INCIDENCE OF AND RISK FACTORS FOR OCCUPATIONAL INJURY AMONG TRANSIT BUS OPERATORS

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ABSTRACT

Driving a bus, professionally, is recognized as a high-risk occupation. This particular occupation has long working hours, irregular schedules, and lack of scheduled time for breaks and meals. Studies have shown professional bus operators have a high risk of cardiovascular disease, hypertension, gastrointestinal disorders and musculoskeletal problems, as well as psychological health issues, including fatigue, depression and anxiety. Based on Karasek's psychological demands/decision model, all of the working characteristics for bus operators result in high workload demand and low job control. Stress is reported as a main risk factor that leads to adverse health outcomes among professional drivers, especially cardiovascular disease and gastrointestinal disorders. Another serious stressor is the risk of violent acts. Bus operators are at potential risk of exposure to work-related violence as part of the requirement to interact with passengers. Numerous studies focused on bus operators' occupational diseases have provided a basic understanding for this study. Thus, the objective of this study was to provide a more comprehensive understanding of the magnitude, potential risk factors, and protective factors that may be associated with occupational injuries (both unintentional and intentional injuries) among bus operators and can serve as a basis for possible intervention strategies to reduce injuries.

Demographic, work-related, and injury information was obtained from a transit company for a five-year period (Dec 1, 2006 to Dec 31, 2011). These data included the bus operators' demographic information: gender and age; work-related characteristics: years of working; job classification (part-time or full-time); working hours per day; driving hours per day; overtime hours per day; bus garage division; work start time; shift schedule; number of busses driven per day; and bus route types. Injury event reports included type of injury and body part(s) affected. Estimates of rates, per 100 Full Time

Equivalents (FTEs), and associated 95% Confidence Intervals (C.I.), were generated using generalized estimating equations (GEEs) with exchangeable working correlation matrices. Adjusted Hazard Ratios (HRs), with associated 95% C.I., were generated, using Cox Proportional Hazards models.

A total of 2,095 bus operators was included in this study. The overall unintentional injury rate with 95% C.I. was 17.8 (16.1-19.7) per 100 FTEs. Multivariable analysis identified increased risks for operators who: were female, compared to male (HR=2.4; 2.0-2.8); worked less than seven, compared to seven to less than 12 hours per day (HR=4.6; 3.8-5.5); and drove less than seven compared to seven to less than 12 hours per day (HR=3.2; 2.7-3.8). Operators who worked split, versus straight shifts, demonstrated a suggestive increased risk (HR=1.2; 1.0-1.4). Bus operators also tended to have an increased risk when driving limited versus regular bus routes (HR=1.36; 1.0-1.8).

For intentional injury, the overall injury rate with 95% C.I. was 1.4 (1.1-1.7) per 100 FTEs. Operators who commenced working between 3 p.m. and 6 p.m. (HR=2.4; 1.2-5.1) and 12 a.m. and 3 a.m. (HR=5.3; 1.6-18.2), had higher risks of intentional injury, compared to those who commenced work between 9 a.m. and 12 p.m. In addition, higher risks were also found for operators who: worked less than seven or more than 12 hours (HR=16.3; 9.5-28.1 and HR=9.6; 3.7-23.5, respectively), compared to seven to less than 12 hours; drove less than seven hours or more than 12 hours (HR=11.3; 6.6-19.5 and HR=11.9; 4.8-29.6, respectively), compared to seven to less than 12 hours. Moreover, those who worked overtime had 30% higher risks, compared to those who did not.

Results of this study serve as a basis for further studies and can inform the development of targeted intervention strategies to reduce occupational injuries relevant to bus operators.

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ORGANIZATION

The organization of this thesis provides initial chapters including an introduction, a comprehensive literature review, and a comprehensive presentation of the research design and methods. These chapters are followed by two major papers (Chapters 4 and 5) that report the major findings from the study; because these papers are prepared for publication in peer-reviewed journals, there is some redundancy with the first three chapters, pertinent to the literature cited and the methods presented. A final chapter provides a discussion of study validity and the results of the study.

CHAPTER I

INTRODUCTION

Driving a bus, professionally, is recognized as a high-risk occupation (Evans, 1994; Tse et al., 2006). This particular occupation has long working hours, irregular schedules, and lack of scheduled time for breaks and meals. Moreover, bus operators are often required to perform multiple tasks, simultaneously, such as maintaining attention to passengers, bus schedules and traffic conditions, collecting fares, helping disabled passengers get on and off the bus, answering questions about directions, routes, schedules, and announcing stops. Bus operators must also maintain strict schedules, with many passengers relying on timely pick-up and drop-off intervals. Most importantly, operators must operate the bus safely, despite rush hour traffic, distractions of passengers, or inclement weather. During winter in Minnesota, their tasks are increased, as roads become narrower due to the large snow banks that accumulate. Bus operators need to stay alert and drive with extreme caution while watching out for both pedestrians and other vehicles.

In their working environment, bus operators are often exposed to both physical and psychological environmental risks. Potential physical risks include injuries from exposures to toxic substances from their bus and surrounding vehicles, as well as potential ergonomic issues from the effects of vibration (hand-arm vibration and whole-body seat vibration) (Stern et al., 1988; Bovenzi & Zadini, 1992; Soll-Johanning et al., 1998; Tse et al., 2006). Furthermore, because bus operators are working alone in restricted cabin space, they are socially isolated. Based on the Karasek's psychological demands/decision model, all of the working characteristics for bus operators result in high workload demand and low job control (Karasek, 1979; Tse et al., 2006). People who work under these conditions may have risk of mental strain, fatigue, depression, burnout, or other negative consequences (Karasek, 1979; Karasek & Theorell, 1992). Studies have shown professional bus operators have a high risk of cardiovascular disease, hypertension, gastrointestinal disorders and musculoskeletal problems, as well as psychological health issues, including fatigue, depression and anxiety (Netterstrøm & Juel, 1988; Stern et al., 1988; Evans, 1994; Hannerz & Tüchsen, 2001; Tse et al., 2006; Szeto & Lam, 2007). Stress is reported as a main risk factor that leads to adverse health outcomes among professional drivers, especially cardiovascular disease and gastrointestinal disorders (Henry & Stephens, 1977; Krantz et al., 1988; Michaels & Zoloth, 1991; Evans, 1994; Aptel & Cnockaert, 2002; Tse et al., 2006).

Another serious stressor is the risk of violent acts (Duffy & McGoldrick, 1990). Bus operators are at potential risk of exposure to work-related violence as part of the requirement to interact with passengers. Work-related violence has become an overwhelming occupational health and safety issue (NIOSH, 1996; Essenberg, 2003; Chappell & Di Martino, 2006; Couto et al., 2009; Harrell, 2011) and, although there have been some studies focused on work-related violence including those that have addressed on healthcare workers (Gerberich et al., 2002; Viitasara et al., 2003; Findorff et al., 2004; Gerberich et al., 2004; Gerberich et al., 2005) and educators (Gerberich et al., 2011; Nachreiner et al., 2012; Wei et al., 2013; Gerberich et al., 2014), research focused on work-related violence against bus operators is limited.

According to occupational employment estimates provided by the Bureau of Labor Statistics in 2013, 157,830 were employed as bus, transit, or intercity drivers in the United States (Bureau of Labor Statistics (BLS), 2014a); 2,910 employees were represented in these occupations in Minnesota (Bureau of Labor Statistics (BLS), 2014b). Although prevalence of employment in these occupations is known, little is known about occupational injury, including violent events, among the employees who work in these jobs. While there is limited literature pertinent to bus operators' occupational injuries, the injury rates and related risk factors have not been adequately investigated.

In addition, numerous studies focused on bus operators' occupational diseases have provided a basic understanding for this study. The objective of this study was to provide a more comprehensive understanding of the magnitude, potential risk factors, and protective factors that may be associated with occupational injuries (both unintentional and intentional injuries) among bus operators and can serve as a basis for possible intervention strategies to reduce injuries. It also serves as a model for future studies to investigate occupational injuries as well as inform the development of relevant interventions to improve bus operators' health.

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CHAPTER II

LITERATURE REVIEW

DATA ON THE PROBLEM – AN OVERVIEW

Professional Driving and Unintentional Injury

Driving professionally has been recognized as a high risk occupation (Kompier et al., 1990; Evans, 1994; Tse et al., 2006). This has been further confirmed by the Bureau of Labor Statistics (BLS) through reported nonfatal occupational injury and illness cases involving days away from work or job transfer/restriction (Bureau of Labor Statistics (BLS), 2009; Bureau of Labor Statistics (BLS), 2010; Bureau of Labor Statistics (BLS), 2011; Bureau of Labor Statistics (BLS), 2012). In 2009, the BLS initiated the category of "bus drivers, transit and intercity;" since then, this occupational category has been associated with the highest incidence rates, followed by "police and sheriff's patrol officers." The incidence rates per 10,000 full-time workers and median days away from work from 2009 to 2012 are summarized in **Table 1 to Table 3**. The incidence rate among "bus drivers, transit and intercity" was slightly decreased in 2010; however, on average, the incidence rates were increasing and were approximately five to seven times greater than for all occupations combined. The average median days away from work was 17.2 days from 2009 to 2012 – nearly two times higher than for all occupations combined (8.2 days) (**Table 1**). The nature of injury incidence rates were high, especially for sprains, strains, and tears, which were eight to 10 times higher than all occupations combined. In addition, musculoskeletal disorder incidence rates were four to eight times higher than for total occupations combined. Additional rates by nature of injury are shown in **Table 2**. **Table 3** identifies the incidence rates by events leading to injury; the "fall to same level" category appeared to have high incidence rates, which were three to six times higher than for all occupations combined.

Professional Driving and Intentional Injury

Work-related or workplace violence has been an important issue for occupational safety (NIOSH, 1996; Essenberg, 2003; Chappell & Di Martino, 2006; Harrell, 2011). According to findings from the National Crime Victimization Survey (NCVS) in 2009, there were 572,000 nonfatal violent events (including sexual assault, robbery, and aggravated and simple assault) reported for those who were at work or on duty; 521 were reported as victims of work-related homicides (Harrell, 2011). However, the nonfatal workplace violence rate has decreased by 35% from 2002 to 2009. In particular, for bus drivers, the average annual work-related violence rate from 2005 to 2009 was 10.0, much higher than for the total occupations combined (5.1 per 1,000 persons) (Harrell, 2011).

In 2009, the Bureau of Labor Statistics (BLS) reported that the "assaults and violence acts by person" incidence rates per 10,000 full-time workers for the category of "bus driver, transit and intercity" was five times greater than for all occupations combined (19.0 versus 3.9) (Bureau of Labor Statistics (BLS), 2010). In 2010, it was three times greater (11.9 versus 4.0) (Bureau of Labor Statistics (BLS), 2011). Subsequently, in 2011, when the BLS reporting changed the name of the violence category from "assaults and violence acts by person" to "intentional injuries by other person," the incidence rate per 10,000 full-time workers was 13 times greater than for all occupations combined (36.6 versus 2.8) (Bureau of Labor Statistics (BLS), 2012) and, in 2012, it was 16 times greater (46.5 versus 2.9) (Bureau of Labor Statistics (BLS), 2013). These rates, noted to increase by year, between 2009 and 2012, are summarized in **Table 4.**

POTENTIAL RISK FACTORS

Work-related Stress and Health

In the past decades, bus drivers have been described as having the worst overall health status (Winkleby et al., 1988; Kompier et al., 1990; Evans, 1994; Tse et al., 2006). Several epidemiology studies have shown that bus operators are at high risk of experiencing three main physical health problems: cardiovascular disease; gastrointestinal disorders; and musculoskeletal problems (Backman, 1983; Winkleby et al., 1988; Evans, 1994; Tse et al., 2006). Among those, stress has been identified as a primary factor associated with cardiovascular disease and gastrointestinal disorders (Henry & Stephens, 1977; Krantz et al., 1988; Evans, 1994; Tse et al., 2006). Italian transport drivers and conductors were reportedly five times more likely to experience digestive problems than transport laborers and office workers (Berlinguer, 1962). One of the associations with these conditions in bus operators was job-related stress. In addition, work-related musculoskeletal disorders (WMSDs) can also be affected by psychosocial risk factors (Bovenzi & Zadini, 1992; Tse et al., 2006). Psychosocial factors include job satisfaction, ability to handle stress, and psychological status (Aptel & Cnockaert, 2002). Study results have suggested that low job control and lack of social support were associated with musculoskeletal problems (Bongers et al., 1993).

Karasek's demand-control model (Karasek, 1979; Karasek & Theorell, 1992) suggested four different kinds of psychological work experiences that were illustrated by two dimensions: high or low job demand and high or low job control (**Figure 1**). Job demands, or workload demands, represent the quantitative workload in the working environment, such as pace of work, time pressure, and reaction time required. Job decision latitude, or job control, is the decision authority or skill level on the job. The four job categories are high strain, low strain, active, and passive. A high strain job has a combination of high demands and low control. The combination of heavy job demands and low job decision is associated with mental strain as well as job dissatisfaction (Karasek, 1979). Bus operators' stress may result from their irregular working shifts, strict time schedules, working alone, social isolation and poor social support. They often engage in multiple activities in which operators of other vehicles do not. They not only need to take care of passengers' inquiries, assist disabled/elderly passengers, deal with riders evading fare payments, but also focus on the traffic/road conditions. Fatigue can also result from their working conditions. Bus operators' duty periods and shifts are often longer than those for other occupations, causing them to work continuously without rest or meal breaks; as a result, it may cause an individual to take a longer time to respond to even simple tasks.

As noted, the working characteristics that include irregular shifts, strict time schedules, break times, and bus incidents, are work-related stressors for bus operators. A potentially greater stressor is the risk of violent acts (Duffy & McGoldrick, 1990; Kompier, 1996; Essenberg, 2003; Sampaio et al., 2009). In particular, a work-related stressor survey among male bus operators indicated that the number one concern for them was the possibility of getting assaulted (Duffy & McGoldrick, 1990). Therefore, in terms of working conditions and working environments, bus operators would be considered to be classified in an occupational position involving high job demand with low job control (Karasek, 1979; Tse et al., 2006). Thus, driving a bus professionally is a high stress occupation.

Work-related Exposures and Health

Because city buses are in operation from early morning to late night, bus operators usually work in shifts. Therefore, in addition to work-related stress, shift work is another potential risk factor for health problems among professional bus operators. From various studies, it has been reported that these operators have a high risk of cardiovascular disease, hypertension, gastrointestinal disorders and musculoskeletal problems, as well as psychological health issues, including fatigue, depression and anxiety (Netterstrøm & Juel, 1988; Evans, 1994; Hannerz & Tüchsen, 2001; Szeto & Lam, 2007). In addition, professional drivers have been found to be at high risk of developing WMSDs due to prolonged sitting and being constrained to their cabin (Bovenzi & Zadini, 1992; Szeto & Lam, 2007). Moreover, bus operators who have had longer driving years have associated long-term vibration exposure (with more than 4.5 years m^2 s^{-4} total vibration dose); as a result, higher odds ratios have been reported among them for all types of low back pain symptoms, low back pain, and disc protrusion, compared to those not exposed to whole body vibration, such as mechanics, electricians, and general operators (Bovenzi & Zadini, 1992).

By being constrained in their seats, bus operators are also exposed to harmful substances in their cabin, and are at risk of cancer (Soll-Johanning et al., 1998; Hansen et al., 2004). Results from a cohort study suggested that bus operators had an increased risk for developing air-pollution-related types of cancers (Soll-Johanning et al., 1998). Another study in Denmark indicated bus operators were more likely to be exposed to polycyclic aromatic hydrocarbons (PAH), nitro-PAH, and other carcinogenic and mutagenic compounds from traffic (Hansen et al., 2004). Reports from BLS also reported that bus operators were highly exposed to harmful substances; incidence rates were three to 13 times greater than for all other occupations in the United States. **Table**

5 identifies rates for exposures to harmful substances or environments from 2009 to 2012.

It has also been suggested that urban bus operators retire earlier than other occupational groups, often due to physical disabilities that require disability compensation (Mulders et al., 1982; Kompier et al., 1990; Evans, 1994; Tse et al., 2006). A study conducted in the Netherlands reported that bus operators were disabled and had to leave their job at younger ages (mean age, 47 years), compared to other civil servants, such as firemen (53 years), policemen (55 years), and craftsmen (54 years) (Kompier et al., 1990).

Work-related Characteristics and Unintentional Injury

In a Handbook of Occupational Health and Wellness, published in 2012 (Gatchel & Schultz, 2012), one of the chapters summarized some literature regarding work-related health and safety risks, based on adverse work schedules (Geiger-Brown & Trinkoff, 2012). The author indicated several work-related characteristics of adverse work schedules, which included shift work, shift rotation, and early start times. As noted, bus operators are involved in all of these types of working conditions. Several previous studies in various occupations indicated that rotating and irregular work shifts were associated with higher risk of work-related injury (Frank, 2000; Horwitz & McCall, 2004; Dong, 2005; Dembe et al., 2006; De Castro et al., 2010; Salminen, 2010; Choobineh et al., 2011; Geiger-Brown & Trinkoff, 2012). Bus operators' duty periods and shifts are often longer than other occupations and frequently result in continuous work without rest or meal breaks. Longer working hours has been suggested as a risk factor for occupational injuries and illnesses among a variety of occupations (Caruso et al., 2004; Dembe et al., 2005; Dong, 2005; Dembe et al., 2007; Dembe et al., 2008; De Castro et al., 2010; Geiger-Brown & Trinkoff, 2012). The National Longitudinal Survey of Youth (NLSY) between 1987 to 2000 suggested that higher hazard rates for occupational injuries and illnesses were found for those who work more than 60 hours per week, more than 12 hours per day, and overtime, when adjusted for age, gender, occupation, industry, and region (Dembe et al., 2005). Another study using the same NLSY survey for a 1979 cohort (NLSY79) of construction workers suggested overtime (working more than eight hours per day and more than 40 hours a week) and irregular work scheduling were risk factors for workers' safety (Dong, 2005).

As noted, bus operators have been reported to have a high prevalence of WMSDs (Evans, 1994; Tse et al., 2006; Szeto & Lam, 2007). The fact that the operators are exposed to prolonged sitting, vibration, and being constrained for long periods to their cabin, may contribute to increased physical loading in the musculoskeletal system — resulting in back pain (Bovenzi & Zadini, 1992; Szeto & Lam, 2007).

Work-related Characteristics and Intentional Injury

The bus operator works and interacts with passengers alone on the bus without social support from colleagues or managers. Work alone has been defined as a risk factor for experiencing workplace violence (Viitasara et al., 2003). A self-report study in a transportation company found that 75% of bus operators and money collectors reported violent events in their work environment (Sampaio et al., 2009); in particular, 43% of bus operators reported assaults involved with weapons on the bus. In addition, a cross-sectional study survey among drivers and conductors in the passenger transport sector reported that, compared to taxi drivers, bus drivers were 3.5 times more likely to experience workplace violence (Couto et al., 2009). Thus, bus operators are one of the occupations at high risk of workplace violence.

Numerous studies have focused on work-related violence in different occupations, such as health sectors, including veterinarians and nurses (Gabel & Gerberich, 2002; Gerberich et al., 2002; Viitasara et al., 2003; Findorff et al., 2004; Gerberich et al., 2004; Gerberich et al., 2005) and educators (Gerberich et al., 2011; Nachreiner et al., 2012; Wei et al., 2013; Gerberich et al., 2014). Workplace violence includes physical assaults (PA) and non-physical violence (NPV). PA occurs when employees are hit, slapped, kicked, or otherwise subjected to physical contact; NPV includes threats, verbal abuse, sexual harassment, and bullying. Studies have indicated that while PA was an important problem in major populations of nurses and educators, higher risks for NPV were identified (Gerberich et al., 2004; Gerberich et al., 2011; Wei et al., 2013). The types of reported violence against bus operators included only physical assault; thus, the objective of this study was to determine the magnitude and risks between occupational exposures and workplace physical assault among urban transit bus operators.

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Table 1. Incidence Rates for Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work per 10,000 Full-Time Workers, 2009-2012, BLS

	Bus drivers, Transit and Intercity		Total Occupation	
	Incidence Rate per 10,000 Full-time workers	Median Days away from Work	Incidence Rate per 10,000 Full-time workers	Median Days away from Work
2009	735.7	16	117.2	8
2010	614.6	18	117.9	8
2011	746.3	16	117.3	8
2012	815.5	19	112.4	9

Table 2. Incidence Rates for Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work per 10,000 Full-Time Workers by Nature of Injury, 2009-2012, BLS

	Sprains, Strains, Tears		Fractures		Cuts, Lacerations, Punctures		Bruises, Contusions	
Year	Bus drivers, Transit and Intercity	Total Occupation	Bus drivers, Transit and Intercity	Total Occupation	Bus drivers, Transit and Intercity	Total Occupation	Bus drivers, Transit and Intercity	Total Occupation
2009	392.3	46.7	8	8.5	24.6	9.2	72.1	10.7
2010	302.3	46.9	11.2	8.5	12.2	9.1	69.9	9.9
2011	330.4	44.4	33.3	9.1	13.8	7.7	112.7	10.2
2012	451.3	43.2	17.4	8.2	20.1	9.6	62.5	9.5

Table 3. Incidence Rates for Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work per 10,000 Full-Time Workers by Events Leading to Injury, 2009-2012, BLS

Year	Struck by Object		Struck Against Object		Caught in or Compressed or Crushed		Fall to Lower Level		Fall to Same Level		Slips or Tips without Fall		Repetitive Motion	
	Bus*	Total†	Bus*	Total†	Bus*	Total†	Bus*	Total†	Bus*	Total†	Bus*	Total†	Bus*	Total†
2009	25.6	5.0	15.5	3.9	10.2	4.6	40.6	7.5	85.7	17.7	30.6	4.6	18.2	3.4
2010	23.3	13.7	37.4	8.2	6.0	4.5	13.9	7.3	61.1	18.0	13.2	3.8	10.8	3.5
2011	23.1	15.3	24.2	6.4	8.9	3.7	20.3	5.6	119.9	18.2	18.0	4.8	7.2	3.4
2012	16.1	14.3	51.3	6.1	5.3	3.7	11.0	5.4	71.0	16.8	21.3	4.7	17.5	3.0

* Bus: Bus drivers, Transit and Intercity

† Total: Total Occupation

Table 4. Incidence Rates for Nonfatal Occupational Injuries and Illnesses Requiring Days Away from Work per 10,000 Full-Time Workers by Assaults and Violence Acts, 2009-2010, BLS

Year	Assaults and Violent Acts (Total)		Assaults and Violent Acts (By Person)		Year	Violence and other injury by persons or animal		Intentional Injury By Other Person	
	Bus*	Total†	Bus*	Total†		Bus*	Total†	Bus*	Total†
2009	33.4	4.9	19	3.9	2011	51.6	7.3	36.6	2.8
2010	12.8	4.9	11.9	4	2012	65.2	7.2	46.5	2.9

* Bus: Bus drivers, Transit and Intercity

† Total: Total Occupation

Table 5. Incidence Rates for Exposures to Harmful Substances or Environments Requiring Days Away from Work per 10,000 Full-Time Workers, 2009-2012, BLS

	Exposure to Harmful Substances or Environments	
	Bus drivers, Transit and Intercity	Total Occupation
2009	49.2	5.2
2010	17.3	5.2
2011	28.9	4.8
2012	65.5	5.0

Table 6. Summary of Literature for Bus Operators and Overall Occupations: Unintentional Injury and Ilness

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
Backman, A.	1983	To investigate the health hazards of professional drivers in the transportation sector To clarify the physical and mental demands and the stress factors associated with work To determine the factors which affect occupational turnover in these occupations	633 Male drivers included local bus drivers, long-distance bus drivers, stock delivery drivers, truck drivers, and tank truck drivers.	Cross-sectional health survey between 1979 and 1980 This study examined the participants' earlier diseases; accidents; back trouble; stomach symptoms; neck, shoulder and limb symptoms; chest pains; respiratory symptoms; and smoking status. The turnover information was collected by asking the drivers what task they performed at the time and the reason they left the position. Descriptive analyses were applied.	The most common health problems for professional drivers were shoulder and back pain Common complaints were dyspepsia and stomachache The most common reasons for early retirement were cardiovascular disease, back symptoms, and disability following some crash events. Bus drivers had the highest frequencies of back trouble, angina pectoris, hypertension, and stomach ulcers.
Bovenzi, M., Zadini, A.	1992	To investigate the prevalence of several types of low back symptoms	436 Urban bus drivers worked on January 1, 1980 at a public transport	Self report by using a modified version of the standardized Nordic questionnaire on	The Odds Ratios (ORs) for the occurrence of low-back symptoms during lifetime, within 12 months,

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
		among bus drivers	company in Italy. The control group involved the maintenance workers who worked at the same company (N=240).	musculoskeletal symptoms Vibrations were measured on the vehicles during driving periods in which task was performed. Student's T test, Chi-square statistics, and multivariate logistic analysis were performed. Data analyses were applied by using GLIM system and the BMDP software	and 7 days among bus drivers were 2.61, 2.54, and 1.98, respectively, compared to the control group. When total vibration dose was more than 4.5 m^2 / s^4 there were significant ORs for low back symptoms, leg pain, acute low back pain, low back pain, disc protrusion. The associations between low back symptoms and both equivalent vibration magnitude and total exposure time, were statistically significant.
Choobineh, A., Soltanzadeh, A., Tabatabaee, H., Jahangiri, M., Neghab, M., Khavaji, S.	2011	To compare psycho-social problems among employees working different 12-hour shift schedules in Iranian petrochemical industries	549 shift workers	Cross-sectional study 8 petrochemical companies in Asalooyeh, Iran from 2009 to 2010. Anonymous self-report questionnaire by using Survey of Shiftwork (SOS) questionnaire. This study examined the participants' individual circumstances, shift	Psychosocial problems among 7D-7N-7R (7 days-7 nights- 7 rests) scheduled shift workers were significantly more prevalent than for those with other schedules.

