's test identified homogeneous subsets of trunk injury severity means that were not significantly different from each at $p \leq 0.05$ (see Figure 4- 127).

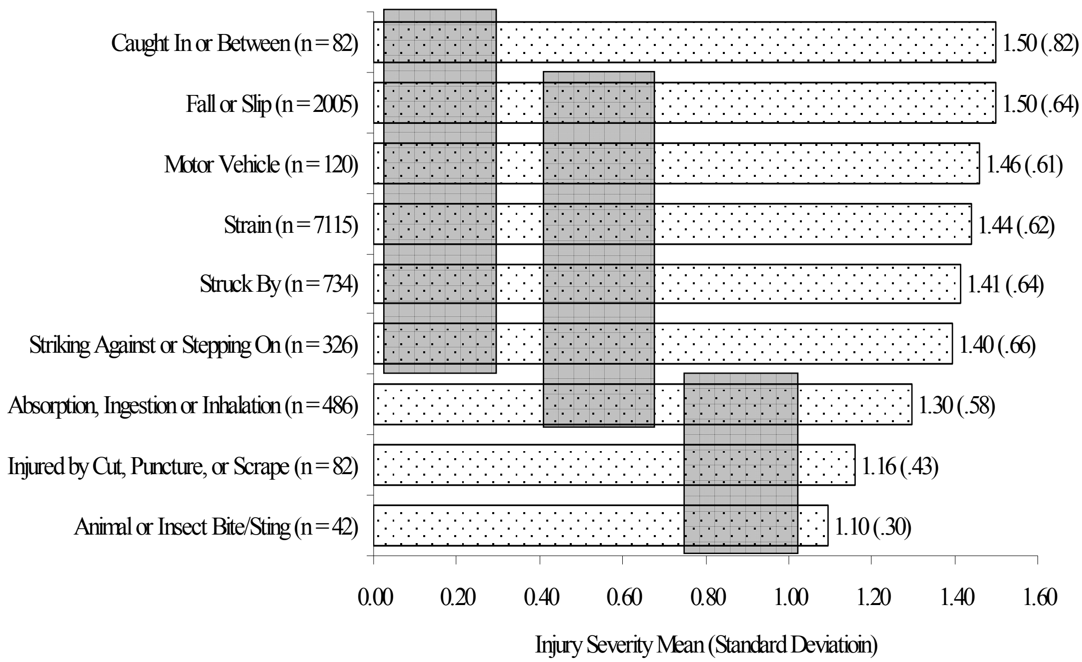

Figure 4- 127. Comparison of injury severity means by general cause of trunk injuries.

From the arrangement of these homogeneous subsets, specific differences of trunk injury severity means between the general causes of injury were inferred, illustrated in Figure 4- 128. Among the trunk injuries, those caused by having been Caught in or between an object or objects had a significantly higher injury severity mean, at $p \leq 0.05$, than trunk injuries resulting from the absorption, ingestion, or inhalation of a substance, having been cut, punctured, or scraped by an object, and of a bite or sting of an animal or insect. Trunk injuries caused by a slip or fall, involvement with a motor vehicle, straining, having been struck by an object, and having struck against or stepped on an object had significantly greater injury severity means, at $p \leq 0.05$ than trunk injuries caused by being cut, punctured, or scraped by an object, and of animal bites or insect stings.

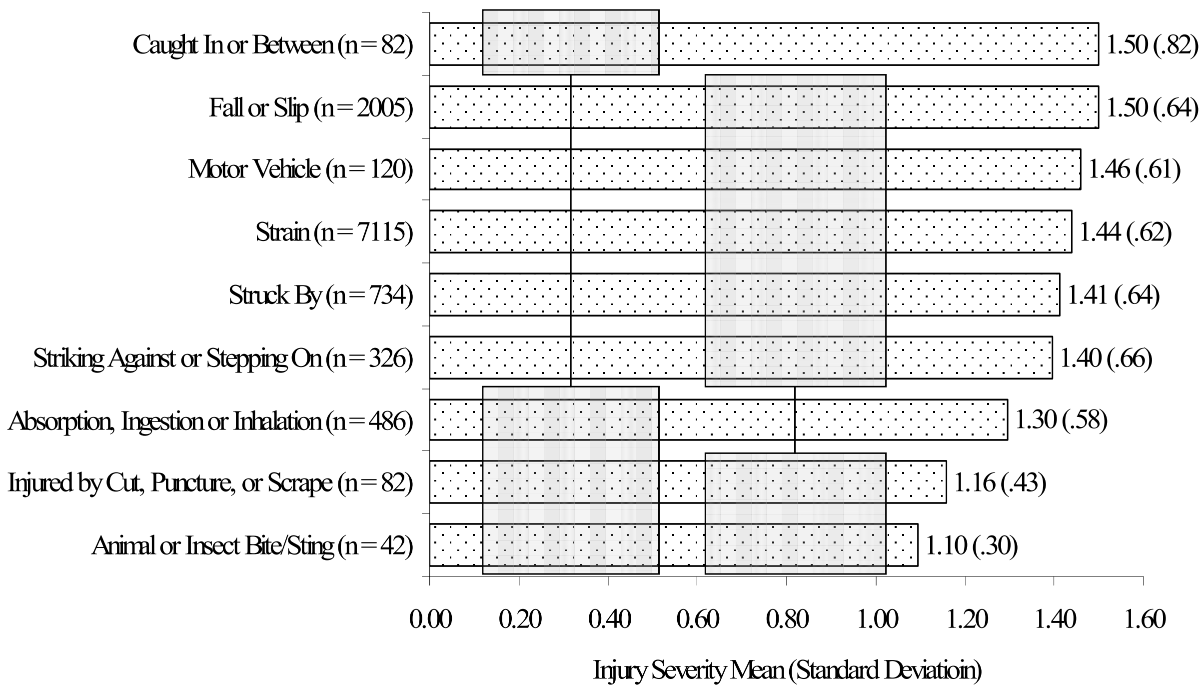

Figure 4- 128. Differences of injury severity means by general causes of trunk injuries.

Occupational Work Area

Frequency information for the general occupational work area in which the worker was working at the time of the trunk injury was provided for 8,791 worker injuries.

Trunk injury distribution for each of the work areas are shown inTable 4- 80. Nearly 18% (n = 1,562) of the trunk injuries occurred while the injured worker was working at some type of carpentry activity. Just over 15% (n = 1,368) of the trunk injuries occurred while the worker was performing electrical work, followed by work involving iron and steel (n = 1,009, 11.48%), concrete (n = 551, 6.27%), technical repair or maintenance (n = 540, 6.14%), pipe fitting (n = 521, 5.93%), masonry (n = 393, 4.47%), equipment or machinery operations (n = 393, 4.47%), and plumbing (n = 325, 3.70%). Workers involved with sheet metal work at the time of the injury comprised around three % (n = 253) of the trunk injuries. The number of cases in each of the remaining 32 work areas, shown in Table 4- combined to account for just under 20% of the injuries to the trunk.

Trunk injury severity means were compared among the 42 general occupational work areas. Injury severity scores were provided for 8,701 workers with trunk injuries. The results of the Levene test of homogeneity of injury severity score variances for the 52 work areas did not allow for an assumption of equal variances, L (41, 8,659) = 4.65, $p < 0.001$. The results of the subsequent Welch test of equality of trunk injury severity means indicated that at least one work area was significantly different from another area, F (41, 256.20) = 2.50, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

Output of the Tukey's b test provided a ranking of the general cause of injury groups by their respective trunk injury severity means (see Figure 4- 129). Work areas associated with the ten highest severity means for trunk injuries included flagging ($\mu = 2.00$,), acoustic installation ($\mu = 2.00$), landscaping ($\mu = 1.89$, , field engineering ($\mu = 1.67$), flooring, tile or carpeting work ($\mu = 1.62$), technical repair or maintenance ($\mu = 1.57$), lathing ($\mu = 1.56$), HVAC and refrigeration ($\mu = 1.53$), painting or plastering ($\mu = 1.53$), and security ($\mu = 1.53$). Occupational work areas having the lowest five severity means for trunk injures included engineering (μ = 1.25), insulation work ($\mu = 1.25$), waterproofing ($\mu = 1.23$), scaffold erection ($\mu = 1.23$), and rigging ($\mu = 1.13$). See Figure 4- for the remaining occupational work areas with trunk injury severity mean rankings. The Tukey's test identified homogeneous subsets of trunk injury severity means that were not significantly different from each at $p \leq 0.05$ (see Figure 4- 129).

Specific trunk injury severity mean differences were discerned from the homogeneous groupings displayed in Figure 4- 129. These are illustrated in Figure 4- 130. Trunk injuries

Table 4- 80. Occupational work area workers with trunk injuries.

Occupational work area	Number of injuries	%	Cumulative %
Carpentry	1,562	17.77%	17.77%
Electrical work	1,368	15.56%	33.33%
Iron/steel work	1,009	11.48%	44.81%
Concrete work	551	6.27%	51.07%
Technical repair and maintenance	540	6.14%	57.22%
Pipe fitting/laying	521	5.93%	63.14%
Masonry	393	4.47%	67.61%
Equipment /machinery operation	393	4.47%	72.09%
Plumbing	325	3.70%	75.78%
Sheet metal work	253	2.88%	78.66%
Boilermaker	212	2.41%	81.07%
Millwright work	173	1.97%	83.04%
Painting and plastering	153	1.74%	84.78%
Supervisory noc	143	1.63%	86.41%
Welding	139	1.58%	87.99%
Drywall work	121	1.38%	89.36%
Insulation	116	1.32%	90.68%
Driving	112	1.27%	91.96%
Lineman	80	0.91%	92.87%
Roofing	67	0.76%	93.63%
Glazing	65	0.74%	94.37%
Clerical	57	0.65%	95.02%
Managing	57	0.65%	95.67%
Sprinkler fitting	50	0.57%	96.23%
Steam fitting	47	0.53%	96.77%
Inspecting	41	0.47%	97.24%
Flooring, tile, or carpeting	37	0.42%	97.66%
Engineering	29	0.33%	97.99%
Scaffold erection	26	0.30%	98.28%
Lathing	18	0.20%	98.49%
Security	17	0.19%	98.68%
Material handling	17	0.19%	98.87%
Hod carrying	17	0.19%	99.07%
HVAC/refrigeration	16	0.18%	99.25%
Conveyor systems	15	0.17%	99.42%
Waterproofing	14	0.16%	99.58%
Landscaping	9	0.10%	99.68%
Rigging	8	0.09%	99.77%
Surveying	7	0.08%	99.85%
Field engineering	6	0.07%	99.92%
Acoustic ceiling work	4	0.05%	99.97%
Flagging	3	0.03%	100.00%
Total	8,791	100.00%	

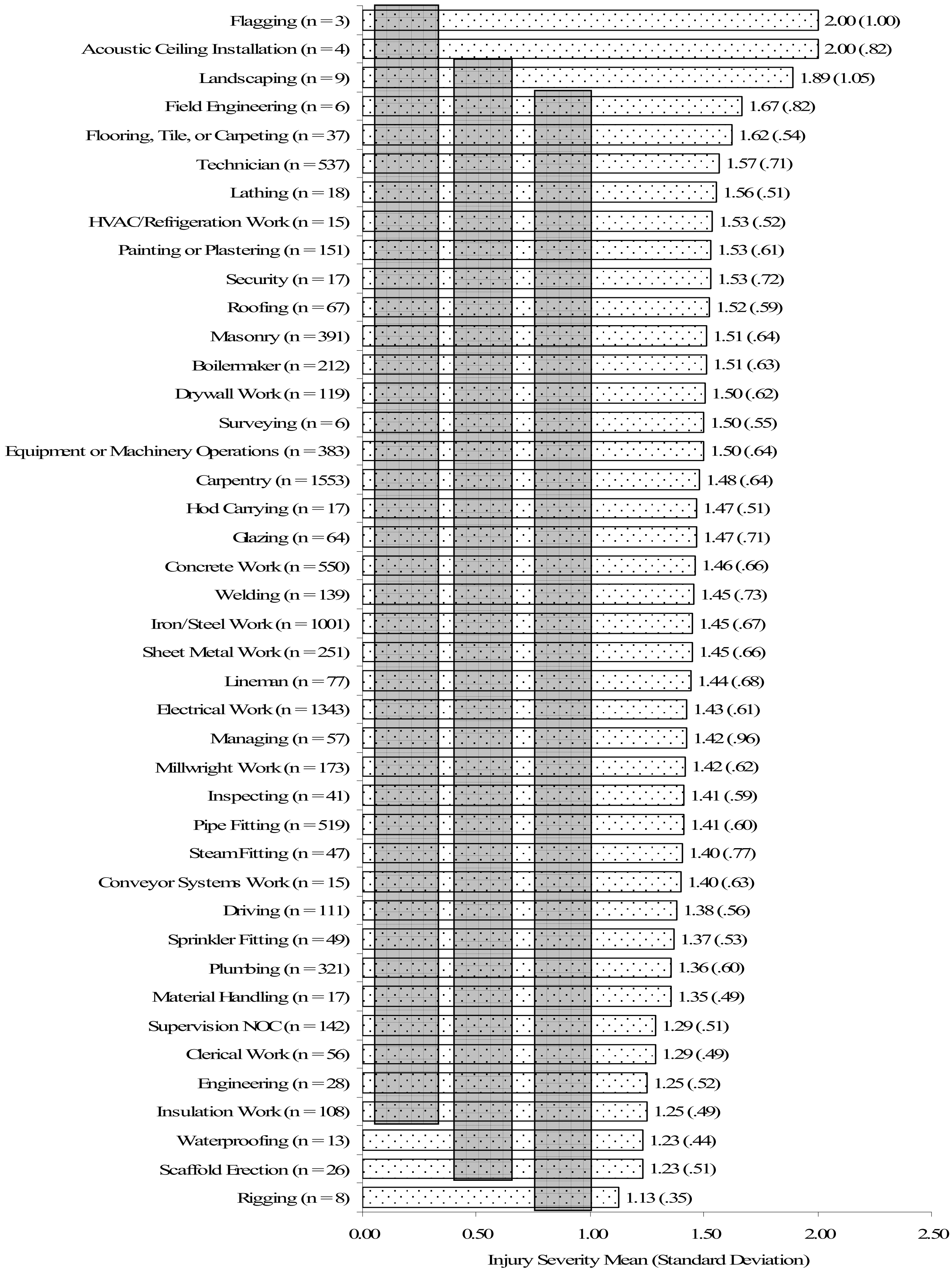

Figure 4- 129. Comparison of injury severity mean by occupational work area for workers with trunk injuries.

which occurred to workers while rigging showed a significantly lower severity mean, at $p \leq 0.05$, than those which occurred while workers were engaged in activities related to landscaping, Acoustic ceiling work, and flagging. In addition to rigging, workers involved with waterproofing or scaffold erection at the time of injury had significantly lower trunk injury severity means, at $p \leq 0.05$, than while flagging or installing acoustic ceiling systems.

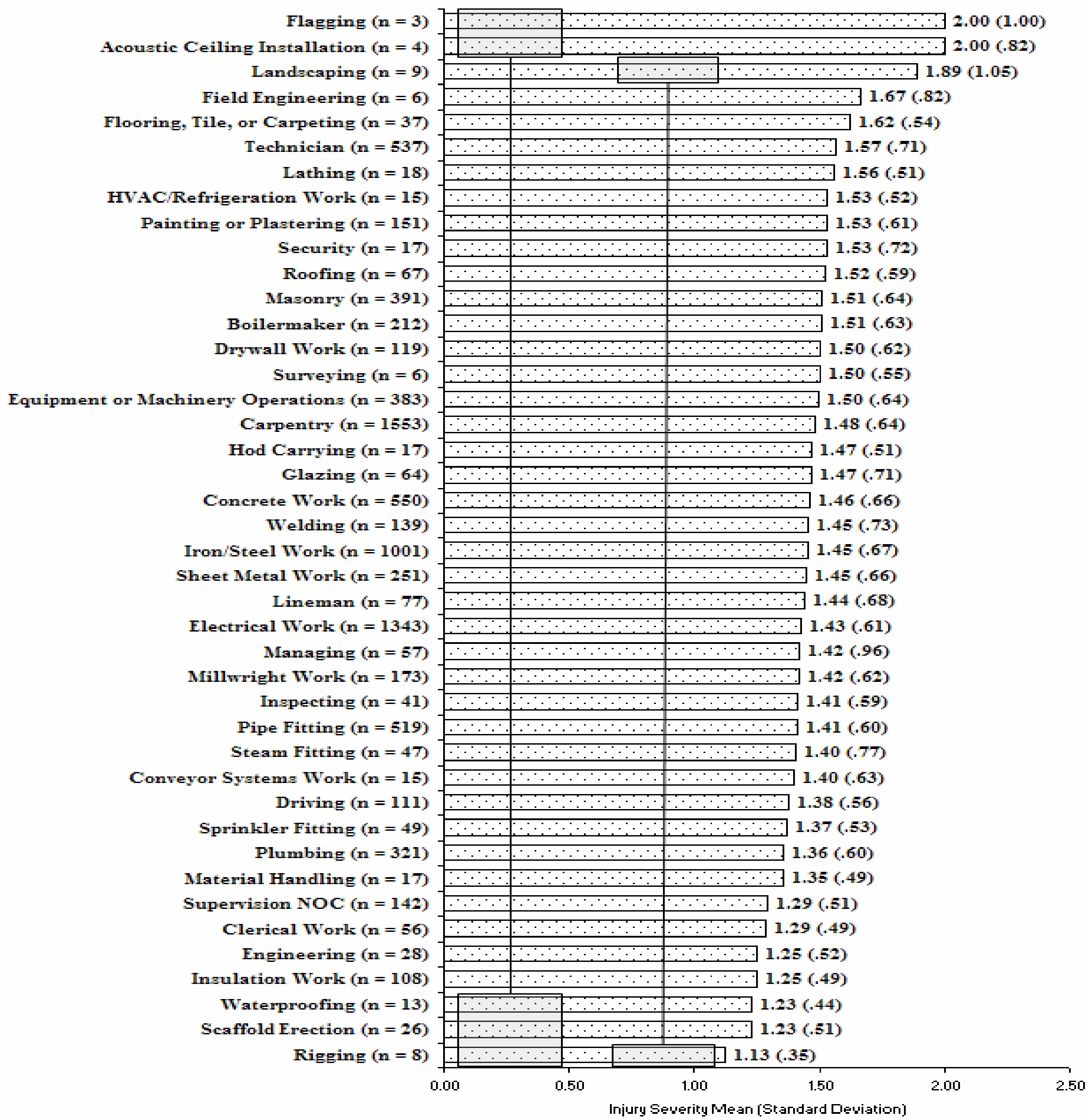

Figure 4- 130. Differences of injury severity means between occupational work area of workers with trunk injuries.

Occupational Experience Level

Trunk injuries were examined by workers' occupational experience levels at the time the injury occurred. Frequency information regarding the number of injured workers with trunk injuries and their respective experience levels was made available for 3,823 workers (see Table 4- 81). Over 56% (n = 2,147) of the trunk injuries were experienced by laborers. Foreman (n = 407) and journeyman (n = 377) level workers accounted for slightly over 20% of the trunk injuries. Apprentices experienced nearly 10% (n = 365) of the 3,823 trunk injuries. Helpers and assistants (n = 194), field supervisors (including superintendents and assistant superintendents) (n = 149), administrative personnel (n = 114), and professional level (n = 70) workers represented just under 9 % of the trunk injuries.

Table 4- 81. Occupational experience level of workers with trunk injuries.

Occupational experience level	Number of injuries	%	Cumulative %
Laborer	2,147	56.16%	56.16%
Foreman	407	10.65%	66.81%
Journeyman	377	9.86%	76.67%
Apprentice	365	9.55%	86.22%
Helper/assistant	194	5.07%	91.29%
Field supervisor	149	3.90%	95.19%
Administrator	114	2.98%	98.17%
Professional	70	1.83%	100.00%
Total	3,823	100.00%	

The severity of trunk injuries relative to a worker's experience level was examined by ranking and comparing experience levels by their respective injury severity means. Since an equal variance of trunk injury severity scores could not be assumed between the experience levels (L (7, 3,788) = 4.07, $p < 0.001$), the Welch test was conducted to assess equality of trunk injury severity means between experience levels. The results of this test indicated that at least one of the levels had a trunk injury severity mean that was significantly different from one of the other levels, F (7, 526.27) = 2.64, $p < 0.02$. The results of the Tukey's b range test confirmed the

Welch test result, and enabled the ranking of the eight occupational experience levels by their respective trunk injury severity means (see Figure 4- 131).

Journeyman level workers displayed the highest trunk injury severity mean ($\mu = 1.50$), followed by laborers ($\mu = 1.45$), apprentices ($\mu = 1.43$), foremen ($\mu = 1.41$), helpers and assistants ($\mu = 1.41$), administrative level workers ($\mu = 1.35$), professionals ($\mu = 1.35$), and field supervisors ($\mu = 1.30$). The results of the Tukey's b range test also identified homogeneous subsets of trunk injury severity means among the occupational experience levels. Experience levels within each subset did not have significantly different trunk injury severity means, at $p \leq 0.05$, (see Figure 4- 131).

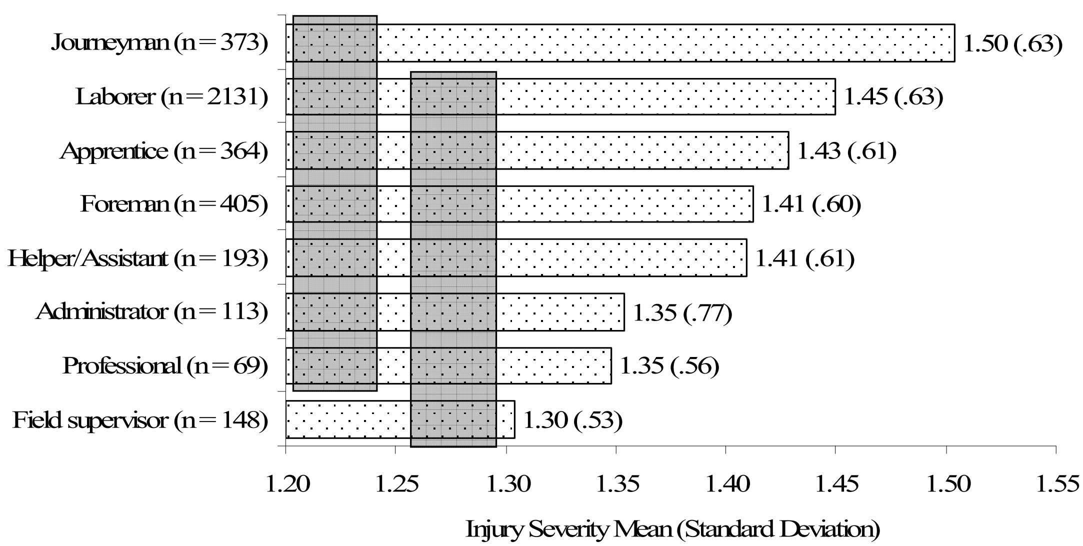

Figure 4- 134. Comparison of injury severity means by occupational experience level of workers with trunk injuries.

Specific trunk injury severity mean differences were discerned from the homogeneous groupings displayed in see Figure 4- 131. These are illustrated in Figure 4- 132. Trunk injuries which occurred to journeyman level workers generated a significantly higher severity mean, at $p \leq 0.05$, than trunk injuries experienced by field supervisors.

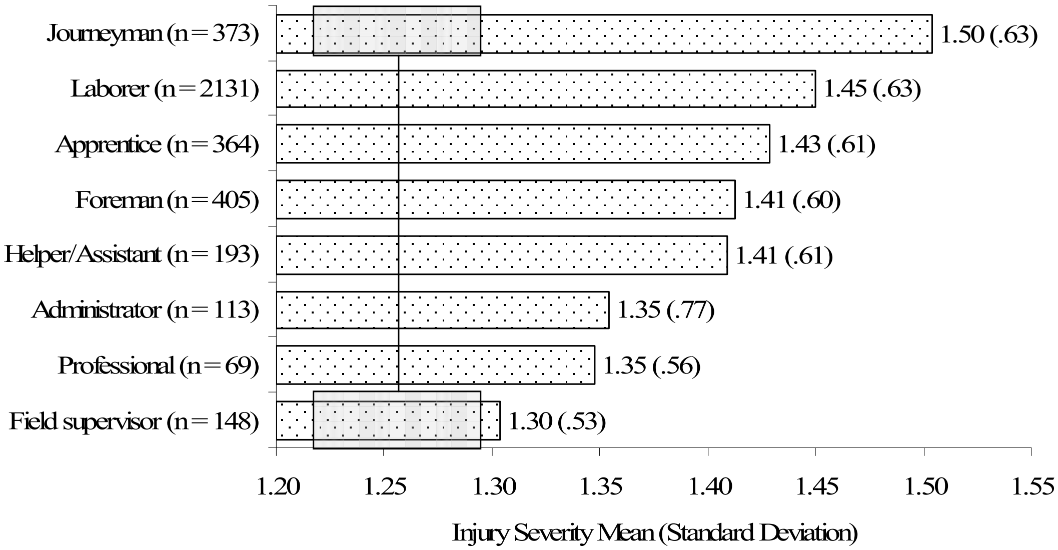

Figure 4- 132. Differences of injury severity means between occupational experience areas of workers with trunk injuries.

Age

The relationship between age and trunk injuries was explored from two perspectives. First, workers with trunk injuries were compared by their respective inclusion in one of seven age groups. With the exception of the under 20 and over 69 age groups, each of the age groups represented ten-year spans. Trunk injuries were distributed between the age groups. This was followed by a comparison of trunk injuries severity means between the age groups. Second, a comparison of mean ages, between specific age groups was conducted.

Frequency data for trunk injuries by the workers' age group were provided for 3,789 workers (seeTable 4- 82). Almost 31% (n = 1,161) of the trunk injuries were experienced by workers between 30 and 39 years of age. Around 26% (n = 977) of the trunk injuries were to workers 40 to 49 years old. Just under 24% (n = 905) of the trunk injuries occurred to workers between 50 and 59 years of age. Workers who were either 60 to 69 years old (n = 123) or under 20 years old (n = 55) combined to represent less than five % of the injuries to the trunk.

Table 4- 82. Age of workers with trunk injuries.

Age (years)	Number of injuries	%	Cumulative %
30 - 39 years	1,161	30.64%	30.64%
40 - 49 years	977	25.79%	56.43%
20 - 29 years	905	23.88%	80.31%
50 - 59 years	568	14.99%	95.30%
60 - 69 years	123	3.25%	98.55%
Under 20 years	55	1.45%	100.00%
Total	3,789	100.00%	

Trunk injury severity means were compared among the six age groups. Injury severity scores were provided for 3,789 workers with trunk injuries. The results of the Levene test of homogeneity of injury severity score variances for the six age groups did not allow for an assumption of equal variances, L (5, 3,731) = 27.49, $p < 0.001$. The results of the subsequent Welch test of equality of trunk injury severity means indicated that at least one age group was significantly different from another, F (5, 389.36) = 14.43, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

The results of the Tukey's b test provided a ranking of the age groups by their respective trunk injury severity means (see Figure 4- 133). Workers 60 to 69 years of age had the highest severity mean ($\mu = 1.71$), followed by workers 50 to 59 ($\mu = 1.48$), 40 to 49 ($\mu = 1.45$), and 30 to 39 ($\mu = 1.40$, $\sigma = 1.0.62$) years old. Workers under the age of 20 ($\mu = 1.37$) and between 20 and 29 years old ($\mu = 1.29$) had the lowest trunk injury severity means among the age groups. The results from the Tukey's b range test also identified homogeneous subsets of trunk injury severity means of among the age groups. Age groups within each subset did not have significantly different trunk injury severity means, at $p \leq 0.05$, (see Figure 4- 133).

Specific trunk injury severity mean differences were discerned from the arrangement of the homogeneous subsets displayed in Figure 4- 133. These are illustrated in Figure 4- 134. The trunk injuries experienced by workers between the 60 and 69 old had a significantly higher injury severity mean, at $p \leq 0.05$, than workers younger than 60 years old. Trunk injuries to workers between the ages of 50 and 59 years of age showed a significantly higher injury severity mean, at $p \leq 0.05$, than trunk injuries experienced by workers 20 to 29 years old.

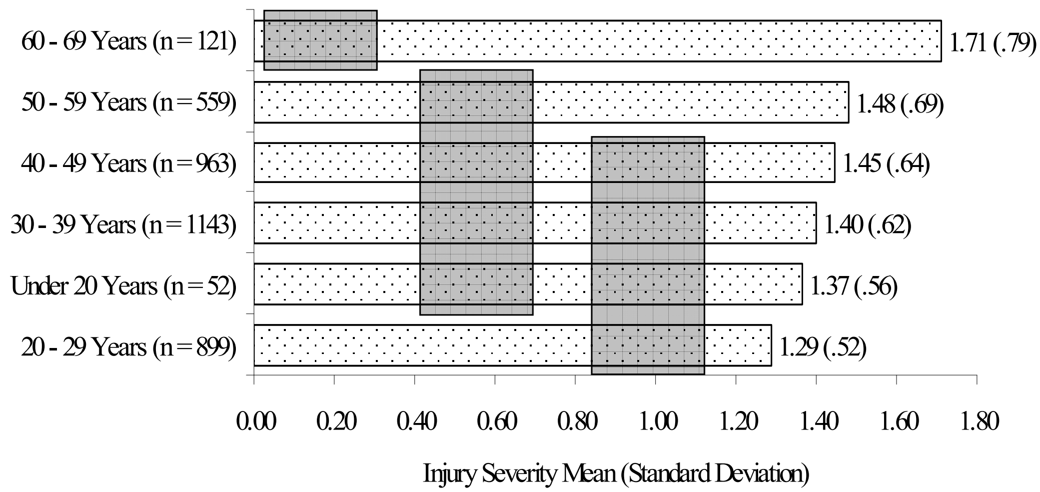

Figure 4- 133. Comparison of injury severity means by age of workers with trunk injuries.

Figure 4- 134. Differences between injury severity means by age group for trunk injuries.

The mean ages of workers with trunk injuries were compared by the specific body part impacted by the trunk injury. The results of the Levene test of homogeneity of age variances between the specific body parts of the trunk allowed for an assumption of equal variances, L (12, 3,776) = 1.62, $p > 0.05$. Subsequently, the results of the ANOVA test indicated that at least one of body parts of the trunk region had a significantly different age mean from one of the other body parts, F (12, 3,776) = 4.11, $p < 0.001$. The results of the Tukey's b range test confirmed this test result, and enabled the ranking of the body parts by their respective trunk injury severity means (see Figure 4- 135 and Figure 4- 136).

Among trunk injuries, workers who experienced an impairment of the heart had the highest mean age ($\mu = 47.44$). Workers with lung injuries ($\mu = 41.60$), multiple trunk injuries ($\mu = 40.00$), and injuries to the pelvis ($\mu = 39.90$) had the second, third, and fourth highest severity means, respectively. Workers with injuries to the lumbar or sacral vertebrae ($\mu = 38.31$), lower back ($\mu = 37.41$), sacrum and coccyx ($\mu = 36.27$), and upper back ($\mu = 36.27$), had the lowest age means. For the rankings of the remaining trunk body parts by mean age, see Figure 4- 135. The Tukey's b test also identified two homogeneous subsets, among the body parts of the trunk, for which mean ages in which body parts were not significantly different from each other at $p \leq 0.05$.

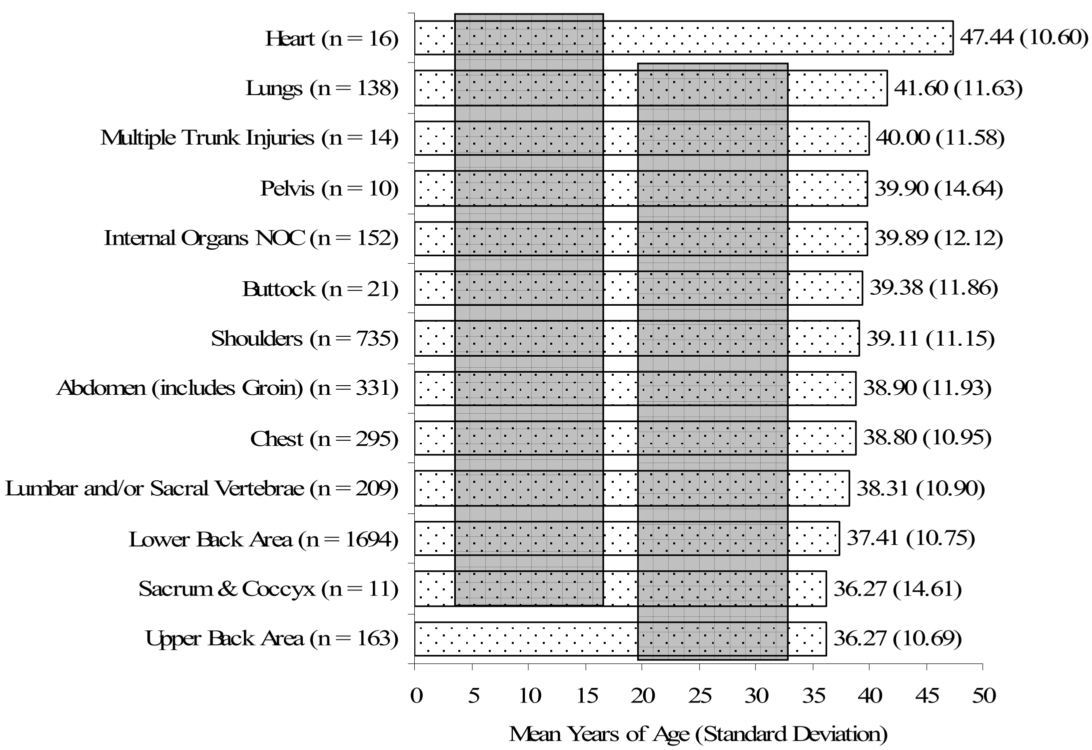

Figure 4- 135. Comparison of mean ages by injured body part of the trunk.

From the two homogeneous groupings shown in Figure 4- 135, it was determined that workers who experienced heart injuries had a significantly higher mean age, at $p \leq 0.05$, than workers who claimed an injury to the upper back (see Figure 4- 136).