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
				schedule details, and health outcomes. One-way ANOVA and Chi-square test were applied by SPSS 11.5	
De Castro, A., Fujishiro, K., Rue, T., Tagalog, E., Samaco-Paquiz, L., Gee, G.	2010	To determine the association between nurses' work characteristics, over and above long work hours, and work-related injury and illness.	655 RN in Philippines	Cross-sectional study Data were collected by questionnaire, information included work hours, shift length, shift, frequency of overtime, number of overtime hours worked per month, work-related injury in the past year, work-related illness in the past year, and missed work for more than two days due to work-related injury or illness. Descriptive statistics analysis and multivariate logistic regression models were conducted with STATA statistical software.	Nurses who work in non-day shifts are at higher risk for occupational injury and illness, and the more frequently a nurse works mandatory or unplanned overtime, the greater the odds of experiencing a work-related injury or illness, and missing work. These significant associations were observed even after hours worked per week and shift length were accounted for. This suggests that non-day shifts and mandatory/unplanned overtime negatively correlate with nurses' health, independent of working long hours.

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
Dembe, A. E., Delbos, R., Erickson, J. B.	2008	To estimate the risk of nonstandard shifts and long-hour schedules among various occupations. To estimate the extent of that risk among various occupations and industries.	10,793 Americans participating in the National Longitudinal Survey of Youth (NLSY)	The National Longitudinal Survey of Youth, 1979 cohort (NLSY79) The NLSY cohort is comprised of 12,686 men and women who were 14–22 years of age when first surveyed in 1979. Follow up interviews with NLSY respondents have been conducted annually from 1979 to 1994 and, biannually, since 1996. This study examined the experience of these individuals between 1987 and 2000. Attempts were made to re-interview every remaining cohort member at each survey. Cox proportional hazards regression analyses were performed to calculate Hazard Ratios and 95% Confidence Intervals.	The greatest risks of job-related injury were among: 1) Construction workers in evening shifts; 2) Professional, technical, and managerial personnel working overtime schedules; 3) Employees working overtime shifts in the business and repair services sectors.
Dembe, A. E., Delbos, R., Erickson, J. B.,	2007	To examine the effect of long-hour work schedules and	10,793 Americans participating in the National Longitudinal	Population-based survey The NLSY cohort is comprised of 12,686 men	The majority reporting injuries involved musculoskeletal disorders

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
Banks, S. M.		non-standard shift work on the ability of injured workers to maintain productivity following workplace injury	Survey of Youth (NLSY)	and women who were 14–22 years of age when first surveyed in 1979. Follow up interviews with NLSY respondents have been conducted annually from 1979 to 1994, and biannually since 1996. Multiple logistic regression models were performed to calculate Odds ratios and 95% confidence interval.	or traumatic injuries (e.g., cuts, bruises, and fractures). Compared to Injured workers in positions with conventional schedules, nonstandard scheduled injured workers were more likely to quit their job (OR=1.68, [1.20-2.36]), or were fired (OR=1.81, [1.15-2.90]). A greater impact on vocational consequences, following a workplace injury, was found when working schedules involved overtime and long working hours, versus night, evening, and other nonstandard shift work.
Dembe, A. E., Erickson, J. B., Delbos, R. G., Banks, S. M.	2005	To analyze the impact of overtime and extended working hours on the risk of occupational injuries and illnesses among a nationally representative sample of working	10,793 Americans participating in the National Longitudinal Survey of Youth (NLSY)	Population-based survey The NLSY cohort is comprised of 12,686 men and women who were 14–22 years of age when first surveyed in 1979. Follow up interviews with NLSY respondents have been conducted annually	After adjusting for those factors, working in jobs with overtime schedules was associated with a 61% higher injury hazard rate compared to jobs without overtime. Working at least 12 hours per day was associated

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
		adults from the United States		from 1979 to 1994, and biannually since 1996. Multivariate analyses were performed to estimate the relative risk of long working hours per day, extended hours per week, commute times, and overtime on work-related injury or illness.	with a 37% increased hazard rate and working at least 60 hours per week was associated with a 23% increased hazard rate. A strong dose-response effect was observed, with the injury rate (per 100 accumulated worker-years in a particular schedule) increasing in correspondence to the number of hours per day (or per week) in the workers' customary schedules.
Dembe, A. E., Erickson, J. B., Delbos, R. G., Banks, S. M.	2006	To determine the association between various types of nonstandard shift schedules and the risk of occupational injuries or illnesses.	10,793 Americans participating in the National Longitudinal Survey of Youth (NLSY)	Population-based survey The NLSY cohort is comprised of 12,686 men and women who were 14–22 years of age when first surveyed in 1979. Follow up interviews with NLSY respondents have been conducted annually from 1979 to 1994, and biannually since 1996 Cox proportional hazards	After adjusting for age, gender, occupation, industry, and region, hazard ratios were 1.43 [1.26-1.62] for evening shifts, 1.36 [1.17-1.58] for rotating shifts, 1.30 [1.12-1.52] for night shifts, 1.15 [1.03-1.06] for irregular shifts, and 1.06 [0.71-1.58] for split shifts. The results indicated that nonstandard shifts were not more risky merely

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
				regression analyses were performed to calculate Hazard Ratios and 95% Confidence Intervals.	because of the concentration of hazardous jobs in those types of schedules or because of underlying differences in the characteristics of employees working nonstandard shifts.
Dong, X.	2005	To examine work scheduling in construction To establish whether there is any connection between work hours and safety outcomes among construction workers	2100 construction workers 8740 people in other industries	The National Longitudinal Survey of Youth, 1979 cohort (NLSY79) from 1992 through 1998 Multiple logistic regression models were performed to estimate the association between long work hours and worker safety after control for potential confounding factors.	The findings showed that (i) construction workers started work earlier, worked longer days and fewer weeks a year, and were more likely to hold multiple jobs and change jobs than their non construction counterparts and (ii) Long work hours and irregular work schedules were significantly associated with a higher work-related injury rate after controlling for possible confounders.
Evans, G. W.	1994	Critical review of findings on urban bus drivers' health status, and focus on the physical and	Urban bus operators	Review: published literature	Urban public transport operators have higher morbidity and mortality rates from stress-related health problems,

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
		psychosocial job environment that may cause health problems.			especially cardiovascular and gastrointestinal disorders. City bus drivers were likely to retire early from stress-related illnesses or from musculoskeletal problems, and retire with some medical disability. Public transportation operator's working conditions resulted in high workload demands and low job controls. The job characteristics have been shown to be strongly associated with cardiovascular disease.
Frank, A. L.	2000	To review the relation of shift work to industrial injuries, and possible methods of injury control.	3489 citations and 79 articles; 7 were found suitable for analysis	Review: published literature Studies from peer-reviewed journals, technical reports, and government reports	Fixed shifts are believed to be preferable to rotating shifts When rotating shifts are used, the general consensus in the literature favors rapid to slower rotations Longer workdays, either 10- or 12-hour shifts, seem no more hazardous than the more usual 8-hour

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
					workday. It should be evident that more and better-focused research is needed in this field of study.
Geiger-Brown, J. M., Trinkoff, A. M.	2012	To review the role of work schedules in occupational health and safety	Research literature about health and safety risks of adverse schedules	Review: published literature.	Adverse work schedules include included shift work, shift rotation, and early start times, which increase the risk for adverse events, injuries, errors, acute health conditions and the development of chronic health problems.
Hannerz, H., Tüchsen, F.	2001	To elucidate the disease pattern among male professional drivers in Denmark	Cohort of all 20-59 year old Danish male professional drivers.	Age-standardized hospital admission ratios (SHRs) were calculated from the Danish National Institute of Occupational Health on hospital admissions database The database used was the occupational hospital admissions register, which is a research register with data at the individual level on occupations, hospital admissions, and dates of	SHR for infectious and parasitic diseases (RR=1.86 [1.36-2.51]) and, diseases of the circulatory system (RR=1.30 [1.15-1.48]) were significantly higher among drivers of passenger vehicles compared to drivers of goods vehicles

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
				migration, and deaths. The SHR was calculated by dividing the observed number of hospital admissions by the expected number. The expected number was obtained from the hospital admission rates (age specific) for all employed men in Denmark.	
Hansen, A. M., Wallin, H., Binderup, M. L., Dybdahl, M., Autrup, H., Loft, S., Knudsen, L. E.	2004	To evaluate 1-hydroxypyrene concentrations, which is a marker of exposure to polycyclic aromatic hydrocarbons (PAH), and mutagenic activity in urine as biomarkers of exposure in non-smoking bus drivers in city and rural areas on a work	Bus drivers and mail carriers	The Twenty-four hour urine samples were collected on a working day and a day off from 60 non-smoking bus drivers in city and rural areas and from 88 non-smoking mail carriers working outdoors (in the streets) and indoors (in the office). Variance component models with backwards selection were used to	Bus drivers had more 1-hydroxypyrene in urine than mail carriers. Male bus drivers had 0.92 [CI=0.37-1.47] revertants/mol creatinine and female bus drivers 1.90 revertants/mol creatinine [CI= 1.01-2.79] higher mutagenic activity in urine than mail carriers. Mail carriers who worked outdoors had higher urinary concentration of 1-

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
		day and a day off in non-smoking mail carriers working outdoors (in the streets) and indoors (in the office).		estimate effects from exposure group on different variables (e.g. urinary 1-hydroxypyrene and mutagenic activity).	hydroxypyrene than those who worked indoors.
Horwitz, I. B., McCall, B. P.	2004	To derive and compare the rates, typologies, costs and disability times of injuries for various hospital worker occupations by day, evening and night shift.	Between 1990 and 1997, there were 7717 compensable workers' compensation claims filed by hospital employees in the state of Oregon, averaging ~965 claims annually.	Oregon hospital employee claim data; hospital employment data from Oregon's Labor Market Information System Multivariate linear regression model was performed to estimate whether total claim costs and lost workdays depended on age, gender, shift, occupation, or other variables.	Evening and night shift hospital employees were found to be at greater risk of sustaining an occupational injury than day shift workers, with those on the night shift reporting injuries of the greatest severity as measured by disability leave. Staffing levels and task differences between shifts may also affect injury risk.
Salminen, S.	2010	To examine the effect of shift work and extended working hours on occupational injury	Review of literature Studies included morning, afternoon, and night shift injury rates Studies included extended working days	To review published in English peer-reviewed journals	Shift work increased the risk of occupational injury in the United States, but not in other countries.

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
Soll-Johanning, H., Bach, E., Olsen, J. H., Tüchsen, F.	1988	To investigate the risk of cancer associated with exposure to air pollution	Bus drivers and tramway employee	A retrospective cohort study: data (personal and occupational information) were collected from company files and Danish Cancer Registry National incidence rates and standardized incidence ratios were calculated according to sex, age, and calendar period.	Increased risk of all malignant neoplasms were found in bus drivers or tramway employees: The standardized incidence ratio (SIR) was 1.24 (95%C.I.=1.19-1.30) Men who worked more than three months had increased risks of lung, laryngeal, kidney, bladder, skin, pharyngeal, rectal and liver cancer. Increased risks of lung cancer were found in women employed more than three months.
Szeto, G. P. Y., Lam, P.	2007	To investigate the prevalence and characteristics of work-related musculoskeletal disorders (WMSD) among bus drivers in Hong Kong	Bus drivers who operated double-deck buses in Hong Kong	Questionnaire survey and physical assessment Two sample t tests and Chi-square tests were used to compare the prevalence of musculoskeletal discomfort between groups. Backward stepwise logistic regression models and linear mixed models were performed	Neck, back, shoulder and knee/thigh areas had the highest 12-month prevalence rates About 90% of the discomfort was work-related. Occupational factors of prolonged sitting and anthropometric mismatch were perceived to be most related to musculoskeletal

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
				to determine the association between musculoskeletal discomfort and risk factors.	discomfort. On physical examination, grip strength was significantly related to neck and shoulder discomfort.
Tse, J. L. M., Flin, R., Mearns, K.	2006	To review the key research on the occupational health of urban bus drivers	Urban bus drivers	Review of literature since 1950s	Work-related stressors for bus operators include poor cabin ergonomics, rotating shifts, and inflexible working/driving times, which resulted in certain physical, psychological and behavioral outcomes.

Table 7. Summary of Literature for Occupational Injury: Workplace Violence

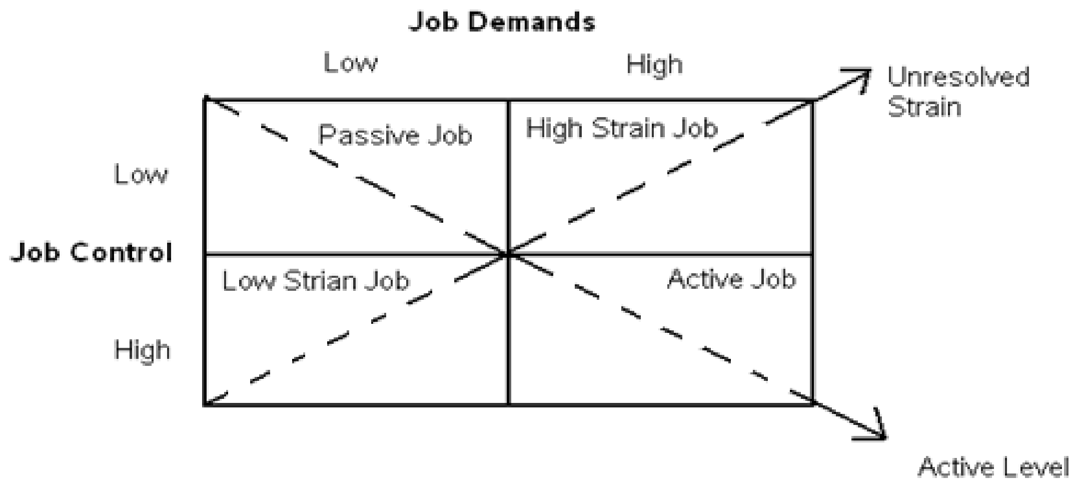
Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
Couto, M. T., Lawoko, S., Svanstrom, L.	2009	To examine the risk factors for workplace violence among the road passenger transport sectors in Mozambique	Road passenger transport drivers included: bus drivers; bus conductors; mini-bus drivers; mini-bus conductors; and taxi drivers A total of 504 participants were randomly sampled from a population of 2,618 registered bus, minibus, and taxi drivers/ conductors.	Cross-sectional study Questionnaire survey for socio-demographic characteristics, literacy level, occupational experience, organizational changes, work environment, health conditions, consequences, and burnout. Chi-square tests and t-tests were performed to determine the associations between violence events and exposures of interest.	Among 504 participants, 77.4% of participants reported to have experienced workplace violence Most frequent type of violence was verbal abuse/aggression, unpleasant experiences, and pushing Bus drivers (OR=3.5, P<0.05) and bus conductors (OR=3.5, P<0.05) had higher risks of workplace violence than taxi drivers. Supervisor had a higher risk of workplace violence (OR=4.0, P<0.001) than those without supervisory roles
Findorff, M. J., McGovern, P. M., Wall, M., Gerberich, S. G., Alexander, B.	2004	To identify the effect of job, family, patient contact, and supervisor on physical and	Employees in a Midwest health care organization	Cross-sectional study Questionnaire survey Multivariate analysis of physical violence was performed to determine the risk of each	7.2% of employees experienced physical assault and 30.6% experienced non-physical violence Increased physical violence risks

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
		non-physical work related violence		exposure—Odds ratios and 95% confidence intervals were calculated	were found among patient care assistants (odds ratio (OR) = 2.5, 95% CI= 1.1-6.1) and decreased risks for clerical workers (OR= 0.1, 95% CI=0.03-0.5). Increased odds of physical violence were identified for moderate (OR=5.9, 95% CI= 2.1-16.0) and high (OR=7.8, 95% CI= 2.9-20.8) patient contact, after adjusting for job family. Similar trends were identified for non-physical violence: moderate (OR= 1.4, 95% CI= 1.1-2.0 and high (OR= 1.7, 95% CI=1.3-2.3) patient contact, after adjusted for job family.
Gerberich, S.G.; Nachreiner, N.M.; Ryan, A.D.; Church, T.R.; McGovern, P.M.; Geisser, M.S.; Mongin, S.J.; Watt, G.D.; Feda, D.M.; Sage, S.K.;	2011	To identify the magnitude and risk factors for work-related occupational physical assault (PA)and nonphysical violence (NPV)	Minnesota licensed kindergarten to 12th grade educators	Population-based questionnaire Survey included: demographic and work-related information; work-related violence events. Generalized linear models were performed to calculate incidence rates for both physical assault and non-physical violence. Logistic regression models were performed to calculate Odds ratios and 95%	Adjusted PA and NPV rates were 8.3 and 38.4 per100 educators Decreased risk of PA was found for educators who taught grades 3 to 12 vs. kindergarten to grade 2. In contrast, those who taught grades 3 to 12 had increased risks for NPV.

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
				confidence intervals in order to determine the strength of the associations between exposures and outcomes.	
Gerberich, S.G.; Church, T.R.; McGovern, P.M.; Hansen, H.E.; Nachreiner, N.M.; Geisser, M.S.; Ryan, A.D.; Mongin, S.J.; Watt, G.D.	2004	To identify the magnitude of and potential risk factors for workplace violence among nurses	Minnesota licensed registered (RNs) and practical (LPNs) nurses	Population-based questionnaire Generalized linear models were performed to calculate incidence rates for both physical assault and non-physical violence. Multiple logistic regression models were performed to calculate Odds ratios and 95% confidence intervals in order to determine the strength of the associations between exposures and outcomes.	Adjusted rates per 100 persons per year for physical and non-physical violence were 13.2 (95%C.I=12.2-14.3) and 38.8 (95%C.I=37.4-40.4) after adjusted for age, gender, license type, and home address Assault rates were 16.4 in LPNs and 12.0 for RNs Non-physical violence rates were 38.5 among RNs, and 39.4 among LPNs Patients/clients were the most reported source of perpetrators (97% and 67%, respectively).
Harrell, E.	2011	To understand the trend of workplace violence	National households	National crime victimization survey (NCVS), can be found in: http://www.bjs.gov/index.cfm?ty=dcdetail&iid=245 Workplace violence rates by occupation were generated from the occupation categories on the screening questionnaire.	There were 572,000 nonfatal violent events (including sexual assault, robbery, and aggravated and simple assault) reported for those who were at work or on duty; 521 were reported as victims of work-related homicides. The nonfatal workplace violence rate was reduced by 35% from

Author(s)	Year	Purpose of Study	Population	Methods	Findings, Conclusions
					2002 to 2009.
Nachreiner, N.M.; Gerberich, S.G.; Ryan, A.D.; Erkal, S.; McGovern, P.M.; Church, T.R.; Mongin, S.J.; Feda, D.M.	2012	To investigate risks of work-related physical assault associated with the history of violence	Minnesota licensed kindergarten to 12th grade educators	Population-based questionnaire Multiple logistic regression models were performed to calculate Odds ratios and 95% confidence intervals, in order to determine the effect of the respective exposures of interest on the outcome of physical assault.	Increased risks were found among educators who had prior histories of work-related (OR=17.3, 95%CI=11.4-26.3) or non work-related physical assault (OR=2.0, 95%CI=1.2-3.5).
Viitasara, E., Sverke, M., Menckel, E.	2003	To examine the violent events among various professional groups in Sweden	Municipal health and welfare sector employees in Sweden Administrators, nursing specialists, supervisors, direct caregivers, nursing auxiliaries, assistant nurses, and personal assistants	Questionnaire survey - information included: violence and threats of violence; individuals' characteristics; work-related characteristics; types of consequences of violence Chi-square tests were used to determine the differences between exposures and outcome Logistic regression models were performed to identify the associations between exposures and outcome	The most frequently exposed to threats/violence were direct caregivers (61.6%) and assistant nurses (60.7%) Greater risks were found among those who were working full-time, working alone, and had high workloads.

Figure 1. Karasek's Demand-Control Model



CHAPTER III

RESEARCH DESIGN AND METHODS

SPECIFIC AIMS

The *long-term goal* of this study is to identify how personal and work-related characteristics contribute to the occurrence of work-related injuries, both unintentional and intentional, among bus operators. To accomplish this, the following two *specific aims* for each types of injury (unintentional and intentional injury) were identified:

Aim 1: Determine the magnitude, consequences, and potential risk factors for occupational injuries among bus operators in a metropolitan area.

The hypothesis was that operators' personal demographic information and work-related characteristics adversely affect the occurrence of injuries. This initial effort focused on identification of incidence rates and overall magnitude of the injury problem. This enabled a greater understanding of the extent of the injury problem and how personal demographic information and work-related factors impact this problem among bus operators.

Aim 2: Determine the association between occupational injury and exposures of interest, which included different bus routes, types of buses driven (express or regular bus), shift schedules, workloads (hours worked per day), work experiences (years worked at the transit company as a bus operator) and demographic information.

This hypothesis, that both personal and work-related characteristics affect the risk of injuries among bus operators, was tested through the application of longitudinal data analysis. This was accomplished by determining the associations between occupational injury and exposures of interest to facilitate identification relevant risk and protective factors.

The benefit of this study was the identification of both the magnitude of the problem and the risk factors associated with occupational injuries among bus operators. In turn, this information provided a basis for development of intervention strategies to reduce related injuries. Those factors could serve as a model for investigating occupational injuries among other occupations and developing relevant interventions in the future.

TARGET POPULATION AND STUDY POPULATION

The target population was licensed transit bus operators. According to occupational employment estimations, provided by the Bureau of Labor Statistics, there were 162,840 bus, transit and intercity drivers in the United States (Bureau of Labor Statistics (BLS), 2013b); 3,030 were identified in Minnesota (Bureau of Labor Statistics (BLS), 2013a).

The study population was urban transit bus operators who worked at a transit company in Minnesota during the study period (December 1, 2006 and December 31, 2011). This study population was selected because of the ability to acquire various demographic information and work-related information, including working years, route information, and working schedules from the employer. In addition, this company is a transit division of the Metropolitan Council and one of the major transit companies in Minnesota that provides local transportation services for the Twin Cities. The transit network includes buses, light rail and commuter trains; however, this study focused specifically on bus transportation operators. This transit company operates 123 bus routes — 66 are local-service routes, 51 are express routes, and six are contract service routes; their transportation service locations covers seven counties in Minnesota metropolitan area: Anoka; Hennepin; Ramsey; Washington; Carver; Scott; and Dakota County. Five different garages/facilities were identified (**Figure 1**) (Metro Transit, 2014); each garage is associated with different bus routes due to geographic locations. Within this transit system, employees are organized through the Amalgamated Transit Union (ATU), which is the largest labor organization, representing transit workers in the United States and Canada. Thus, this working population may be generalizable to other comparable operations in metropolitan areas across the United States.

DATA COLLECTION

Available data, between December 1, 2006 and December 31, 2011, were collected from the company. Data information was accessed from two different systems: 1) the Metropolitan Council injury reporting system - STAR; and 2) a transportation scheduling system - HASTUS. In addition, employees' information such as employment start date, end date, birthday, and gender information was collected from the transit company. From the scheduling system, data included the work-related characteristics – job classification (part-time or full-time), working hours per day, driving hours per day, overtime hours per day, bus garage division, work start time, shift schedule, and number of buses driven per day. Injury reports included type of injury — "burn or scald," "caught in or between," "puncture, or scrape," "fall or slip injury," "motor vehicle," "abrasion," "strain," "striking against or stepping on," "struck by;" and injury body part affected — arm, back, chest, hand, head, leg, and shoulder. The various types of information collected from the company were, then, linked by de-identified dummy employee ID and date of birth information.

As a result, 2,095 eligible bus operators who were employed as bus operators during the study period were included in the data analysis. Those who left before December 1, 2006 or entered after December 31, 2011 were excluded from the data analysis. Every eligible bus operator’s daily working information was included for a five-year period; thus, the final dataset contained 1,585,670 observations.

This study was approved by the Institutional Review Board (IRB) at the University of Minnesota. In addition, a data use agreement was completed and co-signed by the Metropolitan Council and Regents of the University of Minnesota (**Appendix A**).

Measurements and Definitions

Dependent variable: Occupational Injury

Definitions used for work-related injury are consistent with the National Center for Health Statistics (NCHS) and Bureau of Labor Statistics (Bureau of Labor Statistics (BLS), 2012). *Work-related injury* is any wound or damage to the body associated with the job that occurs in the work environment; this includes lacerations, fractures, sprains, amputations, and musculoskeletal disorders, among others.

In particular, *unintentional injury* involves unexpected transfer to a person or group of persons of one of the forms of energy (mechanical/kinetic, chemical, electrical, thermal, etc.) in the environment that exceed the threshold of physical tolerance or resilience.

Intentional injury involves intention to harm oneself or others; physical assault (PA) involves acts that use intentional physical force or emotional abuse with the potential for causing physical or emotional injury and consequences against an employee. These definitions, primarily consistent with those incorporated in prior occupational violence studies (Gerberich et al., 2004; Gerberich et al., 2005; Gerberich et al., 2011; Wei et al., 2013; Gerberich et al., 2014), reflect those identified by the National Institute for Occupational Safety and Health (NIOSH, 1996).

A total of 1,389 injury events were reported between December 1, 2006 and December 31, 2011; the associated injury descriptions were reviewed and classified by the investigators, based on the definitions identified above. After eliminating cases that did not meet the requirement (such as non-work-related, or a chronic event), 1,265 unintentional and 88 intentional work-related injury events were included in the data analysis. Examples of injury descriptions from the injury report are shown in **Table 1**.

Independent variables

Personal Characteristics

Transit bus operators' demographic information of age and gender were obtained for this study.

Occupational Characteristics

Bus Garage: The transit company maintained five different garages located in the metropolitan area. Based on their geographic locations, each of the garages had its own associated bus routes.

Job Classification: This included weekday full-time, weekday part-time, and weekend part-time. Weekday full-time operators had 40 hours of work per week guaranteed. Weekday part-time operators could have worked up to 30 hours per week.

Working Years: This involved years worked as a bus operator at the transit company.

Workload: This was a measure of hours of driving and working per day and included bus operators' overtime hours.

Work Shifts: There were two types of shift work in the bus operators' schedules: a straight shift was a regular day shift and a split shift involved the operators' workdays split into two parts.

Number of Bus Routes: Each operator could have had different driving assignments within a day; that is, the operator could have driven one to as many as seven different routes in a given day, depending on the driving assignment of that day.

Types of Bus Routes: There were three types of bus route services: regular-route; limited stops; and express bus service. Limited stop routes had the same route as regular-route, but with less stops. Express buses traveled on freeways for a distance of at least four miles; the bus fare was higher for travel on express, compared to regular and limited stop bus routes.

Work Start Time: This category examined the time that the bus operator commenced working, within a three-hour period of time, at the company during that working day. Eight subcategories of working time commencement were: 3 a.m. to < 6 a.m., 6 a.m. to < 9 a.m., 9 a.m. to < 12 p.m., 12 p.m. to < 3 p.m., 3 p.m. to < 6 p.m., 6 p.m. to < 9 p.m., 9 p.m. to < 12 a.m., and 12 a.m. to < 3 a.m.

CONCEPTUAL/CAUSAL MODELS

A causal model was developed to determine the variables to be measured and controlled for in the overall study analyses (**Figure 2**) (Greenland et al., 1999). From this model, individual Directed Acyclic Graphs (DAGs) were, then, derived to select the minimum set of potential confounding factors for each exposure of interest (Greenland et al., 1999; Hernán et al., 2002). This approach has been used in several previous studies (Gerberich et al., 2001; Gerberich et al., 2002; Gerberich et al., 2004; Gerberich et al., 2005; Gerberich et al., 2011; Wei et al., 2013; Gerberich et al., 2014).

A DAG is a graph that links from cause to outcome with a one-headed arrow, and with no feedback loop. Each DAG reflects an exposure of interest that was used to define variables, a priori, to guide multivariable analyses of the data (Greenland et al., 1999). Thus, adjusted Hazard Ratios (HR) and associated 95% Confidence Intervals (C.I.), per 100 full time equivalents (FTEs), were calculated to determine the strength of the associations between exposures and outcomes of interest. An example of a DAG, used in the multivariate analysis, is presented in **Figure 3**. In this DAG, an adjusted Hazard Ratio (HR) of work start time was calculated after adjustment for age, gender, work years, job classification, work shift, and bus garage. All the DAGS for each exposure of interest are presented in **Appendix B**.

DATA ANALYSIS

Aim 1: Determine the magnitude, consequences, and potential risk factors for occupational injuries among bus operators in the Minneapolis metropolitan area.

Data analysis commenced with descriptive statistics including number of reported events and consequences, as well as characteristics and exposures of interest. The outcome variable (work-related injuries) involved the number of events occurring in a set of observations; in this study, a transit bus operator could have reported more than one injury event during the study period.

Estimates of rates, per 100 Full Time Equivalents (FTEs), and associated 95% Confidence Intervals (C.I.) were generated, using generalized estimating equations (GEEs) (Liang & Zeger, 1986) with exchangeable working correlation matrices. FTEs were calculated by using total number of working hours, within the study period, divided by 2,000 hours (8 hours/day* 5 days/week* 50 weeks/year). GEEs are an extension of generalized linear models (GLMs) to correlated data. GEEs produce marginal models, which enable comparisons between subjects (transit bus operators). In this study, bus operators selected or were assigned their work shifts and schedules three to four times a year; their work-related characteristics could have changed, based on their daily shift assignments. In other words, each observation is based on their assignments per day and could have involved up to 250 observations for each bus operator per year. Therefore, each observation is time-independent and correlated within a bus operator. In the models, each bus operator was considered to be independent. The exchangeable working correlation structure assumes any two observations within a subject (a transit bus operator) have a consistent correlation — that is, every observation has equal correlation with any other observation within an individual. This is the reason why exchangeable working correlations were used in the GEE models for each exposure of interest.

Aim 2: Determine the association between occupational injury and exposures of interest, which included different bus routes, types of bus driven (express or regular bus), shift schedules, workloads (hours worked per day), work experiences (years worked at the transit company as a bus operator) and demographic information.

In order to estimate the impact of various risk factors on the occurrence of occupational injury, Cox proportional hazards analysis was utilized. Each bus operator was observed and considered to be at risk until the injury event occurred. As noted, this longitudinal dataset contained repeated observations and one bus operator could report more than one injury event; therefore, the "counting process model" for Cox proportional hazard analysis was utilized in the analytic model. The counting process model assumed each reported injury event within a bus operator was independent – i.e., a subsequent event was not related to any previous event, thus, the sequence of the injury events were disregarded.

Multivariable models were conducted using Directed Acyclic Graphs (DAGs) to select the minimum set of confounding factors for each exposure of interests. Thus, adjusted Hazard Ratios (HRs) were calculated. Each adjusted variable for exposures of interest is shown in **Table 2.** All the analyses were conducted using SAS 9.4 for windows (SAS, 2012).

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Table 1. Examples of injury Descriptions and Classification of Unintentional and Intentional Events: Minnesota Bus Operator Study, 2006-2012

Cause	Body Part	Description	Unintentional	Intentional	Note
Struck Or Injured By	Soft Tissue Head	Assaulted over the head by a juvenile using a handbag.	0	1	Assault
Struck Or Injured By	Eye(s)	Passenger spat in operator's face	0	1	Spit
Fall Or Slip Injury	Knee	Operator slipped on ice in garage driveway; fell on left knee	1	0	Ice
Strain Or Injury By	Elbow	Operator strained right elbow when strapping in a wheelchair passenger	1	0	Wheelch air

Table 2. Multivariable Models: Minnesota Bus Operator Study, 2006-2012

Exposures of Interest	Adjusted Variables
Work Years	Age, and Gender
Job Classification	Age, Gender, and Work Years
Operator Type	Age, Gender, and Work Years
Work Start Time	Age, Gender, Work Years, Job Classification, Work Shift, and Garage
Working Hours per day	Age, Gender, Work Years, Job Classification, Number route of Driving, and Route Type
Driving Hours per day	Age, Gender, Work Years, Job Classification, Number route of Driving, and Route Type
Overtime Hours per day	Age, Gender, Work Years, Job Classification, Number route of Driving, and Route Type
Shift	Age, Gender, Work Years, and Job Classification
Number of Routes Driven per day	Age, Gender, Work Years, Job Classification, Bus Garage, Work Start Time and Weekday
Route Type	Age, Gender, Work Years, Job Classification, Bus Garage, Work Start Time and Weekday

Figure 1. Map of Five Bus Garages: Minnesota Bus Operator Study, 2006-2012

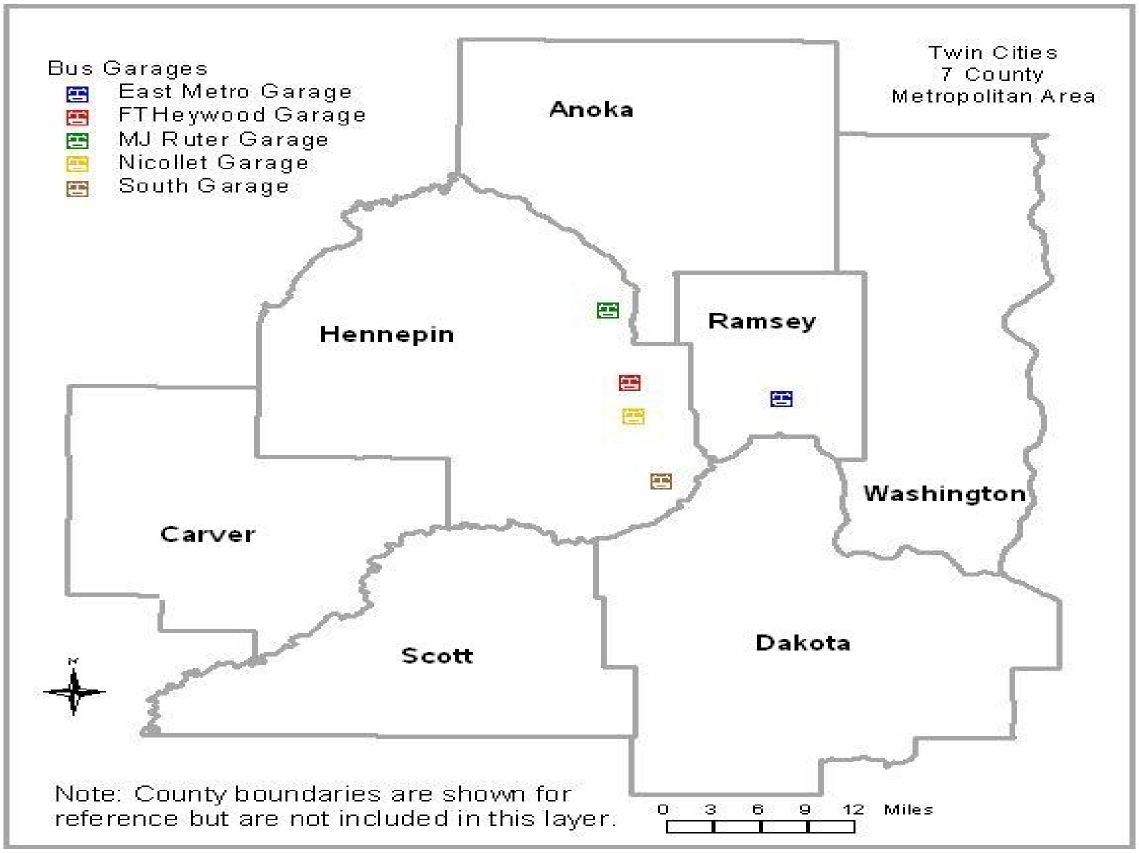


Figure 2. Causal Model: Minnesota Bus Operator Study, 2006-2012

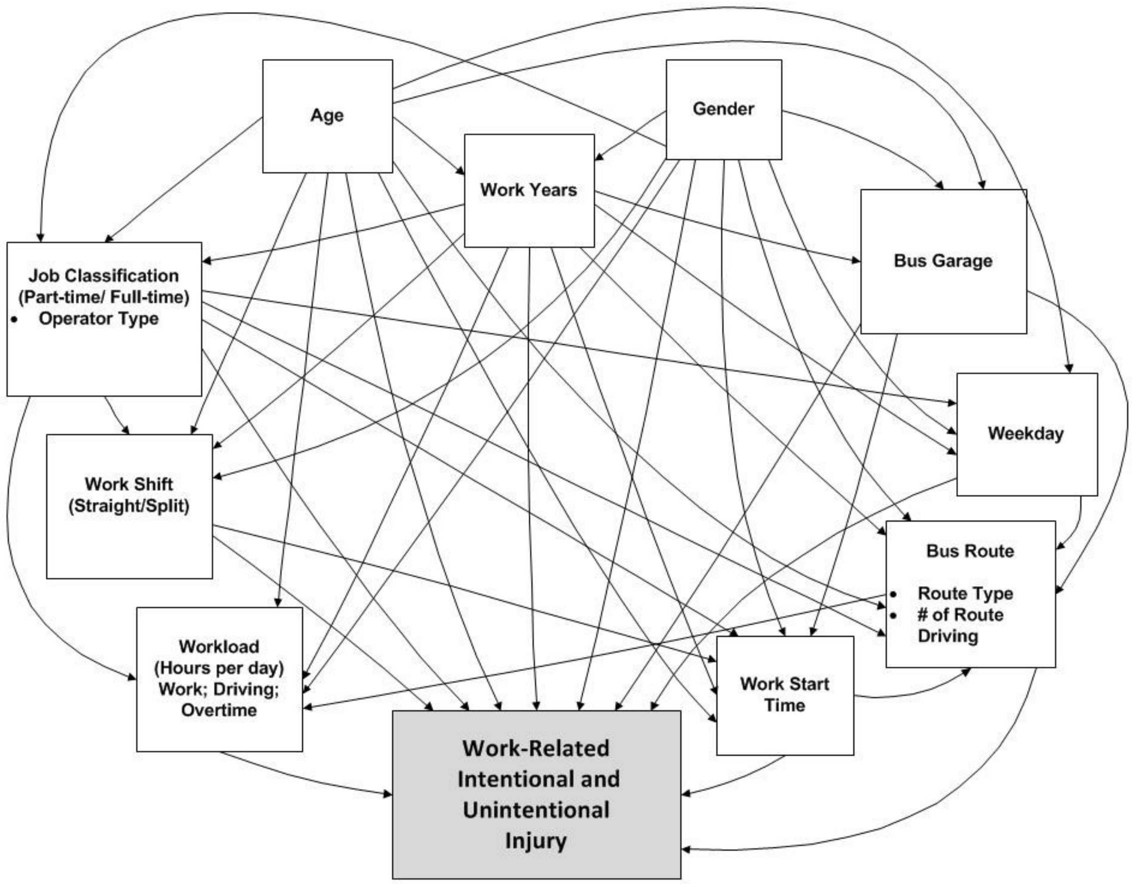
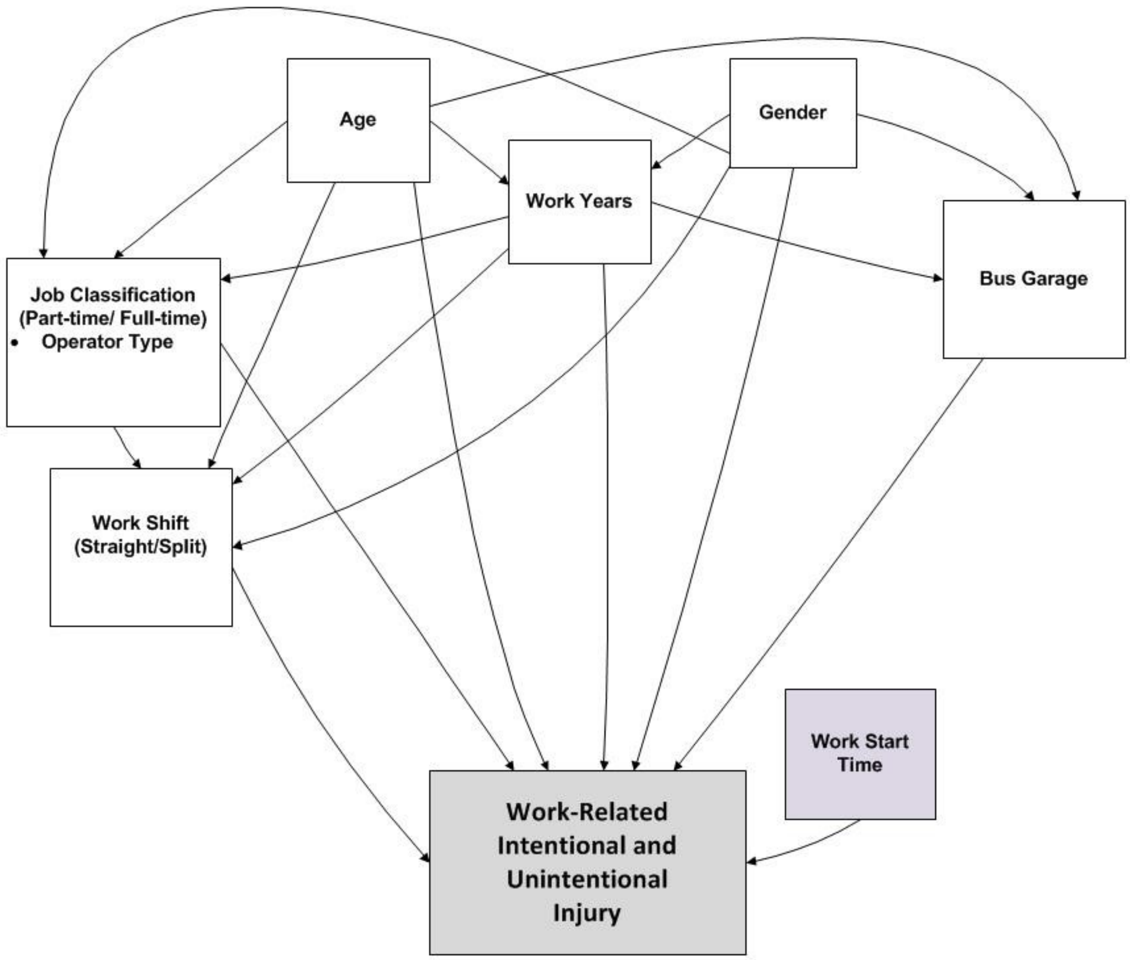


Figure 3. Example of Directed Acyclic Graph (DAG) for Work Start Time: Minnesota Bus Operator Study, 2006-2012



CHAPTER IV

OCCUPATIONAL INJURY AMONG URBAN TRANSIT BUS OPERATORS: UNINTENTIONAL INJURY INCIDENCE AND RISK FACTORS

Abstract

INTRODUCTION

Numerous studies have focused on bus operators' occupational diseases; however, limited data consider the realm of bus operators' work-related injuries and associated risk factors. Thus, this study investigated unintentional injury among bus operators in Minnesota and exposures that may have increased or decreased their risk.

METHODS

Demographic, work-related, and injury information was obtained from a transit company for a five-year period (Dec 1, 2006 to Dec 31, 2011). Estimates of rates, per 100 Full Time Equivalents (FTEs) and adjusted Hazard Ratios (HRs), with associated 95% Confidence Intervals (C.I.), were generated, using Generalized Estimating Equations and Cox Proportional Hazards models, respectively.

RESULTS

A total of 2,095 bus operators was included in this study. The overall unintentional injury rate with 95% C.I. was 17.8 (16.1-19.7) per 100 FTEs. Multivariable analysis identified increased risks for operators who: were female, compared to male (HR=2.4; 2.0, 2.8); worked less than seven, compared to seven to less than 12 hours per day (HR=4.6; 3.8, 5.5); and drove less than seven compared to seven to less than 12 hours per day (HR=3.2; 2.7, 3.8). Operators who worked split, versus straight shifts, demonstrated a

suggestive increased risk (HR=1.2; 1.0, 1.4). Bus operators also tended to have an increased risk when driving limited versus regular bus routes (HR=1.36; 1.0, 1.8).

CONCLUSIONS

Results of this study serve as a basis for further studies and can inform the development of targeted intervention strategies to reduce occupational injuries relevant to bus operators.

1. INTRODUCTION

Driving a bus, professionally, is recognized as a high-risk occupation. In the past decades, some epidemiology studies have shown that bus operators are at high risk of experiencing three main physical health problems: cardiovascular disease; gastrointestinal disorders; and musculoskeletal problems (Backman, 1983; Winkleby et al., 1988; Evans, 1994; Tse et al., 2006). Among those, stress has been identified as a primary factor associated with cardiovascular disease and gastrointestinal disorders (Henry & Stephens, 1977; Krantz et al., 1988; Evans, 1994). Karasek's demand-control model (Karasek, 1979; Karasek & Theorell, 1992) suggested four different kinds of psychological work experiences that were illustrated by two dimensions: high or low job demand and high or low job control. In terms of working conditions and working environments, bus operators have been classified as having high job demand with low job control (Karasek, 1979; Tse et al., 2006). The combination of heavy job demands and low job decision is associated with mental strain as well as job dissatisfaction (Karasek, 1979). Bus operators' stress may be induced by their working characteristics, such as irregular shifts, strict time schedules, adverse bus incidents, and limitations in break times and social support. In addition, bus operators often engage in multiple activities that drivers of other vehicles do not. They not only need to address passengers' inquiries, assist disabled/elderly passengers, and deal with riders evading fare payments but, also, must focus on the traffic and road conditions. In addition, bus incidents (e.g., mechanical failures or crashes) and modifying routes (e.g., to avoid inadvertent events that affect the bus route), were found to have high correlation with psychological job demands (Gimeno et al., 2004).

Bus operators' shifts are often longer than those for other occupations and frequently result in continuous work without rest or meal breaks. From a study conducted on data from the National Longitudinal Survey of Youth (NLSY), it was suggested that higher hazard rates for occupational injuries and illnesses were found for those who worked more than 60 hours per week, more than 12 hours per day, and overtime when adjusted for age, gender, occupation, industry, and region (Dembe et al., 2005). In addition, bus operators have been reported to have a high prevalence of work-related musculoskeletal disorders (WMSDs) (Evans, 1994; Tse et al., 2006; Szeto & Lam, 2007). The fact that the operators are exposed to prolonged sitting, vibration, and being constrained for long periods to their cabin, may contribute to increased physical loading in the musculoskeletal system -- resulting in back pain (Bovenzi & Zadini, 1992; Szeto & Lam, 2007). WMSDs are also associated with psychosocial risk factors (Bovenzi & Zadini, 1992; Tse et al., 2006).