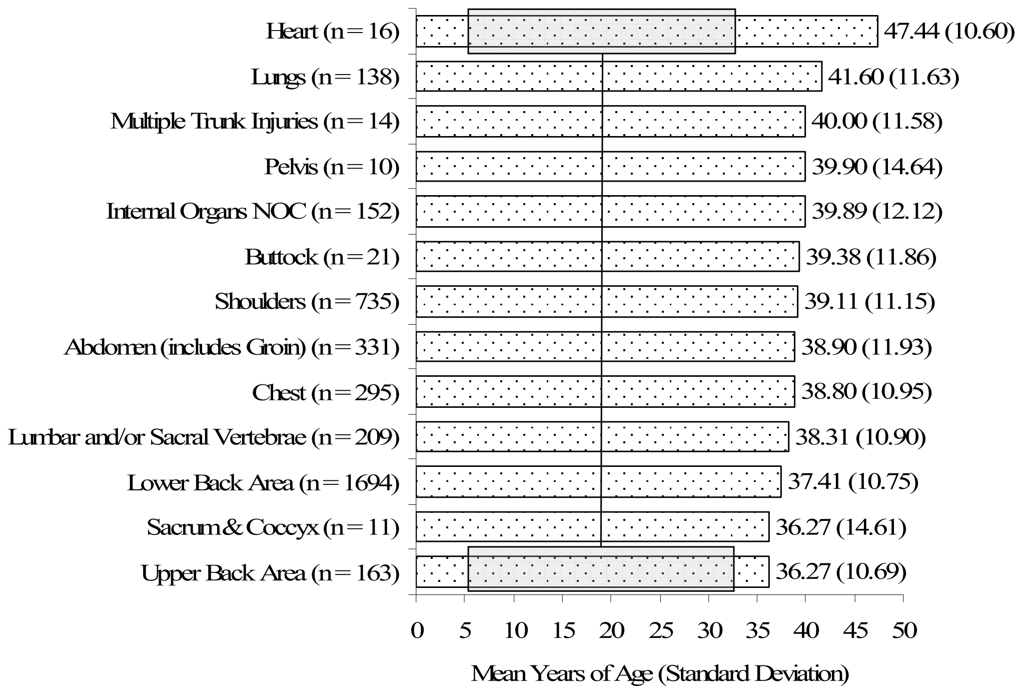

Figure 4- 136. Differences of mean ages between inured body parts of the trunk.

Job Tenure

The number of days between the times an injured worker was hired and the time that injured worker experienced the trunk injury (i.e., job tenure) was examined. Information regarding the frequency of trunk injuries by the nine job tenure categories shown in Table 4- 83 was provided for 9,122 worker injuries. Workers who had been employed from 91 to 180 days (n = 1,565) and those employed from 181 to 365 days (n = 1,529) accounted for nearly 17% each, of the trunk injuries. Nearly 25% of the trunk injuries were experienced by workers in the first 60 days of employment (n = 2,247). Almost 11% of the trunk injuries were among workers employed from 366 to 730 days (n = 998). Workers injured between the 61st and 90th day of employment (n = 817) in addition to those injured between their 16th and 30th day of employment (n = 798) made up almost 18% of the trunk injures. Trunk injury workers who were employed two or more years prior to being injured accounted for just fewer than 13% of the trunk injuries.

Table 4- 83. Job tenure of workers with trunk injuries.

Job tenure	Number of injuries	%	Cumulative %
91 to 180 days	1,565	17.16%	17.16%
181 to 365 days	1,529	16.76%	33.92%
0 to 15 days	1,132	12.41%	46.33%
31 to 60 days	1,115	12.22%	58.55%
366 to 730 days (1 to 2 years)	998	10.94%	69.49%
61 to 90 days	817	8.96%	78.45%
16 to 30 days	798	8.75%	87.20%
> 1461 days (> 4 years)	610	6.69%	93.88%
731 to 1460 days (2 to 4 years)	558	6.12%	100.00%
Total	9,122	100.00%	

Job tenure categories were compared by their respective severity means for trunk injuries. The results of the Levene test of homogeneity of trunk injury severity score variances did not allow for the assumption of equal variances between the nine job tenure categories, L (8, 9,001) = 3.13, $p < 0.003$. Subsequently, the Welch test was performed to test the equality of trunk injury severity means between these categories. The results of this test indicated that at least one of job tenure categories had a trunk injury severity mean that was significantly different from one of the other categories, F (8, 3,246.21) = 2.29, $p < 0.02$. However, this result was not confirmed by the results the of the Tukey's b range test.

The results of the Tukey's b range test are displayed in Figure 4- 137. The single homogeneous subset indicates that, at $p \leq 0.05$, none of the job tenure categories had a significantly different trunk injury severity mean from any of the other categories. Workers who were injured within the first fifteen days of employment, or between the 16th and 30th day, or between the first and second year of employment each had the same trunk injury severity mean of $\mu = 1.51$. Workers with between 61 and 90 days employment had an injury severity mean of

1.50, followed by workers with a job tenure of two or more years (μ = 1.48). Workers who fell within the following job tenure groups had the lowest three trunk injury severity means, 31 to 60 days (μ = 1.47), 91 to 180 days (μ = 1.47), and 181 to 365 days (μ = 1.43).

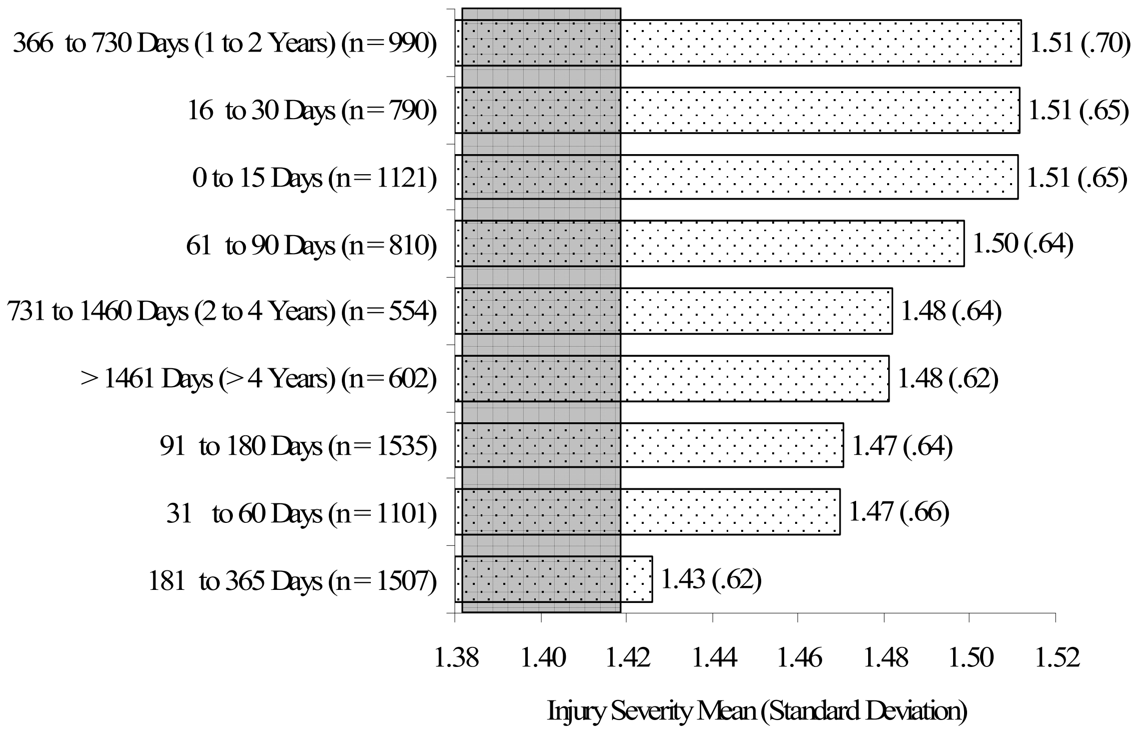

Figure 4- 137. Comparison of injury severity means by job tenure of workers with trunk injuries.

Month of Occurrence of Injury

The frequency of trunk injuries was examined by the month of the year during which the injury had occurred. Table 4- 84 shows the number of trunk injuries for each of the twelve months. Over 54% of the 11,646 trunk injuries occurred within the months of October (n = 1,133), August (n = 1,070), May (n = 1,045), June (n = 1,038), September (n = 1,019), and July (n = 992). Trunk injuries occurring during the months of November (n = 865), December (n = 819), January (n = 865), February (n = 849), March (n = 974), and April (n = 893) combined to account for around 46% of the injuries to the trunk region.

Table 4- 84. Month of occurrence of trunk injuries.

Month of occurrence of injury	Number of injuries	%	Cumulative %
October	1,133	9.73%	9.73%
August	1,070	9.19%	18.92%
May	1,045	8.97%	27.89%
June	1,038	8.91%	36.80%
September	1,019	8.75%	45.55%
July	992	8.52%	54.07%
March	974	8.36%	62.43%
January	949	8.15%	70.58%
April	893	7.67%	78.25%
November	865	7.43%	85.68%
February	849	7.29%	92.97%
December	819	7.03%	100.00%
Total	11,646	100.00%	

Injury severity for trunk injuries by the month of the injury was examined by ranking the months by their respective injury severity means and subsequently comparing the trunk injury severity means between the months to identify possible differences, significant at $p \leq 0.05$. Severity scores, by month of the injury, were provided for 11,490 workers with injuries to the trunk. The results of an initial Levene test allowed for an assumption of equal trunk injury score variances between the twelve months, L (11, 11,478) = 1.62, $p > 0.08$. The results of the subsequent ANOVA indicated that none of the months had a significantly different trunk injury severity mean from any of the other months, F (11, 11,478) = 1.16, $p > 0.30$. This was confirmed by the results of the Tukey's b range test which did not identify any significant differences, at $p \leq 0.05$, of trunk injury severity means between specific months.

The rankings of the months of injury by trunk injury severity means, generated by the Tukey's b test, are displayed in Figure 4- 138. Trunk injuries occurring in January, October, and September had the highest severity mean of $\mu = 1.47$. Trunk injuries in the December and June showed the lowest severity mean of $\mu = 1.41$.

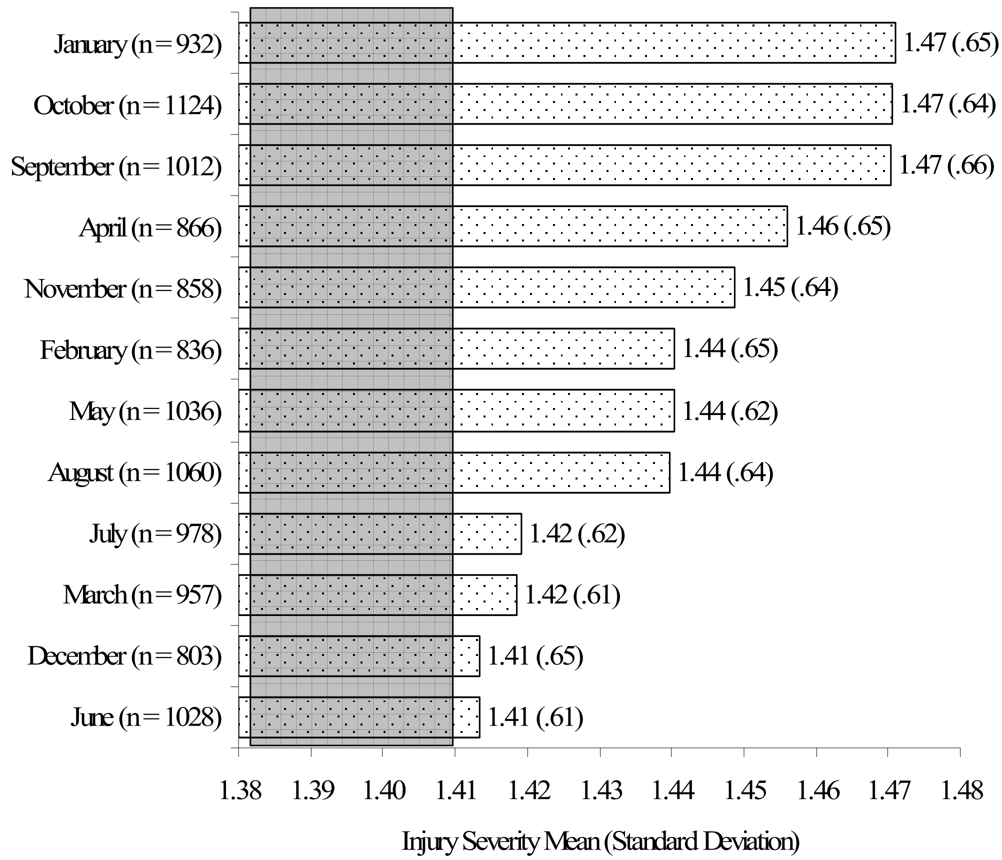

Figure 4- 138. Comparison of injury severity means by month of occurrence of trunk injuries.

Day of the Week of Occurrence of Injury

The possible relationship between trunk injuries and the day of the week on which these injuries occurred was explored. Injury data for trunk injuries by each day of the week is displayed in Table 4- 85. Nearly 20% of the trunk injuries occurred either on a Monday (n = 2,330) or a Tuesday (n = 2,236). Injuries occurring on Wednesdays (n = 2,153) and Thursdays (n = 2,130) each accounted for slightly over 18% of the trunk injuries. Around 16% (n = 1,900) of the trunk injuries occurred on a Friday. The remaining seven % of the trunk injuries occurred on Saturdays (n = 616) and Sundays (n = 281).

Injury severity for trunk injuries by the day of the week on which the injury occurred was examined by ranking the days of the week by their respective injury severity means and subsequently comparing the trunk injury severity means between the days to identify possible differences, significant at $p \leq 0.05$. Severity scores, by day of the injury, were provided for 11,490 worker injuries to the trunk. The results of an initial Levene test did not allow for an assumption of equal trunk injury score variances between the seven days of the week, L (6, 11,483) = 1.62, $p > 0.08$. The results of the subsequent Welch test indicated that none of the days of the week had a significantly different trunk injury severity mean from any of the other days, F (6, 2,454.65) = 1.34, $p > 0.20$. This was confirmed by the results of the Tukey's b range test which did not identify any significant differences, at $p \leq 0.05$, of trunk injury severity mean differences between specific days.

Table 4- 85. Day of the week of occurrence of trunk injuries.

Day of the week of occurrence	Number of injuries	%	Cumulative %
Monday	2,330	20.01%	20.01%
Tuesday	2,236	19.20%	39.21%
Wednesday	2,153	18.49%	57.69%
Thursday	2,130	18.29%	75.98%
Friday	1,900	16.31%	92.30%
Saturday	616	5.29%	97.59%
Sunday	281	2.41%	100.00%
Total	11,646	100.00%	

The rankings of the days of the week of injury by trunk injury severity means, generated by the Tukey's b test, are displayed in Figure 4- 139. Trunk injuries occurring on Saturdays (μ = 1.50) showed the highest injury severity mean among days on the week on which trunk injuries occurred. This was followed by trunk injuries experienced on Fridays (μ = 1.46), Tuesdays (μ = 1.45), Thursdays (μ = 1.44), Sundays (μ = 1.43), and Mondays (μ = 1.43). Trunk injuries occurring on Wednesdays had the lowest severity mean, μ = 1.42, among the days of the week.

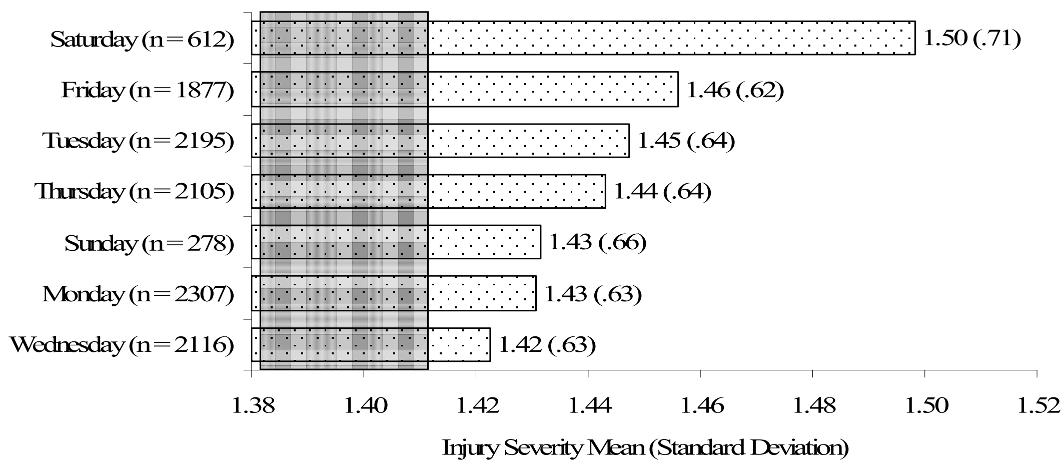

Figure 4- 139. Comparison of injury severity means by day of the week of occurrence of trunk injuries.

Upper Extremities

Upper extremities and the severity of these injuries were examined by the specific body part injured (e.g., hand), the nature of the injury (e.g., laceration), the general cause of the injury (e.g., fall or slip), the occupational work area in which the injured worker was working at the time of the injury (e.g., carpentry), the workers' occupational experience levels (e.g., apprentice), the job tenure of the injured worker prior to the injury, the month of the year and day of the week on which the injury occurred, and the age of the injured worker at the time of the injury. A comparison of mean ages by specific body parts was also performed.

Body Part

Information regarding the specific injured body parts of the upper extremities was provided for 13,152 worker injuries. As Table 4- 86 shows, injuries to fingers comprised almost 32% (n = 4,203) of the injuries to the upper extremities. Injuries to the hands (n = 2,898), upper arm (n = 1,445), wrist (n = 1,401), wrist and hand (n = 122), and thumb (n = 1,318), combined to represent over 55% of the injuries to the upper extremities. Nearly 86% of upper extremities impacted body parts located below the elbow. Elbow injuries (n = 968) combined with upper arm injuries (n = 535) to make up slightly over 11% of the injuries to the upper extremities. Multiple upper extremities injuries (n = 122) occurred just under one % of the time.

Table 4- 86. Injured body parts of the upper extremities.

Body part	Number of injuries	%	Cumulative %
Finger	4,203	31.96%	31.96%
Hand	2,898	22.03%	53.99%
Lower arm	1,445	10.99%	64.98%
Wrist	1,401	10.65%	75.63%
Thumb	1,318	10.02%	85.65%
Elbow	968	7.36%	93.01%
Upper arm	535	4.07%	97.08%
Multiple body patts	262	1.99%	99.07%
Wrist and hand	122	0.93%	100.00%
Total	13,152	100.00%	

Based on the severity scores provided for 12,939 workers with injuries to the upper extremities, the nine specific body part groups were ranked by their respective injury severity means. Injury severity means were also compared between the nine body part groups. The results of the Levene test of homogeneity of injury severity score variances between the nine body parts of the upper extremities did not allow for the assumption of equal variances, L (8, 12,930) = 48.10, $p < 0.001$. Subsequently, the results of the Welch test of equality of injury severity means indicated that at least one of the body parts of the upper extremities had a significantly different injury severity mean than one of the other body parts, F (8, 1,588.97) = 20.62, $p < 0.001$. This was confirmed by the results of Tukey's b range test.

The Tukey's b range test was performed to compare body parts of the upper extremities by their respective injury severity means. From this test, each body part was ranked according to its respective injury severity mean (see Figure 4- 140). Multiple injuries had the highest severity mean ($\mu = 1.55$) among injuries to the upper extremities, followed by injuries to the wrist and the hand ($\mu = 1.52$). Injuries strictly of the wrist had the third highest injury severity mean ($\mu =$

1.38), followed by injuries to the lower arm (μ = 1.32), elbow (μ = 1.27), finger (μ = 1.24), hand (μ = 1.23), and upper arm (μ = 1.19). Injuries to the thumb had the lowest injury severity mean, μ = 1.19, among injuries to the nine body parts of the upper extremities. Additionally, the results of the Tukey's b test identified four homogeneous subsets of body parts of the upper extremities in which there were no individual injury severity mean differences, at $p \leq 0.05$, between subset body parts.

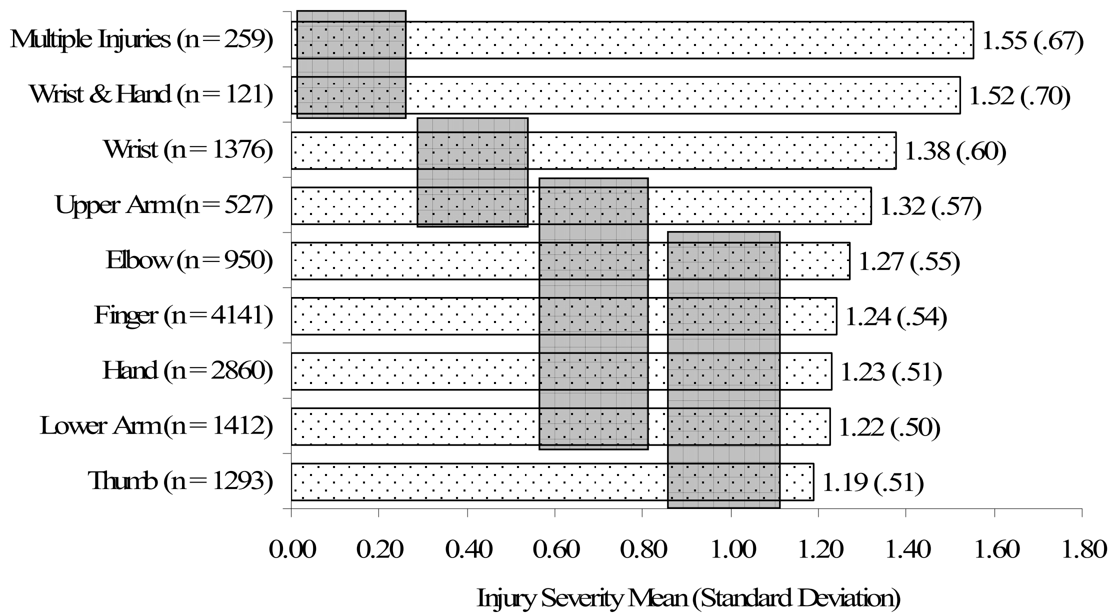

Figure 4- 140. Comparison of injury severity means by injured body parts of the upper extremities.

Specific injury severity mean differences, significant at $p \leq 0.05$, were discerned from the arrangement of the homogeneous subsets (see Figure 4- 141). Among the injuries to the upper extremities, injuries to the wrist, upper arm, elbow, finger, hand, upper arm and thumb, each had a significantly lower severity mean, at $p \leq 0.05$, than multiple injuries to the upper extremities, and injuries to both the hand and the wrist simultaneously. Injuries to the wrist only were significantly more severe, at $p \leq 0.05$, than elbow, finger, hand, lower arm, and thumb injuries.

Upper arm injuries had a significantly greater injury severity mean, $p \leq 0.05$, than thumb injuries.

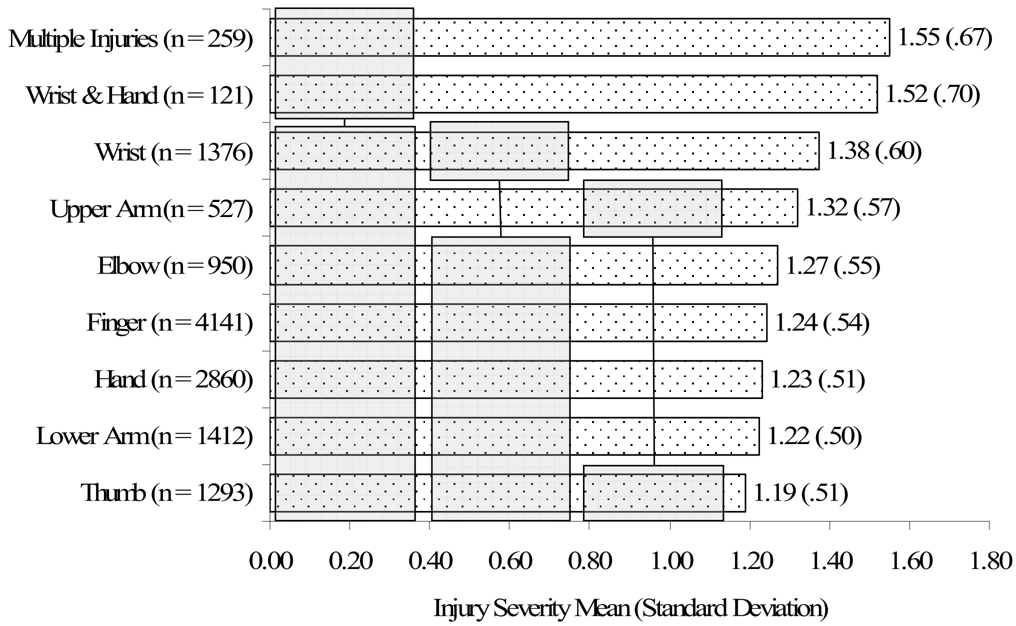

Figure 4- 141. Differences of injury severity means by injured body parts of the upper extremities.

Nature of Injury

Information regarding the upper extremities injuries by the nature of the injury was provided for 12,515 worker injuries. Almost 82% of the injuries to the upper extremities were attributed to the combination of lacerations (n = 4,805), contusions (n = 1,966), strains (n = 1,382), fractures (n = 1,101), and punctures (n = 1,002). As shown in Table 4- 87, laceration (38.39%) was, recognizably, the most frequent nature of injury to the upper extremities. Contusions (n = 1,966), strains (n = 1,382), fractures (n = 1,101), and punctures (n = 1,002) combined to account for 44% of the injuries to the upper extremities. Sprains (n = 557), crushing (n = 361), inflammations (n = 333), and burns (n = 324) together constituted almost 13% of the injuries to the upper extremities. See Table 4- 87 for the relative upper extremity injury frequencies for the remaining 14 nature of injury categories.

Table 4- 87. Nature of injuries to the upper extremities.

Nature of injury	Number of injuries	%	Cumulative %
Laceration	4,805	38.39%	38.39%
Contusion	1,966	15.71%	54.10%
Strain	1,382	11.04%	65.15%
Fracture	1,101	8.80%	73.94%
Puncture	1,002	8.01%	81.95%
Sprain	557	4.45%	86.40%
Crushing	361	2.88%	89.28%
Inflammation	333	2.66%	91.95%
Burn	324	2.59%	94.53%
Carpal tunnel syndrome	93	0.74%	95.28%
Infection	88	0.70%	95.98%
Amputation	74	0.59%	96.57%
Foreign body	74	0.59%	97.16%
Multiple injuries	66	0.53%	97.69%
Dermatitis	60	0.48%	98.17%
Dislocation	49	0.39%	98.56%
Severance	49	0.39%	98.95%
Electric sShock	45	0.36%	99.31%
Rupture	42	0.34%	99.65%
Occupational disease NOC	23	0.18%	99.83%
Poisoning NOC	14	0.11%	99.94%
Freezing	5	0.04%	99.98%
Total	12,515	100.00%	

Based on the severity scores provided for 12,312 worker injuries to the upper extremities, the 23 nature of injury categories were ranked by their respective injury severity means. Injury severity means were also compared by the nature of injury. The results of the Levene test of homogeneity of injury severity score variances between the 23 nature of upper extremity injury groups did not allow for the assumption of equal variances, L (22, 12,289) = 78.85, $p < 0.001$. Since enucleations of the upper extremities showed an injury score variance of zero, the Welch test of equality of severity means could not be performed. In lieu of the Welch test, the ANOVA test was conducted to examine injury severity mean differences between the nature of injury categories of upper extremity injuries. The results of the ANOVA indicated that at least one of the nature of upper extremity injury groups had a significantly different injury severity mean than one of the other groups, F (22, 12,289) = 451.53, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

The Tukey's b range test was performed to compare nature of upper extremity injury classifications by their respective injury severity means. From this test each of the nature of injury categories were ranked according to their respective upper extremity injury severity mean (see Figure 4- 142). Among the nature of injury of upper extremity injury categories, amputations resulted in the highest injury severity mean of 2.10. Along with amputations, ruptures ($\mu = 1.88$) severances ($\mu = 1.87$), carpal tunnel syndrome ($\mu = 1.70$), occupational disease, not otherwise classified ($\mu = 1.67$), fracture ($\mu = 1.60$), freezing ($\mu = 1.53$), dislocation ($\mu = 1.52$), multiple injury ($\mu = 1.43$), and poisoning ($\mu = 1.39$) had the ten highest severity means among the nature upper extremity injury groups. Contusion ($\mu = 1.14$), foreign body ($\mu = 1.10$), puncture ($\mu = 1.05$), and dermatitis ($\mu = 1.00$), were associated with the nature of upper extremity injury categories with the lowest five injury severity means. The remaining nature of upper extremity injury groups with severity means are shown in Figure 4- 142. Additionally, the results of the Tukey's b test identified six homogeneous subsets of nature of upper extremity injury categories in which there were no individual injury severity means differences, at $p \leq 0.05$, between subset members.

Specific injury severity mean differences, significant at $p \leq 0.05$, were discerned from the arrangement of the homogeneous subsets (see Figure 4-143)). Among the injuries to the upper extremities, amputations had a significantly greater injury severity mean, at $p \leq 0.05$, than all of the remaining nature of injury groups except ruptures, severances, and carpal tunnel syndrome. Ruptures had a significantly higher injury severity mean than all of the remaining groups of

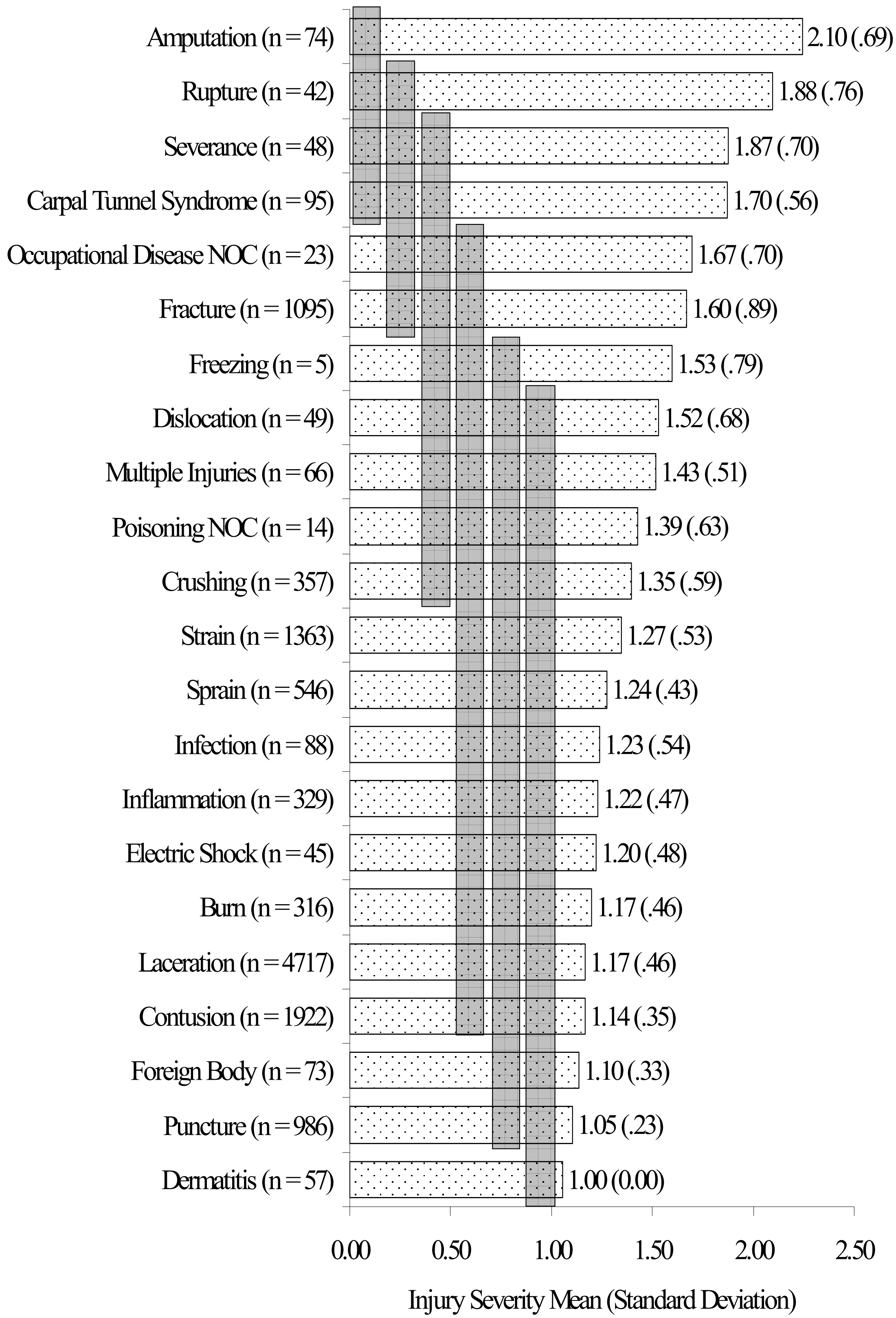

Figure 4- 142. Comparison of injury severity means by nature of injury to the upper extremities.