According to the incidence rates for nonfatal occupational injuries and illnesses, provided by the Bureau of Labor Statistics (BLS) in 2012, the “bus drivers transit and intercity” occupation category had the highest total incidence rate compared to all other worker occupation categories (851.5 versus 112.4 per 100,000 full-time workers). In particular, the “multiple traumatic injuries and disorders” category incidence rate was almost six times greater than for all occupations combined (25.6 versus 4.3 per 10,000 full-time workers) (Bureau of Labor Statistics (BLS), 2013) and WMSD rates for this occupation category, and for all occupations, respectively, were 146.2 and 33.0 per 10,000 full-time workers (Bureau of Labor Statistics (BLS), 2010). Although this occupation category included more than just the transit bus operators that are addressed in the current study, the data identified the magnitude, to some degree, of the problem among transit operators.

Numerous studies have focused on bus operators’ occupational diseases and other health outcomes that provided a basic understanding for this study. However, to date, there are limited data that consider the realm of bus operators' work-related injuries and various working conditions and exposures. The current study addressed the work-related unintentional injury problem among urban transit bus operators in Minnesota to determine the incidence and potential risk factors – information that can provide a basis for relevant intervention efforts.

2. METHODS

2.1. Study Design

The ultimate goal of this study was to identify how personal and work-related characteristics may contribute to the occurrence of unintentional work-related injuries among transit bus operators. This involved first identifying the magnitude and consequences of these injuries for a five-year period of time, followed by analysis to determine the associations between occupational injury and exposures of interest that enable identification of relevant risk factors.

2.2. Study Population and Data Collection

The study population consisted of transit bus operators who worked at a metropolitan transit company that includes a seven county area. Available data, between December 1, 2006 and December 31, 2011, were obtained from the company. These data included the bus operators' demographic information: gender and age; work-related characteristics: years of working; job classification (part-time or full-time); working hours per day; driving hours per day; overtime hours per day; bus garage division; work start time; shift schedule; number of busses driven per day; and bus route type. Unintentional injury event reports included type of injury and body part affected.

In total, there were 2,095 eligible bus operators who were employed during the study period. Those who left before December 1, 2006, or entered after December 31, 2011, were excluded from the data analysis. This study was approved by the Institutional Review Board (IRB) at the University of Minnesota.

2.3. Measurements and Definitions

2.3.1. Dependent Variable—Unintentional Injury

Definitions used for work-related injury are consistent with the National Center for Health Statistics (NCHS) and Bureau of Labor Statistics (Bureau of Labor Statistics (BLS), 2012b). Work-related injuries are any wounds or damage to the body associated with the job that occurs in the work environment; this includes lacerations, fractures, sprains, amputations, and musculoskeletal disorders, among others. In particular, unintentional injury involves unexpected transfer to a person or group of persons of one of the forms of energy (mechanical/kinetic, chemical, electrical, thermal, etc.) within the environment that exceeds the threshold of physical tolerance or resilience.

The injury report information included event date, event time, type of injury ("burn or scald," "caught in or between," "puncture, or scrape," "fall or slip injury," "motor vehicle-related," "abrasion," "strain," "striking against or stepping on," and "struck by") and body part affected (arm, back, chest, hand, head, leg, and shoulder). From these reports, 1,389 injury events were identified between December 1, 2006 and December 31, 2011; these events were reviewed and classified by the investigators, based on the definitions identified above. After eliminating cases that did not meet the requirement (such as non-work-related, or a chronic event), 1,265 unintentional work-related injury events were included in the final data analysis.

2.3.2. Independent Variables

Personal Characteristics

Transit bus operators' demographic information of age and gender were obtained for this study.

Occupational Characteristics

Bus Garage: The transit company maintained five different garages located in the metropolitan area. Based on their geographic locations, each of the garages had its own associated bus route.

Job Classification: This included weekday full-time, weekday part-time, and weekend part-time. Weekday full-time operators had 40 hours of work per week guaranteed. Weekday part-time operators could have worked up to 30 hours per week.

Working Years: This involved years worked as a bus operator at the transit company.

Workload: This was a measure of hours of driving and working per day and included bus operators' overtime hours.

Work Shifts: There were two types of shift work in the bus operators' schedules: a straight shift was a regular day shift and a split shift involved the operators' workdays split into two parts.

Number of Bus Routes: Each operator could have had different driving assignments within a day; that is, the operator could have driven one to as many as seven different routes in a given day, depending on the driving assignment of that day.

Type of Bus Routes: There were three types of bus route services: regular-route; limited stops; and express bus service. Limited stop routes had the same route as regular-route, but with less stops. Express buses traveled on freeways for a distance of at least four miles; the bus fare was higher for travel on express, compared to regular and limited stop, bus routes.

Working Start Time: This category examined the earliest time that the operator started at work at the company each day, during respective three-hour periods. Eight subcategories of working time commencement were: 3 a.m. to < 6 a.m., 6 a.m. to < 9 a.m., 9 a.m. to < 12 p.m., 12 p.m. to < 3 p.m., 3 p.m. to < 6 p.m., 6 p.m. to < 9 p.m., 9 p.m. to < 12 a.m., and 12 a.m. to < 3 a.m.

2.4. Statistical Analysis

Data analysis commenced with descriptive statistics including number of reported events and consequences, as well as characteristics of exposures of interest. The outcome variable (work-related unintentional injuries) described the number of events occurring in a set of observations; in this study, a transit bus operator could have reported more than one injury event during the study period.

Estimates of rates, per 100 Full Time Equivalents (FTEs), and associated 95% Confidence Intervals (C.I.), were generated using generalized estimating equations (GEEs) (Liang & Zeger, 1986) with exchangeable working correlation matrices. FTEs were calculated, using the total number of working hours within the study period, divided by 2,000 hours (8 hours/day* 5 days/week* 50 weeks/year). GEEs are an extension of generalized linear models to correlated data; moreover, they produce marginal models, which calculate average estimates across subjects (transit bus operators), while accounting for the dependency between the repeated measures within subjects. In this study, bus operators selected or were assigned their work shifts and schedules three to four times a year; their work-related characteristics could have changed, based on their daily shift assignments. Thus, each observation was based on their assignments per day and could have involved up to 250 observations for each bus operator per year. Therefore, each observation was time-independent and observations were correlated within a bus operator. In the models, each bus operator was considered to be independent. The exchangeable working correlation structure assumes that any two observations within a subject (transit bus operator) have a consistent correlation, providing the rationale for using exchangeable working correlations in the GEE models for each exposure of interest.

Furthermore, in order to estimate the impact of various risk factors on the occurrence of occupational injury, Cox proportional hazards analysis was utilized. Each bus operator was observed and considered to be at risk until the injury event occurred. The Cox proportional hazards models enable regression of this "survival" time on the potential risk factors and adjust for other factors that are included in the models. As noted, this longitudinal dataset contained repeated observations and one bus operator could have reported more than one injury event; therefore, the "counting process model" for Cox proportional hazard analysis was utilized in the analytic model. This model assumed each reported injury event within a bus operator was independent, i.e., a subsequent event was not related to any previous event; thus, the sequence of the injury events was disregarded. All analyses were conducted using SAS software, version 9.4 of the SAS system for windows.(SAS, 2012)

2.5. Selection of Variables

A causal model was developed to determine the variables to be measured and controlled for in the overall study analyses (**Figure 1**) (Greenland et al., 1999). From this model, individual Directed Acyclic Graphs (DAGs) were derived to select the minimum set of potential confounding factors for each exposure of interest (Greenland et al., 1999;

Hernán et al., 2002). A DAG is a graph that links from cause to outcome with a one-headed arrow, and with no feedback loop. Each DAG reflects an exposure of interest that was used to define variables, a priori, to guide multivariable analyses of the data (Greenland et al., 1999). Thus, adjusted Hazard Ratios (HR) and associated 95% C.I., per 100 FTEs, were calculated to determine the strength of the associations between exposures and the outcome of interest. Because operators could select their own work shifts and schedules three to four times a year, based on their seniority (length of time employed), it was important to adjust for working years when examining the associations between working schedules or shifts among the operators and work-related injury. An example of a DAG, used in the multivariate analysis, is presented in **Figure 2**. In this DAG, an adjusted HR of work start time was calculated after adjustment for age, gender, work years, job classification, work shift, and bus garage.

3. RESULTS

A total of 2,095 bus operators were included in this study; primarily, they were male (78%), with a mean age of 49 years (Standard Deviation (SD) = 10) and mean working time of 11 years (SD= 9). The average working hours per day for full-time and part-time workers were 8.6 and 5.8, respectively (**Table 1)**. According to the injury reports, 30% (N=636) of the bus operators reported at least one unintentional injury event during the five-year study period (December 01, 2006 to December 31, 2011). **Table 2** identifies the number of bus operators who reported unintentional injuries during the study period; 1,459 did not report any events, 351 reported only one event, and 285 reported multiple events. As a result, a total of cumulative 1,265 unintentional injury events were reported during the five years.

As noted, this is a longitudinal study; therefore, the work-related characteristics and exposures were time dependent, and could be changed day-to-day. **Table 3** identifies the numbers of reported events *on the date of injury* among bus operators in the five-year period. In all events, 81% worked as full-time bus operators at the time of injury. Highest percentages of unintentional injury events were reported by operators who: had early start times (3 a.m. to 6 a.m., 40%); worked seven to less than 12 hours per day (64%); drove seven to less than 12 hours per day (61%); did not work overtime (92%); and worked straight shifts (70%). Among full-time operators, 75% reported injury events while working seven to less than 12 hours on the day of injury (**Table 4**). The primary types of reported injuries were strains, followed by fall or slip injuries. Additional reported types of injuries and associated body parts are shown in **Table5.**

3.1. Unintentional Injury Crude Rates and Adjusted Hazard Ratios

Table 6 identifies the results of the estimated rates per 100 FTEs and associated 95% C.I.s, adjusted HRs and associated 95% C.I.s, and working hours for each exposure of interest. Overall, the GEE analysis resulted in the unintentional injury rate of 17.8 per 100 FTEs among transit bus operators; although male operators reported more events than female operators, their estimated rate was much lower. The injury rates increased with age and varied from 12.6 to 21.3 per 100 FTEs. Bus operators who worked less than seven hours per day and drove less than seven hours per day, had the highest unintentional injury rates.

Adjusted HRs and associated 95% C.I.s were generated, using multivariable analysis for Cox proportional models. Female compared to male operators were found to have an increased risk of unintentional injury. Higher risks were found for operators who: worked less than seven, compared to seven to less than 12 hours per day; and drove less than seven or more than 12 hours, compared to seven to less than 12 hours per day. Operators who worked split shifts, versus straight shifts, were associated with a 20% higher risk of unintentional injury. Bus operators tended to have a higher injury risk when driving limited versus regular bus routes (36% elevated risk).

Decreased risks were found among those operators who had worked: less than five versus 15 years; part-time compared to full-time; part-time during weekday compared to full-time eight hours; and drove two or more than three routes, compared to those who drove only one route. Moreover, operators who worked on Thursdays and Saturdays, compared to Sunday, were found to have decreased risks.

4. DISCUSSION

This study determined the occurrence of work-related injuries among transit bus operators in a metropolitan area for different age groups, working years, and work-related characteristics such as job classification, hours of work and driving per day, schedules, and shifts. The overall unintentional injury rate was 17.8 per 100 FTEs; due to different study methods and populations used, these data are not comparable with other studies.

While it has been reported that males were more likely than females to experience work-related injuries, in general (Laundry & Lees, 1991; Bureau of Labor Statistics (BLS), 2011; Bureau of Labor Statistics (BLS), 2012a; Bureau of Labor Statistics (BLS), 2013), it was identified in the current study that, among bus operators, females, compared to males, had a higher risk. In addition to injury risk, occupational studies have suggested that females experience greater injury severity compared to males; one population-based study that utilized workers' compensation data indicated females had a longer estimated period of disability than males, even after adjusting for initial hospitalization (Cheadle et al., 1994). Another study that examined the severity of injury using workers' compensation data also reported that females had a higher injury rate than males (221 versus 178 per 10,000 employees per year) (Horwitz & McCall, 2004). However, studies among bus operators have usually excluded females in their analysis due to small numbers (Backman, 1983; Hedberg et al., 1993; Hannerz & Tüchsen, 2001; Chen et al., 2010). Further study is needed relevant to gender differences among bus operators and associated work-related injury experiences.

Long working hours have also been associated with higher risk of work-related injury (Dembe et al., 2005; Dong, 2005; Dembe et al., 2007; De Castro et al., 2010). However, the current study found increased risks for those operators who worked or drove less than seven hours, compared to more than seven and less than 12 hours. The difference in this finding is likely due to factors controlled for in the multivariable model, established a priori, that controlled for age, gender, work years, job classification, number of routes of driven, and route types. These controlling factors were the main variables that would directly affect bus operators' schedules and working times.

Because metropolitan buses are in operation from early morning to late night, bus operators usually work in shifts. Several previous studies (Dong, 2005; Dembe et al., 2006; De Castro et al., 2010; Salminen, 2010) indicated that rotating and irregular work shifts were associated with increased injury risks. From similar findings identified in the current study, higher risk was found among bus operators who worked split shifts versus straight shifts. Although, as noted, bus operators in the current study engaged in self-scheduling; one study suggested that self-scheduling improved health and well-being (Gauderer & Knauth, 2004), since it enabled the operators to have more control over their working schedules.

Working experience was also an important covariate that affected work-related injury. Current study results suggested that operators who worked less than five years had 40% less risk compared to those who worked more than 15 years. Similarly, bus operators who had greater driving years would be expected to have higher risk (Bovenzi & Zadini, 1992; Ragland et al., 1997; Chen et al., 2010). From one study that investigated vibration exposure among bus operators, results indicated that those with longer driving experiences had longer-term exposures to whole body vibration (with more than 4.5 years m^2 s^{-4} total vibration dose) involving higher risks for all types of low back pain symptoms and disc protrusion compared to those who had no exposure to whole body vibration, such as mechanics, electricians, and general operators (Bovenzi & Zadini, 1992).

Decreased risks were identified for working part-time versus full-time, in particular weekday part-time, compared to full-time eight-hour shifts. This finding was in contrast to some studies reporting that temporary or part-time employees were at higher risk of occupational injuries (Nylen et al., 2001; Benavides et al., 2006; Alamgir et al., 2008). This could be explained by the different classification of part-time bus operators in the current study population that was adjusted for in the multivariable analysis. In this transit company, all new bus operators commenced with the company as part-time operators; after 12 months, they could apply for full-time positions – an approach that enabled a probationary period for monitored training and gradual increase in experience.

Two factors that had not been investigated, previously, in other studies were the number of routes and types of routes driven by bus operators per day. The results of the current study suggested that those operators who drove more than two routes, compared to only one route per day, had decreased risks; in addition, operators who drove limited stop versus regular routes, had an increased risk of injury.

4.1. Strengths and Limitations

The strength of the study included the ability to obtain daily working schedules, shifts, and driving information for all bus operators over a five-year period. By linking an injury reporting system to a work scheduling system, the final dataset provided complete working information for each operator's working day, including any days of injury. While the operators' working shifts and schedules could have changed day-to-day, based on their driving assignments, this longitudinal dataset minimized the bias due to varying work exposures among bus operators.

This study utilized available company records from an urban transit company. Therefore, some information such as occupational history, personal medical information, physical activities, fatigue status, and sleep hours were not available. Potential selection bias could have occurred if employees chose to not report any injury. Therefore, one of the selection biases is the healthy worker effect (HWE). The HWE is a phenomenon that should be considered in any occupational study. Some study results have suggested that the HWE would eliminate 20% to 30% of the association between exposure and outcome (Shah, 2009). In the current study, relevant injury data were collected, based on self-reported information; however, potential biases were minimized, to some degree, through utilization of the longitudinal observations for a five-year period collected directly from the transit company. In addition, the magnitude of injury was estimated by controlling for potential confounding factors and adapting specific statistical models to fit the natural correlated structure of the dataset.

Another potential limitation was the lack of information on days away from work, following injury; therefore, it was not possible to estimate severity of the occupational injuries among bus operators. One prior study compared the age-standardized hospital admission ratios between male operators of passenger transport vehicles and those of goods vehicles in Denmark; it was reported that passenger transport vehicle operators had much lower rates of injuries (Hannerz & Tüchsen, 2001) and noted that most of the injuries did not require hospital admission. However, lost time from work and restricted activity due to injuries, not involving hospitalization, has also been shown to be an important measure of severity (Gerberich et al., 2001; Carlson et al., 2005; Kurszewski et al., 2006).

5. CONCLUSIONS

Results of this study identified several risk factors that are likely to affect the occurrence of work-related injury among urban transit bus operators. These factors serve as a basis for further in-depth studies and can inform the development of targeted intervention strategies to reduce work-related unintentional injuries relevant to bus operators.

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Table 1. Average Working, Driving, Overtime Hours and Standard Deviation (SD) Per Day by Job Classification: Minnesota Bus Operator Study, 2006-2012

	Job Classification		**Overall**
	Full-Time	Part-Time	
Working Hours/day (SD)	8.6 (1.5)	5.8 (1.9)	7.8 (2.0)
Driving Hours/day (SD)	8.1 (1.9)	5.5 (1.8)	7.4 (2.2)
Overtime Hours/day (SD)	0.3 (1.3)	0.8 (2.3)	0.4 (1.6)

Table 2. Number of Bus Operator Reported Injury Events: Minnesota Bus Operator Study, 2006-2012

Number of Events Reported by Bus Operator	**Number of Bus Operators**	**Percent**
0	1459	69.64
1	351	16.75
2	145	6.92
3	66	3.15
4	31	1.48
5	12	0.57
6	14	0.67
7	7	0.33
8	2	0.10
9	2	0.10
10	1	0.05
11	1	0.05
12	2	0.10
13	0	0.00
14	1	0.05
15	0	0.00
16	1	0.05
Total	**2095**	100

Table 3. Characteristics of Injured Bus Operators and Exposures on the Date of Injury: Minnesota Bus Operator Study, 2006-2012

Unintentional Injury Characteristics					
Total Events =1265	**Number Reporting Events**	**Percent**		**Number Reporting Events**	**Percent**
Age (years)			**Working Hours**		
< 30	58	4.6	> 0 to less than 7 Hours	439	34.7
30 to <40	157	12.4	7 to less than 12 Hours	807	63.8
40 to <50	372	29.4	≥ 12 Hours	19	1.5
50 to <60	483	38.2	**Driving Hours**		
60 +	195	15.4	0 Hours	3	0.2
Work Years			> 0 to less than 7 Hours	471	37.2
0 to <5	315	24.9	7 to less than 12 Hours	775	61.3
5 to < 10	367	29.0	≥ 12 Hours	16	1.3
10 to <15	229	18.1	**Overtime Hours**		
> 15	354	28.0	0 Hours	1159	91.6
Job Classification			> 0 to less than 3 Hours	65	5.1
Full-time	1029	81.3	3 to less than 6 Hours	30	2.4
Part-time	236	18.7	≥ 6 Hours	11	0.9
Operator Type			**Shift**		
Full-time 8 Hours	759	60.0	Straight	890	70.4
Full-time 9 Hours	134	10.6	Split	375	29.6
Full-time 10 Hours	136	10.8	**Number of Routes Driven**		
Weekday Part-time	217	17.2	0	3	0.2
Weekend Part-time	19	1.5	1	561	44.3
Work Start Time ‡			2	387	30.6
3 a.m. to < 6 a.m.	505	39.9	3	209	16.5
6 a.m. to < 9 a.m.	357	28.2	4	64	5.1
9 a.m. to < 12 p.m.	106	8.4	5	13	1.0

Unintentional Injury Characteristics					
Total Events =1265	**Number Reporting Events**	**Percent**		**Number Reporting Events**	**Percent**
12 p.m. to < 3 p.m.	177	14.0	6	4	0.3
3 p.m. to < 6 p.m.	108	8.5	Unknown	24	1.9
6 p.m. to < 9 p.m.	3	0.2	**Route Type Driven**		
9 p.m. to < 12 a.m.	1	0.1	None	3	0.2
12 a.m. to < 3 a.m.	8	0.6	Regular only	613	48.5
Weekday			Limited Stop only	55	4.3
Sunday	44	3.5	Express Bus only	129	10.2
Monday	249	19.7	Regular and Limited Stop	115	9.1
Tuesday	241	19.1	Regular and Express Bus	185	14.6
Wednesday	230	18.2	Limited Stop and Express Bus	41	3.2
Thursday	202	16.0	Regular, Limited Stop, and Express Bus	109	8.6
Friday	207	16.4	Unknown Type	15	1.2
Saturday	92	7.3			

Table 4. Number of Injury Reports by Job Classification and Working Hours per day: Minnesota Bus Operator Study, 2006-2012

Working Hours	Job Classification Full-Time (%)	 Part-Time (%)
> 0 to less than 7 Hours	241 (23.4)	198 (83.9)
7 to less than 12 Hours	770 (74.8)	37 (15.7)
≥ 12 Hours	18 (1.7)	1 (0.4)
Total Injury Events	1029 (100)	236 (100)

Table 5. Type of Injury and Associated Body Part: Minnesota Bus Operator Study, 2006-2012

Unintentional Injury Report		
Total Events = 1265	**N**	**%**
Type of Injury		
Strain	736	58.2
Fall or Slip Injury	177	14.0
Struck by	95	7.5
Motor Vehicle-Related	84	6.6
Striking Against or Stepping on	74	5.8
Miscellaneous Causes	54	4.3
Puncture, or Scrape	17	1.3
Caught in or between	14	1.1
Burn or Scald/ Heat or Cold Exposure	13	1.0
Abrasion	1	0.1
Body Part		
Back	272	21.5
Leg	248	19.6
Multiple Body Part	188	14.9
Shoulder	168	13.3
Hand	148	11.7
Head	118	9.3
Arm	68	5.4
Chest	21	1.7
Unknown	19	1.5
No Physical Injury	15	1.2

Table 6. Unintentional Crude Injury Rates and Adjusted Hazard Ratios: Minnesota Bus Operator Study, 2006-2012

	Number Reporting Events	Total Hours (x10,000)	Estimated Crude Rate	95% C.I.	Estimated Adjusted HR	95% C.I.
Total	**1265**	**1244.5**	**17.8**	**16.1-19.7**		
Gender						
Female	485	248.1	34.6	29.7-40.3	2.4	2.0-2.8
Male	780	996.4	13.8	12.2-15.7	1.0	—
Age (years)						
< 30	58	65.1	12.6	8.4-18.9	0.7	0.5-1.1
30 to <40	157	10.9	14.6	11.2-19.1	0.7	0.5-1.1
40 to <50	372	363.0	17.8	15.0-21.0	0.9	0.7-1.2
50 to <60	483	465.0	18.6	16.2-21.4	0.9	0.7-1.2
60 +	195	170.5	21.3	16.6-27.4	1.0	—
Work Years						
0 to <5	315	38.8	14.5	12.2-17.1	0.6	0.5-0.8
5 to < 10	367	322.1	19.3	16.5-22.6	1.0	0.8-1.2
10 to <15	229	21.2	18.8	15.6-22.6	1.0	0.8-1.2
≥ 15	354	322.4	20.3	16.8-24.5	1.0	—
Job Classification †						
Full-time	1029	999.9	18.3	16.5-20.4	1.0	—
Part-time	236	244.6	15.8	13.2-19.0	0.6	0.5-0.7
Operator Type †						
Full-time 8 Hours	759	697.9	19.1	16.9-21.5	1.0	—
Full-time 9 Hours	134	152.7	15	12.2-18.4	0.8	0.6-1.0
Full-time 10 Hours	136	149.3	18.6	14.8-23.4	1.1	0.8-1.4
Weekday Part-time	217	217.1	16.5	13.6-20.1	0.5	0.4-0.7
Weekend Part-time	19	27.4	11.8	6.9-20.3	0.6	0.4-1.0
Work Start Time ‡						
3 am to < 6 am	1	1.9	18.4	15.9-21.1	1.2	0.9-1.5
6 am to < 9 am	8	7.3	18.7	16.2-21.7	1.1	0.9-1.4