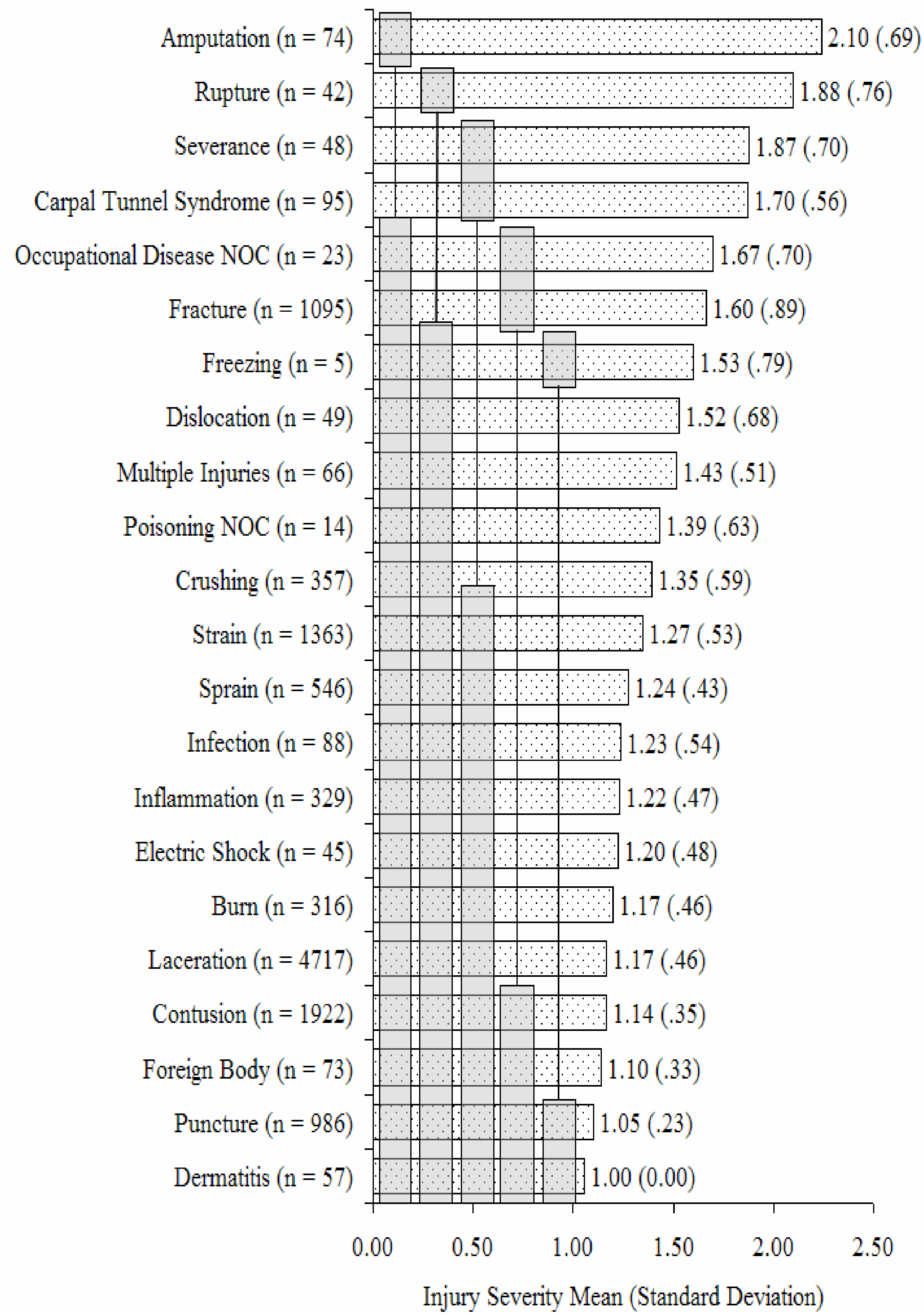

Figure 4- 143. Difference of injury severity means by nature of injury to the upper extremities.

nature of injury means except severances, carpal tunnel syndrome, occupational diseases NOC, and fractures. Occupational diseases NOC and fractures had significantly higher severity means, at $p \leq 0.05$, than strains, sprains, infections, inflammations, electric shocks, burns, lacerations, contusions, foreign bodies, punctures, and dermatitis. Severances and carpal tunnel syndrome had a significantly higher injury severity mean, at $p \leq 0.05$, than that for foreign bodies, punctures, and dermatitis. Dermatitis had a significantly lower injury severity mean, at $p \leq 0.05$, than freezing injuries of the upper extremities. The results of the Tukey's b test identified six homogeneous subsets of nature of upper extremity injury categories in which there was no individual injury severity mean difference, at $p \leq 0.05$, between subset categories

General Cause of Injury

From information provided for 12,849 worker injuries, the upper extremity injury distribution for general cause of injury categories were generated and ranked in descending magnitudes (see Table 4- 88). Almost 34% of the injuries to the upper extremities were caused by cuts, punctures or scrapes (n = 4,331). Having been struck by an object (n = 1,863), Caught in or between an object or objects (n = 1,860), or having suffered a strain (n = 1,791) accounted for around 14% each, of the upper extremity injuries. A fall or slip (n = 1,312) was cited as the cause of injury for 10% of the upper extremity injury cases. Workers who were injured by striking up against or stepping on an object (n = 975), being burned (n = 326), bitten or stung by an animal or insect (n = 223), absorbing, ingesting, or inhaling a substance (n = 137), and engaging with a motor vehicle (n = 31), combined to make up over 13% of the remaining upper extremity injury cases.

Injury severity scores, by the general cause of the injury to the upper extremity, were provided for 12,641 worker injuries. Based on this information, injury severity means were generated for and compared between the ten general cause of injury categories. The results of the Levene test of homogeneity of injury severity score variances between the ten cause of injury

Table 4- 88. General cause of injury to the upper extremities.

General cause of injury	Number of injuries	%	Cumulative %
Cut, puncture, or scrape	4,331	33.71%	33.71%
Struck by	1,863	14.50%	48.21%
Caught in or between	1,860	14.48%	62.68%
Strain	1,791	13.94%	76.62%
Fall or slip	1,312	10.21%	86.83%
Strike against or step on	975	7.59%	94.42%
Burn	326	2.54%	96.96%
Animal or insected bite or sting	223	1.74%	98.69%
Absorption, ingestion or inhalation	137	1.07%	99.76%
Motor vehicle	31	0.24%	100.00%
Total	12,849	100.00%	

categories did not allow for the assumption of equal variances, L (9, 12,631) = 137.81, $p < 0.001$. The results of the subsequent Welch test indicated that at least one of the cause of injury categories had a significantly different injury severity mean than one of the other categories, F (9, 635.70) = 48.95, $p < 0.001$. This was confirmed by the results of Tukey's b range test.

The Tukey's b range test was performed to compare the cause of upper extremity injury categories by their respective injury severity means. From this test, each cause of injury categories was ranked according to its respective upper extremity injury severity mean (see Figure 4- 144). Among the causes of upper extremity injury categories, falls or slips are associated with upper extremity injuries with the highest injury severity mean, $\mu = 1.47$, followed by involvement with a motor vehicle ($\mu = 1.43$) and strains ($\mu = 1.37$). Injuries caused by being Caught in or between an object or objects yielded the fourth highest injury severity mean, $\mu = 1.29$. This was followed by upper extremity injuries caused by being struck by an object ($\mu = 1.25$), having struck against or stepped on an object ($\mu = 1.24$), being burned ($\mu = 1.21$), being cut, punctured, or scraped ($\mu = 1.16$), and having absorbed, ingested, or inhaled a substance (μ = 1.14). Upper extremity injuries caused by an animal or insect bite or sting had the lowest injury severity mean of the general cause of injury categories. The results of the Tukey's b test identified five homogeneous subsets of general cause of upper extremity injury categories in which there was no individual injury severity mean difference, at $p \leq 0.05$, between subset members (see Figure 4- 144).

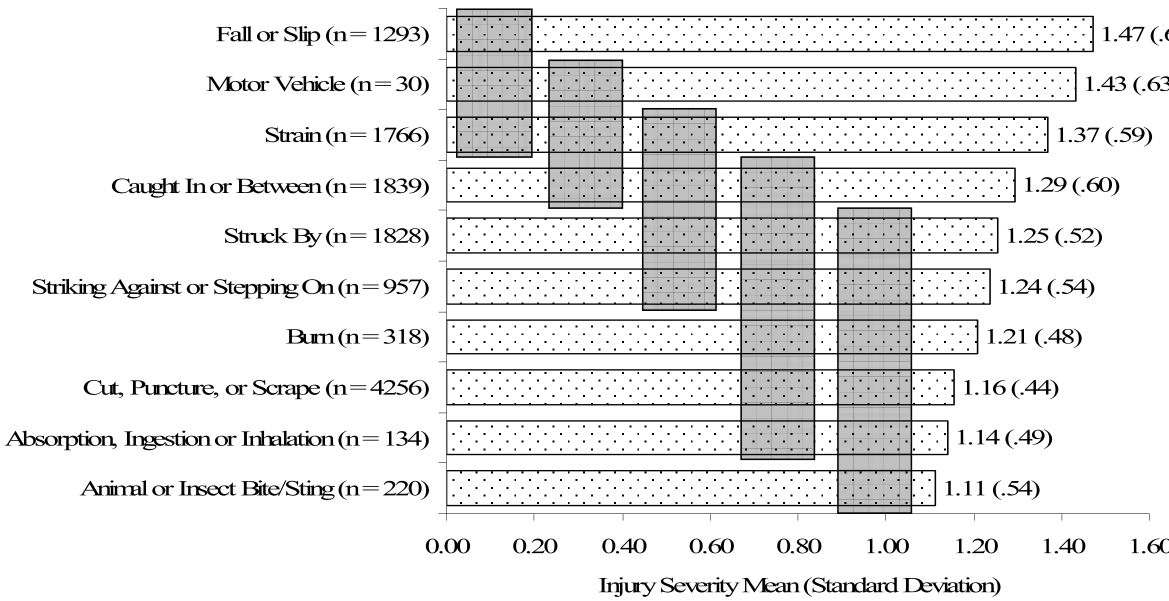

Figure 4- 144. Comparison of injury severity means by general cause of upper extremity injury.

Specific injury severity mean differences, significant at $p \leq 0.05$, were discerned from the arrangement of the homogeneous subsets (see Figure 4- 145). Among the general causes of upper extremity injuries, those of a fall or slip resulted in upper extremities injuries with a severity mean significantly greater, at $p \leq 0.05$, than those associated with the remaining general causes, except involvement with a motor vehicle, and strains. Upper extremities injuries caused by involvement with some type of motor vehicle had a significantly higher severity mean, at $p \leq 0.05$, than having been struck by, struck against or stepped on, Caught in or between an object or objects, burned, cut, punctured, or scraped, having absorbed, ingested, or inhaled a substance, and having been bitten or stung by an animal or insect. Injuries to the upper extremities brought about by a strain had a significantly greater severity mean, at $p \leq 0.05$, than those caused by being burned, cut, punctured, or scraped, absorption, ingestion, or inhalation of a substance, and an animal or insect bite or sting. Having been Caught in or between an object or objects generated upper extremities injuries with a significantly higher severity mean than those due to an animal or insect bite or sting.

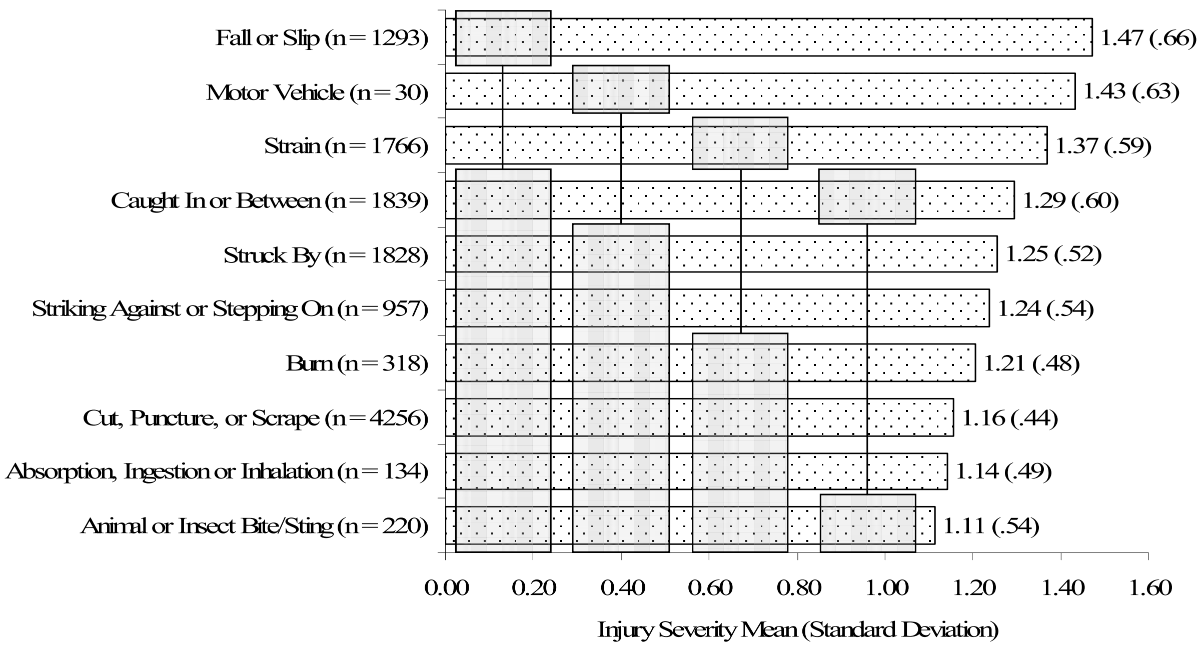

Figure 4- 145. Differences of injury severity means by the general causes of injury to the upper extremities.

Occupational Work Area

The general occupational work area categories identified the specific work area in which the injured worker was involved at the time of the injury. Of the 9,983 upper extremities injury cases, for which occupational work area information was available, over 51% were experienced by workers while working in the of carpentry (n = 2,282), electrical work (n = 1,690), and iron and steel work (n = 1,127). Table 4- 89 shows the upper extremities injury frequencies for 42 occupational work areas. As this table illustrates, work areas associated with least number of injuries to the upper extremities included waterproofing (n = 18), rigging (n = 16), security (n =

16), surveying (n = 13), material handling (n = 12), field engineering (n = 12), acoustic ceiling work (n = 5), hod carrying (n = 5), landscaping (n = 2), and flagging (n = 2). These ten work areas accounted for less than 1 % of the upper extremities injuries.

Injury severity scores, by the occupational work area associated with upper extremity injury, were provided for 9,874 worker injuries. Based on this information, injury severity means were generated for and compared between the 42 occupational work areas. The results of the Levene test of homogeneity of injury severity score variances between the 42 work areas did not allow for the assumption of equal variances, L (41, 9,832) =7.25, $p < 0.001$. The Welch test of equality of means could not be performed because professional engineering, flagging, and landscaping had zero variances (see Figure 4-). In lieu of the Welch test, the ANOVA was conducted and the results suggested that at least one of the work areas could have an injury severity mean for upper injuries that was significantly different than one of the other work areas, F (41, 9,832) = 2.18, $p < 0.001$. This was not confirmed by the results of Tukey's b range test. The Tukey's b range test was performed to compare the occupational work areas by their respective upper extremities injury severity means. From this test, each work area was ranked according to its respective upper extremity injury severity mean (see Figure 4- 146). Among the workers' work areas for upper extremity injuries, rigging was associated with upper extremity injuries with the highest injury severity mean, $\mu = 1.44$, followed by surveying ($\mu = 1.42$), painting or plastering ($\mu = 1.40$), hod carrying ($\mu = 1.40$), driving ($\mu = 1.40$), millwright work ($\mu = 1.38$), and roofing ($\mu = 1.36$). Occupational work areas associated with the ten lowest upper extremities injury severity means were, flooring, tile, or carpeting ($\mu = 1.20$), acoustic ceiling work ($\mu = 1.20$), sheet metal work ($\mu = 1.20$), managing ($\mu = 1.16$), clerical work ($\mu = 1.10$), conveyor systems work ($\mu = 1.09$), field engineering ($\mu = 1.08$), professional engineering

Table 4- 89. Injury frequency by occupational work area of workers with upper extremityinjuries

Occupational work area	Number of injuries	%	Cumulative %
Carpentry	2,282	22.86%	22.86%
Electrical Work	1,690	16.93%	39.79%
Iron/Steel Work	1,127	11.29%	51.08%
Technical repair or maintenance	598	5.99%	57.07%
Concrete work	527	5.28%	62.35%
Pipe Fitting	463	4.64%	66.98%
Sheet Metal Work	433	4.34%	71.32%
Plumbing	376	3.77%	75.09%
Masonry	356	3.57%	78.65%
Equipment or machinery Operation	267	2.67%	81.33%
Boilermaker	225	2.25%	83.58%
Millwright	210	2.10%	85.69%
Supervision	153	1.53%	87.22%
Drywall	151	1.51%	88.73%
Painting and plastering	126	1.26%	89.99%
Welding	120	1.20%	91.20%
Roofing	84	0.84%	92.04%
Glazing	75	0.75%	92.79%
Insulation	74	0.74%	93.53%
Driving	70	0.70%	94.23%
Clerical	70	0.70%	94.93%
Lineman	64	0.64%	95.57%
Flooring. tile, or carpeting	55	0.55%	96.12%
Steam fitting	52	0.52%	96.64%
Sprinkler fitting	41	0.41%	97.05%
Managing	38	0.38%	97.44%
Lathing	33	0.33%	97.77%
Inspecting	30	0.30%	98.07%
Scaffold erection	29	0.29%	98.36%
Conveyor systems work	23	0.23%	98.59%
HVAC/refrigeration	20	0.20%	98.79%
Engineering	20	0.20%	98.99%
Waterproofing	18	0.18%	99.17%
Rigging	16	0.16%	99.33%
Security	16	0.16%	99.49%
Surveying	13	0.13%	99.62%
Material handling	12	0.12%	99.74%
Field engineering	12	0.12%	99.86%
Acoustic ceiling work	5	0.05%	99.91%
Hod carrying	5	0.05%	99.96%
Landscaping	2	0.02%	99.98%
Flagging	2	0.02%	100.00%
Total	9,983	100.00%	

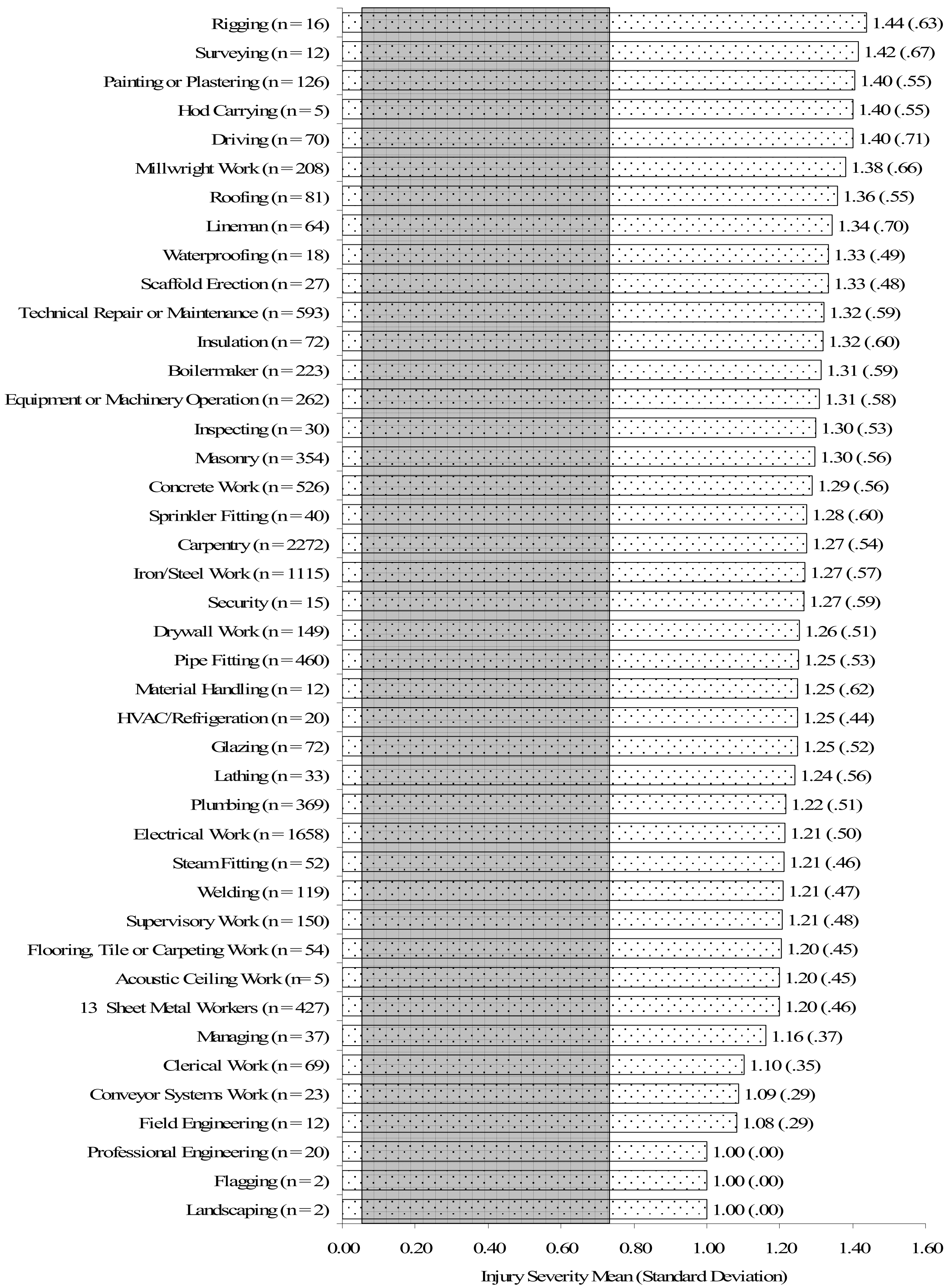

Figure 4- 146. Comparison of injury severity means by occupational work area of workers with upper extremity injuries.

(μ = 1.00), flagging (μ = 1.00), and landscaping (μ = 1.00). See Figure 4- for the rankings of the occupational work areas. The results of the Tukey's b test identified a single homogeneous subset of occupational work in which there was no individual injury severity mean difference, at $p \leq 0.05$, between subset members (see Figure 4- 146).

Occupational Experience Level

Upper extremities injury information regarding the workers' occupational experience was provided for 4,180 worker injuries. As Table 4- 90 shows, laborers had over 53% (n = 2.239) of the injuries to the upper extremities. Apprentices (n = 560), journeymen (n = 426), and foremen (n = 416), experienced over 33% of the total injuries to the upper extremities. Helpers and assistants comprised around five % (n = 216) of the workers with upper extremities injuries. Supervisors (n = 165), administrators (n = 108), and professionals (n = 50) represented less than 8 % each, of the individuals with injuries to the upper extremities.

Table 4- 90. Occupational experience level of workers with injuries to the upper extremities.

Occupational experience level	Number of injuries	%	Cumulative %
Laborer	2,239	53.56%	53.56%
Apprentice	560	13.40%	66.96%
Journeyman	426	10.19%	77.15%
Foreman	416	9.95%	87.11%
Helper/assistant	216	5.17%	92.27%
Field supervisor	165	3.95%	96.22%
Administrative	108	2.58%	98.80%
Professional	50	1.20%	100.00%
Total	4,180	100.00%	

Injury severity means were compared among the eight occupational experience levels for injuries to the upper extremities. Injury severity scores by experience level were provided for 4,139 workers with trunk injuries. The results of the Levene test of homogeneity of injury severity score variances for the eight experience levels did not allow for an assumption of equal variances, L (7, 4,131) = 8.38, $p < 0.001$. The results of the subsequent Welch test of equality of upper extremities injury severity means indicated that at least one general cause of injury group was significantly different from another group, F (7, 483.36) = 3.38, $p < 0.005$. This was confirmed by the results of the Tukey's b range test.

Output of the Tukey's b test provided a ranking of the general cause of injury groups by their respective upper extremities injury severity means (see Figure 4- 147). Upper extremities injuries to journeymen had the highest injury severity mean ($\mu = 1.30$), followed by injuries to laborers ($\mu = 1.27$), foremen ($\mu = 1.26$), apprentices ($\mu = 1.25$), helpers and assistants ($\mu = 1.22$), field supervisors ($\mu = 1.20$), and professionals ($\mu = 1.18$). Administrative level workers with injuries to the upper extremities showed the lowest injury severity mean, $\mu = 1.12$. The Tukey's test identified two homogeneous subsets of injury severity means for injuries to the upper extremities for the occupational experience levels. Experience levels within each subset did not have upper extremities injury severity means that were significantly different from each other at $p \leq 0.05$ (see Figure 4- 147).

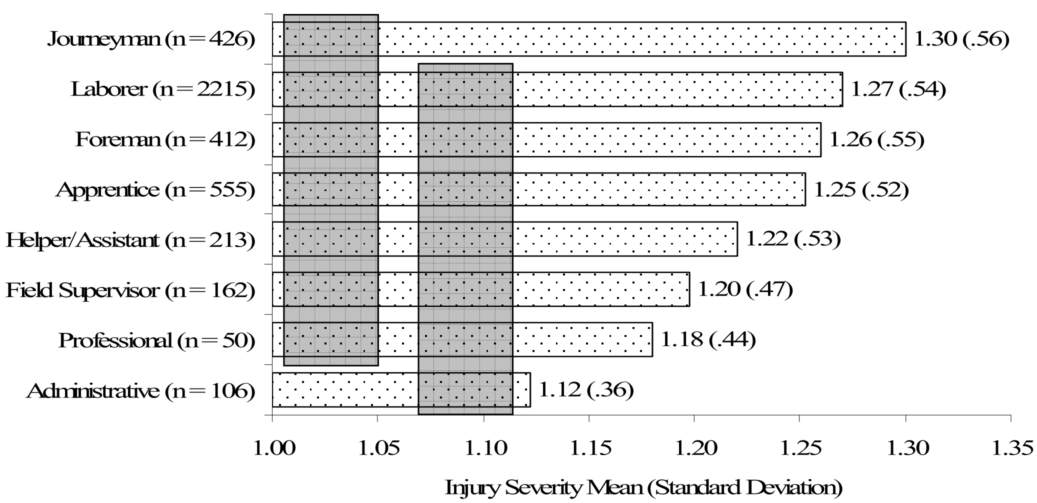

Figure 4- 147. Comparison of injury severity means by occupational experience level of workers with upper extremity injuries.

From the arrangements of the homogeneous groups shown in Figure 4- 148, specific and significant at $p \leq 0.05$, differences of severity means for injuries to the upper extremities were identified between eight occupational experience levels (see Figure 4-). Journeymen with injuries to the upper extremities showed a significantly greater, at $p \leq 0.05$, severity mean than administrative personnel with injuries to the upper extremities.

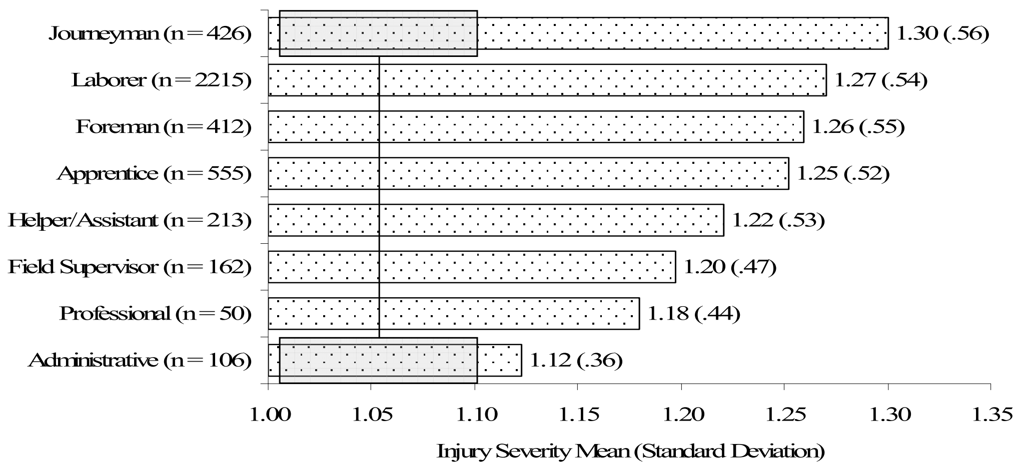

Figure 4- 148. Differences of injury severity mean by occupational experience levels for workers with upper extremity injuries.

Age

The relationship between age and injuries to the upper extremities was explored in two ways. First, workers with upper extremities injuries were compared by their respective ages. With the exception of the under 20 and over 69 groups, each of the age groups represented ten-year spans. Injury frequencies were compared between the age groups. This was followed by a comparison of upper extremities injury severity means between the age groups.

Information for injuries to the upper extremities by the workers' age was provided for 4,333 worker injuries (see Table 4- 91). Almost 29% (n = 1,239) of the injuries to the upper extremities were experienced by workers between 30 and 39 years of age. Around 28% (n = 1,206) of the injuries were to workers 20 to 29 years old. Nearly 25% (n = 1,114) of upper extremity injuries occurred to workers who were between 40 and 49 years of age, followed by workers aged 50 to 59 (n = 558, 12.88%). Workers aged under 20 years old (n = 109) and aged 60 to 69 years (n = 107) experienced almost 5 % total, of the injuries to the upper extremities.

Table 4- 91. Age of workers with upper extremity injuries.

Age (years)	Number of injuries	%	Cumulative %
30 to 39	1,239	28.59%	28.59%
20 to 29	1,206	27.83%	56.43%
40 to 49	1,114	25.71%	82.14%
50 to 59	558	12.88%	95.02%
Under 20	109	2.52%	97.53%
60 to 69	107	2.47%	100.00%
Total	4,333	100.00%	

Injury severity means for upper extremity injuries were compared among the six age groups. Injury severity scores were provided for 4,266 worker injuries to the upper extremities. The results of the Levene test of homogeneity of injury severity score variances for the six age groups did not allow for an assumption of equal variances, L (5, 4,260) = 20.60, $p < 0.001$. The results of the subsequent Welch test of equality of upper extremities injury severity means indicated that at least one age group was significantly different from another group, F (5, 564.01) = 6.16, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

The results of the Tukey's b test provided a ranking of the age groups by their respective upper extremities injury severity means (see Figure 4- 149). Workers 60 to 69 years of age had the highest severity mean ($\mu = 1.33$), followed by workers 40 to 49 ($\mu = 1.30$), 50 to 59 ($\mu = 1.29$), and 30 to 39 ($\mu = 1.25$) years old. Workers under the age 20 ($\mu = 1.17$) and between 20 and 29 years old ($\mu = 1.20$) had the two lowest injury severity means for injuries to the upper extremities among the age groups. The results of the Tukey's b range test identified two homogeneous subsets of severity means for upper extremities injuries among the age groups. Age groups within each subset did not have significantly different injury severity means, at $p \leq 0.05$, from each other (see Figure 4- 149). Figure 4- 149 shows a trend of increasing injury severity of upper extremity injuries as workers get older. The Kendall's tau b correlation test was conducted to examine this relationship. The results of a Kendall's *tau* test for correlation between injury severity and age of the worker with an upper extremity injury indicated a slight, though significant, at $p \leq 0.01$, correlation of 0.70.

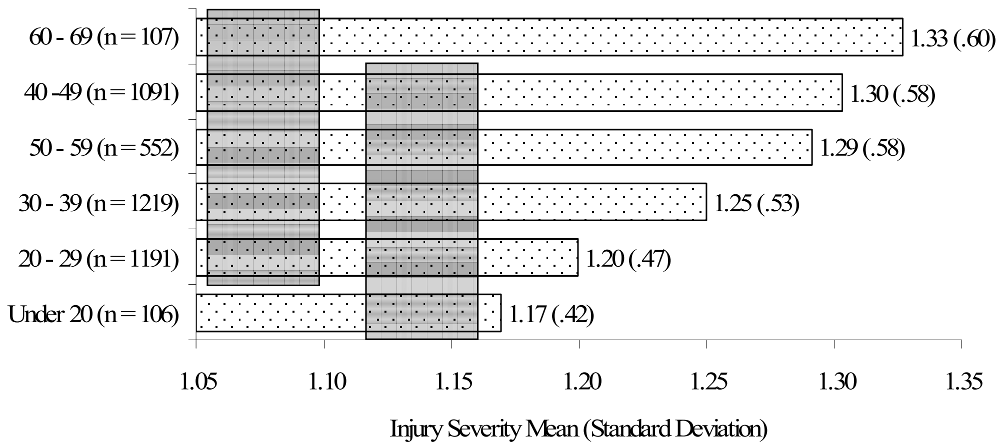

Figure 4- 149. Comparison of injury severity means by age of workers with upper extremity injuries.

Specific upper extremities injury severity mean differences were discerned from the arrangement of the homogeneous subsets displayed in Figure 4- 149. These are illustrated in Figure 4- 150. Workers between 60 and 69 years of age showed a significantly higher injury severity mean, at $p \leq 0.05$, than trunk injuries experienced by workers less than 20 years of age.

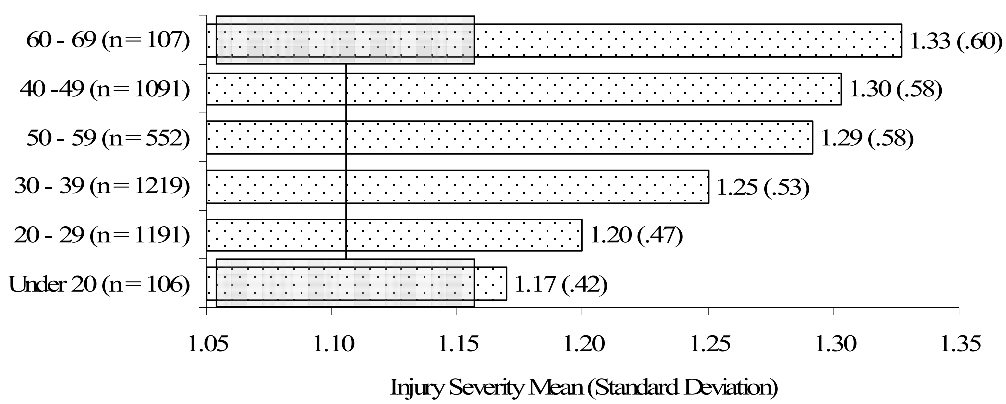

Figure 4- 150. Differences of injury severity means by ages of workers with injuries to the upper extremities.

The mean ages of workers with injuries to the upper extremities were compared by the specific body part impacted by the injury. The results of the Levene test of homogeneity of age variances between the specific body parts of the upper extremities allowed for an assumption of equal variances, L (8, 4,324) = 0.38, $p > 0.90$. Subsequently, the results of the ANOVA test indicated that at least one of body parts of the upper extremities was associated with a significantly different mean age of one from the other body parts, F (8, 4,324) = 6.60, $p < 0.001$. The results of the Tukey's b range test confirmed this test result and enabled the ranking the body parts by their respective injury severity means (see Figure 4- 151).

Among injuries of to the upper extremities, workers who experienced multiple injuries to the upper extremities had the highest mean age, $\mu = 43.13$ years. This was followed by injuries to the wrist and hand ($\mu = 39.88$), elbow ($\mu = 38.97$), upper arms ($\mu = 38.38$), wrist only ($\mu = 37.95$), lower arm ($\mu = 37.12$), finger ($\mu = 36.71$), and hand ($\mu = 36.11$). Workers with injuries to the thumb showed the lowest mean age, $\mu = 35.51$. As illustrated in Figure 4- 151, the Tukey's b test identified three homogeneous subsets of body parts of the upper extremities, in which mean ages were not significantly different at $p \leq 0.05$.