	Number Reporting Events	Total Hours (x10,000)	Estimated Crude Rate	95% C.I.	Estimated Adjusted HR	95% C.I.
9 am to < 12 pm	505	464.6	15.8	12.6-19.9	1.0	—
12 pm to < 3 pm	357	32.9	17.5	14.6-20.9	1.1	0.8-1.4
3 pm to < 6 pm	106	119.1	16.0	12.9-19.8	1.0	0.7-1.3
6 pm to < 9 pm	177	189.6	15.5	5.9-40.8	0.8	0.3-2.6
9 pm to < 12 am	108	129.1	8.9	0.8-101.4	0.7	0.1-4.8
12 am to < 3 am	3	4.3	15.1	6.0-38.3	1.2	0.6-2.6
Weekday §						
Sunday	44	77.1	10.8	7.7-15.2	1.0	—
Monday	249	207.2	21.2	18.2-24.7	0.1	0.0-0.4
Tuesday	241	214.2	19.5	16.6-23.0	0.9	0.2-4.6
Wednesday	230	214.5	18.6	15.5-22.2	0.8	0.2-4.2
Thursday	202	211.7	16.5	13.7-19.9	0.2	0.1-0.9
Friday	207	210.7	17.2	20.8-20.2	0.4	0.1-1.4
Saturday	92	109.1	16.0	12.6-20.2	0.2	0.1-0.5
Working Hours per day ll						
> 0 to less than 7 Hours	439	206.6	50.4	44.2-57.5	4.6	3.8-5.5
7 to less than 12 Hours	807	1008.1	14.2	12.6-16.0	1.0	—
≥ 12 Hours	19	29.8	12.4	7.8-19.7	1.4	0.9-2.2
Driving Hours per day ll						
0 Hours	3	5.6	7.6	1.5-37.9	0.0	0.0-0.0
> 0 to less than 7 Hours	471	245.1	41.2	36.2-46.8	3.2	2.7-3.8
7 to less than 12 Hours	775	970.8	14.3	12.7-16.1	1.0	—
≥ 12 Hours	16	23.0	14	8.6-22.9	1.6	1.0-2.5
Overtime Hours per day ll						
0 Hours	1159	1105.2	18.3	16.5-20.2	1.0	—
> 0 to less than 3 Hours	65	59.5	19.6	14.5-26.6	1.1	0.8-1.4
3 to less than 6 Hours	30	37.9	15.5	10.6-22.6	0.9	0.7-1.3
≥ 6 Hours	11	41.9	5.6	3.0-10.3	0.4	0.2-0.7

	Number Reporting Events	Total Hours (x10,000)	Estimated Crude Rate	95% C.I.	Estimated Adjusted HR	95% C.I.
Shift §						
Straight	890	913.3	16.9	15.1-19.0	1.0	—
Split	375	331.2	20.3	17.6-23.3	1.2	1.0-1.4
Number of Routes Driven per day ¶						
None	3	5.6	7.1	1.3-39.9	0.4	0.1-1.3
One Route	561	472.4	21.7	19.3-24.5	1.0	—
Two Routes	387	412.1	16.4	14.2-19.0	0.7	0.6-0.9
More than 3 routes	314	354.4	15.2	13.0-17.8	0.7	0.6-0.8
Route Type ¶						
Non	3	5.5	7.1	1.2-40.7	0.5	0.2-1.5
Regular Bus Only	613	619.6	17.9	15.9-20.2	1.0	—
Limited Stop Only	55	33.3	28.6	21.0-38.8	1.4	1.0-1.8
Express Bus Only	129	98.1	23.5	19.1-29.1	1.0	0.8-1.3
Multiple Route Type	409	426.4	16.5	14.3-19.2	0.9	0.7-1.0
Unknown Type	56	61.6	14.8	10.5-20.8	0.7	0.5-0.9

* Adjusted for Age, and Gender
† Adjusted for Age, Gender, and Work Years
‡ Adjusted for Age, Gender, Work Years, Job Classification, Work Shift, and Garage
§ Adjusted for Age, Gender, Work Years, and Job Classification
ǁ Adjusted for Age, Gender, Work Years, Job Classification, Number route of Driving, and Route Type
¶ Adjusted for Age, Gender, Work Years, Job Classification, Bus Garage, Work Start Time and Weekday

Figure 1. Causal Model: Minnesota Bus Operator Study, 2006-2012

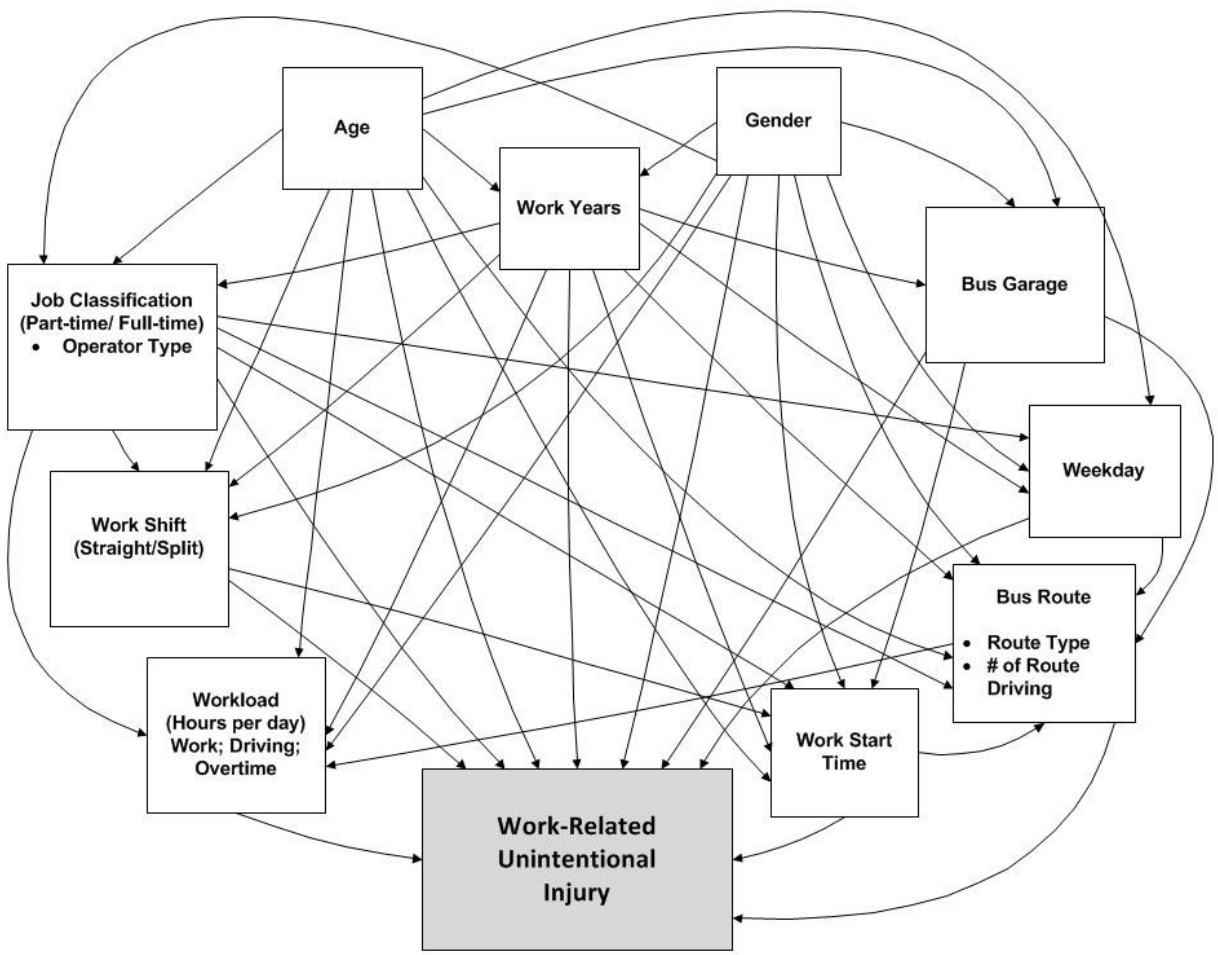
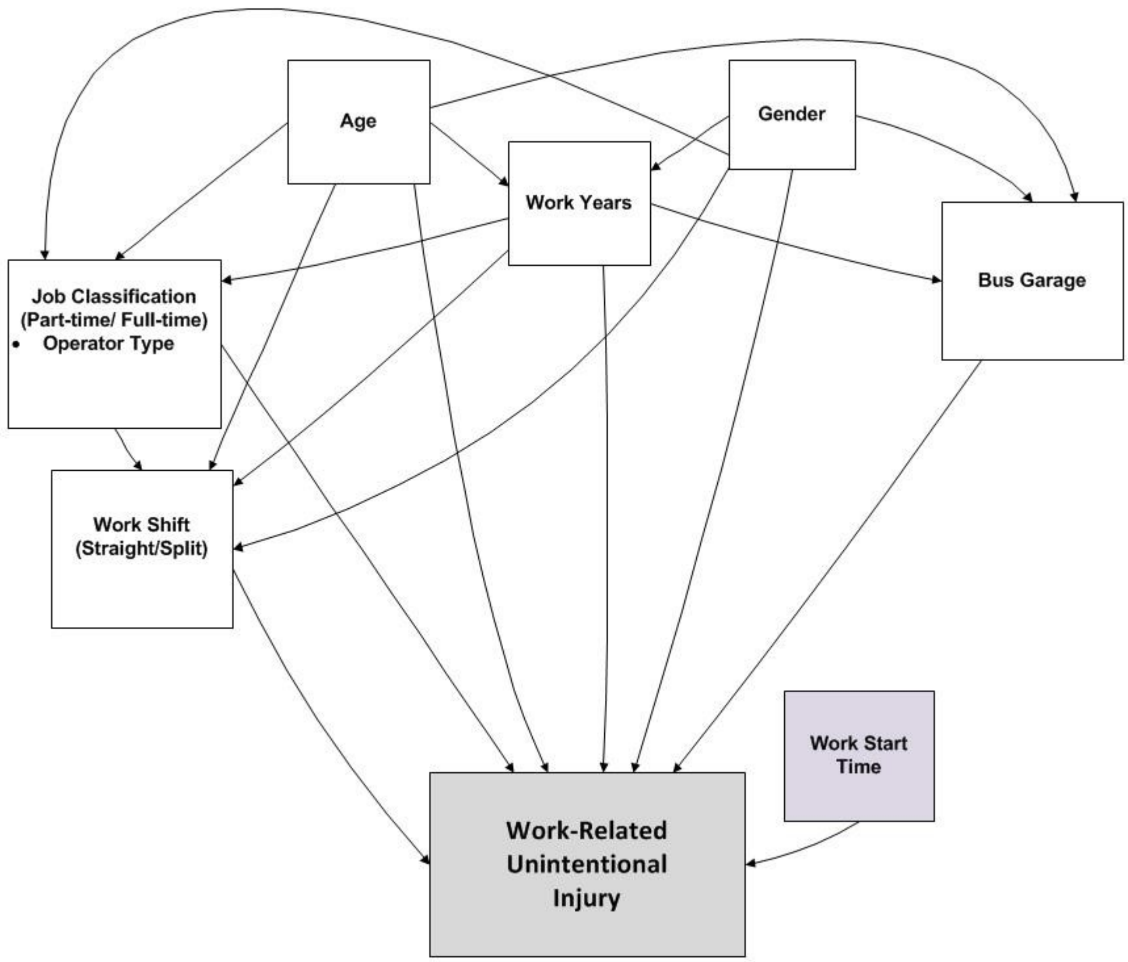


Figure 2. Example of Directed Acyclic Graph (DAG) for Work Start Time: Minnesota Bus Operator Study, 2006-2012



CHAPTER V

WORKPLACE VIOLENCE AMONG URBAN TRANSIT BUS OPERATORS: A LONGITUDINAL STUDY

Abstract

INTRODUCTION

Work-related or workplace violence has been an important issue for occupational safety. According to findings from National Crime Victimization Survey (NCVS) in 2009, there were 572,000 nonfatal violent events reported when people were at work or on duty. In the same year (2009), the Bureau of Labor Statistics (BLS) reported that the "assaults and violence acts by person" incidence rates per 10,000 full-time workers for the category of "bus driver, transit and intercity" was five times greater than for all occupations combined (19.0 versus 3.9). Bus operation involves working alone and interacting with bus passengers without social support from colleagues or managers; and working alone has been identified as a risk factor for experiencing workplace violence. Numerous studies have focused on work-related violence in different occupations, such as health sectors, including veterinarians, nurses, and educators. However, violence against bus operators has not investigated adequately. Thus, the objective of this study was to determine the magnitude of and risks for workplace violence among urban transit bus operators.

METHODS

Demographic, work-related, and injury information were obtained from a transit company for a five-year period (Dec 1, 2006 to Dec 31, 2011). Estimates of rates, per 100 Full Time Equivalents (FTEs) and adjusted Hazard Ratios (HRs), with associated 95%

Confidence Intervals (C.I.), were generated, using Generalized Estimating Equations and Cox Proportional Hazards models, respectively.

RESULTS

A total of 2,095 bus operators was included in this study. According to the injury reports, 78 bus operators reported one intentional event, and six reported multiple events during the study period (December 1, 2006 to December 31, 2011), accounting for a cumulative total of 88 intentional injury events.

Overall, the intentional injury rate with 95% C.I. was 1.4 (1.1-1.7) per 100 FTEs. Operators who commenced working between 3 p.m. and 6 p.m. (HR=2.4; 1.2-5.1) and 12 a.m. and 3 a.m. (HR=5.3; 1.6-18.2), had higher risks of intentional injury, compared to those who commenced work between 9 a.m. and 12 p.m. In addition, higher risks were also found for operators who: worked less than seven hours or worked more than 12 hours (HR=16.3; 9.5-28.1 and HR=9.6; 3.7-23.5, respectively), compared to seven to less than 12 hours; drove less than seven hours or more than 12 hours (HR=11.3; 6.6-19.5 and HR=11.9; 4.8-29.6, respectively), compared to seven to less than 12 hours. Moreover, those who worked overtime had 30% higher risks, compared to those who did not.

CONCLUSIONS

This study identified several risk factors that are likely to affect the occurrence of work-related injury among urban transit bus operators. While potential causes of workplace violence differ by occupational sector, these findings are among the first identified in this particular occupation of bus operators. The risk factors identified could potentially serve as a basis for intervention strategies.

1. INTRODUCTION

Work-related or workplace violence has been an important issue for occupational safety (NIOSH, 1996; Essenberg, 2003; Chappell & Di Martino, 2006; Harrell, 2011). According to findings from the National Crime Victimization Survey (NCVS) in 2009, there were 572,000 nonfatal violent events (including sexual assault, robbery, and aggravated and simple assault) reported when people were at work or on duty; 521 people were reported as victims of work-related homicides (Harrell, 2011). Numerous studies have focused on work-related violence in different occupations, such as health sectors, including veterinarians (Gabel & Gerberich, 2002), nurses (Gerberich et al., 2002; Viitasara et al., 2003; Findorff et al., 2004; Gerberich et al., 2004; Gerberich et al., 2005), and educators (Sage et al., 2010; Gerberich et al., 2011; Nachreiner et al., 2012; Wei et al., 2013; Gerberich et al., 2014). Yet, little is known about occupational violence and relevant risk factors among bus operators, especially urban transit bus operators.

Based on bus operators' working conditions, this occupation had been classified as having high job demand with low job control (Karasek, 1979; Tse et al., 2006). The working characteristics include irregular shifts, strict time schedules, deficient break times, and adverse bus incidents; violent events have also been a source of stress for bus operators (Duffy & McGoldrick, 1990; Kompier, 1996; Essenberg, 2003; Sampaio et al., 2009). In particular, a work-related stressor survey conducted among male bus operators indicated that the number one concern for bus operators was the possibility of assault (Duffy & McGoldrick, 1990). Thus, driving a bus, professionally, has been a high stress occupation. In addition, this particular occupation involves working alone and interacting with bus passengers without social support from colleagues or managers. Working, alone, has also been identified as a risk factor for experiencing workplace violence (Viitasara et al., 2003).

In 2009, the Bureau of Labor Statistics (BLS) reported that the “assaults and violence acts by person” incidence rates per 10,000 full-time workers for the category of “bus driver, transit and intercity” was five times greater than for all occupations combined (19.0 versus 3.9) (Bureau of Labor Statistics (BLS), 2010). In 2010, it was three times greater (11.9 versus 4.0) (Bureau of Labor Statistics (BLS), 2011). In 2011 and 2012, when the BLS reporting changed the name of the violence category from “assaults and violence acts by person” to “intentional injuries by other person,” the incidence rates per 10,000 full-time workers were 13 times greater than for all occupations combined (36.6 versus 2.8) in 2011 (Bureau of Labor Statistics (BLS), 2012b), and 16 times greater than for all occupations combined (46.5 versus 2.9) in 2012 (Bureau of Labor Statistics (BLS), 2013).

In addition, according to the NCVS, the average annual work-related violence rate from 2005 to 2009 among bus drivers was 10.0, which was also much higher than for total occupations combined (5.1 per 1,000 persons) (Harrell, 2011). The NCVS, data collection, conducted by the Bureau of Justice Statistics, included a sample of approximately 90,000 household member interviews in the United States, while the BLS data were collected from the annual Survey of Occupational Injuries and Illness, completed by employers.

A self-report study in a transportation company reported that 75% of bus operators and money collectors reported violent events at workplaces (Sampaio et al., 2009); in particular, 43% of bus operators reported assaults on the bus involving weapons. In addition, a cross-sectional study survey among drivers and conductors in the passenger transport sector reported that bus drivers, compared to taxi drivers, were 3.5 times more likely to experience workplace violence (Couto et al., 2009). Thus, bus operators have been one of the occupations identified with a high risk of workplace violence.

Workplace violence includes both physical assault (PA) and non-physical violence (NPV). PA occurs when employees are hit, slapped, kicked, or otherwise subjected to physical contact; NPV includes threats, verbal abuse, sexual harassment, and bullying. Previous studies have indicated that PA and NPV are important problems among nurses (Gerberich et al., 2004; Gerberich et al., 2005) as well as educators (Gerberich et al., 2011; Wei et al., 2013). Violence against bus operators has not investigated adequately. Thus, the objective of this study was to determine the magnitude of and risks for workplace violence among urban transit bus operators.

2. METHODS

2.1 Study Design

The ultimate goal of this study was to identify how personal and work-related characteristics may contribute to the occurrence of work-related intentional injuries among transit bus operators. This involved first identifying the magnitude of intentional injuries for a five-year period of time, followed by analysis to determine the associations between occupational injury and exposures of interest that can enable identification of relevant risk factors.

2.2 Study Population and Data Collection

The study population consisted of transit bus operators who worked at a metropolitan transit company that covers a seven county area. Available data, between December 1, 2006 and December 31, 2011 were obtained from the company. Data included the bus operators' demographic information: gender and age; work-related characteristics: years of working; job classification (part-time or full-time); working hours per day; driving hours per day; overtime hours per day; bus garage division; work start time; shift schedule;

number of busses driven per day; and bus route types. Intentional injury event reports included type of injury and body part affected.

In total, there were 2,095 eligible bus operators who were employed during the study period. Those who left before December 1, 2006, or entered after December 31, 2011, were excluded from the data analysis. This study was approved by the Institutional Review Board (IRB) at the University of Minnesota.

2.3 Measurements and Definitions

2.3.1 *Dependent variable*

Definitions used for work-related injury are consistent with National Center for Health Statistics (NCHS) and Bureau of Labor Statistics (Bureau of Labor Statistics (BLS), 2012a). *Work-related injury* is any wound or damage to the body associated with the job that occurs in the work environment; this includes lacerations, fractures, sprains, amputations, and musculoskeletal disorders, among others. In particular, *intentional injury* involves intention to harm oneself or others. The outcome of interest in this study was PA, which involves acts that use intentional physical force with the potential for causing physical injury and consequences against an employee. These definitions, primarily consistent with those incorporated in prior occupational violence studies (Gerberich et al., 2004; Gerberich et al., 2005; Gerberich et al., 2011; Wei et al., 2013; Gerberich et al., 2014), reflect those identified by the National Institute for Occupational Safety and Health (NIOSH, 1996).

The injury report information included: event date; event time; type of injury (“burn or scald,” “caught in or between,” “caught, puncture, or scrape,” “fall or slip injury,” “motor vehicle-related,” “abrasion,” “strain,” “striking against or stepping on,” “struck by;”); and body part affected (arm, back, chest, hand, head, leg, and shoulder). From these reports, 1,389 total injury events were identified between December 1, 2006 and December 31, 2011; these events were reviewed and classified by the investigators, based on the definitions identified above. After eliminating cases that did not meet the requirement (such as non-work-related and unintentional work-related injuries), 88 intentional work-related injury events were included in the final data analysis.

2.3.2 Independent variable

Personal Characteristics

Transit bus operators' demographic information of age and gender were obtained for this study.

Occupational Characteristics

Bus Garage: The transit company maintained five different garages located in the metropolitan area. Based on their geographic locations, each of the garages had its own associated bus route.

Job Classification: This included weekday full-time, weekday part-time, and weekend part-time. Weekday full-time operators had 40 hours of work per week guaranteed. Weekday part-time operators could have worked up to 30 hours per week.

Working Years: This involved years worked as a bus operator at the transit company.

Workload: This was a measure of hours of driving and working per day and included bus operators' overtime hours.

Work Shifts: There were two types of shift work in the bus operators' schedules: a straight shift was a regular day shift and a split-shift involved the operators' workdays split into two parts.

Number of Bus Routes: Each operator could have had different driving assignments within a day; that is, the operator could have driven one to as many as seven different routes in a given day, depending on the driving assignment of that day.

Types of Bus Routes: There were three types of bus route services: regular-route; limited stops; and express bus service. Limited stop routes had the same routes as regular-routes, but with less stops. Express buses traveled on freeways for a distance of at least four miles; the bus fare was higher for travel on express buses, compared to regular and limited stop bus routes.

Work Start Time: This category examined the time that the bus operator commenced working, within a three-hour period of time, at the company during that working day. Eight subcategories of working time commencement were: 3 a.m. to < 6 a.m., 6 a.m. to < 9 a.m., 9 a.m. to < 12 p.m., 12 p.m. to < 3 p.m., 3 p.m. to < 6 p.m., 6 p.m. to < 9 p.m., 9 p.m. to < 12 a.m., and 12 a.m. to < 3 a.m.

2.4 Statistical Analysis

Data analysis commenced with descriptive statistics including number of reported events and characteristics of injured bus operators. The outcome variable (work-related intentional injuries) involved the number of events occurring in a set of observations; in this study, a transit bus operator could have reported more than one injury event during the study period.

Estimates of rates, per 100 Full Time Equivalents (FTEs) and associated 95% Confidence Intervals (C.I.), were generated using generalized estimated equations (GEEs) (Liang & Zeger, 1986) with exchangeable working correlation matrices. FTEs were calculated using the total number of working hours within the study period, divided by 2,000 hours (8 hours/day* 5 days/week* 50 weeks/year). GEEs are an extension of generalized linear models to correlated data; moreover, they produce marginal models, which compare between subjects (transit bus operators). In this study, bus operators selected or were assigned their work shifts and schedules three to four times a year; their work-related characteristics could have changed, based on their daily shift assignments. Thus, each observation was based on their assignments per day and could have involved up to 250 observations for each bus operator per year. Therefore, each observation was time-independent and correlated within a bus operator. In the models, each bus operator was considered to be independent. The exchangeable working correlation structure assumes that any two observations within a subject (transit bus operator) have a consistent correlation, providing the rationale for using exchangeable working correlations in the GEE models for each exposure of interest.