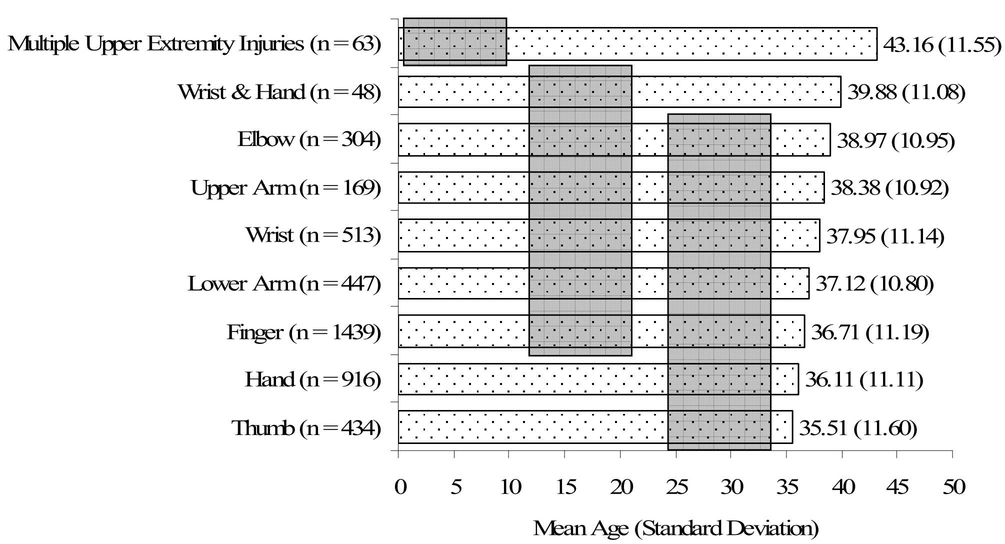

Figure 4- 151. Comparison of mean ages by upper extremity body part injured.

From the arrangement of the three homogeneous subsets, it was discerned that workers with multiple injuries to the upper extremities had a significantly greater mean age, at $p \leq 0.05$, than workers experiencing injuries to any of the other body parts of the upper extremities (see Figure 4- 152). In addition, workers with injuries to both the hand and the wrist had a significantly greater mean age, at $p \leq 0.05$, than workers with injuries to thumb and injuries to the hand only.

Figure 4- 152. Differences of mean ages by injured upper extremity body part.

Job Tenure

The number of days between the time an injured worker was hired and the time that worker sustained an injury to the upper extremities (i.e., job tenure) was explored. Information regarding the frequency of injuries to the upper extremities by the nine job tenure groups, shown in Table 4- 92, was provided for 9,833 worker injuries. Workers who had been employed of 91 to 180 days (n = 1,647) and those employed of 181 to 365 days (n = 1,626) accounted for nearly 17% each, of the injuries to the upper extremities. Nearly 13% of the upper extremities injuries were experienced by workers in the first 15 days of employment (n = 1,301) and 13% by those with 31 to 60 days (n = 1,234) of employment. Almost 11% of the injuries to the upper extremities were among workers employed of 366 to 730 days (n = 1,027). Workers injured between the 61st and 90th day of employment (n = 845) in addition to those injured between their 16th and 30th day of employment (n = 857) made up almost 17% of the upper extremity injuries. Workers with injuries to the upper extremities who were employed two or more years prior to being injured accounted for just over 13% of the upper extremities injuries.

Table 4- 92. Job tenure for workers with injuries to the upper extremities.

Job tenure	Number of injuries	%	Cumulative %
91 to 180 days	1,647	16.75%	16.75%
181 to 365 days	1,626	16.54%	33.29%
0 to 15 days	1,301	13.23%	46.52%
31 to 60 days	1,234	12.55%	59.07%
366 to 730 days (1 to 2 years)	1,027	10.44%	69.51%
16 to 30 days	857	8.72%	78.23%
61 to 90 days	845	8.59%	86.82%
731 to 1460 days (2 to 4 years)	681	6.93%	93.75%
> 1461 days (> 4 years)	615	6.25%	100.00%
Total	9,833	100.00%	

Job tenure categories were compared by their respective severity means for injuries to upper extremities. The results of the Levene test of homogeneity of trunk injury severity score variances did not allow for the assumption of equal variances between the nine job tenure categories, L (8, 9,683) = 6.78, $p < 0.001$. Subsequently, the Welch test was performed to test the equality of the upper extremities injury severity means between these categories. The results of this test indicated that at least one of the job tenure categories had an injury severity mean that was significantly different from one of the other categories, F (8, 3,501.05) = 2.23, $p < 0.03$. This result was not confirmed by the results the of the Tukey's b range test (see Figure 4- 153).

Figure 4- 153 displays the results of the Tukey's b range test. The single homogeneous subset indicates that, at $p \leq 0.05$, none of the job tenure categories had a significantly different trunk injury severity mean from any of the other categories. Workers who were injured within

the first fifteen days of employment (μ = 1.33), along with those employed for more than four years (μ = 1.33), had the highest severity means for injuries to the upper extremities. These were followed by workers who had been employed between two and four years (μ = 1.31), between 61 and 90 days (μ = 1.30), 16 and 30 days (μ = 1.30), of one to two years (μ = 1.28), and 31 to 60 days (μ = 1.28). The lowest two upper extremities injury severity means were associated with workers employed 91 to 180 days (μ = 1.27) and 181 to 365 days (μ = 1.26). The single homogeneous subset of job severity means (see Figure 4- 153) by job tenure categories indicates that, at $p \leq 0.05$, none of the job categories had a severity mean for injuries to the upper extremities significantly different of any of the other job tenure categories.

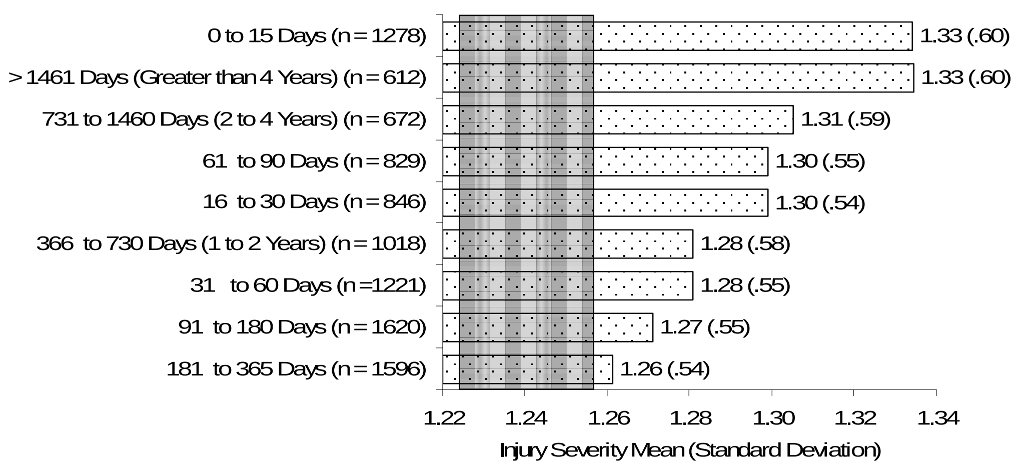

Figure 4- 153. Comparison of injury severity means by job tenure of workers with upper extremity injuries.

Month of Occurrence of Injury

Based on information provided for 13,147 cases the frequency of upper extremity injuries was examined by the month of the year during which the injury had occurred. Table 4- 93 shows the distribution of injuries to the upper extremities by month. Almost 40% of the injuries occurred within the months of July (n = 1,333), August (n = 1,315), October (n = 1,258), and September (n = 1,206). Around eight % of the injuries to the upper extremities occurred during each of the months of June (n = 1,151), April (n = 1,106), May (n = 1,077), March (n = 1,039), and November (n = 1,024). The remaining 20% of the injuries to the upper extremities occurred during winter months of January (n = 898), December (n = 887), and February (n = 853).

Table 4- 93. Month of occurrence of upper extremity injuries.

Month of injury occurrence	Number of injuries	%	Cumulative %
July	1,333	10.14%	10.14%
August	1,315	10.00%	20.14%
October	1,258	9.57%	29.71%
September	1,206	9.17%	38.88%
June	1,151	8.75%	47.64%
April	1,106	8.41%	56.05%
May	1,077	8.19%	64.24%
March	1,039	7.90%	72.15%
November	1,024	7.79%	79.93%
January	898	6.83%	86.77%
December	887	6.75%	93.51%
February	853	6.49%	100.00%
Total	13,147	100.00%	

Injury severity for injuries to the upper extremities by the month of the injury was examined by ranking the months by their respective injury severity means and subsequently comparing the injury severity means between the months to identify possible differences, significant at $p \leq 0.05$. Severity scores, by month of the injury, were provided for 12,934 worker injuries to the upper extremities. The results of an initial Levene test did not allow for an assumption of equal injury severity score variances between the twelve months, L (11, 12,922) = 3.62 $p < 0.001$. The results of the subsequent Welch test indicated that none of the months had a significantly different upper extremities injury severity mean from any of the other months, F (11, 4,953.67) = 1.32, $p > 0.20$. This was confirmed by the results of the Tukey's b range test which did not identify any significant differences, at $p \leq 0.05$, of injury severity mean between specific months.

The rankings of the month of injury occurrence by upper extremity injury severity means, generated by the Tukey's b test, are displayed in Figure 4- . Injuries to the upper extremities which occurred in April ($\mu = 1.29$) and March ($\mu = 1.29$) had the highest severity means. The months of January and May each had the second highest severity mean for injuries to the upper extremities, $\mu = 1.28$. These were followed by the months of December, November, and October, each recording an upper extremities injury severity mean of $\mu = 1.26$. Injuries occurring during the month of February ($\mu = 1.25$) had the fifth lowest severity mean, preceded by the months of September, August, June and July, each with a severity mean for injuries to the upper extremities equal to 1.24.

The results of the Tukey's b test identified a single homogeneous group of severity means over twelve months. (see Figure 4- 154). This indicates that no significantly different severity means, at $p \leq 0.05$, could be detected between specific months when injuries to the upper extremities occurred.

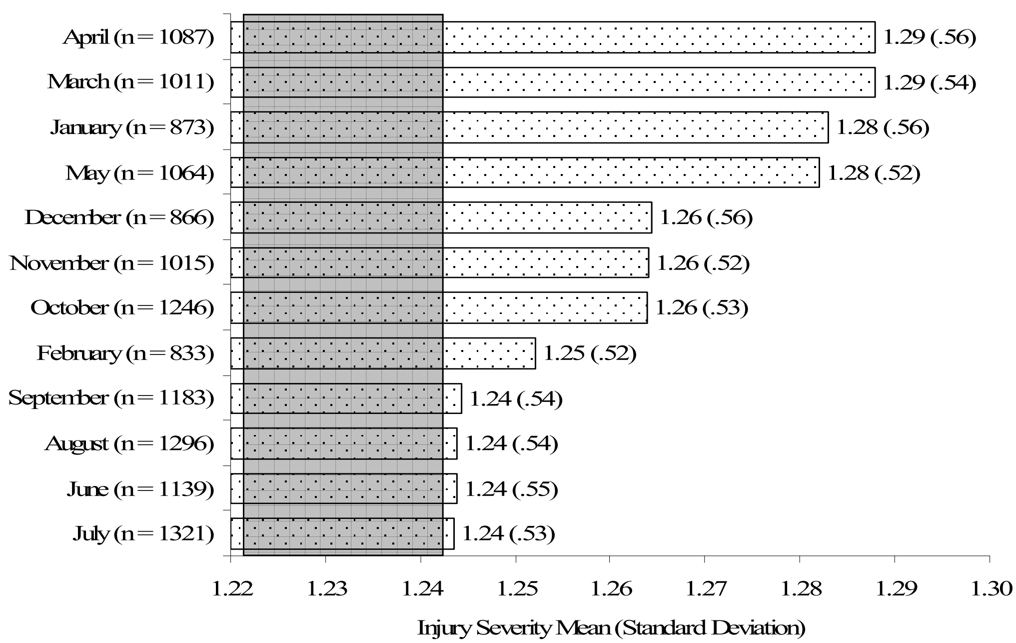

Figure 4- 154. Comparison of injury severity means by month of occurrence of injuries to the upper extremities.

Day of the Week of Occurrence of Injury

The possible relationship between injuries to the upper extremities and the day of the week on which these injuries occurred was explored. Injury data for upper extremity injuries by day of the week is displayed in Table 4- 94. Nearly 20% of the upper extremity injuries occurred either on a Wednesday (n = 2,528), Thursday (n = 2,525), or Tuesday (n = 2,503). Injuries occurring on Monday (n = 2,467) accounted for nearly 19% of the injuries to the upper extremities. Around 17% of the trunk injuries occurred on a Friday (n = 2,290). Nearly four % of upper extremity injuries occurred on Saturdays (n = 625) and over one % on Sundays (n = 209).

Injury severity for injuries to the upper extremities by the day of the week on which the injury occurred was examined by ranking the days of the week by their respective injury severity means and subsequently comparing the upper extremity injury severity means between the days to identify possible differences, significant at $p \leq 0.05$. Severity scores, by day of the injury, were provided for 11,490 worker injuries to the upper extremities. The results of an initial Levene test did not allow for an assumption of equal upper extremity injury score variances between the seven days of the week, L (6, 12,927) = 3.39, $p < 0.003$. The results of the subsequent Welch test indicated that none of the days of the week had a significantly different injury severity mean from any of the other days of the week, F (6, 2,125.18) = 1.19, $p > 0.30$. This was confirmed by the results of the Tukey's b range test, which did not identify any significant differences, at $p \leq 0.05$, of upper extremity injury severity means between specific days of the week.

The rankings of the days of the week by upper extremity injury severity means, generated by the Tukey's b test, are displayed in Figure 4- 155. Injuries to the upper extremities occurring on Sundays ($\mu = 1.31$) showed the highest injury severity mean among days on the week on which trunk injuries occurred. This was followed by injuries experienced on Fridays ($\mu = 1.28$), Mondays (μ = 1.27), Wednesdays (μ = 1.26), Saturdays (μ = 1.26), and Tuesdays (μ = 1.25). Injuries occurring on Thursdays had the lowest severity mean, μ = 1.24, among the days of the week.

Table 4- 94. Day of the week of occurrence of upper extremity injuries.

Day of the week of njury	Number of injuries	%	Cumulative %
Wednesday	2,528	19.23%	19.23%
Thursday	2,525	19.21%	38.43%
Tuesday	2,503	19.04%	57.47%
Monday	2,467	18.76%	76.24%
Friday	2,290	17.42%	93.66%
Saturday	625	4.75%	98.41%
Sunday	209	1.59%	100.00%
Total	13,147	100.00%	

A single homogeneous group of severity means including Monday through Sunday was identified by the Tukey's b test (see Figure 4- 155). This indicates that no significantly different severity means, at $p \leq 0.05$, could be detected between specific days of the week on which the injuries to the upper extremities occurred.

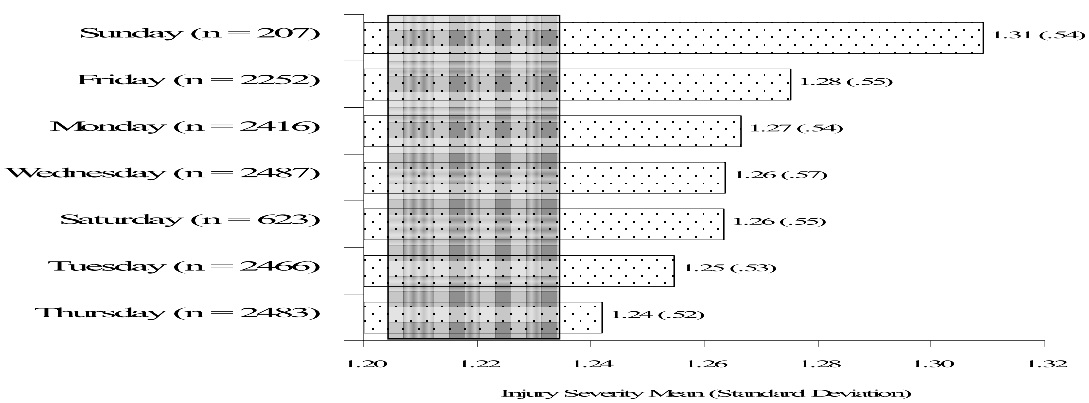

Figure 4- 155. Comparison of injury severity means by day of the week of occurrence of upper extremity injuries

Lower Extremities

Injuries to the lower extremities and the severity of these injuries were examined by the specific body part injured (e.g., knee), the nature of the injury (e.g., laceration), the general cause of the injury (e.g., fall or slip), the occupational work area in which the injured worker was working at the time of the injury (e.g., carpentry), the workers occupational experience level (e.g., apprentice), the job tenure of the injured worker prior to the injury, the month of the year and day of the week on which the injury occurred, and the age of the injured worker at the time of the reported injury. A comparison of mean ages by specific body parts injured was also performed.

Body Part

Frequency information regarding the specific injured body parts of the lower extremities was provided for 9,193 worker injuries. Table 4- 95 illustrates, injuries to the knee comprised almost 34% (n = 3,106) of the injuries to the lower extremities. Ankle (n = 1,867) and foot (n = 1,847) injuries each accounted for just over 20% of the lower extremity injuries. Nearly 13% of the lower extremity injuries were to the lower leg (n = 1,167). Fewer injuries were sustained by the upper leg (n = 440), the toe (n = 307), hip (n = 220), great toe (n = 123), and multiple body parts of the lower extremities (n = 116).

Table 4- 95. Injured body parts of the lower extremities.

Body part	Number of injuries	%	Cumulative %
Knee	3,106	33.79%	33.79%
Ankle	1,867	20.31%	54.10%
Foot	1,847	20.09%	74.19%
Lower leg	1,167	12.69%	86.88%
Upper leg	440	4.79%	91.67%
Toe	307	3.34%	95.01%
Hip	220	2.39%	97.40%
Great toe	123	1.34%	98.74%
Multiple injuries	116	1.26%	100.00%
Total	9,193	100.00%	

Based on the severity scores provided for 9,080 worker injuries to the lower extremities, the nine specific body part groups were ranked by their respective injury severity means. Injury severity means were also compared between the nine body part groups. The results of the Levene test of homogeneity of injury severity score variances between the nine body parts of the lower extremities did not allow for the assumption of equal variances, L (8, 9,071) =53.22, $p < 0.001$. Subsequent the results of the Welch test of equality of injury severity means indicated that at least one of the body parts of the lower extremities had a significantly different injury severity mean than one of the other body parts, F (8, 963.13) = 25.17, $p < 0.001$. This was confirmed by the results of Tukey's b range test.

The Tukey's b range test was performed to compare body parts of the lower extremities by their respective injury severity means. From this test, each of the body parts was ranked according to its respective injury severity mean (see Figure 4- 156). Multiple injuries had the highest severity mean ($\mu = 1.58$) among injuries to the lower extremities, followed closely by injuries to the knee ($\mu = 1.51$). Injuries to the hip had the third highest injury severity mean ($\mu = 1.44$), followed by injuries to the ankle ($\mu = 1.39$), lower leg ($\mu = 1.36$), toe ($\mu = 1.36$), upper leg ($\mu = 1.33$), great toe ($\mu = 1.31$), and foot ($\mu = 1.27$). Additionally, the results of the Tukey's b test identified four homogeneous subsets of lower extremities body parts in which there was no individual injury severity mean difference, at $p \leq 0.05$, between subset members.

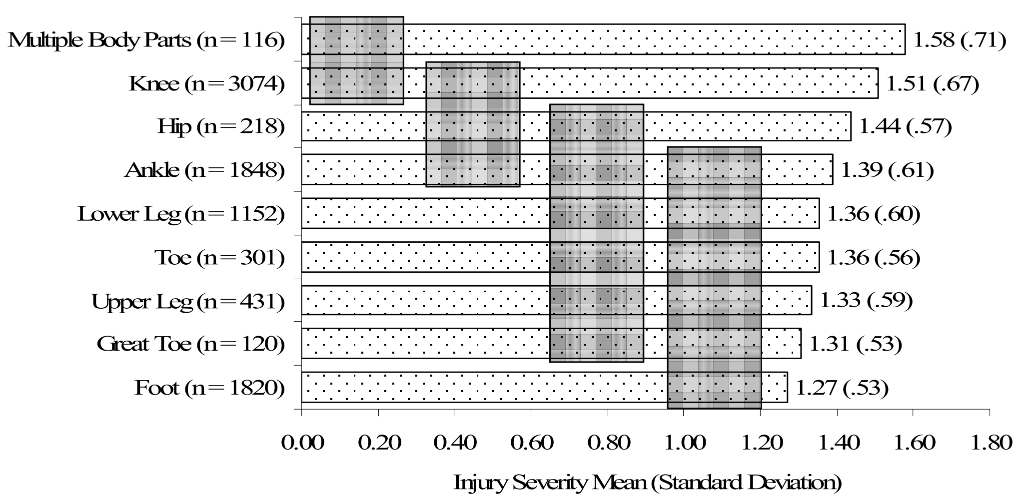

Figure 4- 156. Comparison of injury severity means by injured body parts of the lower extremities.

Specific injury severity mean differences, significant at $p \leq 0.05$, were discerned from the arrangement of the homogeneous subsets (see Figure 4- 157). Among the injuries to the lower extremities, injuries to multiple body parts of the lower extremities had a significantly greater injury severity mean, at $p \leq 0.05$, than all of the other body arts, except the knee. Knee injuries had a significantly greater injury severity mean, $p \leq 0.05$, than injuries to the lower leg, toe, upper leg, great toe, and foot. Hip injuries had a significantly higher severity mean, at $p \leq 0.05$, than foot injuries.

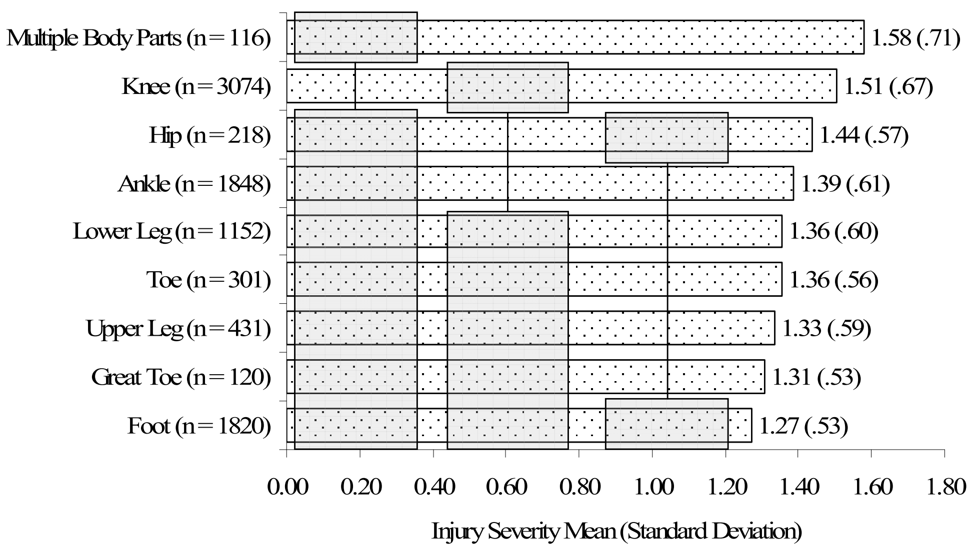

Figure 4- 157. Differences of injury severity means between injured body parts of the lower extremities.

Nature of Injury

Information regarding the injury frequency of lower extremities injuries by the nature of the injury was provided for 8,620 worker injuries (see Table 4- 96). Around 26% of the injuries to the upper extremities were strain injuries (n = 2,228). Contusions (n = 1,952) accounted for almost 23%, while sprains accounted for nearly 17% (n = 1,430), and punctures accounted for 10% (n = 862) of the reported injuries to the lower extremities. Fractures (n = 802) and lacerations (n = 561) combined to represent almost 16% of the injuries. The nature of injury for the remaining 9 % of the upper extremity injuries was distributed among the 16 remaining classifications shown in Table 4- 96.

Table 4- 96. Nature of injury to the lower extremities.

Nature of injury	Number of injuries	%	Cumulative %
Strain	2,228	25.85%	25.85%
Contusion	1,952	22.65%	48.49%
Sprain	1,430	16.59%	65.08%
Puncture	862	10.00%	75.08%
Fracture	802	9.30%	84.39%
Laceration	561	6.51%	90.89%
Inflammation	217	2.52%	93.41%
Rupture	159	1.84%	95.26%
Burn	134	1.55%	96.81%
Crushing	73	0.85%	97.66%
Infection	51	0.59%	98.25%
Dislocation	45	0.52%	98.77%
Multiple injuries	42	0.49%	99.26%
Dermatitis	14	0.16%	99.42%
Foreign body	12	0.14%	99.56%
Amputation	10	0.12%	99.68%
Poisoning NOC	9	0.10%	99.78%
Severance	6	0.07%	99.85%
Occupational disease NOC	6	0.07%	99.92%
Electric shock	3	0.03%	99.95%
Freezing	3	0.03%	99.99%
Chemical poisoning	1	0.01%	100.00%
Total	8,620	100.00%	

Based on the severity scores provided for 8,515 workers with injuries to the lower extremities, 21 nature of injury categories were ranked by their respective injury severity means. The single chemical poisoning case had an injury severity score of one. Since the Tukey's b range test could not be performed when one of the groups has a sample size less than two the single chemical poisoning case was excluded from the comparative analysis of severity means between the nature of injury categories. Injury severity means were also compared between the remaining 21 nature of injury groups. The results of the Levene test of homogeneity of injury severity score variances between the 21 nature of lower extremity injury groups did not allow for the assumption of equal variances, L (20, 8,494) = 50.90, $p < 0.001$. However, due to the fact that electric shocks and occupational disease not otherwise classified (NOC) of the lower extremities had injury score variances of zero, the Welch test of equality of severity means could not be performed. In lieu of the Welch test, the ANOVA test was conducted to explore injury severity mean differences between the nature of lower extremity injury groups. The results of the ANOVA indicated that at least one of the nature of lower extremity injury groups had a significantly different injury severity mean than one of the other groups, F (20, 8,494) = 82.50, $p < 0.001$. This was confirmed by the results of Tukey's b range test.

The Tukey's b range test was performed to compare nature of lower extremity injury classifications by their respective injury severity means. From this test, each nature of injury category was ranked according to its respective lower extremity injury severity mean (see Figure 4- 158). Among the nature of injury of lower extremity injury categories, amputations resulted in the highest injury severity mean, $\mu = 2.50$. Along with amputations, ruptures ($\mu = 2.37$), dislocations ($\mu = 2.31$), occupational disease NOC ($\mu = 2.00$), multiple injuries to the lower extremities ($\mu = 1.86$), fractures ($\mu = 1.85$), severances ($\mu = 1.83$), poisoning ($\mu = 1.67$), crushing ($\mu = 1.65$), and foreign body ($\mu = 1.50$) comprised the top ten injury severity means by nature of injury to the lower extremities. The remaining eleven nature of lower extremity injury groups with severity means are shown in Figure 4- 158. Additionally, the results of the Tukey's b test identified five homogeneous subsets of nature of lower extremity injury categories in which there was no individual injury severity mean difference, at $p \leq 0.05$, between subset members.

Specific injury severity mean differences, significant at $p \leq 0.05$, were discerned from the arrangement of the homogeneous subsets (see Figure 4- 159). Among the injuries to the lower extremities, amputations and ruptures had significantly greater injury severity means, at $p \leq 0.05$, than all of the remaining nature of injury groups except, dislocations, occupational diseases NOC, multiple injuries, fractures, and severances. Dislocations had a significantly higher injury severity mean than the same group as amputations and ruptures, except poisoning NOC, and crushing. Occupational diseases NOC had a significantly greater injury severity mean, at $p \leq 0.05$, than lacerations, contusions, dermatitis, punctures, and electric shocks. Electric shock injuries of the lower extremities also showed a significantly lower severity mean, at $p \leq 0.05$, than multiple injuries to the lower extremities, fractures, and severances among the lower extremities.

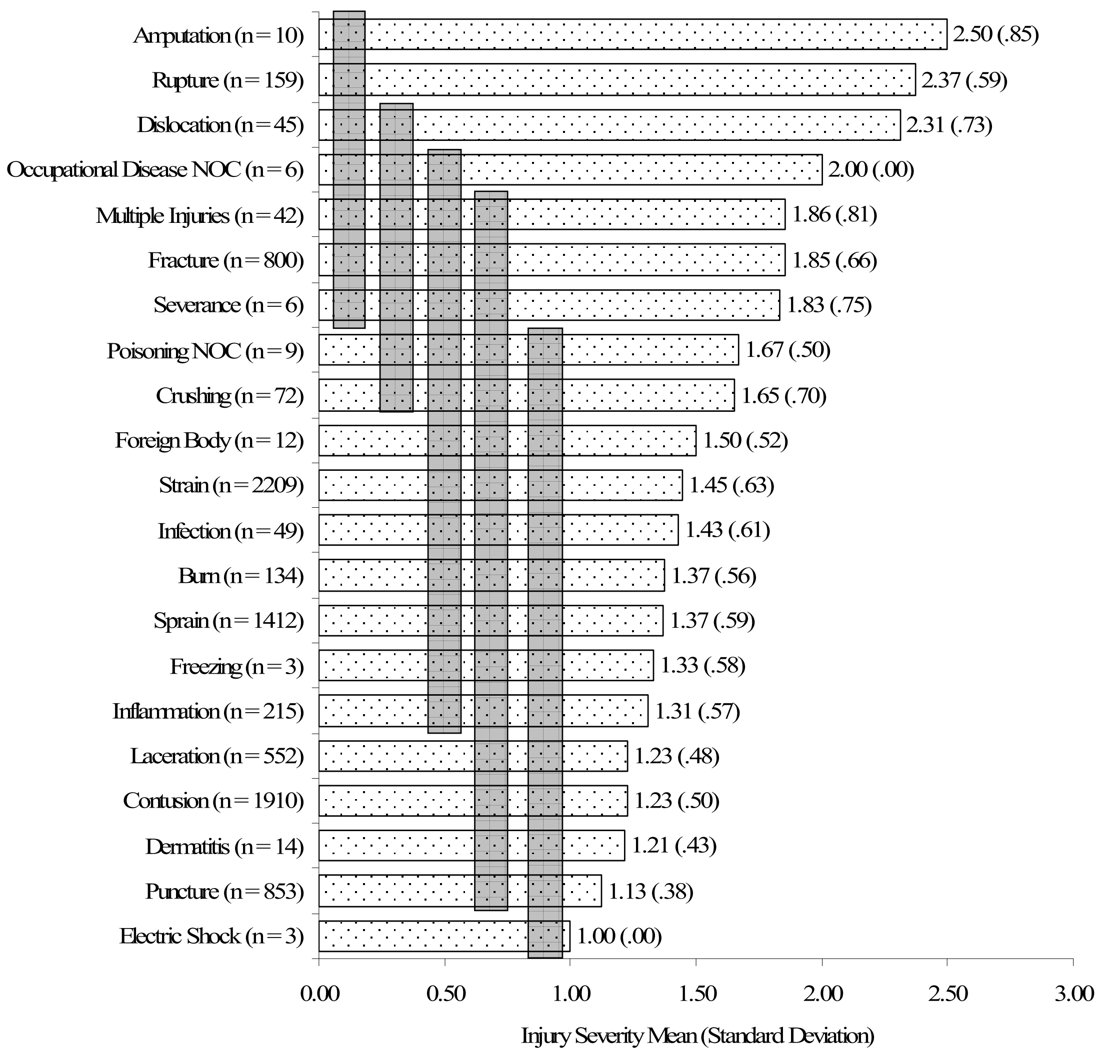

Figure 4- 158. Comparison of injury severity means by nature of lower extremity injuries.

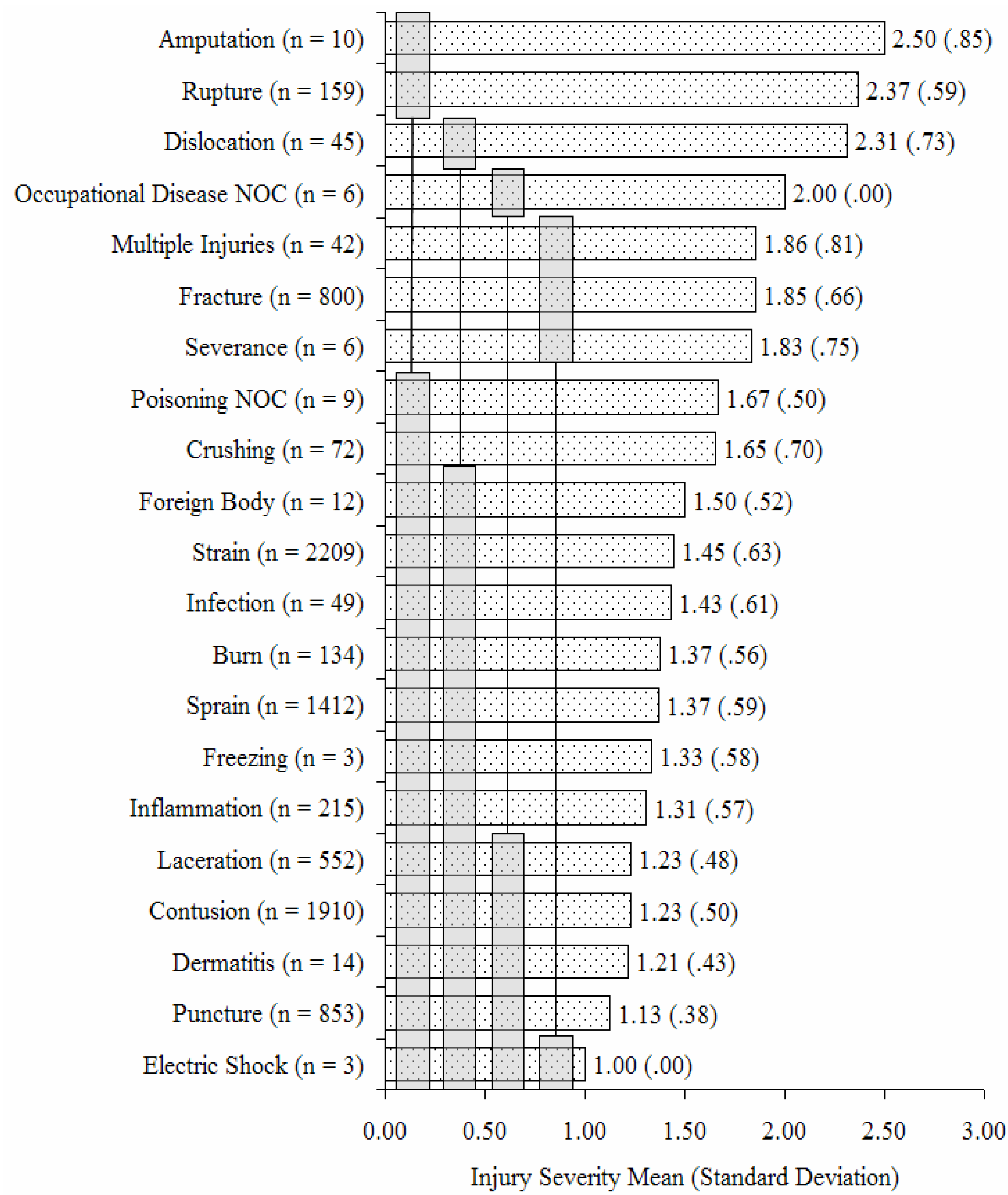

Figure 4- 159. Differences of injury severity means by nature of injury to the lower extremities.