Furthermore, in order to estimate the impact of various risk factors on the occurrence of occupational injury, Cox proportional hazards analysis was utilized. Each bus operator was observed and considered to be at risk until the injury event occurred. As noted, this longitudinal dataset contained repeated observations and one bus operator could have reported more than one injury event; therefore, the “counting process model” for Cox proportional hazard analysis was utilized in the analytic model. This model assumed each reported injury event within a bus operator was independent, i.e., a subsequent event was not related to any previous event; thus, the sequence of the injury events was disregarded. All analyses were conducted using SAS 9.4 for windows (SAS, 2012).

2.4.1 Selection of Variables

A causal model was developed to determine the variables to be measured and controlled for in the overall study analyses (**Figure 1**) (Greenland et al., 1999). From this model, individual Directed Acyclic Graphs (DAGs) were derived to select the minimum set of potential confounding factors for each exposure of interest (Greenland et al., 1999; Hernán et al., 2002). A DAG is a graph that links from cause to outcome with a one-headed arrow, and with no feedback loop. Each DAG reflects an exposure of interest that was used to define variables, a priori, to guide multivariable analyses of the data (Greenland et al., 1999). Thus, adjusted Hazard Ratios (HR) and associated 95% C.I., per 100 FTEs, were calculated to determine the strength of the associations between exposures and the outcome of interest. Because operators could select their own work shifts and schedules three to four times a year, based on their seniority (length of time employed), it was important to adjust for years worked when examining the associations between working schedules or shifts among the operators and intentional work-related injury. An example of a DAG, used in the multivariate analysis, is presented in **Figure 2**. In this DAG, adjusted HR of commencement of work start time was calculated after adjustment for age, gender, work years, job classification, work shift, and bus garage.

3. RESULTS

A total of 2,095 bus operators were included in this study; 78% of this population was male, the overall average working years was 11 years (Standard Deviation (SD) = 9), and average age was 49 years (SD = 10). According to the injury reports, 78 bus operators reported one intentional event, and six reported multiple events during the study period (December 1, 2006 to December 31, 2011), accounting for a cumulative total of 88 intentional injury events (**Table 1**). These 88 physical assault events involved hitting, slapping, punching, attacking, and spitting. Event occurrences for times and days were: more than 21%, 23% and 20% that occurred during working commencement periods between 3 p.m. and 6 p.m., 6 p.m. and 9 p.m. and 9 p.m. and 12 a.m., respectively; 19% and 20% occurred on Monday and Friday, respectively (data not shown).

As noted, this was a longitudinal study design; thus, personal demographic information, such as age and work-related characteristics were time dependent, and could have changed day-to-day. As a result, the descriptive findings presented are the numbers of reported events *on the dates of injury* among bus operators during the five-year period. **Table 2** identifies the characteristics of injured bus operators. Among those reporting intentional injury, highest percentages were found among operators who: were 50 to less than 60 years old; had worked less than five years; worked full-time; commenced working between 3 p.m. and 6 p.m.; worked and drove seven to less than 12 hours; drove one route, and drove a regular bus route, only. The primary type of injury involved a “struck by” mechanism with the head being injured most frequently.

Results of the GEE analysis for estimated rates per 100 FTEs, associated 95% Confidence Intervals (C.I.), and working hours are shown in **Table 3**. Overall, the intentional injury rate was 1.4 per 100 FTEs among transit bus operators; male versus female operators had a higher estimated rate. The intentional injury rates decreased with working years, from 1.7 to 0.9 per 100 FTEs. Highest intentional injury rates were found among bus operators who: commenced work between 12 a.m. and 3 a.m.; worked on Sunday; and worked less than seven hours per day. Also, highest rates were also shown for those who drove: more than 12 hours per day; one route per day; and regular routes.

Adjusted Hazard Ratios (HR) and associated 95% C.I.s were generated using multivariable analysis for Cox proportional models; results are also shown in **Table 3**. Operators who commenced working between 3 p.m. and 6 p.m. and 12 a.m. and 3 a.m., had higher risks of intentional injury, compared to those who commenced work between 9 a.m. and 12 p.m. In addition, for operators who worked and drove less than seven hours and more than 12 hours, compared to seven to less than 12 hours, had higher risks. Moreover, those who worked overtime, versus those who did not, had higher risks.

Decreased intentional injury risks were found among bus operators who worked part-time, and drove more than three routes. In addition, working on Monday, compared to Sunday, was suggestive of less risk.

4. DISCUSSION

The primary objective of this study was to determine the magnitude of intentional injury, and to investigate the individual and work-related characteristics that enabled identification of potential risk factors among urban bus operators. The strength of the study included the ability to obtain daily working schedules, shifts, and driving information for all bus operators over a five-year period. By linking an injury report system to a work scheduling system, the final dataset provided complete working information for each operator's working day, including any days of injury. While the operators' working shifts and schedules could have changed day-to-day, based on their driving assignments, this longitudinal dataset minimized bias due to varying work exposures among bus operators. Moreover, this study was based on a representative population of urban transit bus operators in Minnesota.

The overall intentional injury rate of 1.5 per 100 FTEs, was slightly higher than the BLS estimated intentional injury incidence rate for the category of "bus driver, transit and intercity" (0.7 per 100 full-time workers) in 2012. However, it is important to recognize that transit and intercity drivers are exposed to different types of passengers. In this current study, a higher rate of intentional injury was found among males; this was consistent with other violence-related studies, although different occupations were addressed (Gerberich et al., 2004; Privitera et al., 2005; Couto et al., 2009). In addition, it was not surprising that more than 60% of intentional injury events occurred between 3 p.m. and 12 a.m., and bus operators who commenced working during evening hours (3 p.m. to 6 p.m.), experienced higher risks of violent events compared to those who commenced working during daytime morning hours (9 a.m. to 12 p.m.).

Bus operators who worked part-time versus full-time had an 80% decreased risk of intentional injury. A similar finding was identified in a different occupational setting (Viitasara et al., 2003). Yet, bus operators who worked or drove less than seven hours and more than 12 hours, compared to those who worked or drove seven to less than 12 hours, had increased risks. In addition, those who worked overtime had increased risks of intentional injury compared to those who did not. A study conducted for the road passenger transport sector (registered bus, minibus, and taxi drivers/conductors) in the city of Mozambique, Maputo, indicated those who had worked less than five, compared with over 15 years had a lower risk of workplace violence (Odds ratio=0.3, $p < 0.05$) (Couto et al., 2009); however, in this current study, through the multivariable analyses, no significant risks were found among those who worked less than five compared to more than 15 years.

Although this study utilized available company records from an urban transit company, some information including occupational history, personal medical information, physical activities, fatigue status, and sleep hours were not available. The lack of information on days away from work, following injury, also prevented estimation of severity. Potential selection bias could have occurred if employees chose to not report one or more injuries. One of the selection biases is the healthy worker effect (HWE, a phenomenon that should be considered in any occupational study). Some study results have suggested that the HWE would eliminate 20% to 30% of the association between exposure and outcome (Shah, 2009). However, the strengths of this current study were the ability to collect data directly from the transit company, for a five-year period and, therefore, to utilize the longitudinal observations. In addition, the magnitude of injury was estimated by controlling for potential confounding factors and adapting specific statistical models to fit the natural correlated structure of the dataset.

5. CONCLUSIONS

This study identified several risk factors that are likely to affect the occurrence of work-related injury among urban transit bus operators. While potential causes of workplace violence differ by occupational sector, these findings are among the first identified in this particular occupation of bus operators. The risk factors identified could potentially serve as a basis for intervention strategies. In addition, future studies could provide important data on nonphysical violence, including verbal abuse, bullying, threats, and sexual harassment that have been shown in prior studies to be more detrimental than physical violence (Gerberich et al., 2004; Gerberich et al., 2011).

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Table 1. Number of Bus Operators Reporting Intentional Injury Events: Minnesota Bus Operator Study, 2006-2012

Number of Events Reported by Bus Operator	Number of Bus Operators	Percent
0	2013	96.1
1	77	3.7
2	4	0.2
3	1	0.0
Total	**2095**	

Table 2. Characteristics of Injured Bus Operators and Exposures On the Dates of Intentional Injuries: Minnesota Bus Operator Study, 2006-2012

Intentional Injury Characteristics					
Total Events = 88	**Number Reporting Events**	**Percent**		**Number Reporting Events**	**Percent**
Age (years)			**Working Hours**		
< 30	4	4.5	> 0 to less than 7 Hours	38	43.2
30 to <40	13	14.8	7 to less than 12 Hours	45	51.1
40 to <50	23	26.1	≥ 12 Hours	5	5.7
50 to <60	35	39.8	**Driving Hours**		
60 +	13	14.8	0 Hours	0	0.0
Work Years			> 0 to less than 7 Hours	38	43.2
0 to <5	34	38.6	7 to less than 12 Hours	45	51.1
5 to < 10	26	29.5	≥ 12 Hours	5	5.7
10 to <15	13	14.8	**Overtime Hours**		
> 15	15	17.0	0 Hours	72	81.8
Job Classification		0.0	> 0 to less than 3 Hours	8	9.1
Full-time	83	94.3	3 to less than 6 Hours	5	5.7
Part-time	5	5.7	≥ 6 Hours	3	3.4
Operator Type		0.0	**Shift**		
Full-time 8 Hours	55	62.5	Straight	65	73.9
Full-time 9 Hours	15	17.0	Split	23	26.1
Full-time 10 Hours	13	14.8	**Number of Routes Driven**		
Weekday Part-time	4	4.5	0	0	0.0
Weekend Part-time	1	1.1	1	44	50.0
Work Start Time ‡			2	34	38.6
3 a.m. to < 6 a.m.	15	17.0	3	3	3.4

Intentional Injury Characteristics					
Total Events = 88	**Number Reporting Events**	**Percent**		**Number Reporting Events**	**Percent**
6 a.m. to < 9 a.m.	18	20.5	4	4	4.5
9 a.m. to < 12 p.m.	9	10.2	5	2	2.3
12 p.m. to < 3 p.m.	17	19.3	6	0	0.0
3 p.m. to < 6 p.m.	26	29.5	Unknown	1	1.1
6 p.m. to < 9 p.m.	0	0.0	**Route Type Driven**		0.0
9 p.m. to < 12 a.m.	0	0.0	None	0	0.0
12 a.m. to < 3 a.m.	3	3.4	Regular only	57	64.8
Weekday			Limited Stop only	3	3.4
Sunday	9	10.2	Express Bus only	1	1.1
Monday	17	19.3	Regular and Limited Stop	5	5.7
Tuesday	11	12.5	Regular and Express Bus	16	18.2
Wednesday	11	12.5	Limited Stop and Express Bus	0	0.0
Thursday	14	15.9	Regular, Limited Stop, and Express Bus	4	4.5
Friday	18	20.5	Unknown Type	2	2.3
Saturday	8	9.1			

Table 3. Work-Related Intentional Crude Injury Rates and Adjusted Hazard Ratios: Minnesota Bus Operator Study, 2006-2012

	Number Reporting Events	Total Hours (x10,000)	Estimated Crude Rate	95% C.I.	Estimated Adjusted HR	95% C.I.
Total	88	**1244.5**	1.4	1.1-1.7		
Gender						
Female	13	248.1	1.0	0.6-1.8	0.7	0.4-1.2
Male	75	996.4	1.5	1.2-1.9	1.0	—
Age (years)						
< 30	4	65.1	1.2	0.5-3.3	0.7	0.2-2.3
30 to <40	13	10.9	1.4	0.8-2.5	0.9	0.4-2.2
40 to <50	23	363.0	1.3	0.9-1.9	0.8	0.4-1.9
50 to <60	35	465.0	1.5	1.1-2.1	1.0	0.5-2.1
60 +	13	170.5	1.5	0.8-2.9	1.0	—
Work Years						
0 to <5	34	38.8	1.7	1.2-2.5	1.8	0.9-3.4
5 to < 10	26	322.1	1.6	1.0-2.4	1.8	0.9-3.6
10 to <15	13	21.2	1.2	0.7-2.3	1.3	0.6-2.9
≥ 15	15	322.4	0.9	0.5-1.6	1.0	—
Job Classification †						
Full-time	83	999.9	1.6	1.3-2.1	1.0	—
Part-time	5	244.6	0.4	0.2-1.0	0.1	0.1-0.3
Operator Type †						
Full-time 8 Hours	55	697.9	1.6	1.2-2.1	1.0	—
Full-time 9 Hours	15	152.7	2.0	1.2-3.2	1.2	0.7-2.1
Full-time 10 Hours	13	149.3	1.7	1.0-3.1	1.4	0.7-2.7
Weekday Part-time	4	217.1	0.4	0.1-1.0	0.1	0.0-0.4
Weekend Part-time	1	27.4	0.7	0.1-5.3	0.3	0.0-1.9

	Number Reporting Events	Total Hours (x10,000)	Estimated Crude Rate	95% C.I.	Estimated Adjusted HR	95% C.I.
Work Start Time Interval ‡						
3 a.m. to < 6 a.m.	15	464.6	0.6	0.4-1.1	0.5	0.2-1.3
6 a.m. to < 9 a.m.	18	32.9	1.1	0.7-1.7	0.9	0.4-1.9
9 a.m. to < 12 p.m.	9	119.1	1.5	0.8-2.8	1.0	—
12 p.m. to < 3 p.m.	17	189.6	1.8	1.1-2.9	1.2	0.5-2.6
3 p.m. to < 6 p.m.	26	129.1	4.0	2.7-5.8	2.4	1.2-5.1
6 p.m. to < 9 p.m.	0	4.3	—		—	
9 p.m. to < 12 a.m.	0	1.9	—		—	
12 a.m. to < 3 a.m.	3	7.3	7.9	2.7-22.7	5.3	1.6-18.2
Weekday §						
Sunday	9	77.1	2.3	1.2-4.4	1.0	—
Monday	17	207.2	1.6	1.0-2.7	0.1	0.0-0.5
Tuesday	11	214.2	1.0	0.6-1.8	0.2	0.0-0.9
Wednesday	11	214.5	1.0	0.6-1.8	0.3	0.1-1.5
Thursday	14	211.7	1.3	0.8-2.2	0.2	0.0-1.2
Friday	18	210.7	1.7	1.1-2.7	2.3	0.4-13.9
Saturday	8	109.1	1.4	0.7-2.9	0.0	0.0-0.1
Working Hours per day ll						
> 0 to less than 7 Hours	38	206.6	3.8	2.7-5.4	16.3	9.5-28.1
7 to less than 12 Hours	45	1008.1	0.9	0.6-1.2	1.0	
≥ 12 Hours	5	29.8	3.3	1.4-7.9	9.3	3.7-23.5
Driving Hours per day ll						
0 Hours	0	5.6	—		—	
> 0 to less than 7 Hours	38	245.1	3.2	2.3-4.5	11.3	6.6-19.5
7 to less than 12 Hours	45	970.8	0.9	0.7-1.2	1.0	—
≥ 12 Hours	5	23.0	4.3	1.8-10.2	11.9	4.8-29.6

	Number Reporting Events	Total Hours (x10,000)	Estimated Crude Rate	95% C.I.	Estimated Adjusted HR	95% C.I.
Overtime Hours per day ‖						
0 Hours	72	1105.2	1.3	1.0-1.6	1.0	—
> 0 to less than 3 Hours	8	59.5	2.6	1.3-5.2	3.0	1.4-6.4
3 to less than 6 Hours	5	37.9	2.6	1.1-6.2	3.9	1.6-9.5
≥ 6 Hours	3	41.9	1.4	0.5-4.5	3.0	1.0-8.9
Shift §						
Straight	65	913.3	1.4	1.1-1.8	1.0	—
Split	23	331.2	1.4	0.9-2.1	0.8	0.5-1.3
Number of Routes Driven per day ¶						
None	0	5.6	—		—	
One Route	44	472.4	1.8	1.4-2.5	1.0	—
Two Routes	34	412.1	1.6	1.2-2.3	1.0	0.6-1.5
More than 3 routes	10	354.4	0.6	0.3-1.0	0.4	0.2-0.7
Route Type ¶ **						
Regular	82	1005.9	1.6	1.3-2.0	3.6	1.5-8.9
Limited Stop	12	265.2	0.9	0.5-1.7	0.7	0.4-1.4
Express Bus	21	414.5	1.0	0.7-1.6	0.8	0.5-1.5

* Adjusted for Age, and Gender
† Adjusted for Age, Gender, and Work Years
‡ Adjusted for Age, Gender, Work Years, Job Classification, Work Shift, and Garage
§ Adjusted for Age, Gender, Work Years, and Job Classification
‖ Adjusted for Age, Gender, Work Years, Job Classification, Number route of Driving, and Route Type
¶ Adjusted for Age, Gender, Work Years, Job Classification, Bus Garage, Work Start Time and Weekday
** Reference: Regular versus Non-regular; Limited Stop versus Non-Limited Stop; Express Bus versus Non-Express Bus

Figure 1. Causal Model: Minnesota Bus Operator Study, 2006-2012

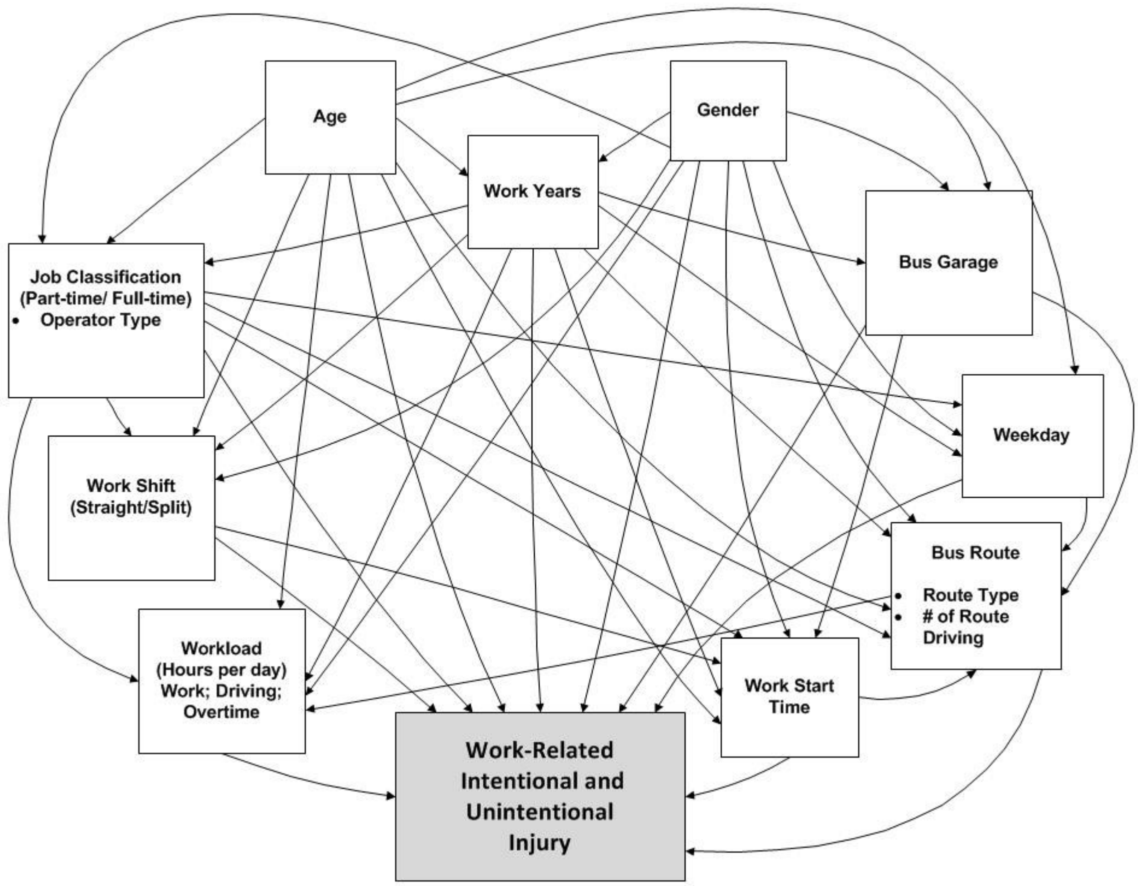
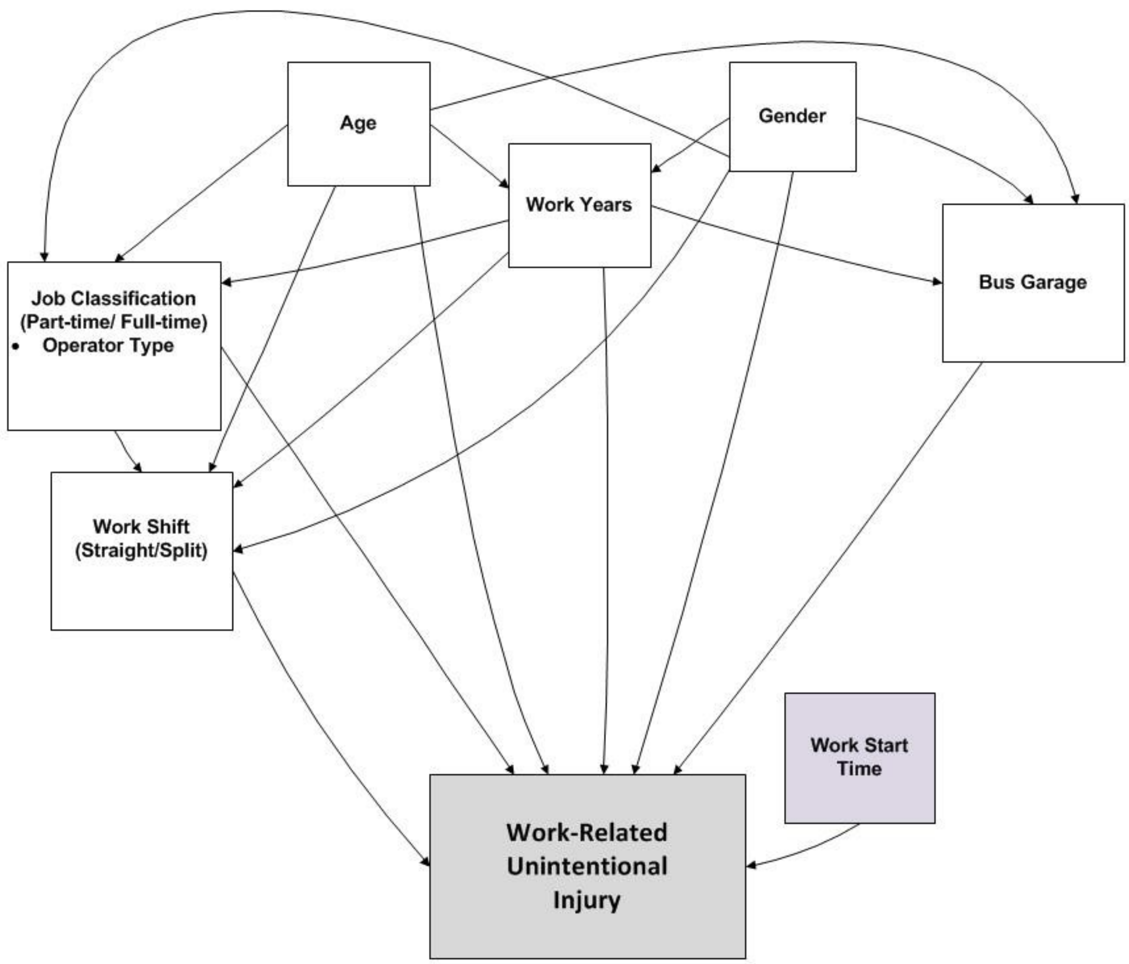


Figure 2. Example of Directed Acyclic Graph (DAG) for the Exposure of Work Start Time and Outcome of Intentional Injury: Minnesota Bus Operator Study, 2006-2012



CHAPTER VI

DISCUSSION

OVERVIEW

The goal of this study was to examine the role of personal and work-related characteristics as potential risk factors for work-related injury (both unintentional and intentional injury) among urban transit bus operators. Most studies of bus operators have suggested that physical health problems and physiological effects are caused by their working environment (Evans, 1994; Aptel & Cnockaert, 2002; Tse et al., 2006; Szeto & Lam, 2007). Bus operators' long working hours, irregular shifts, inconsistent break times, lack of social support, and interaction with passengers are reportedly the main reasons why bus drivers sustain high job strain that can result in adverse health outcomes. However, there are limited data that consider bus operators' personal and various working conditions relevant to injury outcomes.

The five-year longitudinal study is important because it enabled examination of the association between work-related characteristics and work-related injuries while controlling for potential confounding factors. The use of company data to investigate bus operators' personal and work-related characteristics, workload (hours worked per week), working years, working schedules, and routes as well as reported injury events, serves as a basis for intervention efforts and further research. Multivariable analyses were used to adjust for potential factors, and to examine the relations between exposures of interests and occupational injuries (unintentional and intentional) to identify risk and protective factors.

The aim of this study was to understand the magnitude, potential risk factors, and protective factors that are associated with work-related injuries among bus operators. As the results suggested, risk factors for urban transit bus operators were different between intentional and unintentional injuries. The intentional injury rate was higher among male operators; however, the unintentional injury rate was higher for female operators. Those aged 65 years and older had a higher intentional injury rate than other age groups, but yielded the lowest rate for unintentional injury. These and other results are discussed below.

UNINTENTIONAL INJURY

This study analysis determined the occurrence of work-related injuries among transit bus operators in a metropolitan area for different age groups, working years, and work-related characteristics such as job classification, hours of work and driving per day, schedules, and shifts. The overall unintentional injury rate was 17.8 per 100 FTEs; due to different study methods and populations used, these data are not comparable with other studies.

While it has been reported that males were more likely than females to experience work-related injuries, in general (Laundry & Lees, 1991; Bureau of Labor Statistics (BLS), 2011; Bureau of Labor Statistics (BLS), 2012; Bureau of Labor Statistics (BLS), 2013) it was identified in the current study that, among bus operators, females, compared to males, had a higher risk. In addition to injury risk, occupational studies have suggested that females experience greater injury severity compared to males; one population-based study that utilized workers' compensation data indicated females had a longer estimated period of disability than males, even after adjusting for initial hospitalization (Cheadle et al., 1994). Another study that examined the severity of injury using workers' compensation data also reported that females had a higher injury rate than males (221 versus 178 per 10,000 employees per year).(Horwitz & McCall, 2004)

However, studies among bus operators have usually excluded females in their analysis due to small numbers (Backman, 1983; Hedberg et al., 1993; Hannerz & Tüchsen, 2001; Chen et al., 2010). Further study is needed relevant to gender differences among bus operators and associated work-related injury experience.

Long working hours have also been associated with higher risk of work-related injury (Dembe et al., 2005; Dong, 2005; Dembe et al., 2007; De Castro et al., 2010). However, the current study found increased risks for those operators who worked or drove less than seven hours, compared to more than seven and less than 12 hours. The difference in this finding is likely due to factors controlled for in the multivariable model, established a priori, that controlled for age, gender, work years, job classification, number of routes driven, and route types. These controlling factors were the main variables that would directly affect bus operators' schedules and working times.

Because metropolitan buses are in operation from early morning to late night, bus operators usually work in shifts. Several previous studies (Dong, 2005; Dembe et al., 2006; De Castro et al., 2010; Salminen, 2010) indicated that rotating and irregular work shifts were associated with increased injury risks. From similar findings identified in the current study, higher risk was found among bus operators who worked split shifts versus straight shifts. Although, as noted, bus operators engaged in self-scheduling; one study suggested that self-scheduling improved health and well-being (Gauderer & Knauth, 2004) since it enabled the operators to have more control over their working schedules.

Working experience was also an important covariate that affected work-related injury. Current study results suggested that operators who worked less than five years had 40% less risk compared to those who worked more than 15 years. Similarly, bus operators who had greater driving years would be expected to have a higher risk

(Bovenzi & Zadini, 1992; Ragland et al., 1997; Chen et al., 2010). From one study that investigated vibration exposure among bus operators, results indicated those with longer driving experiences had longer-term exposures to whole body vibration (with more than 4.5 years m^2 s^{-4} total vibration dose) involving higher risks for all types of low back pain symptoms and disc protrusion compared to those who were not exposed to whole body vibration, such as mechanics, electricians, and general operators.(Bovenzi & Zadini, 1992)

Decreased risks were identified for working part-time versus full-time, in particular, weekday part-time, compared to full-time eight hour shifts. This finding was in contrast to some studies reporting that temporary or part-time employees were at higher risk of occupational injuries (Nylen et al., 2001; Benavides et al., 2006; Alamgir et al., 2008). This could be explained by the different classification of part-time bus operators in the current study population that was adjusted for in the multivariable analysis. In this transit company, all new bus operators commenced with the company as part-time operators; after 12 months, they could apply for full-time positions – an approach that enabled a probationary period for monitored training and gradual increase in experience.

Two factors that had not been investigated, previously, in other studies were the number of routes and types of routes driven by bus operators per day. The results of the current study suggested that those operators who drove more than two routes, compared to only one route per day, had decreased risks; in addition, operators who drove limited stop versus regular routes, had an increased risk of injury.

INTENTIONAL INJURY

The overall intentional injury rate of 1.5 per 100 FTEs, was slightly higher than the BLS estimated intentional injury incidence rate for the category of “bus driver, transit and intercity" (0.7 per 100 full-time workers) in 2012. However, it is important to recognize that transit and intercity drivers are exposed to different types of passengers. In this current study, a higher rate of intentional injury was found among males; this was consistent with other violence-related studies, although different occupations were addressed (Gerberich et al., 2004; Privitera et al., 2005; Couto et al., 2009). In addition, it was not surprising that more than 60% of intentional injury events occurred between 3 p.m. and 12 a.m., and bus operators who commenced working during evening hours (3 p.m. to 6 p.m.), experienced higher risks of violent events compared to those who commenced working during daytime morning hours (9 a.m. to 12 p.m.).

Bus operators who worked part-time versus full-time had an 80% decreased risk of intentional injury. A similar finding was identified in a different occupational setting (Viitasara et al., 2003). Yet, bus operators who worked or drove less than seven hours and more than 12 hours, compared to those who worked or drove seven to less than 12 hours, had increased risks. In addition, those who worked overtime had increased risks of intentional injury compared to those who did not. A study conducted for the road passenger transport sector (registered bus, minibus, and taxi drivers/conductors) in the city of Mozambique, Maputo, indicated those who had worked less than five, compared with over 15 years had a lower risk of workplace violence (Odds ratio=0.3, $p < 0.05$) (Couto et al., 2009); however, in this current study, through the multivariable analyses, no significant risks were found among those who worked less than five compared to more than 15 years.

STRENGTHS AND LIMITATIONS

The strength of the study included the ability to obtain daily working schedules, shifts, and driving information for all bus operators over a five-year period. By linking an injury reporting system to a work scheduling system, the final dataset provided complete working information for each operator's working day, including any days of injury. While the operators' working shifts and schedules could have changed day-to-day, based on their driving assignments, this longitudinal dataset minimized the bias due to varying work exposures among bus operators.

This study utilized available company records from an urban transit company; as a result, some information such as occupational history, personal medical information, physical activities, fatigue status, and sleep hours were not available. Potential selection bias could have occurred if employees chose to not report any injury. In the current study, relevant injury data were collected, based on self-reported information; however, potential biases were minimized, to some degree, through utilization of the longitudinal observations for a five-year period collected directly from the transit company. In addition, the magnitude of injury was estimated by controlling for potential confounding factors and adapting specific statistical models to fit the natural correlated structure of the dataset.

Another potential limitation was the lack of information on days away from work, following injury; therefore, it was not possible to estimate severity of the occupational injuries among bus operators. One prior study compared the age-standardized hospital admission ratios between male operators of passenger transport vehicles and those of goods vehicles in Denmark; it was reported that passenger transport vehicle operators had much lower rates of injuries (Hannerz & Tüchsen, 2001) and noted that most of the injuries did not require hospital admission. However, lost time from work and restricted activity due to injuries, not involving hospitalization, has also been shown to be an important measure of severity (Gerberich et al., 2001; Carlson et al., 2005; Kurszewski et al., 2006).

STUDY VALIDITY

The ultimate goal of this epidemiologic study was to obtain accurate estimations of the effect of work-related exposures on the occurrence of work-related injury. Accuracy includes two components: validity and precision. Validity can be explained by external validity and internal validity. External validity is the ability of the study results to be generalized to people outside the population studied. The current study population may be generalizable to other comparable operations in metropolitan area transit systems across the United States. On the other hand, the violation of internal validity could be classified into three categories: information bias, selection bias, and confounding. Each of the categories is explained as follows.

Selection Bias

Potential selection bias occurred if operators chose to not report any injury. Nonphysical violence (NPV), including threat, harassment, verbal abuse, or bullying, is one form of violence; however, due to the nature of NPV, which doesn't involve direct physical assault, the ability to capture these events through reporting in a system such as that managed by the transit company, is limited. However, the primary focus in this study was physical assault events which are typically associated with exposures different from those associated with NPV; furthermore, they can be more readily validated (Gerberich et al., 2004). In this study, only three reported intentional events involved NPV (verbal abuse).

Another selection bias is the healthy worker effect (HWE). The HWE is a phenomenon that should be considered in any occupational study. Some study results have suggested that the HWE would eliminate 20% to 30% of the association between exposure and outcome (Shah, 2009).

Information Bias

Information bias is a systematic error, which results from inadequate measurement of some variable(s) in the study, resulting in measurement error. In this study, injury data collected, based on self-report information by the bus operators, and submitted to the company record system, might lead to misclassification of outcomes. In order to minimize the error, injury events were reviewed and classified by the investigators, based on the injury definitions. After eliminating cases that did not meet the requirement (such as non-work-related, or a chronic event), 1,356 work-related injury events (both unintentional and intentional) were included in the final data analysis.

Confounding

Confounding factors involve extraneous factors that cloud the effect of the exposure of interest and the outcome. As previously noted, a causal model was developed to determine the variables to be measured and controlled for in the overall study analyses. From the conceptual model, individual Directed Acyclic Graphs (DAGs) were derived to select the minimum set of potential confounding factors for each exposure of interest. Each DAG reflected an exposure of interest and was used to define variables to be included in the data analyses. Multivariable models were used to control potential confounding factors. DAGs for each exposure of interest, used in the study analyses, are identified in **Appendix B**.

CONCLUSIONS AND FUTURE DIRECTIONS

While health problems among bus operators have been investigated as occupational outcomes in previous studies, this study identified the magnitude of injury and determined the potential risk/protective factors between exposures of interest and the outcomes of unintentional and intentional occupational injury. Regardless of the limitations due to the nature of the data source, this study provided a substantive departure from the status quo through identification of important new knowledge. This study is only a beginning. Further studies, utilizing the transit company data, could examine additional aspects relevant to unintentional and intentional injury. Most importantly, results of the current study also provide a basis for potential development of intervention strategies.

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APPENDICES

APPENDIX A

Internal Review Board, Human Subjects Committee Approval

Data Agreement with Metro Transit

Chia Wei
<weixx138@umn.edu>

1301E26343 - PI Wei - IRB - Exempt Study Notification
1 message

irb@umn.edu <irb@umn.edu>
Thu, Jan 10, 2013 at 3:33 PM To: weixx138@umn.edu

TO : gerbe001@umn.edu, weixx138@umn.edu,

The IRB: Human Subjects Committee determined that the referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #4 EXISTING DATA; RECORDS REVIEW; PATHOLOGICAL SPECIMENS.

Study Number: 1301E26343

Principal Investigator: Chia Wei

Title(s):

Occupational Injury Among Bus Drivers in Minnesota Metropolitan Area

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This e-mail confirmation is your official University of Minnesota HRPP notification of exemption from full committee review. You will not receive a hard copy or letter. This secure electronic notification between password protected authentications has been deemed by the University of Minnesota to constitute a legal signature.

The study number above is assigned to your research. That number and the title of your study must be used in all communication with the IRB office.

If you requested a waiver of HIPAA Authorization and received this e-mail, the waiver was granted. Please note that under a waiver of the HIPAA Authorization, the HIPAA regulation [164.528] states that the subject has the right to request and receive an accounting of Disclosures of PHI made by the covered entity in the six years prior to the date on which the accounting is requested.

If you are accessing a limited Data Set and received this email, receipt of the Data Use Agreement is acknowledged.

This exemption is valid for five years from the date of this correspondence and will be filed inactive at that time. You will receive a notification prior to inactivation. If this research will extend beyond five years, you must submit a new application to the IRB before the study's expiration date.

Upon receipt of this email, you may begin your research. If you have questions,

please call the IRB office at (612)626-5654.

You may go to the View Completed section of eResearch Central at http://eresearch.umn.edu/ to view further details on your study.

The IRB wishes you success with this research.

We have created a short survey that will only take a couple of minutes to complete. The questions are basic, but will give us guidance on what areas are showing improvement and what areas we need to focus on:
https://umsurvey.umn.edu/index.php?sid=94693&lang=um

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Sponsored Projects Administration
Un-Funded Research Agreements

450 McNamara Alumni Center
~~200 Oak Street S.E.~~
Minneapolis, MN 55455-2070
e-mail: doyen@umn.edu/lower019
612-625-8826/612-625-3379
Fax: 612-624-4843

Duane Oyen
UFRA Coordinator
Becky Lowery Contracts Assistant

24 July, 2013

To: Susan Gerberich

From: The UFRA Group re: mtarf 758125

Subject: Your Completed and Active MTA is Attached

Source of Materials: Metropolitan Council

Materials: Occupational injury records

If you have not yet received the materials from your scientific counterpart at the institution or company providing them to you, feel free to contact them, in any manner you wish, to expedite the delivery.

Please note: ***The burden of complying with this contract is on the PI running the project.***

1) The terms for handling the materials, and the prohibition against passing them on to others, using them for any research not identified, or with other materials received under an MTA, without coordinating with SPA and your supplier. In particular, note the instructions on how to handle the remaining material after the research is completed.

2) After the experiments are done and you are disposing of or returning the material, it would be extremely helpful if you would notify the UFRA office of SPA (mat-transfer@umn.edu) that the agreement can be terminated.

3) Finally, it is especially important that you remember to refer to both your project sponsor *and* to the provider of these materials in any invention disclosure related to discoveries resulting from this research. There may also be intellectual property rights granted to the material provider as a result of this provision of materials, so it is very important that you let us know right away if you wish to use the materials for experiments in conjunction with any other project so that we can assure that the legal "coast is clear".

This particular MTA has the following key provisions:

Export Control: Ask the material provider to if any confidential info is export-controlled N/A

Intellectual property grantbacks and invention reporting requirements: See agreement

Acknowledge the source of materials in any publications: yes

Provide a copy of any proposed publication 30 days before submitting

For instruction on return of materials, see provider

Mark or identify confidential information in writing yes. period of time to protect confidentiality of such information – years after provided, or – years after end of agreement term.

If we may be of further assistance to you, feel free to call or e-mail, and best of luck with your research.

July 9, 2013

Mr. Duane Oyen
Sponsored Projects Administration
University of Minnesota
200 Oak Street SE
450 McNamara Alumni Center
Minneapolis MN 55445

RE: Data Use Agreement Between Metropolitan Council & Regents of the University of Minnesota
Metropolitan Council #131039
Agreement Transmittal

Dear Mr. Oyen:

Enclosed you will find the executed Agreement in reference.

Please contact Brian Funk at 612-349-7571 if there are any questions or if you require further assistance.

Sincerely,

Micky Gutzmann CPPO

Micky Gutzmann, CPPO
Director, Contracts and Procurement

MG:bkd

cc: Brian Funk

N:\ESGM\CPU\TRANSIT\131039 Data Use Agreement MetCouncil & Regents University of MN

390 Robert Street North | Saint Paul, MN 55101-1805
P. 651.602.1000 | F. 651.602.1550 | TTY. 651.291.0904 | metrocouncil.org
An Equal Opportunity Employer

METROPOLITAN
COUNCIL

DATA USE AGREEMENT BETWEEN Contract No. 13I039

Metropolitan Council

and

Regents of the University of Minnesota

This Data Use Agreement ("Agreement") is made and entered into by and between the **Metropolitan Council, through its Metro Transit Division** ("the Council"), and **Regents of the University of Minnesota by and through its School of Public Health** ("U of M").

1. This Agreement sets forth the terms and conditions pursuant to which the Council will disclose a limited data set excerpt from certain potentially protected private personnel data under the Minnesota Government Data Practices Act, Chapter 13 ("MGDPA") ("the Data") to the U of M.

2. The U of M is receiving this Data for the purposes set forth in Attachment A, which includes, in part, summarizing the Data to make conclusions regarding occupational injuries of Metro Transit bus operators and to ensure that no individuals can be identified from the resulting study report.

3. Permitted Uses and Disclosures

3.1 Except as otherwise specified herein, the U of M may make all uses and disclosures of the Data for the purposes described herein:

The Council will grant access to the Data for the following purposes provided:

1. The U of M has obtained all required internal review board approvals;

2. The U of M agrees to comply with all applicable, laws, policies and procedures related to the access and use of the Data, including but not limited to the MGDPA; and

3. The U of M and the individuals identified in 3.2 acknowledge that consistent with Minnesota Statutes section 13.05, subd. 6, any data on individuals contained in the Data will be administered and maintained by them in accordance with the MGDPA, and any other statutory provisions applicable to the Data. They further acknowledge that the remedies of Minnesota Statutes section 13.08 apply. In the event the U of M receives a request to disclose or release the Data, it must immediately notify the Council. The U of M will not release the Data under such circumstances until instructed by the Council.

3.2 The individuals affiliated with the U of M who are permitted to use the Data for the purpose(s) described by Attachment A are set forth in the first paragraph of Attachment A.

4. The U of M's Responsibilities

   4.1 The U of M will not use or disclose the Data for any purpose other than permitted by this Agreement pertaining to the purpose(s) described above or as required by law;

   4.2 The U of M will use appropriate administrative, physical and technical safeguards to prevent use or disclosure of the Data other than as provided for by this Agreement;

   4.3 The U of M will report to the Council any use or disclosure of the Data not provided for by this Agreement of which the U of M becomes aware within 5 days of becoming aware of such use or disclosure;

   4.4 Other than the persons identified in 3.2, the U of M will not disclose the Data to any other person or entity without the express written permission of the Council prior to any disclosure;

   4.5 The U of M will not contact the individuals who are the subject of the Data;

   4.6 The U of M shall return and/or destroy the Data after completion of the research and publication process, including peer reviews and responses to published material, or after the passage of five (5) years, whichever occurs first. In addition to compliance with this agreement, all use of the Data will be governed by the U of M Institutional Review Board (IRB) conducting its Research Subjects Protection Programs responsibilities. The U of M shall certify to the Council within 30 days of such end date of authorization that all such Data has been returned or destroyed. The U of M will provide the draft publication to the Council thirty (30) days prior to submittal for publication to permit Council to review and comment, and ensure that Data are protected. The Council shall have the right to audit U of M data storage and handling procedures on-site to ensure proper protection of Data as required by law; and

   4.7 The U of M shall be liable to the Council for any harm or loss, damage or expense , incurred by the Council, whether caused by the U of M or by any third party's unauthorized disclosure or unauthorized use of the Data obtained through the U of M's negligence or fault.

5. Term and Termination

   5.1 The terms of this Agreement shall be effective as of the date this Agreement is executed by authorized representatives of both parties and shall remain in effect until all Data provided to the U of M is destroyed or returned to the Council.

   5.2 Upon the Council's knowledge of a material breach of this Agreement by the U of M, the Council shall provide an opportunity for the U of M to cure the breach or end the violation. If efforts to cure the breach or end the violation are not successful within the reasonable time period specified by the Council or the Council determines cure of the breach is not possible, the Council may terminate this Agreement.

6. General Provisions

Contract No. 131039

6.1 The U of M and the Council understand and agree that individuals who are the subjects of the Data are not intended to be third party beneficiaries of this Agreement.

6.2 This Agreement shall not be assigned by the U of M without the prior written consent of the Council.

6.3 Nothing in this Agreement shall constitute a waiver of any immunities or liability limitations conferred on either party by Minnesota Statutes Chapter 466, Minnesota Statutes section 3.736, or other applicable state or federal law.

6.4 The individuals executing this Agreement represent and warrant that they are authorized to execute this Agreement on behalf of their respective organizations.

IN WITNESS WHEREOF, the parties hereto execute this Agreement as follows:

Regents of the University of Minnesota

Date: 6/24/13

By: Duane Oyen

(Title person with authority to sign agreement)

Duane Oyen
Sr. Grants & Contracts Administrator
UFRA Coordinator

Metropolitan Council

Date: 7.3.2013

By: ____________

(Title of recipient or person with authority to sign agreement)

Attachment A:

Contract No. 131039

Letter from the Council dated January 7, 2013, to U of M employee Susan Goodwin Gerberich, PhD, Professor and Director, Midwest Center for Occupational Health and Safety, University of Minnesota School of Public Health. Authorized users of Data comprise:

1) Susan Goodwin Gerberich, PhD, Professor- *Principal Investigator responsible for project and Data*
2) Chia Wei, Graduate student, *Primary Researcher*
3) Michael Manser, PhD, Professor, Director of HumanFIRST program
4) Andrew Ryan, Senior Research Fellow
5) Bruce Alexander, PhD, Professor

Metro Transit

January 7, 2013

Susan Goodwin Gerberich, PhD, Professor and Director
Midwest Center for Occupational Health and Safety
University of Minnesota, School of Public Health
420 Delaware Street SE
Minneapolis, Minnesota 55455
Telephone: 612-625-5934
Email: gerbe001@umn.edu

Dear Dr. Gerberich:

We have met with you, your graduate student, Ms. Chia Wei, and Dr. Michael Manser, Director of the HumanFIRST program in the Department of Mechanical Engineering at the University to discuss the proposal titled, "Occupational Injury among Bus Drivers in the Minnesota Metropolitan area." More recently, Dr. Bruce Alexander and Andrew Ryan have also participated in relevant discussions.

This proposed effort involves two steps: 1) a comprehensive study of the magnitude and consequences of occupational injuries (violence-related and accidental) among bus drivers in a 5-year period; and 2) a case-control study that will analyze differences between injured and non-injured drivers for a specific one-month period to determine both factors that may increase risk and those that decrease risk. In turn, this information can, then, serve as a basis for developing relevant intervention efforts.

Initially, all current Metro Transit bus drivers (non-light rail) will be included in the study involving the two steps. The work-related information and reported work-related injury data provided by Metro Transit will be de-identified; that is, investigators at the University of Minnesota will not be able to identify the individual and for whom there is no reasonable basis to believe the individual can be identified from the data. In addition, all data will be maintained in secure facilities with appropriate procedures to maintain confidentiality. Only investigators at the University of Minnesota will ever have access to this information. No individual information will ever be reported.