General Cause of Injury

From information provided for 8,995 worker injuries, the lower extremity injury distribution by general cause of injury categories was generated and ranked in descending order of frequency (see Table 4- 97). Over 30% of the injuries to the lower extremities were caused by a slip or fall (n = 2,709). Strains were attributed as the cause of injury for over 27% (n = 2,444) of the injuries to the lower extremities. Around 17% of the workers with lower extremity injuries had sustained struck by injuries (n = 1,538). Ten % of the lower extremity injuries were caused by the workers striking against or stepping on an object (n = 900). Nearly nine % were caused by a cut, puncture or scrape (n = 778). The remaining seven % of injuries to the lower extremities are displayed in Table 4- 97.

Table 4- 97. General cause of lower extremity injuries.

General cause of injury	Number of injuries	%	Cumulative %
Fall or slip	2,709	30.12%	30.12%
Strain	2,444	27.17%	57.29%
Struck by	1,538	17.10%	74.39%
Strike against or stepping on	900	10.01%	84.39%
Cut, puncture, or scrape	778	8.65%	93.04%
Caught in or between	308	3.42%	96.46%
Burn	121	1.35%	97.81%
Animal or insect bite or sting	107	1.19%	99.00%
Absorption, ingestion, or inhalation	53	0.59%	99.59%
Motor vehicle	37	0.41%	100.00%
Total	8,995	100.00%	

Injury severity scores, by the general cause of the injury to the lower extremities, were provided for 8,883 worker injuries. Based on this information, injury severity means were generated for and compared between the ten general cause of injury categories. The results of the Levene test of homogeneity of injury severity score variances between the general cause of injury groups did not allow for the assumption of equal variances, L (9, 8,873) = 95.30, $p < 0.001$. The results of the subsequent Welch test indicated that at least one of the cause of injury categories had a significantly different injury severity mean than one of the other categories, F (9, 471.74) = 42.20, $p < 0.001$. This was confirmed by the results of Tukey's b range test.

The Tukey's b range test was performed to compare general cause of lower extremity injury classifications by their respective injury severity means. From this test, each of the cause of injury categories was ranked according to their respective lower extremity injury severity mean (see Figure 4- 160). Among the causes of lower extremity injuries, involvement with a motor vehicle was associated with the highest injury severity mean, $\mu = 1.57$. This was followed by lower extremity injuries caused by having been Caught in or between an object or objects ($\mu = 1.53$), falling or slipping ($\mu = 1.49$), strains ($\mu = 1.44$), and being burned ($\mu = 1.36$). Having been struck by an object was associated with lower extremity injuries with the fifth highest severity mean, $\mu = 1.35$. This was followed by lower extremity injuries caused by the absorption, ingestion, or inhalation of a substance ($\mu = 1.25$), having struck against or having stepped on an object ($\mu = 1.25$), and being cut, punctured, or scraped ($\mu = 1.17$). Lower extremity injuries caused by an animal or insect bite or sting had the lowest injury severity mean, $\mu = 1.14$. The results of the Tukey's b test identified three homogeneous subsets of general cause of lower extremity injury categories in which there was no individual injury severity mean difference, at $p \leq 0.05$, between subset members (see Figure 4- 160).

Specific injury severity mean differences, significant at $p \leq 0.05$, were discerned from the arrangement of the homogeneous subsets (see Figure 4- 161). Among the general causes of lower extremity injuries, those involving a motor vehicle, having been Caught in or between an object or objects, and of falling or slipping, each had significantly higher injury severity means, at $p \leq 0.05$, than the severity means associated with lower extremity injuries caused by the absorption, ingestion, or inhalation of a substance, having struck against, or stepped on an object, been cut, punctured, or scraped, and a bite from an animal or insect sting. In addition, lower extremity injuries of straining had a significantly greater severity mean, at $p \leq 0.05$, than injuries of cuts, punctures, or scrapes, and injuries of animal bites and stings of insects.

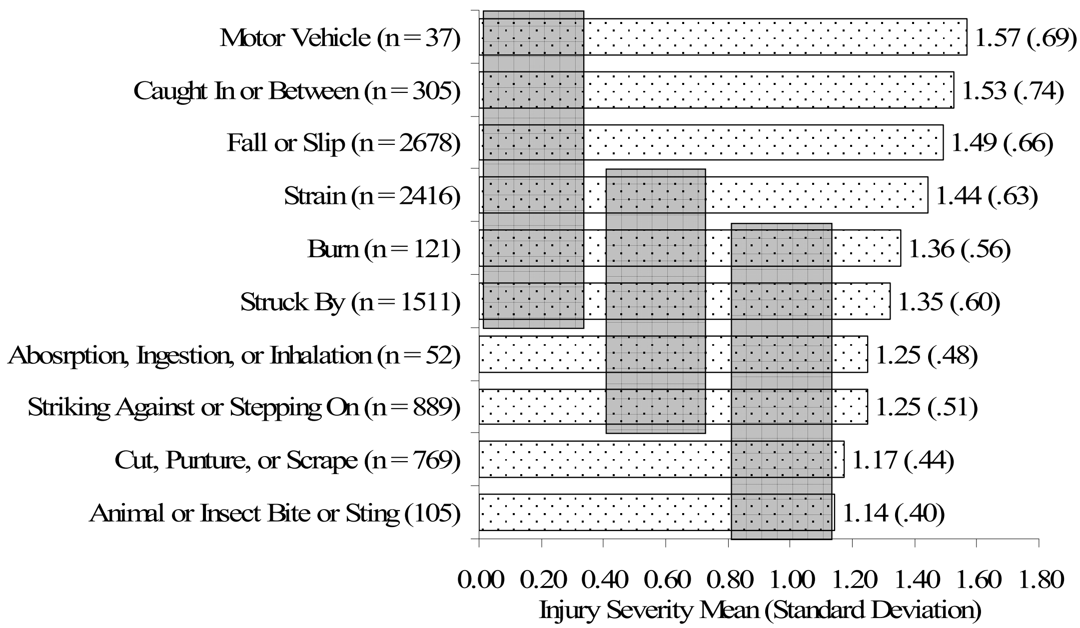

Figure 4- 160. Comparison of injury severity means by general cause of lower extremity injuries.

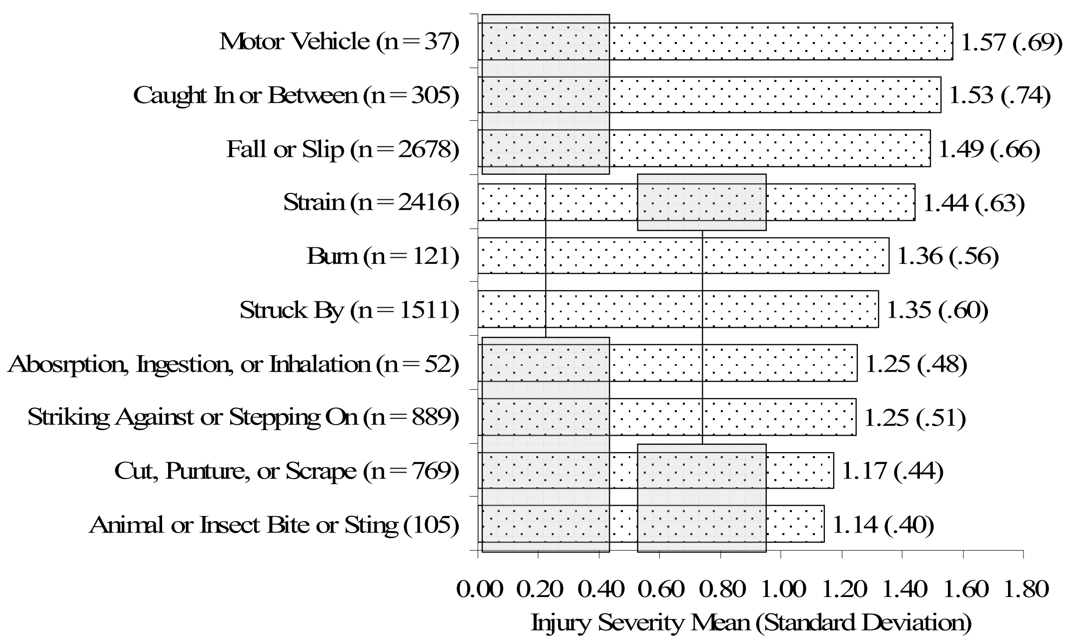

Figure 4- 161. Difference of injury severity means by general causes of lower extremity injuries.

Occupational Work Area

The general occupational work area categories identified the specific work area in which the injured worker was involved at the time of the injury. Of the 6,941 lower extremities injury cases, 46% were experienced by workers while working in areas, such as carpentry (n = 1,293), electrical work (n = 1,072), and iron and steel work (n = 828). Table 4- 98 shows the lower extremities injury frequencies for all 42 of the general occupational work areas. As this table illustrates, work areas associated with least number of injuries to the lower extremities included waterproofing (n = 11), material handling (n = 10), lathing (n = 9), acoustic ceiling work (n = 8), surveying (n = 8), field engineering (n = 8), HVAC/refrigeration work (n = 6), hod carrying (n = 6), landscaping (n = 3), and flagging (n = 3). These ten work areas accounted for around 1 % of the injuries to the lower extremities.

Injury severity scores, by the occupational work area associated with the injury to the lower extremity, were provided for 6,871 worker injuries. Based on this information, injury severity means were generated for and compared between the 42 occupational work areas. The results of the Levene test of homogeneity of injury severity score variances between the 42 occupational areas did not allow for the assumption of equal variances, L (41, 6,829) = 4.27, $p < 0.001$. The Welch test of equality of means could not be performed because hod carrying and acoustic ceiling work each had zero variances (see Figure 4- 162). In lieu of the Welch test, the ANOVA was conducted and the results suggested that at least one of the work areas could have had an injury severity mean for lower extremity injuries that was significantly different than one of the other work areas, F (41, 6,829) = 1.75, $p < 0.003$. However, this was not confirmed by the results of Tukey's b range test.

The Tukey's b range test was performed to compare the occupational work areas by their respective lower extremities injury severity means. This test ranked each work area according to its lower extremity injury severity mean (see Figure 4- 162). Among the 42 work areas, workers involved in conveyor systems work showed the highest severity mean ($\mu = 1.79$) for injuries to the lower injuries.Flagging ($\mu = 1.67$), material handling ($\mu = 1.60$), flooring, tile, and carpentry

Table 4- 98. Occupational work areas of workers with lower extremity injuries.

Occupational work area	Number of injuries	%	Cumulative %
Carpentry	1,293	18.63%	18.63%
Electrical	1,072	15.44%	34.07%
Iron/steel	828	11.93%	46.00%
Concrete	469	6.76%	52.76%
Technical repair or maintenance	448	6.45%	59.21%
Pipe fitting	383	5.52%	64.73%
Equipment or machinery operation	296	4.26%	69.00%
Plumbing	250	3.60%	72.60%
Masonry	238	3.43%	76.03%
Sheet metal	204	2.94%	78.97%
Boilermaker	156	2.25%	81.21%
Supervision NOC	155	2.23%	83.45%
Millwright	134	1.93%	85.38%
Painting or plastering	110	1.58%	86.96%
Welding	97	1.40%	88.36%
Drywall	79	1.14%	89.50%
Driving	74	1.07%	90.56%
Clerical	65	0.94%	91.50%
Glazing	60	0.86%	92.36%
Lineman	55	0.79%	93.16%
Roofing	54	0.78%	93.93%
Insulating	50	0.72%	94.65%
Steam fitting	49	0.71%	95.36%
Engineering	42	0.61%	95.97%
Managing	40	0.58%	96.54%
Sprinkler fitting	31	0.45%	96.99%
Flooring. tile, or carpeting	30	0.43%	97.42%
Inspecting	28	0.40%	97.82%
Scaffold erection	23	0.33%	98.16%
Security	23	0.33%	98.49%
Rigging	19	0.27%	98.76%
Convey systems work	14	0.20%	98.96%
Waterproofing	11	0.16%	99.12%
Material handling	10	0.14%	99.27%
Lathing	9	0.13%	99.39%
Acoustic ceiling work	8	0.12%	99.51%
Surveying	8	0.12%	99.63%
Field engineering	8	0.12%	99.74%
HVAC/refrigeration	6	0.09%	99.83%
Hod carrying	6	0.09%	99.91%
Landscaping	3	0.04%	99.96%
Flagging	3	0.04%	100.00%
Total	6,941	100.00%	

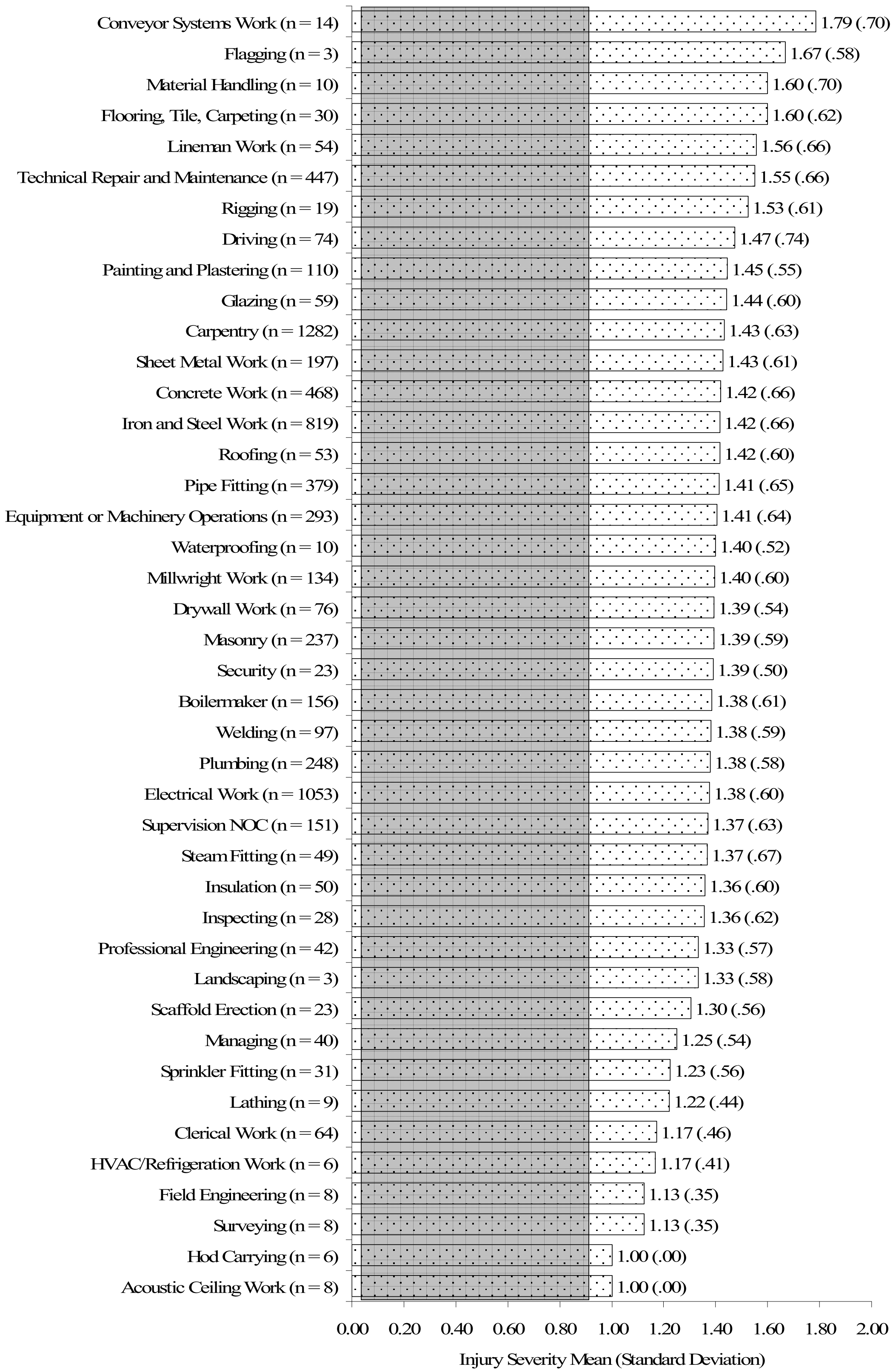

Figure 4- 162. Comparison of injury severity means by occupational work areas of workers with lower extremity injuries.

work (μ = 1.60), lineman work (μ = 1.56), and technical repair and maintenance (μ = 1.55) represented the work areas with the top five lower extremity injury severity means. Work areas associated with the lowest seven severity means for injuries to the lower extremities included sprinkler fitting (μ = 1.23), lathing (μ = 1.22), clerical work (μ = 1.17), HVAC/refrigeration work (μ = 1.17), field engineering (μ = 1.13), surveying (μ = 1.13), hod carrying (μ = 1.00), and acoustic ceiling work (μ = 1.00).

The single homogeneous subset of injury severity means shown in Figure 4- 162 indicated that none of the work areas had an upper injury severity mean that significantly different, at $p \leq 0.05$, of any of the other work areas.

Occupational Experience Level

Lower extremities injury frequency information regarding the workers' occupational experience was provided for 3,168 worker injuries. As Table 4- 99 shows, laborers had over 56% (n = 1.783) of the injuries to the lower extremities. Foreman level workers (n = 337), apprentices (n = 299), and journeyman level workers (n = 272), sustained over 28% total, of the injuries to the lower extremities. Field supervisors represented around five % (n = 163) of the workers with lower extremities injuries. Workers at the helper or assistant level (n = 138), administrative (n = 105), and professional (n = 71) experience levels represented about 10% total, of the workers with injuries to the lower extremities.

Injury severity means were compared among the eight occupational experience levels for injuries to the lower extremities. Injury severity scores by experience level were provided for 3,137 workers with lower extremity injuries. The results of the Levene test of homogeneity of injury severity score variances for the eight experience levels did not allow for an assumption of equal variances, L (7, 3,129) = 9.36, $p < 0.001$. The results of the subsequent Welch test of equality of lower extremities injury severity means indicated that at least one general cause of injury group was significantly different from another group, F (7, 482.34) = 4.00, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

Table 4- 99. Occupational experience level of workers with lower extremity injuries.

Occupational experience level	Number of injuries	%	Cumulative %
Laborer	1,783	56.28%	56.28%
Foreman	337	10.64%	66.92%
Apprentice	299	9.44%	76.36%
Journeyman	272	8.59%	84.94%
Field supervisor	163	5.15%	90.09%
Helper/assistant	138	4.36%	94.44%
Administrator	105	3.31%	97.76%
Professional	71	2.24%	100.00%
Total	3,168	100.00%	

Output of the Tukey's b test provided a ranking of the general cause of injury groups by their respective lower extremities injury severity means (see Figure 4- 163). Lower extremities injuries to journeymen had the highest injury severity mean ($\mu = 1.49$), followed by injuries to foremen ($\mu = 1.48$), helpers and assistants ($\mu = 1.39$), laborers ($\mu = 1.38$), apprentices ($\mu = 1.37$), field supervisors ($\mu = 1.36$), professionals ($\mu = 1.35$), administrative personnel ($\mu = 1.20$). The Tukey's test identified two homogeneous subsets of injury severity means for injuries to the lower extremities between the eight occupational experience levels. Experience levels within each subset did not have lower extremities injury severity means that were significantly different, at $p \leq 0.05$, from one another (see Figure 4- 163).

From the arrangements of the homogeneous groups shown in Figure 4- 163, specific and significant at $p \leq 0.05$, differences between the experience levels of severity means for injuries to the lower extremities were differentiated (see Figure 4- 164). Journeyman and foreman level workers showed a significantly greater, at $p \leq 0.05$, severity mean than administrative personnel for injuries to the lower extremities.

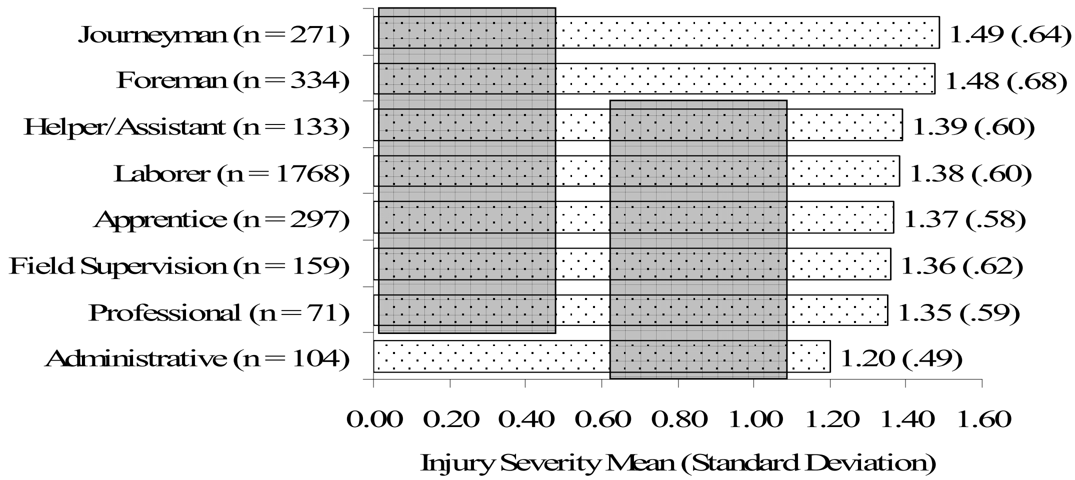

Figure 4- 163. Comparison of injury severity means by occupational experience level of workers with lower extremity injuries.

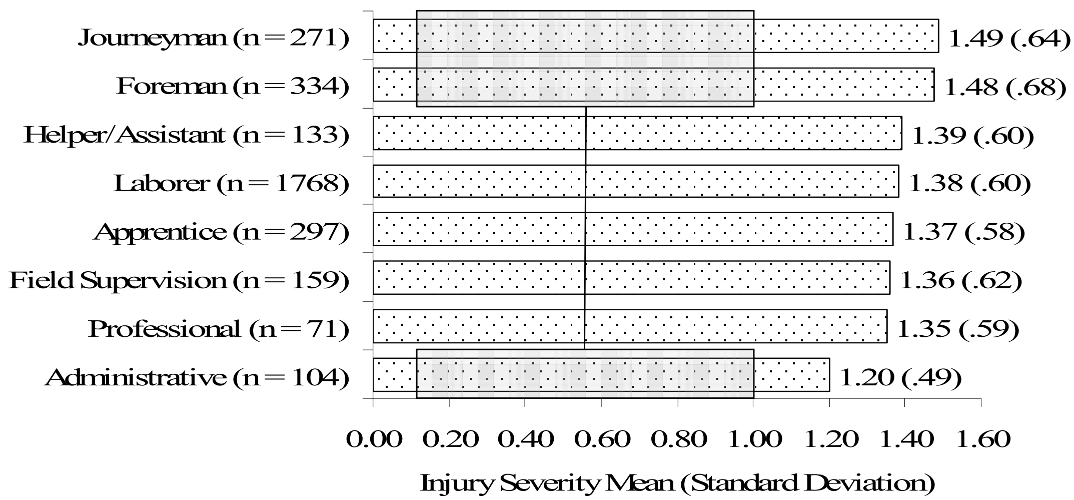

Figure 4- 164. Differences of injury severity means by occupational experience levels of workers with lower extremity injuries.

Age

The relationship between age and injuries to the lower extremities was explored in two ways. First, workers with lower extremities injuries were compared by their respective age groups. With the exception of the under 20 and over 69 age groups, each of the age groups represented ten-year spans. Injury frequencies were compared between the age groups. Second, lower extremity injury severity means were compared between the age groups.

Data for injuries to the lower extremities by the worker age were provided for 2,949 worker injuries (see Table 4- 100). Almost 29% (n = 1,239) of the injuries to the lower extremities were experienced by workers between 40 and 49 years of age. Around 27% (n = 792) of the injuries were to workers 30 to 39 years old. Twenty-five % (n = 749) of the lower extremities injuries occurred to workers 20 to 29 years old. Workers aged 50 to 59 years sustained around 14% (n = 423) of the injuries to the lower extremities. Workers under 20 years old (n = 62) and aged 60 to 69 years (n = 86) experienced just over 5 % total, of the injuries to the lower extremities.

Table 4- 100. Age of workers with injuries to lower extremities.

Age group (years)	Number of injuries	%	Cumulative %
40 - 49	837	28.38%	28.38%
30 - 39	792	26.86%	55.24%
20 - 29	749	25.40%	80.64%
50 - 59	423	14.34%	94.98%
60 - 69	86	2.92%	97.90%
Under 20	62	2.10%	100.00%
Total	2,949	100.00%	

Lower extremity injury severity means were compared among the six age groups. Injury severity scores were provided for 2,907 workers with injuries to the lower extremities. The results of the Levene test of homogeneity of injury severity score variances for the six age groups did not allow for an assumption of equal variances, L (5, 2,901) = 30.27, $p < 0.001$. The results of the subsequent Welch test of equality of lower extremities injury severity means indicated that at least one age group was significantly different from another group, F (5, 379.86) = 12.40, $p < 0.001$. This was confirmed by the results of the Tukey's b range test.

The results of the Tukey's b test provided a ranking of the age groups by their respective lower extremities injury severity means (see Figure 4- 165). Workers 50 to 59 years of age had the highest severity mean ($\mu = 1.45$), followed by workers 40 to 49 ($\mu = 1.43$), 60 to 69 ($\mu =$

1.42), and 30 to 39 (μ = 1.38) years old. Workers under the age 20 (μ = 1.29) and between 20 and 29 years old (μ = 1.24) had the two lowest injury severity means for injuries to the lower extremities among the age groups. The results of the Tukey's b range test identified two homogeneous subsets of severity means for lower extremities injuries among the age groups.

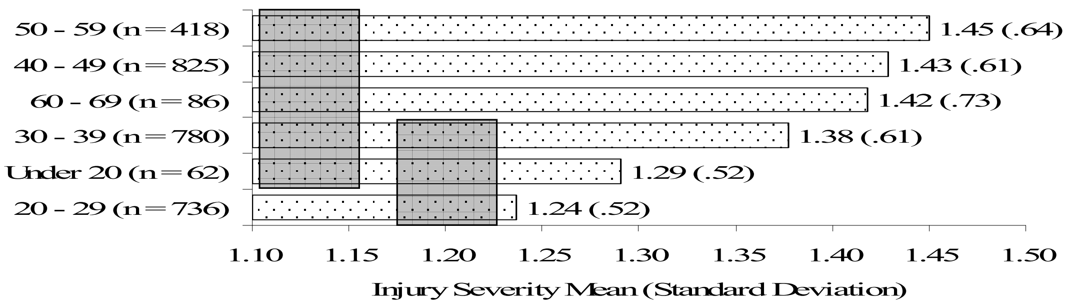

Figure 4- 165. Comparisons of injury severity means by age of workers with lower extremity injuries.

Specific lower extremities injury severity mean differences were discerned from the homogeneous subsets displayed in Figure 4- 165. As illustrated in Figure 4- 166, workers aged 40 to 69 years had a significantly lower, at $p \leq 0.05$, lower extremity injury severity mean than for workers between 20 and 29 years of age.

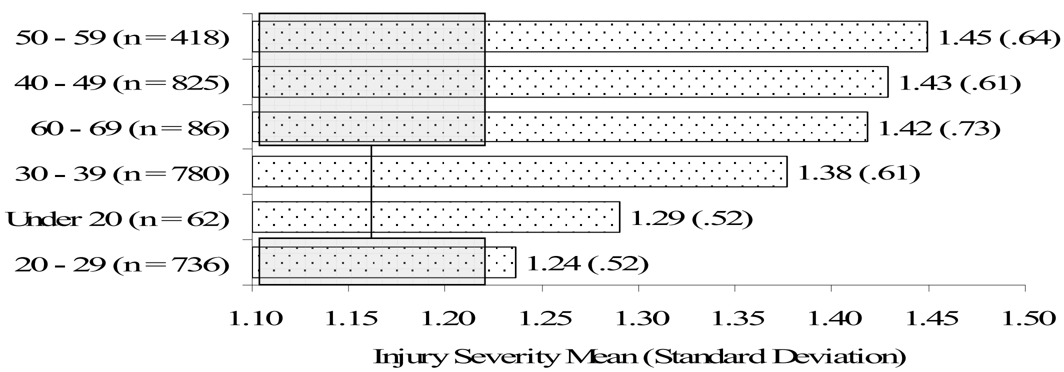

Figure 4- 166. Differences of injury severity means by age of workers with lower extremity injuries.

The mean ages of workers with injuries to the lower extremities were compared by the specific body part impacted by the injury. The results of the Levene test of homogeneity of age variances between the specific body parts of the lower extremities allowed for an assumption of equal variances, L (8, 2,940) = 1.76, $p > 0.07$. Subsequently, the results of the ANOVA test indicated that at least one of body parts of the lower extremities had a significantly different mean age from one of the other body parts, F (8, 2,940) = 11.66, $p < 0.001$. The results of the Tukey's b range test confirmed this test result and enabled ranking the body parts by the worker's respective mean ages (see Figure 4- 167).

Among injuries of to the lower extremities, workers with hip injuries had the highest mean age, $\mu = 41.60$ years. This was followed by workers with knee injuries ($\mu = 39.89$), lower leg ($\mu = 39.70$), great toe ($\mu = 38.90$), toe ($\mu = 38.40$), upper leg ($\mu = 36.82$), multiple injuries ($\mu = 36.58$), ankle ($\mu = 36.10$), and foot injuries ($\mu = 35.58$). As illustrated in Figure 4- 167, the Tukey's b test also identified two homogeneous subsets of body parts of the lower extremities, in which mean ages were not significantly different at $p \leq 0.05$.

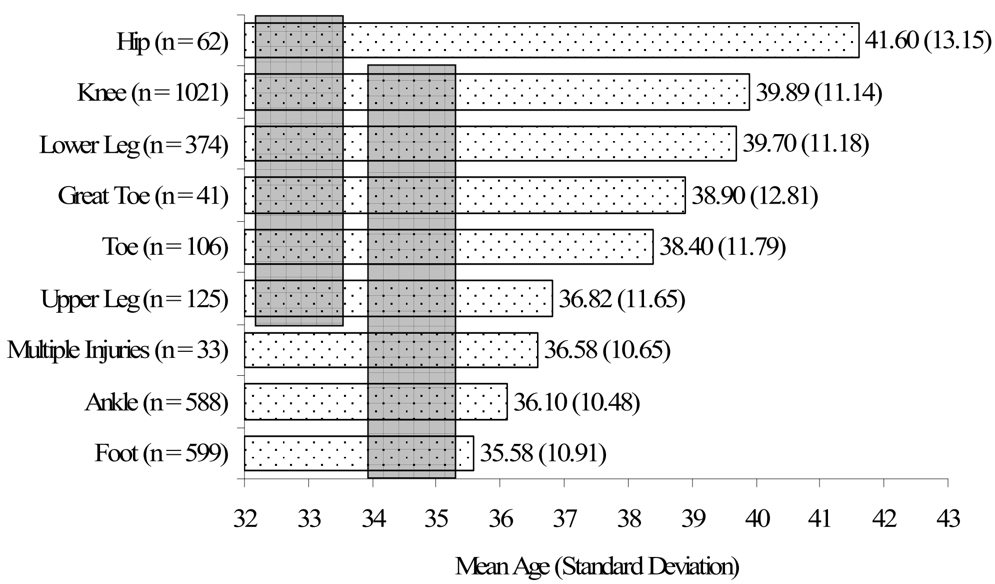

Figure 4- 167. Comparison of mean ages by injured body parts of lower extremity injuries.

From the two homogeneous subsets, it was discerned that among workers with injuries to the lower extremities, those with hip injuries had a significantly greater mean age, at $p \leq 0.05$, than workers experiencing multiple lower extremity injuries, ankle injuries, and foot injuries (see Figure 4- 168).

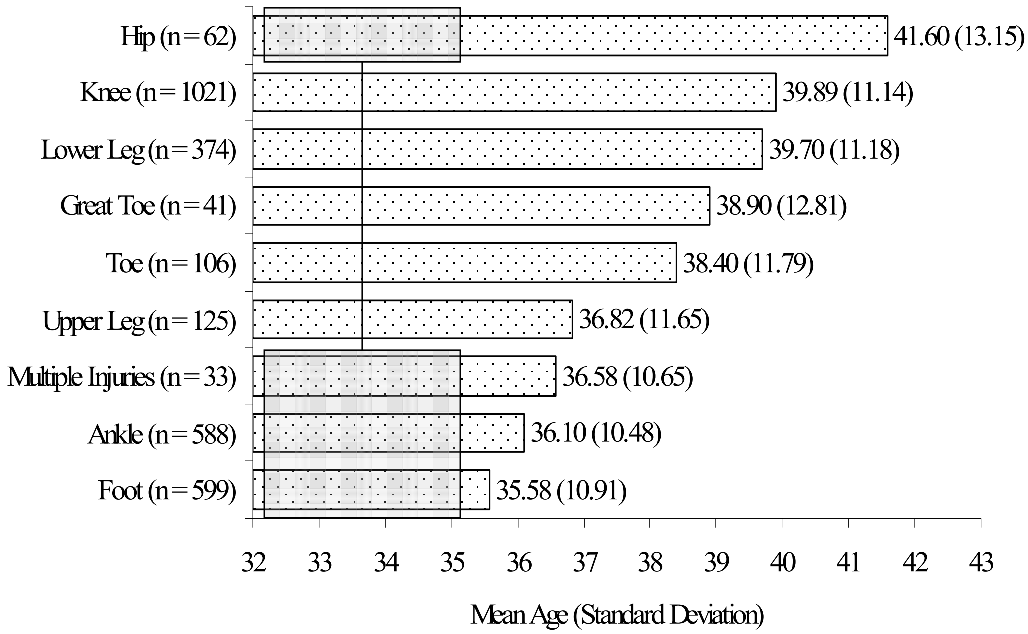

Figure 4- 168. Differences of mean ages by injured body parts of the lower extremities.

Job Tenure

The number of days between the time an injured worker was hired and the time that injured worker sustained an injury to the lower extremities (i.e., job tenure) was explored. Information regarding the frequency of injuries to the lower extremities by the nine job tenure categories, shown in Table 4- 101, was provided for 7,052 worker injuries. Workers who had been employed for 181 to 365 days (n = 1,185) and those employed for 91 to 180 days (n = 1,091) each accounted for around 16% of the injuries to the lower extremities. Nearly 14% of the lower extremities injuries were experienced by workers in their first 15 days of employment (n = 1,974) and 12% were sustained by workers employed 31 to 60 days (n = 1,866). Ten % of the injuries to the lower extremities were among workers employed from 366 to 730 days (n = 729). Workers injured between the 16th and 30th day of employment (n = 672), and those injured between their 61st and 90th day of employment (n = 637) each made up about 19% of the lower extremity injures. Workers with injuries to the lower extremities who were employed two or more years prior to being injured accounted for just over 13% of the lower extremities injuries.

Table 4- 101. Job tenure of workers with lower extremity injuries.

Job tenure	Number of injuries	%	Cumulative %
181 to 365 days	1,185	16.80%	16.80%
91 to 180 days	1,091	15.47%	32.27%
0 to 15 days	974	13.81%	46.09%
31 to 60 days	866	12.28%	58.37%
366 to 730 days (1 to 2 years)	729	10.34%	68.70%
16 to 30 days	672	9.53%	78.23%
61 to 90 days	637	9.03%	87.27%
731 to 1460 days (2 to 4 years)	460	6.52%	93.79%
> 1461 days (> 4 years)	438	6.21%	100.00%
Total	7,052	100.00%	

Job tenure categories were compared by their respective severity means for injuries to lower extremities. The results of the Levene test of homogeneity of trunk injury severity score variances did not allow for the assumption of equal variances between the nine job tenure categories, L (8, 6,967) = 2.40, $p < 0.02$. Subsequently, the Welch test was performed to test the equality of lower extremities injury severity means between these categories. The results of this test indicated that none of job tenure categories had an injury severity mean that was significantly different from one of the other categories, F (8, 2,526) = 0.83, $p > 0.50$. This result was confirmed by the results the of the Tukey's b range test.

Figure 4- 169 displays the results of the Tukey's b range test. The single homogeneous subset indicates that, at $p \leq 0.05$, none of the job tenure categories had a significantly different lower extremity injury severity mean from any of the other categories. Workers with over two years of employment ($\mu = 1.50$) prior to experiencing an injury to a lower extremity had the highest severity mean for lower extremity injuries than all of the other job tenure categories. This

was followed by workers with more than four years of employment prior to having their injury (μ = 1.48) and workers with one to two years of experience (μ = 1.47). Injured workers employed between 91 and 180 days had the lowest injury severity mean (μ = 1.42) for injuries to the lower extremities.

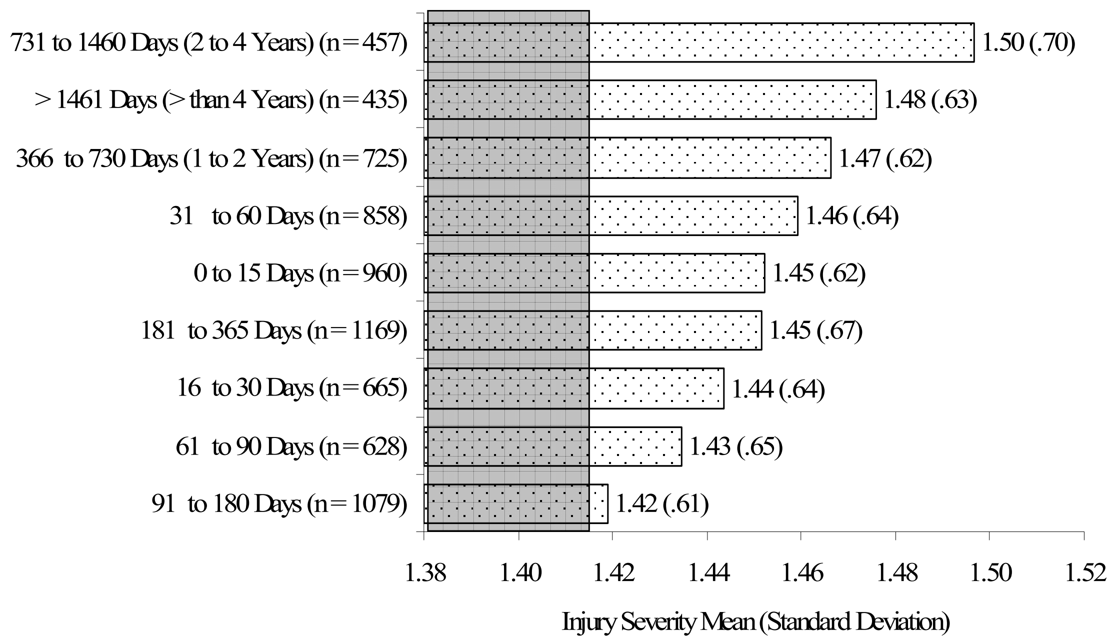

Figure 4- 169. Comparison of injury severity means by job tenure of workers with lower extremity injuries.

Month of Occurrence of Injury

Based on information provided for 9,193 cases the distribution of injuries to the lower extremities was examined by the month of the year during which the injury had occurred. Table 4- 102 shows the distribution of injuries to the lower extremities for each of the twelve months. Each of the months of August (n = 889), October (n = 873), and July (n = 867) accounted for slightly more than 9 % of the lower extremity injuries to workers. June (n = 818), March (n = 779), September (n = 767), and April (n = 746) had slightly more than eight % of the lower extremity injuries. December (n = 694), May (n = 689), November (n = 689), and February (n = 654) were associated with slightly less than 7 % total of the lower extremity injuries to workers.

Injury severity for injuries to the lower extremities by the month of the injury was examined by ranking the months by their respective injury severity means and subsequently comparing the injury severity means between the months to identify possible differences, significant at $p \leq 0.05$. Severity scores, by month of the injury occurrence, were provided for 9,080 worker injuries to the lower extremities. The results of an initial Levene test did not allow

Table 4- 102. Month of occurrence of lower extremity injuries.

Month of injury occurrence	Number of injuries	%	Cumulative %
August	889	9.67%	9.67%
October	873	9.50%	19.17%
July	867	9.43%	28.60%
June	818	8.90%	37.50%
March	779	8.47%	45.97%
September	767	8.34%	54.31%
April	746	8.11%	62.43%
January	728	7.92%	70.35%
December	694	7.55%	77.90%
May	689	7.49%	85.39%
November	689	7.49%	92.89%
February	654	7.11%	100.00%
Total	9,193	100.00%	

for an assumption of equal injury severity score variances between the twelve months, L (11, 9,068) = 2.69 $p < 0.003$. The results of the subsequent Welch test indicated that none of the months had a significantly different lower extremities injury severity mean of any of the other months, F (11, 3,529.01) = 1.71, $p > 0.06$. The results of the Tukey's b range test were used to rank the months of occurrence lower extremity injuries severity means, (see Figure 4- 170). Injuries to the lower extremities which occurred in February ($\mu = 1.46$), November ($\mu = 1.43$), and June ($\mu = 1.43$) had the highest severity means. These were followed by the months of August ($\mu = 1.41$), January ($\mu = 1.40$), December ($\mu = 1.39$), July ($\mu = 1.39$), October ($\mu = 1.38$), March ($\mu = 1.38$), April ($\mu = 1.38$), and May ($\mu = 1.38$), and September ($\mu = 1.36$).

Day of the Week of Occurrence of Injury

The possible relationship between injuries to the lower extremities and the day of the week on which these injuries occurred was explored. Injury frequency data for lower extremity injuries

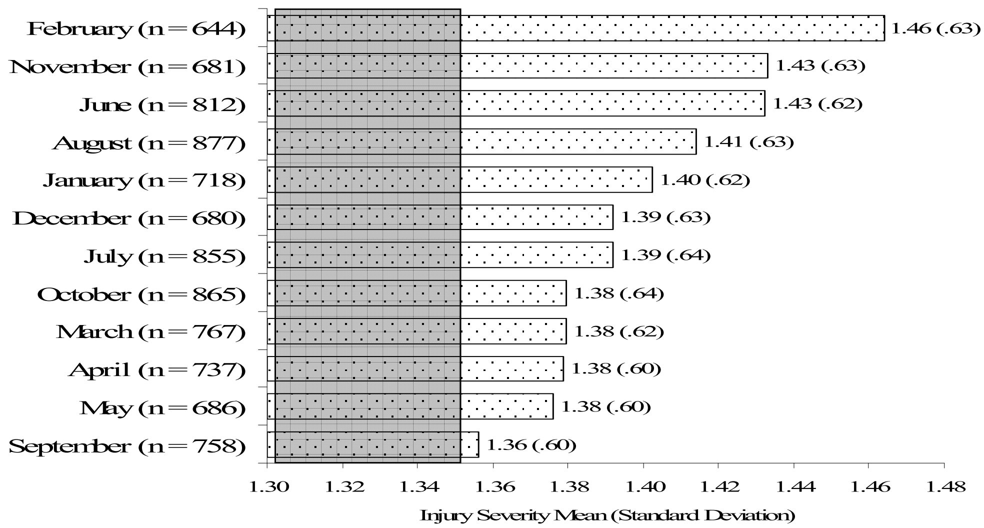

Figure 4- 170. Comparison of injury severity means by month of occurrence of lower extremity injuries.

by each day of the week is displayed in Table 4- 103. About 19% of the lower extremity injuries occurred either on a Wednesday (n = 1,805), Tuesday (n = 1,772), Monday (n = 1,723), or Thursday (n = 1,703). Around 16% of the lower extremities injuries occurred on a Friday (n = 1,496). Slightly more than seven % of lower extremity injuries occurred during the weekend, namely on Saturdays (n = 540) and Sundays (n = 154).

Table 4- 103. Day of the week of occurrence of lower extremity injuries.

Day of the week of occurrence	Number of injuries	%	Cumulative %
Wednesday	1,805	19.63%	19.63%
Tuesday	1,772	19.28%	38.91%
Monday	1,723	18.74%	57.65%
Thursday	1,703	18.52%	76.18%
Friday	1,496	16.27%	92.45%
Saturday	540	5.87%	98.32%
Sunday	154	1.68%	100.00%
Total	9,193	100.00%	

Injury severity for injuries to the lower extremities by the day of the week on which the injury occurred was examined by ranking the days of the week by their respective injury severity means and subsequently comparing the lower extremity injury severity means between the days to identify possible differences, significant at $p \leq 0.05$. Severity scores, by day of the injury, were provided for 9,080 worker injuries to the lower extremities. The results of an initial Levene test did not allow for an assumption of equal lower extremity injury score variances between the seven days of the week, L (6, 9,073) = 4.24, $p < 0.001$. The results of the subsequent Welch test indicated that none of the days of the week had a significantly different lower injury severity mean of any of the other days of the week, F (6, 1,588.75) = 1.69, $p > 0.10$.

The results of the Tukey's b range test were used to rank the days of the week of occurrence of lower extremity injuries severity means, (see Figure 4- 171). Injuries to the lower extremities occurring on Sundays (μ = 1.49) showed the highest injury severity mean among days on the week on which lower extremities injuries occurred. This was followed by injuries experienced on Saturdays (μ = 1.46), Mondays (μ = 1.41), Thursdays (μ = 1.40), Fridays (μ = 1.39), Wednesdays (μ = 1.39), Tuesdays (μ = 1.38).

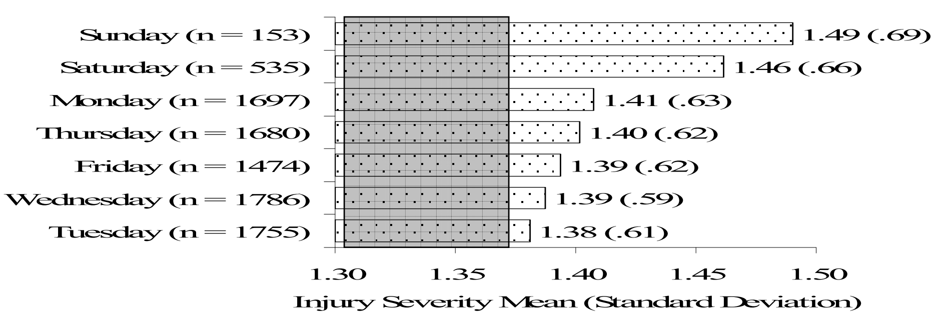

Figure 4- 171. Comparison of injury severity means by day of the week of occurrence of lower extremity injuries.

Multiple Body Regions or Body Systems

Injury severity to multiple body regions or body systems (MBRBS) was examined by the specific body part injured (e.g., knee), the nature of the injury (e.g., laceration), the general cause of the injury (e.g., fall or slip), the occupational work area in which the injured worker was working at the time of the injury (e.g., carpentry), the injured workers' occupational experience level (e.g., apprentice), the job tenure of the injured worker at the time of the injury, the month of the year and day of the week on which the injury occurred, and the age of the injured worker at the time of the injury. A comparison of mean ages by specific body parts injured was also performed.

Body Part

Information regarding the specific injured body parts involving MBRBS injuries was provided for 1,699 worker injuries. As Table 4- 104 shows, injuries to multiple body parts constituted over 91% (n = 1,557) of the MBRBS injuries. The remaining injuries were associated with one or more body systems, such as respiratory system and circulatory system, skeletal and nervous systems.

Table 4- 104. Injured body parts of MBRBS injuries.

Body part	Number of injuries	%	Cumulative %
Multiple body regions	1,557	91.64%	91.64%
Body systems	142	8.36%	100.00%
Total	1,699	100.00%	

Injury severity scores were provided for 1,687 worker injuries to MBRBS. Injuries to multiple body parts had a higher injury severity mean ($\mu = 1.60$) than injuries associated with body systems (see Figure 4- 172). The results from an independent t-test for quality means show that this difference was not statistically significant, t (1,685) = 0.08, $p > 0.90$.

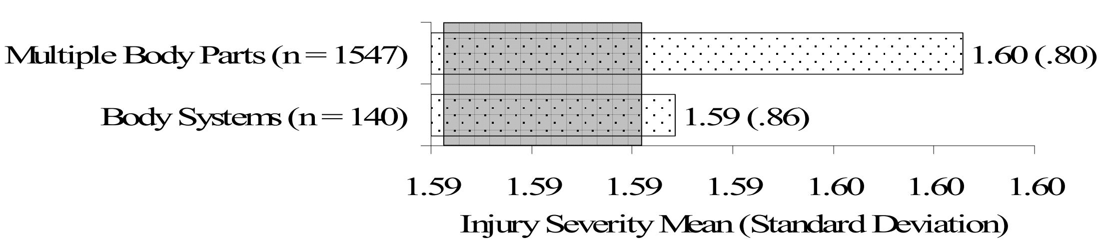

Figure 4- 2. Comparison of injury severity means by injured body parts of MBRBS injuries.

Nature of Injury

Information regarding the MBRBS injuries by the nature of the injury was provided for 1,526 worker injuries (see Table 4- 105). The top ten nature of injury categories accounted for 86% of the MBRBS injuries. These included multiple injuries (n = 488), strains (n = 234), contusions (n = 220), heat prostration (n = 73), electric shock (n = 55), burns (n = 52), dermatitis (n = 50), occupational disease NOC (n = 50), inflammations (n = 48), and fractures (n = 46). Table 4- 105 shows the distribution of the MBRBS injuries by nature of injury.

Injury severity scores were provided for 1,514 workers with MBRBS injuries for 24 nature of injury categories. Injury severity means were compared for each of these categories. The

Table 4- 105. Nature of injury to multiple body regions and body systems.

Nature of injury	Number of injuries	%	Cumulative %
Multiple injuries	488	31.98%	31.98%
Strain	234	15.33%	47.31%
Contusion	220	14.42%	61.73%
Heat prostration	73	4.78%	66.51%
Electric shock	55	3.60%	70.12%
Burn	52	3.41%	73.53%
Dermatitis	50	3.28%	76.80%
Occupational disease NOC	50	3.28%	80.08%
Inflammation	48	3.15%	83.22%
Fracture	46	3.01%	86.24%
Laceration	38	2.49%	88.73%
Sprain	26	1.70%	90.43%
Chemical poisoning	22	1.44%	91.87%
Respiratory disorder	18	1.18%	93.05%
Mental stress/disorder	18	1.18%	94.23%
Poisoning NOC	17	1.11%	95.35%
Puncture	17	1.11%	96.46%
Syncope	16	1.05%	97.51%
Crushing	11	0.72%	98.23%
Infection	10	0.66%	98.89%
Rupture	10	0.66%	99.54%
Severance	3	0.20%	99.74%
Dislocation	2	0.13%	99.87%
Asphyxiation	2	0.13%	100.00%
Total	1,526	100.00%	

results from the Leven test of homogeneity of variances of severity scores between the nature of injury categories did not allow for an assumption of equal variances of scores between the categories , L (23, 1,490) = 6.52, $p < 0.001$. The results from the subsequent Welch test of equality of injury severity means indicated that at least one of the nature of MBRBS injury categories had a significantly different injury severity mean than one of the other categories, F (23, 56.88) = 14.16, $p < 0.001$. This was confirmed by the results from the Tukey's b range test which identified five homogeneous subsets of injury severity means among the 24 nature of MBRBS categories. Injury severity means between the nature of injury categories within each subset did not significantly differ from one another at $p \leq 0.05$. From the arrangement of the subsets, the following four relationships were discerned (see Table 4- 105 for the listing of all the nature of injury categories associated with MBRBS injuries):

- Crushing, as a nature of MBRBS injuries, had the highest injury severity mean ($\mu = 3.64$, $\sigma = 1.63$). Crushing injuries had a significantly greater injury severity mean, at $p \leq 0.05$, than the remaining nature of injury categories, except ruptures.

- Ruptures ($\mu = 2.80$, $\sigma = 0.42$) had a significantly greater MBRBS injury severity mean, at $p \leq 0.05$, than strains, contusions, heat prostration, electric shocks, dermatitis, occupational disease NOC, inflammations, lacerations, sprains, chemical poisonings, respiratory disorders, general poisonings, punctures, syncope, and infections.

- Dislocations ($\mu = 2.50$, $\sigma = 0.71$) had a significantly greater injury severity mean, at $p \leq 0.05$, than the following nature of MBRBS injuries: punctures, syncope, heat prostrations, infections, inflammations, general poisonings, and dermatitis.

- Severances ($\mu = 2.33$, $\sigma = 0.58$) showed a greater MBRBS injury severity mean, at $p \leq 0.05$, than inflammation, general poisoning, and dermatitis.

General Cause of Injury

From information provided for 2,246 worker injuries, the multiple body regions and body systems (MBRBS) injury distribution by general cause of injury categories was generated and ranked in descending order of frequency (see Table 4- 106). Nearly 30% of the MBRBS injuries were caused by a slip or fall (n = 664). Strains were attributed as the cause of injury for 20% (n = 457) of the MBRBS injuries. Around 16% of the workers with MBRBS injuries had sustained these injuries by the absorption, ingestion, or inhalation of a substance (n = 348). Ten % of the MBRBS injuries were caused by the workers being struck by an object (n = 229). Around 6% were caused by burns (n = 142). Five % were caused when the workers struck against or stepped on an object (n = 115), followed by involvement with a motor vehicle (4.59%, n = 103), and animal bite or insect sting (3.16%, n = 71).The remaining 5% of the MBRBS injuries were caused by a combination of having been Caught in or between an object or objects (n = 49), cut, punctured, or scraped (n = 47), and foreign matter (n = 21).

Table 4- 106. General cause of multiple body region or body systems (MBRBS) injuries.

General cause of injury	Number of injuries	%	Cumulative %
Fall or slip	664	29.56%	29.56%
Strain	457	20.35%	49.91%
Absorption, ingestion, or inhalation	348	15.49%	65.41%
Struck by	229	10.20%	75.60%
Burn	142	6.32%	81.92%
Striling against or stepping on	115	5.12%	87.04%
Motor vehicle	103	4.59%	91.63%
Animal or insect bite or sting	71	3.16%	94.79%
Caught in or between	49	2.18%	96.97%
Cut, puncture, or scrape	47	2.09%	99.07%
Foreign Matter	21	0.93%	100.00%
Total	2,246	100.00%	

Injury severity scores relative to the eleven general cause of injury categories were provided for 2,210 workers with MBRBS injuries. Injury severity means were compared for each of these categories. The results from the Leven test of homogeneity of variances of severity scores between the general cause of injury categories did not allow for an assumption of equal variances of scores between the categories , L (10, 2,199) = 12.07, $p < 0.001$. The results from the subsequent Welch test of equality of injury severity means indicated that at least one of the general cause of MBRBS injury categories had a significantly different injury severity mean than one of the other categories, F (10, 301.19) = 12.34, $p < 0.001$. This was confirmed by the results from the Tukey's b range test which identified three homogeneous subsets of injury severity means among the eleven general cause of MBRBS injury categories. Injury severity means between the general cause of injury categories within each subset did not significantly differ from one another, at $p \leq 0.05$. From the arrangement of the subsets, the following two relationships were discerned (see Table 4- 106 for the listing of all the general cause of injury categories associated with MBRBS injuries):

- MBRBS injuries caused by being Caught in or between an object or objects (μ = 1.51, σ = 1.20), a fall or slip (μ = 1.68, σ =0.86), being struck by an object (μ = 1.68, σ = 0.95), and by involvement with a motor vehicle (μ = 1.62, σ = 0.78), demostrated injury severity means significantly greater, at $p \leq 0.05$, than MBRBS injuries caused by cuts, punctures, or scrapes (μ = 1.20, σ = 0.40), an animal bite or insect sting (μ = 1.18, σ = 0.62), and foreign matter (μ = 1.14, σ = 0.48).

- Injuries caused by having been Caught in or between an object or objects also had a significantly greater MBRBS injury severity mean, at $p \leq 0.05$, than that of injuries caused by having struck against or stepped on an object (μ= 1.41, σ = 0.63), and from the absorption, ingestion, or inhalation of a substance (μ = 1.31, σ = 0.68).

Occupational Work Area

The occupational work area categories identified the specific work area in which each injured worker was involved at the time of the MBRBS injury. Table 4- 107 displays the distribution the 2,307 MBRBS injuries among 41 occupational work areas. Almost 75% of the MBRBS injuries were associated with workers working in the following ten occupational areas at the time of injury: electrical (n = 386), carpentry (n = 293), iron and steel work (n = 238), technical repair or maintenance (n = 151), concrete work (n = 146), masonry (n = 121), plumbing

Table 4- 107. Occupational work areas of workers with multiple body regions or body systems (MBRBS) injuries.

Occupational work area	Number of injuries	%	Cumulative %
Electrical	386	16.73%	16.73%
Carpentry	293	12.70%	29.43%
Iron/steel	238	10.32%	39.75%
Technical repair or maintenance	151	6.55%	46.29%
Concrete	146	6.33%	52.62%
Masonry	121	5.24%	57.87%
Plumbing	110	4.77%	62.64%
Equipment/machinery operation	103	4.46%	67.10%
Pipe fitting	93	4.03%	71.13%
Drywall	83	3.60%	74.73%
Sheet metal	63	2.73%	77.46%
Painting and plastering	61	2.64%	80.10%
Boilermaker	56	2.43%	82.53%
Welding	40	1.73%	84.27%
Supervising	37	1.60%	85.87%
Driving	34	1.47%	87.34%
Insulating	31	1.34%	88.69%
Lineman	28	1.21%	89.90%
Managing	26	1.13%	91.03%
Millwright	25	1.08%	92.11%
Roofing	19	0.82%	92.93%
Clerical	18	0.78%	93.71%
Inspecting	17	0.74%	94.45%
Steam fitting	14	0.61%	95.06%
Security	13	0.56%	95.62%
Glazing	12	0.52%	96.14%
Engineering	12	0.52%	96.66%
Conveyor systems	10	0.43%	97.10%
Sprinkler fitting	10	0.43%	97.53%
HVAC/refrigeration	10	0.43%	97.96%
Flooring, tile, carpeting	8	0.35%	98.31%
Scaffold erection	7	0.30%	98.61%
Flagging	6	0.26%	98.87%
Lathing	5	0.22%	99.09%
Landscaping	4	0.17%	99.26%
Hod carrying	4	0.17%	99.44%
Waterproofing	4	0.17%	99.61%
Surveying	3	0.13%	99.74%
Rigging	2	0.09%	99.83%
Material handling	2	0.09%	99.91%
Field engineering	2	0.09%	100.00%
Total	2,307	100.00%	

(n = 110), equipment or machinery operations (n = 93), pipe fitting (n = 83), and drywall work (n = 63). See Table 4-107 for all the occupational work areas associated with MBRBS injuries.

Injury severity scores, by the occupational work areas associated with the MBRBS injuries, were provided for 2,285 worker injuries. Based on this information, injury severity means were generated for and compared between the 41 occupational work areas. The results of the Levene test of homogeneity of injury severity score variances between the 42 occupational areas did not allow for the assumption of equal variances, L (40, 2,244) = 3.02, $p < 0.001$. The results of the Welch test of equality of results suggested that at least one of the work areas could have had an injury severity mean for MBRBS injuries that was significantly different than one of the other work areas, F (40, 87.10) = 1.87, $p < 0.01$. However, this was not confirmed by the results of the Tukey's b range test.

The single homogeneous subset of injury severity means resulting from the Tukey's b range test indicated that none of the work areas had a MBRBS severity mean that was significantly different, at $p \leq 0.05$, from any of the other work areas. The occupational work areas associated with the ten highest severity means for MBRBS injuries were as follows: hod carrying ($\mu = 1.75$, $\sigma = 0.50$), roofing ($\mu = 1.63$, $\sigma = 0.68$), carpentry ($\mu = 1.63$, $\sigma = 0.85$), working with or as a lineman ($\mu = 1.59$, $\sigma = 0.93$), engineering ($\mu = 1.58$, $\sigma = 1.16$), glazing ($\mu = 1.58$, $\sigma = 1.16$), steam fitting ($\mu = 1.57$, $\sigma = 1.09$), driving ($\mu = 1.56$, $\sigma = 1.05$), equipment or machinery operation ($\mu = 1.55$, $\sigma = 0.89$), and iron and steel work ($\mu = 1.55$, $\sigma = 0.81$).

Occupational Experience Level

Multiple body regions and body systems injury information regarding the workers' occupational experience was provided for 3,168 worker injuries. As Table 4- 108 shows, laborers had over 56% (n = 1.783) of the MBRBS injuries. Foreman level workers (n = 337), apprentices (n = 299), and journeyman level workers (n = 272), sustained over 28% of the MBRBS injuries.

Field supervisors represented around five % (n = 163) of the workers with MBRBS injuries. Workers at the helper or assistant level (n = 138), administrative (n = 105), and professional (n = 71) experience levels represented about 10% of the workers with MBRBS injuries.

Injury severity means were compared among the eight occupational experience levels for MBRBS injuries. Injury severity scores by experience level were provided for 877 workers with MBRBS injuries. The results of the Levene test of homogeneity of injury severity score variances for the eight experience levels allowed for an assumption of equal variances, L (7,7, 869) = 0.47, $p > 0.85$. The results of the subsequent ANOVA test indicated that none of the experience levels had a significantly different severity mean from another level, F (7, 869) = 5.76, $p > 1.48$. This was confirmed by the results of the Tukey's b range test.

Table 4- 108. Occupational experience level of workers with injuries to multiple body regions and body systems.

Occupational experience level	Number of injuries	%	Cumulative %
Laborer	539	60.36%	60.36%
Foreman	78	8.73%	69.09%
Journeyman	59	6.61%	75.70%
Apprentice	56	6.27%	81.97%
Helper/assistant	48	5.38%	87.35%
Administrator	44	4.93%	92.27%
Field supervisor	39	4.37%	96.64%
Professional	30	3.36%	100.00%
Total	893	100.00%	

The single homogeneous subset of injury severity means resulting from the Tukey's b range test indicated that none of the experience levels had an MBRBS severity mean that was significantly different, at $p \leq 0.05$, than any of the other experience levels. Journeymen (μ = 1079, σ = 0.83) were associated with the highest severity means for MBRBS injuries. This was followed by apprentices (μ = 1.58, σ = 0.76), professionals (μ = 1.53, σ = 0.82), laborers (μ = 1.51, σ = 0.70), helpers and assistants (μ = 1.50, σ = 0.78), field supervisors (μ = 1.49, σ = 0.60), foremen (μ = 1.44, σ = 0.83), and administrative personnel (μ = 1.41, σ = 0.76).

Age

The relationship between age and injuries to MBRBS was explored in two ways. First, workers with MBRBS injuries were compared by their respective age groups. With the exception of the under 20 and over 69 age groups, each of the age groups represented ten-year spans. Injury frequencies were compared between the age groups. Second, MBRBS injury severity means were compared between the age groups.

Data for MBRBS injuries by worker age were provided for 1,137 worker injuries (see Table 4- 109). Almost 29% (n = 333) of the MBRBS injuries were sustained by workers between 30 and 39 years of age. Twenty-six % (n = 297) of the injuries were to workers 40 to 49 years old. Nearly 25% (n = 162) of the MBRBS injuries occurred to workers 50 to 59 years old. Workers aged 60 to 69 years sustained around 4% (n = 42) of the MBRBS injuries. Workers under 20 years old (n = 20) experienced just under 2 % of the MBRBS injuries.

Table 4- 109. Age of workers with MBRBS injuries.

Age (years)	Number of injuries	%	Cumulative %
30 - 39	333	29.29%	29.29%
40 -49	297	26.12%	55.41%
20 - 29	283	24.89%	80.30%
50 - 59	162	14.25%	94.55%
60 - 69	42	3.69%	98.24%
Under 20	20	1.76%	100.00%
Total	1,137	100.00%	

Multiple body region and body systems injury severity means were compared among the six age groups. Injury severity scores were provided for 1,123 workers with MBRBS injuries. The results of the Levene test of homogeneity of injury severity score variances for the six age groups did not allow for an assumption of equal variances, L (5, 1,117) = 13.12, $p < 0.001$. The results of the subsequent Welch test of equality of MBRBS injury severity means indicated that at least one age group was significantly different from another group, F (5, 156.97) = 10.78, $p <$

0.001. This was confirmed by the results of the Tukey's b range test. Three homogeneous subsets of age groups by MBRBS injury severity means were identified by the Tukey's b range test. From the arrangement of these subsets the following was discerned:

- Workers between 60 and 69 years old had a significantly larger injury severity mean ($\mu = 1.88$, $\sigma = 1.02$), at $p \leq 0.05$, for MBRBS injuries than each of the remaining age groups.

- Workers 40 to 49 ($\mu = 1.38$, $\sigma = 0.74$) and 50 to 59 ($\mu = 1.45$, $\sigma = 0.69$) years old were associated with MBRBS injury severity means significantly greater, at $p \leq 0.05$, than MBRBS injuries to workers under 20 years old ($\mu = 1.05$, $\sigma = 0.22$).

The results from Kendall's tau b test for correlation between age and MBRBS injury severity means showed that age had a slight, though significant, positive correlation with the injury severity mean of MBRBS injuries, r (1,135), $p < 0.01$.

The mean ages of workers with MBRBS injuries were compared between the two body parts associated with multiple body parts or body systems injuries using the independent t-test. The results from this test did not indicate a significant mean age difference between multiple body parts ($\mu = 41.50$ years, $\sigma = 11.62$) and body systems ($\mu = 40.77$ years, $\sigma = 10.83$), t (266) = 0.40, $p > 0.60$.

Job Tenure

The number of days between the time an injured worker was hired and the time that injured worker sustained a MBRBS injury was explored. Information regarding the frequency of injuries to MBRBS by the nine job tenure categories, shown in Table 110, was provided for 2,259 worker injuries. Workers who had been employed for 91 to 365 days (n = 687) accounted for 30% of the MBRBS injuries. Nearly 14% of the MBRBS injuries were sustained by workers in their first 15 days of employment (n = 309) and 13% were sustained by workers employed 31 to 60 days (n = 291). Ten % of the MBRBS injuries were among workers employed from 366 to

730 days (n = 237). Workers injured between the 16th and 30th day of employment (n = 222) and those injured between their 61st and 90th day of employment (n = 209) comprised about 9% of the MBRBS injures. Workers with MBRBS injuries who were employed two or more years prior to being injured accounted for 13% of the MBRBS injuries.

Job tenure categories were compared by their respective severity means for MBRBS injuries. The results of the Levene test of homogeneity of MBRBS injury severity score variances allowed for the assumption of equal variances between the nine job tenure categories, L (8, 2,217) = 1.90, $p > 0.05$. Subsequently, the ANOVA test was performed to test the equality of MBRBS injury severity means between these categories. The results of this test indicated that none of the job tenure categories had an injury severity mean that was significantly different from any of the other categories, F (8, 2,217) = 4.13, $p > 0.54$. This result was confirmed by the results the of the Tukey's b range test.

Table 4- 110. Job tenure of workers with MBRBS injuries.

Job tenure	Number of injuries	%	Cumulative %
91 to 180 days	355	15.71%	15.71%
181 to 365 days	332	14.70%	30.41%
0 to 15 days	309	13.68%	44.09%
31 to 60 days	291	12.88%	56.97%
366 to 730 days (1 to 2 years)	237	10.49%	67.46%
16 to 30 days	222	9.83%	77.29%
61 to 90 days	209	9.25%	86.54%
731 to 1460 days (2 to 4 years)	157	6.95%	93.49%
> 1461 days (Greater than 4 years)	147	6.51%	100.00%
Total	2,259	100.00%	

Month of Occurrence of Injury

Based on information provided for 3,433 cases the distribution of MBRBS injuries was examined by the month of the year during which the injuries had occurred. Table 4- 111 shows the distribution of the MBRBS injuries for each of the twelve months. The highest frequency of injuries occurred in the summer months of July (n = 401), August (n = 385), September (n=

318), and June (n = 304), accounted for 41% of the MBRBS injuries. At nearly 7% of the MBRBS injuries each, the months of January (n = 240), November (n = 239), April (n = 235), and December (n = 223) had the lowest frequency of MBRBS injuries.

Injury severity for MBRBS injuries by month of injury occurrence was examined by ranking the months by their respective injury severity means and subsequently comparing the injury severity means between the months to identify possible differences, significant at $p \leq 0.05$. Severity scores, by month of injury occurrence, were provided for 3,433 worker MBRBS injuries. The results of an initial Levene test did not allow for an assumption of equal injury severity score variances between the twelve months, L (11, 3,361) = 3.06 $p < 0.001$. The results of the subsequent Welch test indicated that at least one of the months had a significantly different MBRBS injury severity mean from one of the other months, F (11, 1,266.05) = 1.84, $p < 0.05$ This was not confirmed by the results from the Tukey's b range test. MBRBS injuries which occurred in April (μ = 1.60, σ = 0.87), January (μ = 1.55, σ = 0.85), and October (μ = 1.54, σ =0.79), had the highest injury severity means.

Table 4- 111. Month of occurrence of MBRBS injuries.

Month of injury occurrence	Number of injuries	%	Cumulative %
July	401	11.68%	11.68%
August	385	11.21%	22.90%
September	318	9.26%	32.16%
June	304	8.86%	41.01%
October	296	8.62%	49.64%
May	282	8.21%	57.85%
March	267	7.78%	65.63%
February	243	7.08%	72.71%
January	240	6.99%	79.70%
November	239	6.96%	86.66%
April	235	6.85%	93.50%
December	223	6.50%	100.00%
Total	3,433	100.00%	

However, these were included with the remaining nine months in a single homogenous subset of injury severity means. This indicated that none of the months of occurrence of MBRBS injuries had a significantly different severity mean, at $p \leq 0.05$, from any of the other months.

Day of the Week of Occurrence of Injury

The possible relationship between MBRBS injuries and the day of the week on which these injuries occurred was explored. Injury frequency data for MBRBS injuries by each day of the week is displayed in Table 4- 112. About 19% of the MBRBS injuries occurred on a Monday (n = 671) or Thursday (n = 642). Around 18% occurred on a Tuesday (n = 626), Wednesday (n = 616), or Friday (n = 600). Slightly more than eight % of MBRBS injuries occurred during the weekend, namely on Saturdays (n = 216) and Sundays (n = 62).

Table 4- 112. Day of the week of occurrence of multiple body regions or body systems injuries.

Day of the week of occrrence	Number of injuries	%	Cumulative %
Monday	671	19.55%	19.55%
Thursday	642	18.70%	38.25%
Tuesday	626	18.23%	56.48%
Wednesday	616	17.94%	74.42%
Friday	600	17.48%	91.90%
Saturday	216	6.29%	98.19%
Sunday	62	1.81%	100.00%
Total	3,433	100.00%	

Injury severity for MBRBS by the day of the week on which the MBRBS injury occurred was examined by ranking the days of the week by their respective injury severity means and subsequently comparing MBRBS injury severity means between the days to identify possible differences, significant at $p \leq 0.05$. Severity scores, by day of the injury, were provided for 3,373 worker MBRBS injuries. The results of an initial Levene allowed for an assumption of equal MBRBS injury score variances between the seven days of the week, L (6, 3,366) = 1.30, $p >$ 0.25. The results of the subsequent ANOVA test indicated that none of the days of the week had a significantly different MBRBS injury severity mean from any of the other days of the week, F (6, 629.60) = 0.90, $p > 0.47$. This was confirmed by the results of the Tukey's b range test. The results of the Tukey's b range test ranked the days of the week of occurrence of MBRBS injuries severity means. MBRBS injuries occurring on Sundays ($\mu = 1.55$) showed the highest injury severity mean among days on the week on which MBRBS injuries occurred. This was followed by MBRBS injuries sustained on Saturdays ($\mu = 1.52$, $\sigma = 0.76$), Fridays ($\mu = 1.41$, $\sigma = 0.79$), Tuesdays ($\mu = 1.47$, $\sigma = 0.76$), Mondays ($\mu = 1.47$, 0.73), Wednesdays ($\mu = 1.45$, $\sigma = 0.69$), and Thursday ($\mu = 1.43$, 0.71).

CHAPTER 5
CONCLUSIONS

Injury information was obtained from a large private workers' compensation insurance provider for a total of 46,056 injured workers performing work on construction projects between 1992 and 2006. Injury frequencies from the data in my study were compared with US Bureau of Labor Statistics data for construction injuries from 1992 through 2005 (USDOL-BLS, 2005) and Hinze, Devenport, and Giang (2006). Following these comparisons, the investigator was confident that these data were representative of the U.S. construction industry.

The study's purpose was to demonstrate that data from a large provider of workers' compensation insurance could generate insights about the relative frequency and severity of various occupational injuries and diseases sustained in construction. The study examined data relative to worker experience levels, age, gender, job tenure, year, month, and day of the week of occurrence. The histogram of the distribution of all the injuries by severity score was examined and injury severity means ≤ 1.10 were determined to represent low severity injuries, while injury severity means ≥ 1.35 were determined to be of high severity. Severity means between 1.1 and 1.35 were considered to be of medium level of severity.

Injured workers were generally young, averaging 37 years. Injured laborers, apprentices, and helpers or assistants, tended to be younger than injured foremen, administrative personnel, field supervisors, and professionals. Age of the injured worker had a strong effect on the severity of sustained injuries. Even though workers over 69 were rarely injured, their injuries tended to be more severe than those sustained by younger workers. There was a trend of increasing injury severity with increasing age.

Workers employed less than 30 days (new hires) had a disproportionately higher daily rate of injury than workers employed beyond the conventional 30 day orientation and training period (non-new hires). There was a distinct downward trend of the daily injury rate as the job tenure of workers increased. Overall job tenure had no affect on the severity of the sustained injury.

Among all the injuries, a disproportionate number of workers were injured while working in carpentry, electrical work, iron and steel work, technical repair and maintenance, concrete work, pipe fitting, plumbing, equipment and machinery operation, and sheet metal work. The occupational work area of the injured worker had no affect on the severity of the sustained injury.

Between 2001 and 2006 there was a distinct downward trend in the severity of injuries. There was little difference in distribution of injuries between the months in which the injuries occurred. Slightly fewer injuries occurred during the winter months of November, January, December, and February, than during the warmer months of June, July, and August, when construction work is more intense. Contrary to Brogmus (2007), no “Monday peak” was discernable. Injuries occurred on Mondays, Tuesdays, Wednesdays, Thursdays, and Fridays with rather even distributions. Fewer injuries occurred on Saturdays or Sundays, when less work is performed; however, injuries occurring on the weekend tended to be more severe than injuries occurring during several of the business days of the week; namely Tuesdays, Thursdays, and Wednesdays. This may be somewhat attributable to less supervision by safety management personnel being conducted on the weekends and an increased disconnect from first aid emergency medical services when the fewer workers on the job site.

This investigation provides clues as to which construction occupational experience levels and occupational work areas generate the highest number of various injuries and occupational diseases and which were at risk for severe injuries (see Table 5- 1). Working as laborers generated the highest number of head, neck, trunk, lower extremity, and upper extremity injuries as well as injuries affecting multiple body regions and body systems. This can best be explained by the fact that laborers make up the largest segment of the labor pool. Generally, occupational experience levels had no effect on the severity of injury sustained by the worker.

Table 5- 1. Most and least severely injured workers by occupational experience level from injuries to the general body regions.

General Body Region (n, μ[1])		Experience Level (n)	% of Injuries to Body Region	Severity Mean[2] High	Med	Low
Head (n = 1976, μ = 1.13)	Most Severe	Field supervisors (n = 76)	3.85%		1.32	
		Laborers (n = 1034)	52.33%		1.13	
	Least Severe	Apprentices (n = 258)	13.06%		1.11	
		Helpers/assistants (n = 140)	7.09%		1.10	
		Journeymen (n = 185)	9.36%			1.09
Neck (n = 302, μ = 1.48)	Most Severe	Professional (n = 8)	2.65%	1.63		
		Administrative (n = 7)	2.32%	1.57		
		Laborers (n = 157)	51.99%	1.57		
	Least Severe	Apprentices (n = 35)	11.59%	1.37		
		Helpers/assistants (n = 13)	4.31%		1.31	
		Field supervisors (n = 16)	5.30%		1.19	
Trunk (n = 1976, μ = 1.13)	Most Severe	Field supervisors (n = 76)	3.85%		1.32	
		Administrative (n = 68)	3.44%		1.28	
		Laborers (n = 1034)	52.33%		1.13	
	Least Severe	Apprentices (n = 258)	13.06%		1.11	
		Helpers/assistants (n = 140)	7.09%		1.10	
		Journeymen (n = 185)	9.36%			1.09
Upper Extremities (n = 4139, μ = 1.26)	Most Severe	Journeymen (n = 426)	10.29%		1.30	
		Laborers (n = 2215)	53.52%		1.27	
		Foremen (n = 412)	9.95%		1.26	
	Least Severe	Professionals (n = 50)	1.21%		1.18	
		Administrative (n = 106)	2.56%		1.12	
Lower Extremities (n = 3137, μ = 1.39)	Most Severe	Journeymen (n = 271)	8.64%	1.49		
		Foremen (n = 334)	10.65%	1.48		
		Helpers/Assistants (n = 133)	4.24%	1.39		
		Laborers (n = 1768)	56.36%	1.38		
	Least Severe	Professionals (n = 71)	2.26%	1.35		
		Administrative (n = 104)	3.32%		1.20	
Multiple Body Regions or Body Systems (n = 877, μ = 1.52)	Most Severe	Journeymen (n = 58)	6.61%	1.79		
		Apprentices (n = 55)	6.27%	1.58		
		Professional (n = 30)	3.42%	1.53		
		Laborers (n = 530)	60.43%	1.50		
	Least Severe	Foremen (n = 75)	8.55%	1.44		
		Administrative (n = 44)	5.02%	1.41		

[1] μ = Severity Mean, [2] High Severity set at $\mu \geq 1.35$; Low Severity set at $\mu \leq 1.10$

This investigation provided insight as to which particular body regions and body parts were observed to have frequencies of occurrence and which tended to be most severe. With respect to particular body parts, injuries or diseases affecting the heart, spinal cord, pelvis, brain, multiple head, trunk, upper extremities, lower extremities, abdomen, and body systems were the most severe. Injuries to the eyes tended to be the least severe. This degree of severity likely results from vigilance in the industry to the fact that eye injuries occurred very frequently and that medical attention is dedicated to even the most minor injuries.

Among the general body regions, injuries to the neck, trunk, and multiple body regions and body systems, tended to be the more severe injuries (see Table 5- 2). Even though neck and multiple injuries to body regions or body systems are rare, they deserve special attention because of the potential for these injuries to by highly severe. Similarly, trunk injuries tend to be both frequent and highly severe.

Table 5- 2. Most and least severe injuries by body region.

All injuries (n = 45291, $\mu^1 = 1.33$)						
Body region		% of Injuries	Severity Mean²			Mean Age
			High	Medium	Low	
Most Severe	Neck (n = 964)	2.13%	1.48			38.56
	Multiple body region or body systems (n = 3388)	7.48%	1.47			38.22
	Trunk (n = 11490)	25.69%	1.44			38.30
Least Severe	Lower extremities (n = 9083)	20.05%	1.40			38.04
	Upper extremities (n = 12939)	28.57%		1.26		37.00
	Head (n = 7427)	16.40%		1.11		36.68

[1] μ = Severity Mean, [2] High Severity set at $\mu \geq 1.35$; Low Severity set at $\mu \leq 1.10$

As Table 5- 3 shows, injuries to the brain, neck vertebrae, heart, and discs of the neck were among the most severe of all the injuries. Special attention in terms of both prevention and emergency response, should include consideration of all injuries with an injury mean of 1.50 and above (see Table 5- 3).

Crushing injuries to the head and multiple body regions generated the most severe injuries to construction workers (see Table 5- 4). Crushing also generated some of the more sever injuries to the trunk. Rupture injuries were especially severe to the neck, trunk, upper extremities, lower extremities, and injuries impacting multiple body regions or body systems. Ruptures are most likely to occur when an excessive force is exerted on an otherwise healthy disc, knee, elbow, etc. Finally, severance produced highly severe injuries to the neck, trunk, and upper extremities. The high severity of neck injuries, often resulting from ruptures, may be due to the vulnerability of the neck and the lack of personal protective devices designed to protect against neck injuries.

Table 5- 3. Most and least severe injured body parts per body region (also shows mean age).

General Body Region (n, μ[1], Mean Age)		Body Part (n)	% of Body Region	Severity Mean[2] High	Med	Low	Mean Age
Head (n = 7427, μ = 1.11)	Most Severe	Brain (n = 6)	0.49%	2.22			38.50
		Multiple Parts (n = 90)	1.21%	1.64			37.88
	Least Severe	Eyes (n = 4709)	63.35%			1.05	36.51
Neck (n = 964, μ = 1.48)	Most Severe	Vertebrae (n = 29)	3.00%	2.07			27.75
		Disc (n = 187)	18.98%	1.87			40.70
	Least Severe	Soft tissue (n = 630)	0.6579		1.34		38.63
Trunk (n = 11490, μ = 1.44)	Most Severe	Heart (n = 57)	0.52%	2.19			47.44
		Pelvis (n = 33)	0.28%	1.82			39.90
	Least Severe	Sacrum & coccyx (n = 28)	0.24%		1.25		36.27
Upper Extremities (n = 12939, μ = 1.26)	Most Severe	Multiple body parts (n = 259)	1.99%	1.55			43.16
		Wrist & hand (n = 121)	0.93%	1.52			39.88
	Least Severe	Thumb (n = 1293)	9.99%		1.19		35.51
Lower Extremities (n = 9080, μ = 1.40)	Most Severe	Multiple parts (n = 116)	1.28%	1.58			41.60
		Knee (n = 3074)	33.85%	1.51			39.89
		Hip (n = 218)	2.39%	1.44			47.60
	Least Severe	Foot (n = 1820)	20.04%		1.27		35.58
Multiple Body Regions of Body Systems (n = 1684, μ = 1.60)	Most Severe	Multiple body parts (n = 1546)	91.81%	1.60			41.50
	Least Severe	Multiple body system(s) (n = 138)	8.19%	1.59			40.77

[1] μ = Severity Mean, [2] High Severity set at $\mu \geq 1.35$; Low Severity set at $\mu \leq 1.10$

Heart attacks (myocardial infarctions) were the most severe trunk injury. This is likely to be highly associated with the age and health attributes of the injured worker. Silicosis, though rarely identified, generated the second most severe trunk injuries. Similar to asbestosis, the low frequency of silicosis may be due to the potentially long onset period for this occupational disease. Workers may be removed from the contributing occupational environment long before that worker is identified with silicosis. Often associated with repeated motions and exposure to constant vibration, carpal tunnel syndrome tended to be highly severe. This may indicate a lack or ergonomic controls in place. These injuries may be common among workers in masonry, concrete, carpentry, and clerical work.

Although electric shock was associated with some of the more severe trunk injuries, it was also associated with the least severe injuries to the lower extremities. This may reflect the value of the protective footwear often worn by construction workers.

Falling was among the causes of the most severe injuries among all six general body regions. The most severe neck injuries were caused by falling, as were the most severe upper extremity injuries. This reflects a continued lack of regard for the importance of fall arrest systems. Falling was among the most frequent causes of injuries to neck, trunk, upper extremities, and especially of injuries to the lower extremities and multiple body regions and body systems injuries. Both the relatively high frequencies and the associated high severity of injury from falls suggest a delinquency on the part of supervisors to enforce the use of fall protection systems especially at dangerous elevations.Injuries due to falls from ladders or scaffolding resulted in a high degree of severity.

The most severe head injuries and injuries to multiple body regions or body systems were caused by the worker being caught in or between objects. Being caught in between objects was also associated with some of the more severe injuries to the trunk and lower extremities. Being struck by an object was a frequent cause of the more severe injuries to multiple body regions or body systems (MBRBS). Severe MBRBS injuries also tended to be caused by involvement with a motor vehicle. As a cause of injury, motor vehicles caused some of the more severe injuries to the head, upper extremities, and lower extremities. Being burned, though infrequent, was associated with the most severe injuries to the trunk. The high severity may be attributed to the fact that second and third degree burns

Table 5- 4. Most and least severe nature of injures by body part.

General Body Region (n, μ[1])	Nature of Injury (n)		% of Injuries to Body Region	Severity Mean[2]		
				High	Med	Low
Head (n = 6908, μ = 1.10)	Most Severe	Crushing (n = 7)	0.10%	2.86		
		Mental stress/disorder (n = 7)	0.10%	1.86		
		Hearing loss or impairment (n = 53)	0.77%	1.64		
	Least Severe	Poisoning NOC (n = 3)	0.04%			1.00
		Foreign Body (n = 3733)	53.94%			1.03
Neck (n = 868, μ = 1.49)	Most Severe	Rupture (n = 78)	8.85%	2.51		
		Severance (n = 2)	0.22%	2.50		
		Fracture (n = 22)	2.46%	2.41		
	Least Severe	Burn (n = 20)	2.24%			1.05
Trunk (n = 10681, μ = 1.45)	Most Severe	Myocardial infarctions (n = 40)	0.37%	2.60		
		Silicosis (n = 6)	0.06%	2.50		
		Rupture (n = 156)	1.46%	2.37		
		Severance (n = 6)	0.06%	2.33		
		Crushing (n = 13)	0.12%	2.23		
		Electric Shock (n = 14)	0.13%	2.00		
	Least Severe	Chemical Poisoning (n = 65)	0.61%			1.08
		Foreign Body (n = 5)	0.05%			1.00
Upper extremities (n = 12312, μ = 1.26)	Most Severe	Amputation (n = 74)	0.60%	2.24		
		Rupture (n = 42)	0.34%	2.10		
		Severance (n = 48)	0.39%	1.88		
		Carpal tunnel sryndrome (n = 95)	0.77%	1.87		
		Fracture (n = 1095)	8.89%	1.67		
	Least Severe	Foreign Body (n = 73)	0.59%		1.14	
		Puncture (n = 986)	8.01%		1.10	
		Dermatitis (n = 57)	0.46%			1.05
Lower extremities (n = 8515, μ = 1.40)	Most Severe	Amputation (n = 10)	0.12%	2.50		
		Rupture (n = 159)	1.87%	2.37		
		Dislocation (n = 45)	0.53%	2.31		
	Least Severe	Puncture (n = 853)	10.02%		1.13	
		Electric Shock (n = 3)	0.04%			1.00
Multiple body regions or body system(s) (n = 1514, μ = 1.60)	Most Severe	Crushing (n = 11)	0.73%	3.64		
		Rupture (n = 10)	0.66%	2.80		
	Least Severe	Poisoning NOC (n = 16)	1.06%		1.13	
		Dermatitis (n = 50)	3.30%			1.08

[1] μ = Severity Mean, [2] High Severity set at $\mu \geq 1.35$; Low Severity set at $\mu \leq 1.10$

Among all the injuries, there was no apparent affect of the workers occupational work area on the severity of the sustained injury. Based on the scale utilized in Table 5- 1 through Table 5- 5, workers, generally, sustained medium to low severity injuries ($\mu = 1.33$, $\sigma = 0.60$). Workers in landscaping sustained the most severe injuries among all the injuries. Workers involved in technical repair and maintenance, roofing, flooring, tile, and carpeting, working as or with a lineman, driving, hod carrying, painting and plastering, rigging, operating equipment or machinery, security, inspection, masonry, glazing, carpentry, concrete work, , and working as or with a millwright, tended to sustain the most severe injuries. Workers with both high frequency (> 200 injuries) and high severity levels may warrant special attention. A grouping of the most severely injured and least severely injured workers according to their occupational work areas suggests that workers in carpentry, electrical work, concrete work, and driving sustain the many of the more severe injuries to all the body regions (see Table 5- 5).

Among all the injuries, general building materials were disproportionately identified as the object or agent contributing to the injury. Tools, machinery, ladders and scaffolding, changes in surface texture, vehicles, and co-workers, contributed to high numbers of injuries. The most severe injuries involved vehicles, lead containing products, ladder and scaffolds, weighted items, and changes in surface textures. Of these agents, weighted items, and lead had low frequencies of occurrence. Among the building materials, nails, piping, wood, and wire and metal material contributed to the highest number of injuries, but were associated with some of the least severe injuries. Injuries involving powered hand tools tended to be the most severe injuries involving tools. Injuries from contact with an organism (animal, insect, bacteria) rarely occurred, compared with injuries from contact with materials. Animal or insect related injuries also resulted in the least severe injuries. However, among these injuries, it is important to note that injuries associated with bacteria were more severe than injuries involving contact with animals or insects. This may suggest an inattention to hygiene and proper first aid for minor injuries on a construction jobsite.

Table 5- 5. Most and least severe occupational work areas by body region.

General Body Region (n, μ[1])		Occupational work area (n)	% of Injuries to Body Region	Severity Mean[2]		
				High	Med	Low
Head (n = 5958, μ = 1.11)	Most Severe	Security (n = 13)	0.22%	1.38		
		Supervising (n = 76)	1.28%		1.32	
		Managing (n = 32)	0.54%		1.31	
		Roofing (n = 21)	0.35%		1.29	
		Flooring, tile, carpeting (n = 7)	0.12%		1.29	
		Clerical (n = 36)	0.60%		1.25	
		Waterproofing (n = 8)	0.13%		1.25	
		Scaffold erection (n = 18)	0.30%		1.22	
		Rigging (n = 5)	0.08%		1.20	
		Driving (n = 45)	0.76%		1.18	
		Carpentry (n = 924)	15.51%		1.13	
		Concrete (n = 306)	5.14%		1.11	
		Electrical (n = 740)	12.42%		1.10	
	Least Severe	Boilermaker (n = 365)	6.13%			1.08
		Iron/steel (n = 920)	15.44%			1.08
		Welding (n = 279)	4.69%			1.08
		Pipe Fitting (n = 476)	7.99%			1.08
		Sheet metal (n = 251)	4.21%			1.07
		Drywall (n = 50)	0.84%			1.04
		Steam fitting (n = 70)	1.18%			1.03
		Conveyor systems work (n = 13)	0.22%			1.00
Neck (n = 725, μ = 1.49)	Most Severe	Glazing (n = 3)	0.41%	2.00		
		Driving (n = 14)	1.93%	1.79		
	Most Severe	Iron/steel (n = 92)	12.69%	1.76		
		Plumbing (n = 28)	3.86%	1.68		
		Inspecting (n = 8)	1.10%	1.63		
		Millwright (n = 13)	1.79%	1.62		
		Concrete (n = 43)	5.93%	1.53		
		Carpentry (n = 115)	15.86%	1.52		
		Electrical (n = 99)	13.66%	1.41		
	Least Severe	Boilermaker (n = 19)	2.62%		1.21	
		Scaffold erection (n = 5)	0.69%		1.20	
		Supervising (n = 16)	2.21%		1.19	
		Landscaping (n = 3)	0.42%			1.00
Trunk (n = 8701, μ = 1.45)	Most Severe	Flagging (n = 3)	0.03%	2.00		
		Acoustic ceiling work (n = 4)	0.05%	2.00		
		Landscaping (n = 9)	0.10%	1.89		
		Technical Maintenance & Repair (n = 537)	6.17%	1.57		
		Painting & Plastering (n = 151)	1.74%	1.53		
		Masonry (n = 391)	4.49%	1.51		
		Boilermaker Work (n = 212)	2.44%	1.51		

Table 5- 5. Continued

General Body Region (n, μ¹)	Occupational work area (n)		% of Injuries to Body Region	Severity Mean²		
				High	Med	Low
Trunk (n = 8701, μ = 1.45)	Most Severe	Drywall (n = 119)	1.37%	1.50		
		Equipment/machinery operations (n = 383)	4.40%	1.50		
		Carpentry (n = 1553)	17.85%	1.48		
		Iron/steek (n = 1001)	11.50%	1.45		
		Electrical (n = 1343)	15.44%	1.43		
		Pipe Fitting (n = 519)	5.97%	1.41		
		Plumbing (n = 321)	3.69%	1.36		
	Least Severe	Waterproofing (n = 13)	0.15%		1.23	
		Scaffold erection (n = 26)	0.30%		1.23	
		Rigging (n = 8)	0.09%		1.13	
Upper extremities (n = 9874,μ = 1.26)	Most Severe	Rigging (n = 16)	0.16%	1.44		
		Surveying (n = 12)	0.12%	1.42		
		Painting and plastering (n = 126)	1.28%	1.40		
		Hod carrying (n = 5)	0.05%	1.40		
		Driving (n = 70)	0.71%	1.40		
		Millwright work (n = 208)	2.11%	1.38		
		Roofing (n = 81)	0.82%	1.36		
		Technical maintenance and repair (n = 593)	6.01%		1.32	
		Boilermaker Work (n = 223)	2.26%		1.31	
		Equipment/ machinery operations (n = 262)	2.65%		1.31	
		Carpentry (n = 2272)	23.01%		1.27	
		Iron/steel (n = 1115)	11.29%		1.27	
		Pipefitting (n = 460)	4.66%		1.26	
		Plumbing (n = 369)	3.74%		1.22	
		Electrical Work (n = 1658)	16.79%		1.21	
		Sheet Metal Work (n = 427)	4.32%		1.20	
	Least Severe	Clerical (n = 69)	0.70%		1.10	
		Conveyor systems work (n = 23)	0.23%			1.09
		Filed Engineering (n = 12)	0.12%			1.08
		Engineering (n = 20)	0.20%			1.00
		Flagging (n = 2)	0.02%			1.00
		Landscaping (n = 2)	0.02%			1.00
Lower extremities (n = 6871, μ = 1.41)	Most Severe	Conveyor systems work (n = 14)	0.20%	1.79		
		Flagging (n = 3)	0.04%	1.67		
		Material handling (n = 10)	0.15%	1.60		
		Flooring. Tile, Carpeting (n = 30)	0.44%	1.60		
		Lineman Work (n = 54)	0.79%	1.56		
		Technical Maintenance & Repair (n = 447)	6.51%	1.55		
		Rigging (n = 19)	0.28%	1.53		
		Driving (n = 74)	1.08%	1.47		
		Painting & Plastering (n = 110)	1.60%	1.45		
		Glazing (n = 59)	0.86%	1.44		

Table 5- 5. Continued.

General Body Region (n, μ[1])	Occupational work area (n)		% of Injuries to Body Region	Severity Mean[2]		
				High	Med	Low
Lower extremities (n = 6871, μ = 1.41)	Most Severe	Carpentry (n = 1282)	18.66%	1.43		
		Sheet Metal Work (n = 197)	2.87%	1.43		
		Roofing (n = 53)	0.77%	1.42		
		Pipe Fitting (n = 379)	5.52%	1.41		
		Equipment/Machinery Operations (n = 293)	4.26%	1.41		
		Millwright work (n = 134)	1.95%	1.40		
		Drywall (n = 76)	1.11%	1.39		
		Masonry (n = 237)	3.45%	1.39		
		Plumbing (n = 248)	3.61%	1.38		
		Electrical Work (n = 1053)	15.33%	1.38		
	Least Severe	Clerical (n = 64)	0.93%		1.17	
		HVAC/refrigeration (n = 6)	0.09%		1.17	
		Field engineering (n = 8)	0.12%		1.13	
		Surveying (n = 8)	0.12%		1.13	
		Hod carrying (n = 6)	0.09%			1.00
		Acoustic ceiling work (n = 8)	0.12%			1.00
Multiple Body Regions and Body Systems (n = 2285, μ = 1.45)	Most Severe	Hod carrying (n = 4)	0.18%	1.75		
		Roofing (n = 19)	0.83%	1.63		
		Carpentry (n = 289)	12.65%	1.63		
		Lineman Work (n = 27)	1.18%	1.59		
		Engineering (n = 12)	0.53%	1.58		
		Glazing (n = 12)	0.53%	1.58		
		Steam fitting (n = 14)	0.61%	1.57		
		Driving (n = 32)	1.40%	1.56		
		Equipment/Machinery Operations (n = 103)	4.51%	1.55		
		Iron/Steel Work (n = 235)	10.28%	1.55		
		Technical Maintenance and Repair (n = 151)	6.61%	1.54		
	Least Severe	Plumbing (n = 109)	4.77%		1.28	
		Security (n = 13)	0.57%		1.23	
		HVAC/refrigeration (n = 10)	0.44%		1.20	
		Drywall (n = 83)	3.63%		1.17	
		Flagging (n = 6)	0.26%		1.17	

[1] μ = Severity Mean, [2] High Severity set at $\mu \geq 1.35$; Low Severity set at $\mu \leq 1.10$

CHAPTER 6
RECOMMENDATIONS

Because of the constantly changing conditions at construction jobsites, the construction industry is particularly hazardous. Dangers include falls, being struck by falling or swinging objects, and collapse of trenches, temporary structures, and building components. One major component of any injury-control program must be worker training and education. Other elements should include the establishment of company policies for injury prevention, incorporating worker safety considerations into the design and planning of buildings and jobsite throughout the entire life cycle of a built structure, maintaining accurate records of causes of injury, and placing workers in jobs suitable to their physical abilities.

Recommendations for Industry

The prevention of head and neck injuries requires the control of the transfer of destructive energy to reduce jobsite hazards:

- At the source of energy (e.g., securing concrete masonry units (CMU) so they don't fall on workers).
- At the point of transmission of energy (e.g., building overhead barriers so a falling CMU does not strike workers).
- At the worker level (e.g., requiring workers to wear hard hats).

Hearing impairment or loss, though not common, can be easily prevented. Effective hearing conservation programs should identify the following areas where noise levels are hazardous: employ administrative and engineering controls over noise levels; provide effective worker education and training; provide and enforce the use of hearing protectors (inserts, muffs, canal caps); and establish periodic audiometric testing to monitor the effectiveness of the program. Workers frequently do not realize the damaging effects of loud noise, and simply accept it as part of the job. For this reason training programs should include the education of workers about the delicate nature of the hearing mechanism, and the importance of the protecting this mechanism with hearing protection.

The prevention of injuries at the source involves initial safe design of sites, plants, equipment and construction processes. Companies should also implement formal injury prevention programs. The notion that workplace injuries are primarily caused by unsafe behavior on the part of workers may inhibit the construction company and owners from exercising safe design. At the construction sites, falls can be prevented by the proper use of ladders, scaffolding. Ladders and scaffolding should be strong enough, high enough, as well as promote the adequate blockage of openings.

Safe design at the planning stage can prevent the collapse of temporary structures (e.g., scaffolding) and building components. Shoring trenches and sloping trench sides will prevent collapse.

Designing construction sites so that workers do not need to enter areas where there are flying objects will avoid injury as will using heavy equipment fitted with cages around the driver's seat to protect the worker from falling and from swinging objects. Cranes with swinging loads can be sited away from work areas. Planning and scheduling can minimize the presence of other workers while cranes are in operation.

The prevention of motor vehicle accidents depends highly on the proper training of drivers, provision of adequate braking systems on trucks and earth moving equipment, and effective trafficking schedules to minimize the presence of other workers in the vicinity of motor vehicle.

Construction workers must depend on protective headgear for the immediate protection from injury. Hard hats are not foolproof. Defects and improper maintenance can lead to unexpected hard hat failures. Workers may refuse to wear hard hats for various reasons. Workers must be required to wear hard hats. Neck restraining devices, such as neck rolls used in football, may help reduce the likelihood of severe ruptures. The design of the workplace and of equipment may help decrease the rate of neck strains due to posture. The work method may also be altered to reduce the likelihood and severity of strain related injuries to the neck (e.g., frequent rest periods to allow the workers' muscles to more completely relax).

Eye injuries were among the most common yet one of the least severe head injuries in my study. The high frequency of eye injury suggests reluctance on the worker to use recommended eye protection devices. The low severity reflects the importance of preserving maximum utility of the eyes during tasks, thus warranting immediate and focused attention even for the most minor of injuries. Workers should always conduct an eye hazard evaluation on the jobsite. As much as is possible, eye hazards should be removed by using engineering controls. Construction companies should always have the appropriate safety eye protection at the jobsite.

The prevention and minimization of the severity of upper and lower extremity injuries to construction workers should involve education and training, the use of appropriate personal protective equipment, ergonomic programs to fit the job to the worker, and tool design. Tools can be designed to minimize the amount of work required to operate them; this includes the angle and size of the handle, the weight of the tool, and the use of tool balancers or slings for heavy tools. Also important is a monitoring system to ensure that safety procedures are in use (e.g., many workers who sustained hand injuries may have removed or altered safety devices in order to improve the presumed efficiency of their tools).

The thrust of preventing hand and foot injuries should be on protective clothing. Protective footwear and gloves should be designed to protect the worker from hazards specific to the worker. No less important is the attention to floor surfaces, to prevent slips, which are often associated with shoulder, knee, ankle, hand, and wrist injuries. Surface conditions can be improved through effective design and maintenance. Most protective shoes for construction workers should be able to protect against impact, compression, heat, static electricity, high voltage and slippery surfaces. To be effective, safety gloves and shoes appropriate for the job must be worn. This means that their use must be required and that workers be educated in their proper use and upkeep.

The steel toe cap is a critical protective device for many construction workers who are frequently at risk for injuries due to objects being dropped on the foot. Additional protection for the foot and ankle could be provided by the inclusion of metatarsal shields, used to protect the top surface of the foot, specially designed gaiters (foot and/or leg coverings), and high-top boots.

Recommendations for Insurance Carriers

Insurance companies who provide workers' compensation to construction firms can do much to assist construction companies in identifying, evaluating, controlling and removing safety and health hazards during the entire construction process. The insurance provider can consult with construction companies on various safety activities. They can assist small construction firms by providing training that addresses key areas of potential injury, including fall protection, welding, trenching and shoring, Cooperative efforts between contractors, owners, designers, and insurance providers could work toward insuring that:

- Safety, health and welfare provisions should be included as mandatory in contract documents, so as to remove these considerations from competition.

- All contractors, subcontractors, sub-subcontractors, etc. should ebe rquireed to include safety and welfare items in their estimated costs.

- All management and supervisory staff should demonstrate competence in occupational health and safety. Insurance providers could offer incentives or even require that certification be provided.

- All workers should have to demonstrable skill levels, incorporating safety.
- Safety compliance should be monitored and recorded accurately and consistently.
- Ensure that recording of injury occurrences be detailed and that as much preexisting information regarding the task, environment, and worker be provided.

Insurance companies could assist independent researchers who use workers' compensation data by including information regarding the ethnicity of workers, and preexisting health and medical conditions (blood pressure, weight, height, prior injuries and illnesses, etc.). They could also assist the research by ensuring quality recording of injury information; this would include consistent and accurate coding of data. The apparent ease and economy of using pre-collected data cannot eliminate the need for critical selection, examination, and analysis of these data. Once in hand, the completeness and coding of the data should be examined in detail before attempting to test hypotheses.

Recommendations for Future Research

Future research could examine in greater detail the impact of age, experience level, and job tenure on the frequency and severity of injuries in construction. The effect of preexisting ethnic, social, health and medical conditions should be examined in conjunction with age, occupational, and environmental variables on the frequency and severity of injuries to construction workers.

Research could also identify those aspects and types of construction work where the effort devoted to risk management is disproportionately low with respect to the potential for multi-injury consequences. Additionally, injuries that show the potential to be quite severe, even though there likelihood of occurrence may be quite low, deserve special attention. Having identified these aspects, recommendations could be made in whatever action seems most appropriate (e.g. through regulation, guidance, education, detection, and emergency response).

Future research could focus on specific trades, tasks, and phases of construction. Biomechanical profiles could be constructed for trades relative to their specific tasks. Research of the dynamic characteristic of particular phases of construction could provide a clearer understanding of the hazards associated with specific activities on a jobsite (e.g., limitations, worker density). This would include the examination of the impact of overtime on the frequency and severity of injuries. Such research would entail the generation of injury profiles of workers relative to the specific type of project, and to the percentage of project completion.

APPENDIX A
DEFINITIONS FOR NATURE OF INJURY CODES

Table A- 1. Specific Injuries

Code#	Label	Description
101	No physical injury	Specific injury not listed; or nature stated as “no injury.”
102	Amputation	Loss of limb, part of organ; bone loss must be involved to consider a finger or toe injury an amputation.
103	Angina pectoris	Condition associated with heart disease.
104	Burn	Resulting from contact with hot or cold temperature extremes; tissue damage resulting from corrosive action of chemical compounds (acids, alkalis), fumes, etc. Includes skin burns from anhydrous ammonia, and dry ice, cement, friction, lightning, and sunburns. Does not include electrical shock or heat stroke.
107	Concussion	Injury resulting from impact with an object; may include loss of consciousness.
110	Contusion	Bruise; skin is intact, broken blood vessels (includes broken blood vessels in the eye).
113	Crushing	Skin intact, broken blood vessels.
116	Dislocation	Temporary displacement of a bone from its normal position in a joint. Includes herniated or ruptured disc; pinched nerve in back, slipped disc, and sciatica.
119	Electric shock	Injury due to contact with electrical current; electrocution, “struck by lightning.”
122	Enucleation	Removal of an entire mass without rupture, i.e. eye.
125	Foreign body	Slivers, cinders, dirt or other small objects that lodge in the eyes, ears, nose, skin or internally. Does not include needle stick.
128	Fracture	Sudden breaking of a bone.
130	Freezing	Limb or part of body becoming stiff, rigid and inflexible due to exposure to cold. Includes hypothermia and frostbite.
131	Hearing loss or impairment	Loss of hearing; traumatic only; also includes deterioration of hearing subsequent to specific incident.

Table A- 1. Continued.

Code#	Label	Description
132	Heat prostration	Exhaustion resulting from excessive exposure to heat, “heat stroke.”
134	Hernia	Protrusion, projection, or rupture of an organ or a part of an organ through the wall of the cavity that normally contains it. Includes inguinal and non-inguinal hernia. Does not include herniated disc.
136	Infection	Condition in which part of the body is invaded by a pathogenic agent (microorganism or virus). Includes boils, carbuncles, cellulitis, abscesses, lymphadenitis, impetigo, pyodermia, etc.
137	Inflammation	Tissue reaction due to injury (internal or external) of joints, tendons, or muscles. Includes tendonitis, arthritis, dermatitis, bursitis, etc. Does not include Occupational Diseases or injuries that developed over a period of time.
140	Laceration	Cut or tear of the skin; an open or superficial wound.
141	Myocardial infarction	Heart Attack.
142	Poisoning – General	Not an overdose or Cumulative Injury; specific incident of poisoning.
143	Puncture	Hole or wound made by a sharp pointed instrument. Includes injection of paint, grease, water or other fluid under pressure. Includes needle stick.
146	Rupture	Breaking of internal tissue or organ, e.g., rupture of appendix.
147	Severance	Loss of soft tissue, bone remains intact. May involve fingertips, earlobes, etc.
149	Sprain	Trauma to joint, may include torn ligaments; torn, ruptured muscles; ruptured knee cartilage (no dislocation); and spinal subluxation.
152	Strain	Trauma to muscle from violent contraction, strong effort, or excessive use.
153	Syncope	Fainting; loss of consciousness due to inadequate blood flow to the brain.
154	Asphyxiation	Insufficient intake of oxygen may or may not result in death. Includes drowning, strangulation, suffocation, etc.

Table A- 2. Occupational diseases or cumulative injuries

Code #	Label	Description
155	Vascular loss	Loss of circulation.
158	Vision loss	Loss of eyesight; traumatic only.
159	All other specific injuries, NOC	Specific injury Not Otherwise Classified.
260	Dust disease NOC	Condition of respiratory tract due to inhalation of dust particles (Dust diseases Not Otherwise Classified).
261	Asbestosis	Lung disease resulting from inhalation of asbestos particles.
262	Black Lung	Chronic lung disease or pneumoconiosis, often found in coal miners.
263	Byssinosis	Pneumoconiosis of cotton, flax and hemp workers.
264	Silicosis	Pneumoconiosis resulting from inhalation of silica (quartz dust).
265	Respiratory disorder	Respiraton ailments resulting from exposure to gases, fumes, chemicals, etc.
266	Poisoning – chemical	Any chemical substance taken into the body by ingestion, inhalation, or absorption that interferes with normal physiological functions. Includes pesticides, insecticides, cleaning agents, drug poisoning, etc.
267	Poisoning – metal	Any metallic substance taken into the body by ingestion, inhalation or absorption that interferes with normal physiological functions. Includes alkalies, mercury, lead, arsenic compounds, etc.
268	Dermatitis	Inflammation of skin evidenced by itching, redness, boils, or lesions. Generally resulting from direct contact with drugs, agents, plants, woods, liquids, etc. Does not include tissue damage resulting from corrosive action of chemicals, burns from contact with hot substances, or effects or radiation or temperature extremes.
269	Mental disorder	Acute anxiety, neurosis (nontoxic or toxic), and shock (when not incurred by physical trauma). Does not include mental stress.

Table A- 2.Continued.

Code #	Label	Description
270	Radiation	Radiation syndrome; illness resulting from exposure of body tissue to ionizing radiations from radioactive substances.
271	All Other occupational disease NOC	Applies to occupational diseases and cumulative injuries occurring over a period of time as a result of repetitive motion, which may include sitting, typing, folding, etc. And are not otherwise classified. Includes varicose veins and bone spurs. Does not apply to specific injuries.
272	Loss of hearing	Loss of hearing due to cumulative circumstances.
273	Contagious disease	An Ailment resulting from contact with an infectious organism. May include TB, conjunctivitis, meningitis, chicken pox, anthrax, hepatitis, etc.
274	Cancer	Malignant or benign tumor; includes leukemia.
375	AIDS	An ailment resulting from contact with an infectious individual. Acquired Immune Deficiency Syndrome.
376	VDT-related disease	Video Display Terminal-related; may affect eyes, hands, back, neck, etc.
377	Mental stress	Psychological disruption (fear, anxiety, crisis, depression).
378	Carpal tunnel sryndrome	Soreness, tenderness and weakness of the muscles of the thumb caused by pressure on the median nerve at the point where it goes through the carpal tunnel of the wrist. May involve damage to the hands, wrists, forearms, elbows, and shoulders. May also include ganglion cysts in the wrist area.

Table A- 3. Multiple Injuries

Code#	Label	Description
490	Multiple physical injuries only	Involves more than one nature of injury: does not include psychological disorders.
491	Multiple injuries (including phys & psych)	Involves multiple injuries where at least one is of the psychological nature.

APPRENDIX B
DEFINITIONS FOR PART OF BODY CODES

Table B- 1. Head

Code#	Label	Description
10	Multiple head injury	Any combination of brain, scalp, skull with or without ears, eyes, nose, mouth, teeth, face, or neck. Includes head – not otherwise classified.
11	Skull	Cranial bones
12	Brain	Includes brain concussion; brain damage.
13	Ear(s)	Includes inner and outer ear, eardrum, hearing and loss of hearing.
14	Eye(s)	Includes optic nerves, vision and loss of vision.
15	Nose	Includes nasal passages, sinus and sense of smell.
16	Teeth	Does not include gums or false teeth.
17	Mouth	Includes tongue, gums, lips, throat, and sense of taste. Includes jaw and chin. Does not include teeth.
18	Soft tissue	Pertaining to cuts and bruises; includes cheek, eyebrow, forehead, and scalp.
19	Facial bones	Pertaining to fractures of facial bones, not the skull.

Table B- 2. Neck

Code#	Label	Description
20	Multiple injury	Any combination of vertebrae, disc, spinal cord or soft tissue in neck. Also, neck – not otherwise classified.
21	Vertebrae	Spinal column bone in the neck includes the first seven bones of the spinal column (cervical vertebrae).
22	Disc	Spinal column cartilage in the neck.
23	Spinal cord	Nerve tissue in the neck.
24	Larynx	“voice box,” includes loss of voice, vocal chords.
25	Soft tissue	Soft tissue in the neck area (internal) other than the larynx or trachea.

Table B- 2. Continued.

Code#	Label	Description
26	Trachea	Cartilage tube leading from the larynx to the bronchial tubes.

Table B- 3. Upper extremities.

Code#	Label	Description
30	Multiple upper extremities	Any combination of arm, elbow, or fingers. Also arm – not otherwise classified. Does not include a specific wrist & hand combination.
31	Upper arm(s)	Arm between elbow and shoulder. Does not include shoulder, clavicle (collarbone), scapula (shoulder blade) or rotator cuff.
32	Elbow(s)	Joint of the upper arm and the forearm.
33	Lower arm(s)	Portion of the arm between the elbow and the wrist.
34	Wrist	Joint of the hand and the forearm.
35	Hand(s)	Does not include the wrist or fingers. Includes metacarpal bones, top of hand and the palm. Use for any injury described as "between the fingers."
36	Finger(s)	Includes fingernail(s).
37	Thumb(s)	Includes thumbnail(s)
39	Wrist(s) and hand(s)	Specific injury or occupational disease where both the wrist(s) and hand(s) are involved.

Table B- 4. Trunk

Code#	Label	Description
38	Shoulder(s)	Junction of clavicle and scapula where arm meets trunk; includes rotator cuff, collarbone and shoulder blade.
40	Multiple trunk	Any combination of hip, abdomen, chest, back, and shoulder. Also, trunk – not otherwise classified. Includes "side."
41	Upper back	Thoracic area, includes vertebrae and muscle pull or ligament strain.
42	Lower back	Lumbar and lumbo-sacral areas, includes muscle pull or ligament strain; use when description does not differentiate between upper and lower back, i.e., "back." Does not include lumbar or sacral vertebrae.

Table B- 4. Continued.

Code#	Label	Description
43	Disc	Spinal column cartilage in the back..
44	Chest	Includes ribs, sternum (breastbone), soft tissue and “chest pain”; does not include heart or lungs.
45	Sacrum and coccyx	Posterior boundary of pelvis and base of vertebral column (tailbone).
46	Pelvis	Bone structure formed by innominate (nameless) bones and the ligament uniting them
47	Spinal chord	Nerve tissue in the back.
48	Internal organs	Applies when the functioning of an entire body system has been affected without specific injury to any other part, as in the case of poisoning, corrosive action affecting internal organs, insect bites resulting in an allergic reaction, damage to nerve centers, stress, etc.
49	Heart	Heart attack (myocardial infarction) or congestive heart failure.
60	Lungs	Specific injury or condition affecting the lungs only.
61	Abdomen including groin	Specific injury to specific parts only; includes stomach, lower esophagus, groin, small or large intestines, liver, gall bladder, spleen, pancreas, kidneys, and appendix. Do not use if functioning of entire body system is affected (internal organs).
62	Buttocks	External posterior of pelvis & hip area.
63	Lumbar and/or sacral vertebrae	Vertebrae of the lumbar and/or sacral areas; also includes vertebrae in trunk area that are not otherwise classified.

Table B- 5. Lower extremities

Code#	Label	Description
50	Multiple lower extremities	Any combination of leg, hip, thigh, knee, ankle, foot, and toe. Also, leg – not otherwise classified.
51	Hip(s)	Upper part of thigh formed by femur and innominate (nameless) bones. The region on each side of pelvis; does not include buttocks or “side.”
52	Upper leg(s)	Part of leg between knee and hip; part of thigh below hip.
53	Knee(s)	Includes the patella (kneecap) and supporting ligaments.

Table B- 5. Continued

Code#	Label	Description
54	Lower leg(s)	Part of leg above the ankle, below the knee.
55	Ankle(s)	Joint between the leg and the foot.
56	Foot/feet	Part of the foot/feet that does not include the ankle or toes. Includes the heel. Used for any injury described as “between the toes.”
57	Toe(s)	Toes and toenail(s) but excludes the great toe(s).
58	Great toe	Large toe(s)

Table B- 6. Multiple body parts

Code#	Label	Description
64	Artificial appliance	Damage to a device that is used to augment performance of a natural function, e.g., hearing aids, eyeglasses, dentures, artificial limbs, etc.
65	Unclassified or known.	Applies when specific part of body is not identified
66	No physical injury	Applies when specific part of body is stated as “no injury.”
90	Multiple body parts	Applies when more than one major body part has been affected, such as an arm and a leg.
91	Body systems and multiple body systems	Applies when one or more body systems have been affected, i.e. Circulatory and/or respiratory systems. Includes aids, paralysis, electrocution, electrical shock, forms of infectious or parasitic illnesses, such as scabies, ticks, chicken pox, shingles, etc. Also includes fatality, noc.

APPENDIX C
DEFINITIONS OF CAUSE OF INJURY CODES

Table C- 1. Burn or scald

Code #	Label	Description
101	Acid chemicals	Includes hydrochloric acid, sulfuric acid, battery acid, and methanol and antifreeze.
102	Contact with hot objects or substances:	In cases where contact with a specific hot object occurs; does not include steam or hot fluids.
103	Temperature extremes	Applies to non-impact injuries resulting in a burn due to hot or cold temperature extremes; includes freezing or frostbite.
104	Fire or flame	Burns to the skin as a result of exposure to fire not caused by an explosion.
105	Steam or hot fluids:	Contact with steam or hot fluids.
106	Dust, gases, fumes, or vapors:	Includes inhalation of carbon dioxide, carbon monoxide, propane, methane, silica (quartz), and asbestos dust. Includes smoke inhalation.
107	Welding operations	Includes welder's flash, burns to skin or eyes as a result of exposure to intense light from welding.
8	Radiation	Includes effects of ionizing radiation found in x-rays, microwaves, nuclear reactor waste, and radiating substances and equipment. Also includes non-ionizing radiation such as sunburn.
109	Contact with, noc:	Burned or scalded by contact with heat or cold but exact injury is not discernable on first report of injury or is not otherwise classified in any other code; may include injury due to cleaning agents fertilizers, etc.
111	Contact with cold objects or substances	In cases where contact with a specific cold object or substance occur; does not include freezing or frostbite.
114	abnormal air pressure:	Burn or scald injury caused by exposure to abnormal air pressure.
184	Electrical current	Burn or scald injury from electric shock, electrocution, lightning, etc.

Table C- 2. Caught in or between

Code #	Label	Description
210	Machine or machinery:	Running or meshing objects, a moving and a stationary object, two or more moving objects (not necessarily a machine).
212	Object handled:	May include medical hospital bed & parts, 30. Slipped; did not fall.
213	Caught in, under or between, noc	Not otherwise classified; "caught between" codes do not apply when the source of injury is a flying or falling object.
220	Collapsing materials	Slides of earth, collapse of buildings, etc.)

Table C- 3. Cut, puncture, scrape

Code #	Label	Description
315	Broken glass	Cut or puncture caused by the handling of broken glass.
316	Hand tool, utensil; not powered:	Includes injury caused by needle, pencil, knife, hammer, saw, axe, screwdriver, etc.
317	Object being, lifted or handled	Includes being cut, punctured or scraped by a person or object being lifted or handled; not including powered hand tools, appliances, utensils or broken glass.
318	Powered hand tool; appliance	Includes injury caused by drill, grinder, sander, iron, blender, welding tools, etc.
319	Cut, puncture, scrape, noc	Not otherwise classified; includes injury by power-actuated tools such as a gun.

Table C- 4. Fall or slip

Code #	Label	Description
425	From a different level	Fall to a lower level from a higher level; includes collapsing chairs, falling from piled materials, etc.
426	From ladder or scaffolding	Fall to a lower level from ladder / scaffolding.
427	From liquid or grease spills:	Fall to the same or a lower level as a result of slipping in a liquid or grease spill.
428	Into openings	Fall or slip into opening i.e. Mining shafts, holes in the floor, elevator shafts.

Table C- 4. Continued.

Code #	Label	Description
429	On same level	Fall to the same level or walkway; does not include falling as a result of liquid or grease spills.
431	Fall, slip, trip, noc	Not otherwise classified; includes tripping over object, slipping on organic material, slip but fall not specified.
432	On ice or snow	Fall to same or lower level as a result of slipping on ice or snow, wheelchair, clothespin, vise etc.
433	On stairs	Fall or slip injury caused by falling down stairs, “missed step while going down,” falling “up” the stairs, etc.

Table C- 5. Motor vehicle

Code #	Label	Description
540	Crash of water vehicle	Collision of water vehicle with a fixed object or another water vehicle.
541	Crash of rail vehicle	Collision of rail vehicle with a fixed object or another rail vehicle.
545	collision with another vehicle	Collision occurring when both vehicles are in motion; does not apply to water or rail vehicles.
546	Collision with a fixed object	Collision occurring when one vehicle or another object are stationary; does not apply to water or rail vehicles.
547	Crash of airplane	Collision of airplane with a fixed object or another airplane.
548	Vehicle upset	Rollover of vehicle.
550	Motor vehicle, noc	Not otherwise classified; injuries due to sudden stop or start. Includes being thrown against interior parts of the vehicle and vehicle contents being struck by a water, rail or motor vehicle.

Table C- 6.. Strain

Code #	Label	Description
652	Continual noise	Injury to ears or hearing due to constant or repetitive noise, cumulative.
653	Twisting	Free bodily motion which imposes stress or strain on some part of body; assumption of un-natural position; also involuntary motions induced by sudden noise, fright or efforts to recover from slips or loss of balance.

Table C- 6. Continued.

Code #	Label	Description
654	Jumping	Injury occurs as a result of jumping or leaping; does not include injuries as a result of landing on the ground.
655	Holding or carrying	Applies to objects or people. Includes “restraining a person.” Does not include “struck by a person.”
656	Lifting	Applies to objects or people.
657	Pushing or pulling	Applies to objects or people.
658	Reaching	Injury resulting from reaching up, down, out, or across to retrieve an object or a person.
659	Using yool or machine	Sudden overexertion while using a tool or a machine.
660	Strain or injury by, noc	Injury resulting in a strain where cause is unknown or not otherwise classified.
661	Wielding or throwing	Excessive physical effort resulting in overexertion may result from attempts to resist a force applied by an object being handled.
697	Repetitive motion	Cumulative injury or condition caused by continual, repeated motions; strain by excessive use.

Table C- 7. Striking against or stepping on

Code #	Label	Description
765	Moving parts of machine	None
766	Object being lifted or handled	None
767	Sanding, scraping, cleaning	May include scratches or abrasions caused by sanding, scraping, and cleaning operations.
768	Stationary object	None
769	Stepping on sharp object	None
770	Striking against or stepping on, noc	Injuries caused by striking against or stepping on something that is not otherwise classified.

Table C- 8. Struck by

Code #	Label	Description
874	Fellow worker, patient	Struck by co-worker, either on purpose or accidentally; includes being struck by a patient while lifting or moving them.
875	Falling or flying object	
876	Hand tool or machine in use	
877	Motor vehicle	Applies when a person is struck by a motor vehicle, including rail vehicles, water vehicles and airplanes.
878	Moving parts of machine	
879	Object being lifted of handled	
880	Object handled by others	Includes another person dropping object on injured person's body part.
881	Struck by noc	Injury caused by being struck or injured by something that is not otherwise classified.
885	Animal or insect	Includes bite or sting from a living organism. Includes an allergic reaction to the presence of a dog, cat, etc.
886	Explosion or flare back	Rapid expansion, outbreak, bursting or upheaval. Includes explosion of cars, bottles, aerosol cans, buildings, etc. Does not include electrical short circuits ("blown fuses"). "flare back" involves superheated air and combustible gases at temperatures just below the ignition temperature. Flare back may have same effects as welder's flash.

Table C- 9. Rubbed or abraded by

Code 3	Label	Description
994	Repetitive motion	Caused by repeated rubbing or abrading; applies to non-impact cases in which the injury was produced by pressure, vibration or friction between the person and the source of injury.
995	Rubbed or abraded, noc	Caused by a specific incident of rubbing or abrading that is not otherwise classified; includes foreign body in ears.

Table C- 10. Miscellaneous causes

Code #	Label	Description
1082	Absorption, ingestion, or inhalation, noc	Applies only to non-impact cases in which the injury resulted from inhalation, absorption (skin contact), or ingestion of harmful substances not otherwise classified.
1087	Foreign matter in eye(s)	None
1089	Person in act of crime	Specific injury caused as a result of physical contact between injured person and another person in the act of committing a crime; does not include stress or psychological trauma that develops secondary to physical injuries.
1090	Other than physical cause of injury	Stress, shock, or psychological trauma that develops in relation to a specific incident or cumulative exposure to conditions.
1098	Cumulative, noc	Involves cases in which the cause of injury occurred over a period of time; any condition increasing in severity over time, not otherwise classified.
1099	Other-miscellaneous, noc	Any injury or condition that does not apply or is not otherwise classified in other categories; includes specific injury to ears/hearing, etc.

APPENDIX D
AGENT OF INJURY CODES AND DEFINITIONS

Table D- 1. Agent of injury

Code #	Label/description
101	Building exposure - carbon monoxide
102	Building exposure - components/sick building
103	Building exposure - construction products
104	Building exposure - other fumes - non-products
105	Building exposure - windows/doors
201	Chemical - acid
202	Chemical - fumes
203	Chemical - fumes - hard metals, including welding
204	Chemical - fumes - pesticides, herbicides, fertilizers
205	Chemical - fumes - coatings, paint (not lead)
206	Chemical - smoke
301	Furniture - bed
302	Furniture - commode
303	Furniture - display items
304	Furniture - fixtures, furnishings
401	Ladder or scaffolding
501	Lead
502	Lead - other
503	Lead - paint - premises
504	Lead _ paint - products
601	Machinery - belts, pulleys, gears, shafts
602	Machinery - conveyors
603	Machinery - deli slice
604	Machinery - furnace or heating equipment
605	Machinery - hoisting apparatus
606	Machinery - maintenance equipment
607	Machinery - metal working
608	Machinery - noc
609	Machinery - pumps
610	Machinery - scanner, scanning equipment
611	Machinery - weaving
612	Machinery - wood working
613	Machinery - wrap dispenser
614	Machinery - turnstile
615	Machinery - electrical apparatus
701	Manhole
801	Material - asbestos
802	Material - asbestos - contractor
803	Material - asbestos - premises
804	Material - automotive parts
805	Material - boxes, barrels, containers, packages

Table D- 1. Continued.

Code #	Label/description
807	Material - china or glass
808	Material - coal and petroleum product(s)
809	Material - door or door part
810	Material - door or drawer
811	Material - fence
812	Material - fence - gate or gate arm
813	Material - garbage cans, bags
814	Material - gravel
815	Material - luggage
816	Material - nail
817	Material - not mold, mildew, window, door
818	Material - other foreign matter not listed
819	Material - plastic
820	Material - plumbing
821	Material - pulp or paper
822	Material - rock or stone (minerals)
823	Material - scrap materials not listed
824	Material - shoes, clothing, apparel
825	Material - splinter
826	Material - windows, doors
827	Material - wire or metal
828	Material - wood
901	Organism - animal - animal or insect - converted claims only
902	Organism - animal - animal part
903	Organism - animal - insect part
904	Organism - bacteria
905	Organism - plant
1001	Person - administrator
1002	Person - medical personnel
1003	Person - employee or coworker
1004	Person - maintenance personnel
1005	Person - nurse - lpn or lvn
1006	Person - nurse practitioner
1007	Person - occupational therapist
1008	Person - operating room technical repair and maintenance
1009	Person - orderly
1010	Person - other patient
1011	Person - other person, not listed
1012	Person - social worker
1013	Person - terrorist attack - 9/11
1101	Pothole(s)
1201	Power lines or poles
1301	Sharp object - not listed
1401	Spills - leakage - tank or vessel

Table D- 1. Continued.

Code #	Label/description
1402	Spills - liquid, food or grease
1501	Surface texture - change in
1502	Surface texture - wet floor, cleaning or wax
1601	Tool - hand - non power - carton cutter
1602	Tool - hand - non power - knife
1603	Tool - hand - non power
1604	Tool - hand - power
1605	Tool - power - band saw
1606	Tool -
1701	Hose
1801	Pipe
1901	Vehicle
1902	Vehicle - cart, wagon, bicycle
1903	Vehicle - golf cart
1904	Vehicle - machinery - mobile equipment
2001	Weather conditions - ice, rain, snow
3001	Weighted item - up to 25 lbs.
3002	Weighted item - 26 to 50 lbs.
3003	Weighted item - 51 to 75 lbs.
3004	Weighted item - 76 to 100 lbs.
3005	Weighted item - 101 to 150 lbs.
3006	Weighted item - more than 150 lbs.
3007	Weighted item -
3008	Weighted item -
99999	Missing

Table D- 2. General agent of injury.

Code #	Label
100	Building exposure
200	Chemical
300	Furniture
400	Ladder/scaffold
500	Lead
600	Machinery
700	Manhole
800	Material
900	Organism
1000	Person
1100	Pothole(s)
1200	Power lines or poles
1300	Sharp object
1400	Spills
1500	Change in surface texture
1600	Tool(s)

Table D- 2. Continued.

1700	Hose
1800	Pipe
1900	Vehicle
2000	Weather conditions
3000	Weighted item

APPENDIX E
STANDARD INDUSTRIAL CLASSIFICATION (SIC) CODES AND DEFINITIONS

Table E- 1. Standard industrial classification (SIC) codes.

Code	Label	Description
1521	General contractors – single family houses	The category covers general contractors primarily engaged in construction activities (including new work, additions, alterations, remodeling, and repair) of single-family houses.
1522	General contractors – residential buildings, other than single-family houses	This industry consists of general contractors primarily engaged in the construction of residential buildings other than single family homes. This type of construction includes new work, additions, alterations, remodeling, and repair of such establishments as apartment buildings, dormitories, and hotels and motels.
1541	General contractors – industrial buildings and warehouses	This category covers general contractors primarily engaged in the construction, alteration, remodeling, repair, and renovation of industrial buildings and warehouses, including aluminum plants, automobile assembly plants, food processing plants, pharmaceutical manufacturing plants, and commercial warehouses. General contractors working on nonresidential buildings other than industrial buildings and warehouses are classified in SIC 1542: general contractors—nonresidential buildings, other than industrial buildings and warehouses.
1542	General contractors – nonresidential buildings, other than industrial buildings and warehouses	This category covers general contractors primarily engaged in the construction, alteration, remodeling, repair, and renovation of nonresidential buildings, other than industrial buildings and warehouses. Included are nonresidential buildings of commercial, institutional, religious, or recreational nature, such as office buildings, churches and synagogues, hospitals, museums and schools, restaurants and shopping centers, and stadiums.
1543	General contractor - noc	This group includes general contractors and operative builders primarily engaged in the construction of residential, farm, industrial, commercial, or other buildings, not elsewhere classified.

Table E- 1. Continued.

Code	Label	Description
1611	Highway and street construction	This industry covers general and special trade contractors primarily engaged in the construction of roads, streets, alleys, public sidewalks, guardrails, parkways, and airports.
1622	Bridge, tunnel, and elevated highway construction.	This category covers general contractors primarily engaged in the construction of bridges; viaducts; elevated highways; and highway, pedestrian, and railway tunnels. General contractors engaged in subway construction are classified in sic 1629: heavy construction, not elsewhere classified.
1623	Water, sewer, and utility lines	This industry covers general and special trade contractors primarily engaged in the construction of water and sewer mains, pipelines, and communications and power lines.
1629	Heavy construction - noc	This classification covers general and special trade contractors primarily engaged in the construction of heavy projects, not elsewhere classified.
1711	Plumbing, heating, and air conditioning	This industry classification covers special trade contractors primarily engaged in plumbing, heating, air conditioning, and similar work. Sheet metal work performed by plumbing, heating, and air conditioning contractors in conjunction with the installation of plumbing, heating, and air conditioning equipment is included here, but roofing and sheet metal work contractors are classified in sic 1761: roofing, siding, and sheet metal work.
1721	Painting and paper hanging	This classification includes special trade contractors primarily engaged in painting and paper hanging. Special trade contractors primarily engaged in roof painting are classified in sic 1761: roofing, siding, and sheet metal work.
1731	Electrical work	This category covers special trade contractors primarily engaged in electrical work at the site.
1741	Masonry, stone setting, and other stone work	This category covers special trade contractors primarily engaged in masonry work, stone setting, and other stone work.

Table E- 1. Continued.

Code	Label	Description
1742	Plastering, drywall, acoustical, and insulation	This category is comprised of special trade contractors primarily engaged in applying plain or ornamental plaster, or in the installation of drywall and insulation. Activities include taping and finishing drywall, applying solar-reflecting insulation film, installing lathing, and constructing ceilings.
1743	Terrazzo, tile, marble, and mosaic work	This category is comprised of special trade contractors primarily engaged in setting and installing ceramic tile, marble, and mosaic, and in mixing marble particles and cement to make terrazzo.
1751	Carpentry work	This category includes special trade contractors primarily engaged in carpentry work. Establishments primarily engaged in building and installing cabinets at the job site are classified in this industry.
1752	Floor laying and other floor work, not elsewhere classified	This category includes special trade contractors primarily engaged in the installation of asphalt tile, carpeting, linoleum, and resilient flooring. The industry also includes special trade contractors engaged in laying, scraping, and finishing parquet and other hardwood flooring.
1761	Roofing, siding, and sheet metal work	Special trade contractors primarily engaged in the installation of roofing, siding, and sheet metal work. Sheet metal work performed by plumbing, heating, and air-conditioning contractors in conjunction with the installation of plumbing, heating, and air-conditioning equipment are classified in sic 1711: plumbing, heating, and air-conditioning.
1771	Concrete work	Special trade contractors primarily engaged in concrete work, including portland cement and asphalt. This industry includes the construction of private driveways and walks of all materials.
1781	Water well drilling	This category covers special trade contractors primarily engaged in water well drilling.
1791	Structural steel erection	This category covers special trade contractors primarily engaged in the erection of structural steel and of similar products of prestressed or precast concrete.

Table E- 1. Continued.

Code	Label	Description
1793	Glass and glazing work	This category is comprised of establishments primarily engaged in cutting, coating, tinting, and installing glass. Companies that install automotive glass are described in sic 7536: automotive glass replacement shops.
1794	Excavation work	This category covers special trade contractors primarily engaged in excavation work and digging foundations, including digging and loading. Contractors in this industry may also perform incidental concrete work.
1795	Wrecking and demolition work	This category covers special contractors that primarily wreck and demolish buildings and other structures, except marine property. They may or may not sell material salvaged from demolition sites.
1796	Installation or erection of building equipment – not elsewhere classified	Special trade contractors primarily engaged in the installation, erection, or dismantling of miscellaneous building equipment make up this industry, which encompasses numerous firms that offer a wide range of services. Common activities include the installation, repair, and dismantling of conveyor systems, dumbwaiters, dust collecting equipment, elevators, incinerators, industrial machinery, power generation devices, revolving doors, and vacuum cleaning systems.
1799	Special trade contractors – not elsewhere classified	The special trade contractors, not elsewhere classified industry is comprised of a plethora of firms that provide a broad range of miscellaneous construction services. Examples of industry activities include bathtub refinishing, gasoline pump installation, grave excavation, swimming pool construction, post hole digging, wallpaper stripping, mobile home setup, house moving, fire escape installation, bowling alley construction, artificial turf installation, and sandblasting.

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BIOGRAPHICAL SKETCH

Raymond Godfrey was born on June 24, 1961, in Turin, Italy. Raymond earned his bachelor's degree in 1984 from the University of Florida majoring in psychology. In May of 1994 Raymond earned a Master of Education in Counseling Education from Florida Atlantic University, in Boca Raton, Florida. In the spring of 1999 he was admitted to the M.E. Rinker Sr. School of Building Construction at the University of Florida, where he achieved his master's degree in building construction management. In the fall of 2003, he was admitted to the Ph.D. program in the College of Design, Construction, and Planning at U.F. under the mentorship of Professor Jimmie Hinze. Raymond will begin his academic career in 2007 in the Construction Management program at the University of Southern Mississippi.

Raymond's research interests include health and safety in the construction industry, sustainable construction, ethics in construction management, and labor relations.