In order to collaborate with this study, we agree to provide the following data on bus drivers from December 01, 2006 through December 31, 2011. This includes the following that can be provided on spreadsheets:

Demographic Characteristics for all bus drivers (whether injured or not)

Age (year of birth)

Gender

Race

Height and Weight

Work-Related Data for all bus drivers (whether injured or not)

Job Classification
Part-Time; Full-Time
Job Title
Bus Operator; Dispatcher; Relief Instructor
Workloads
Hours of driving per day or per week
Overtime; Built-in Overtime

Types of Routes

Express; Regular Bus

Work Schedule

Regular; Vacation; Extra Board; On-call

Work Shifts

Straight; Split Shifts

Work Experiences

Years worked in Metro Transit

Bus Routes/ Garage

Injury Data— Intentional (Violent) and Unintentional (Accidental) Injury for all injured bus drivers

All data from Metropolitan council employee report of injury or illness form for Metro Transit Staff:

Employee section

1. *Date incident occurred*

2.a *Time of incident*

2.b *Time shift began*

5. *Date of birth*
6. *Facility*
7. *Location of incident*
9. *Gender*
10. *Date of hire*
12. *Union*
14. *Job title*
15. *Division, department or unit*
16. *What were you doing just before the incident occurred?*
17. *What happened? / How did injury occur?*
18. *List the injury or illness and part of body affected*
19. *What object or substance directly harmed you?*
22. *Number of witnesses/people present?*

Supervisor's section

27. *Job Title*
28. *Division, Department or Unit*
29. *Is this a "sharps injury"?*
30. *Did injury or illness result in employee being transferred to another job or task?*
31. *Did injury or illness cause loss of consciousness?*
32. *Is this an injury caused by an animal (e.g.: bite, scratch, sting, etc)?*
33. *Are you convinced that this injury or illness is work-related?*
34. *Contributing factors (all that apply)*
35. *Corrective measures (all that apply)*

Additional information

43. *Did injury/illness cause lost time from work?*
44. *If yes, first date of lost time*
45. *Did employee lose time from work on day of injury?*
46. *If yes, hours lost*
47. *Did employee return to work?*
48. *If yes, date returned to work*
49. *Did injury/illness result in restricted workdays?*
50. *If yes, first day of restricted time on the job*
51. *Date of death*
53. *Employment status*
54. *Does employee have other regular employment?*
55. *Has employee sustained a previous injury?*
56. *If yes, previous injury date*
57. *Where*

58. *Body parts injured or exposed*
59. *Regular days off*

Bus Crash-related events (whether or not associated with injuries)

Cost-related data

We believe that this is an important study that will benefit both the Metro Transit bus drivers and Metro Transit, in general. Therefore, we fully support this effort and agree to provide data; We plan to meet with the ATU (Amalgamated Transit Union) soon. We look forward to working with you to ensure the success of this study.

Sincerely,

Christy Bailly
Director of Bus Transportation
Metro Transit
560 6th Avenue North
Minneapolis, MN 55411
Phone: 612-349-7309
christy.bailly@metc.state.mn.us

APPENDIX B

Casual Model and

Directed Acyclic Graphs (DAGs)

Figure 1. Causal Model: Minnesota Bus Operator Study, 2006-2012

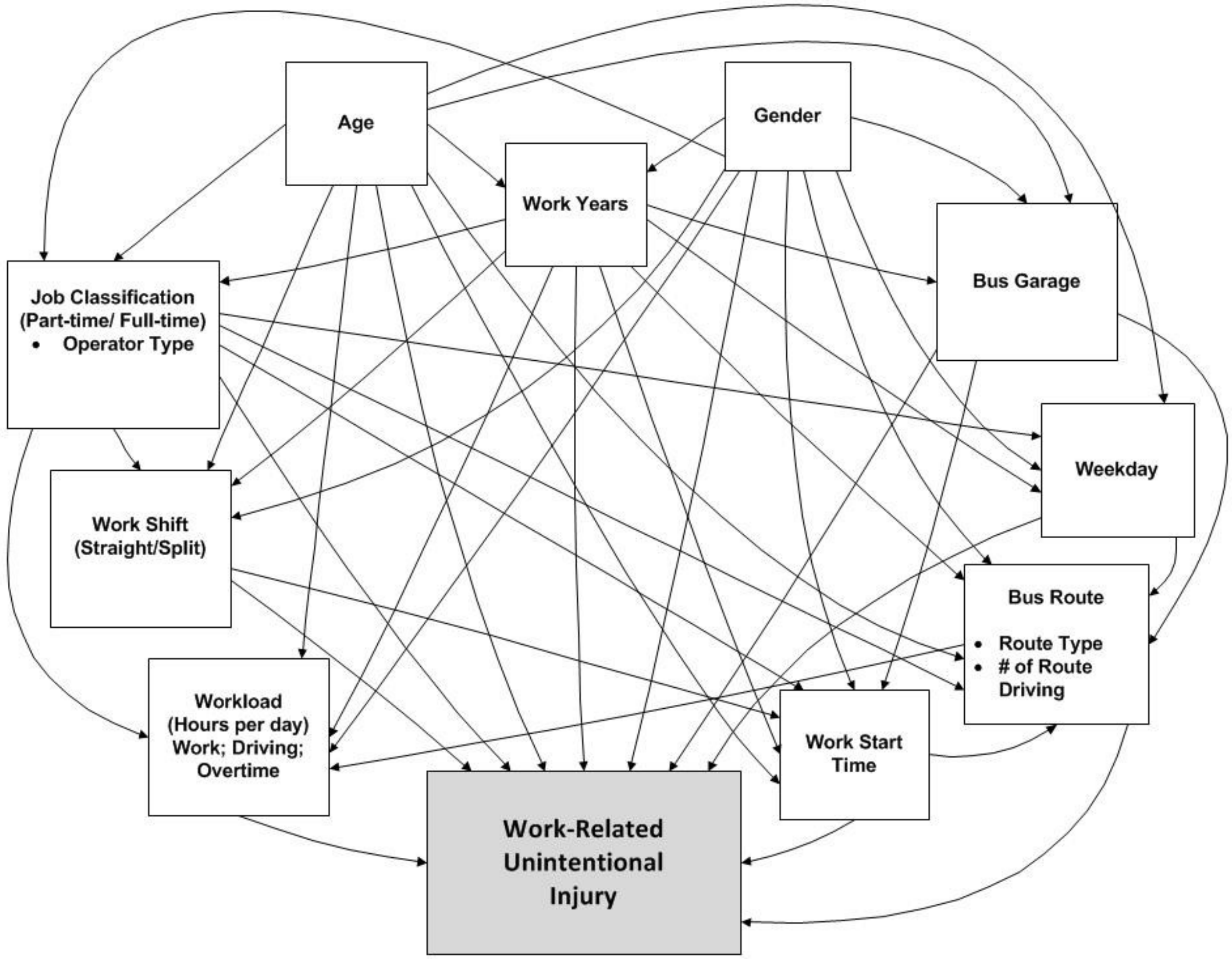

Figure 2. Directed Acyclic Graph (DAG) for Work Year: Minnesota Bus Operator Study, 2006-2012

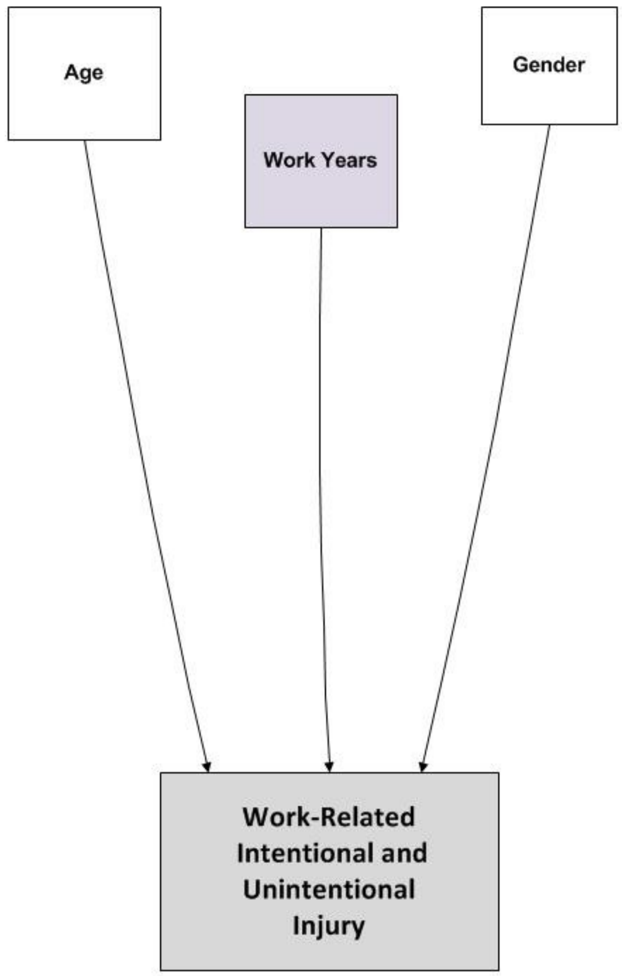

Figure 3. Directed Acyclic Graph (DAG) for Job Classification: Minnesota Bus Operator Study, 2006-2012

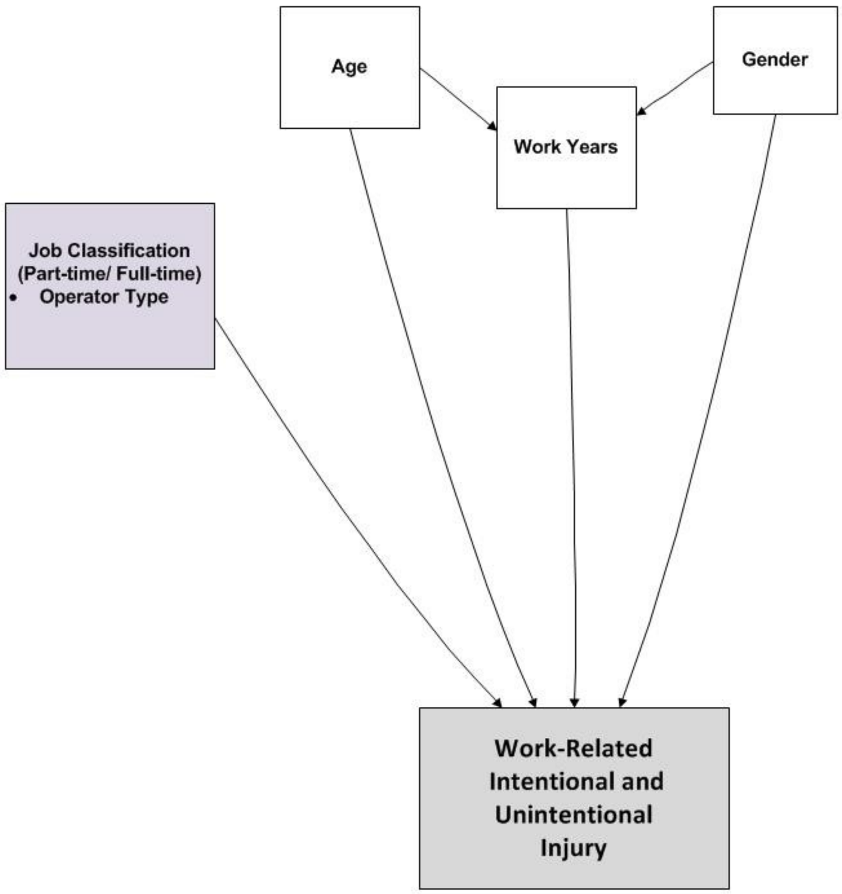

Figure 4. Directed Acyclic Graph (DAG) for Work Start Time: Minnesota Bus Operator Study, 2006-2012

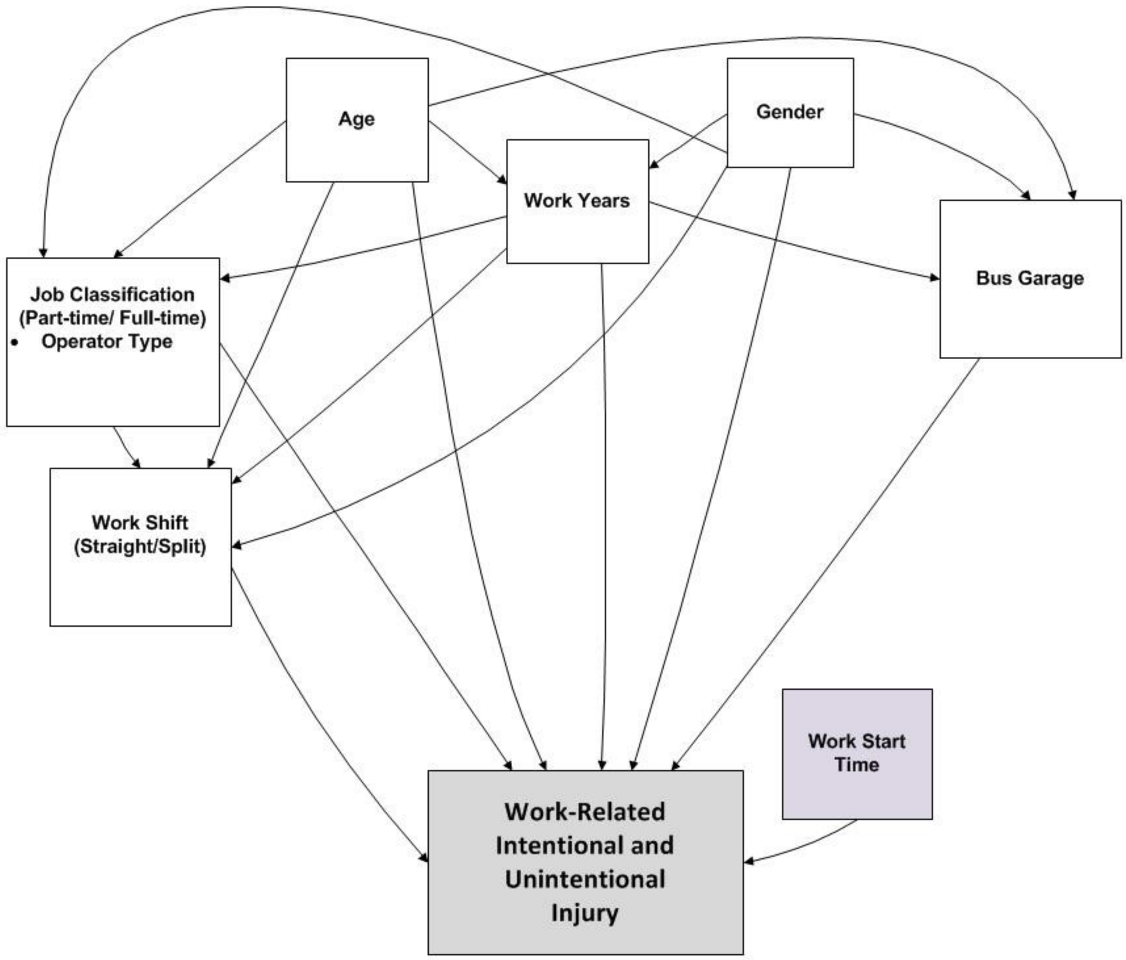

Figure 5. Directed Acyclic Graph (DAG) for Workload: Minnesota Bus Operator Study, 2006-2012

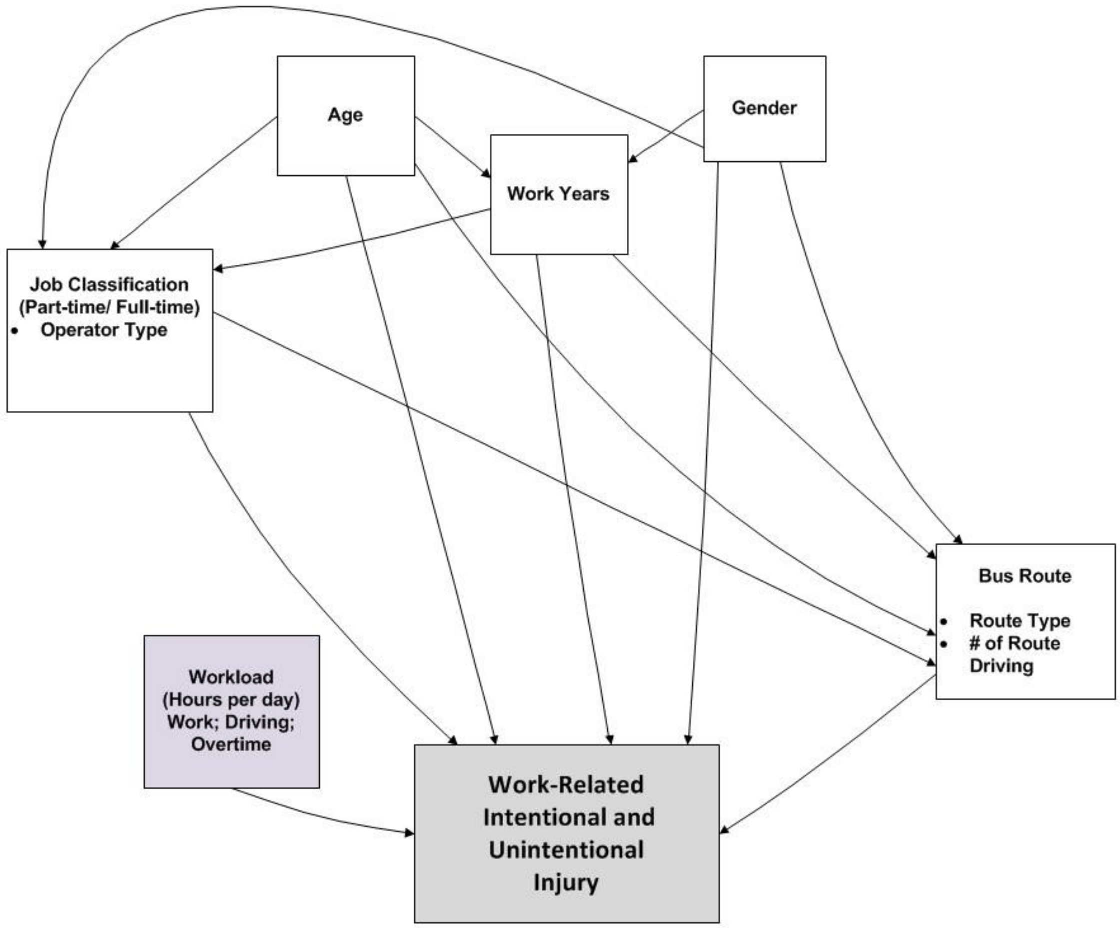

Figure 6. Directed Acyclic Graph (DAG) for Work Shift: Minnesota Bus Operator Study, 2006-2012

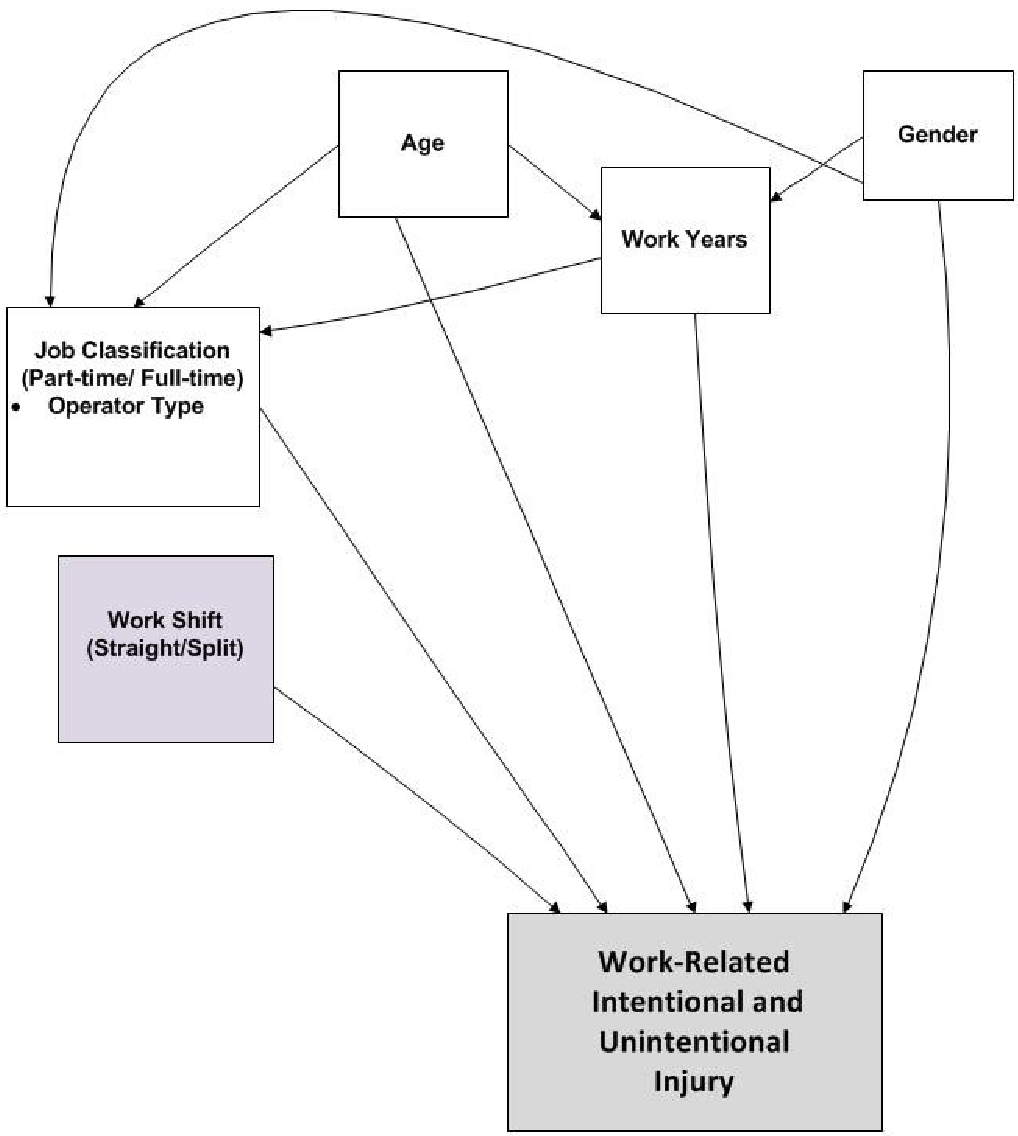

Figure 7. Directed Acyclic Graph (DAG) for Bus Garage: Minnesota Bus Operator Study, 2006-2012

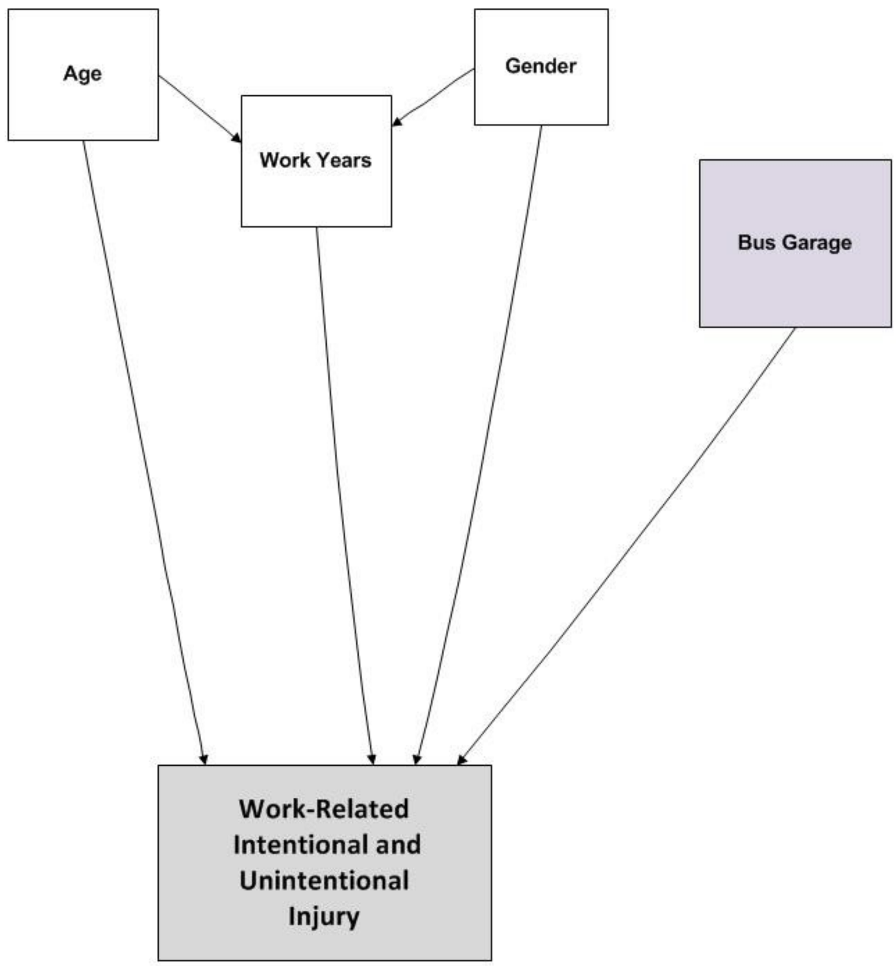

Figure 8. Directed Acyclic Graph (DAG) for Bus Route: Minnesota Bus Operator Study, 2006-2012

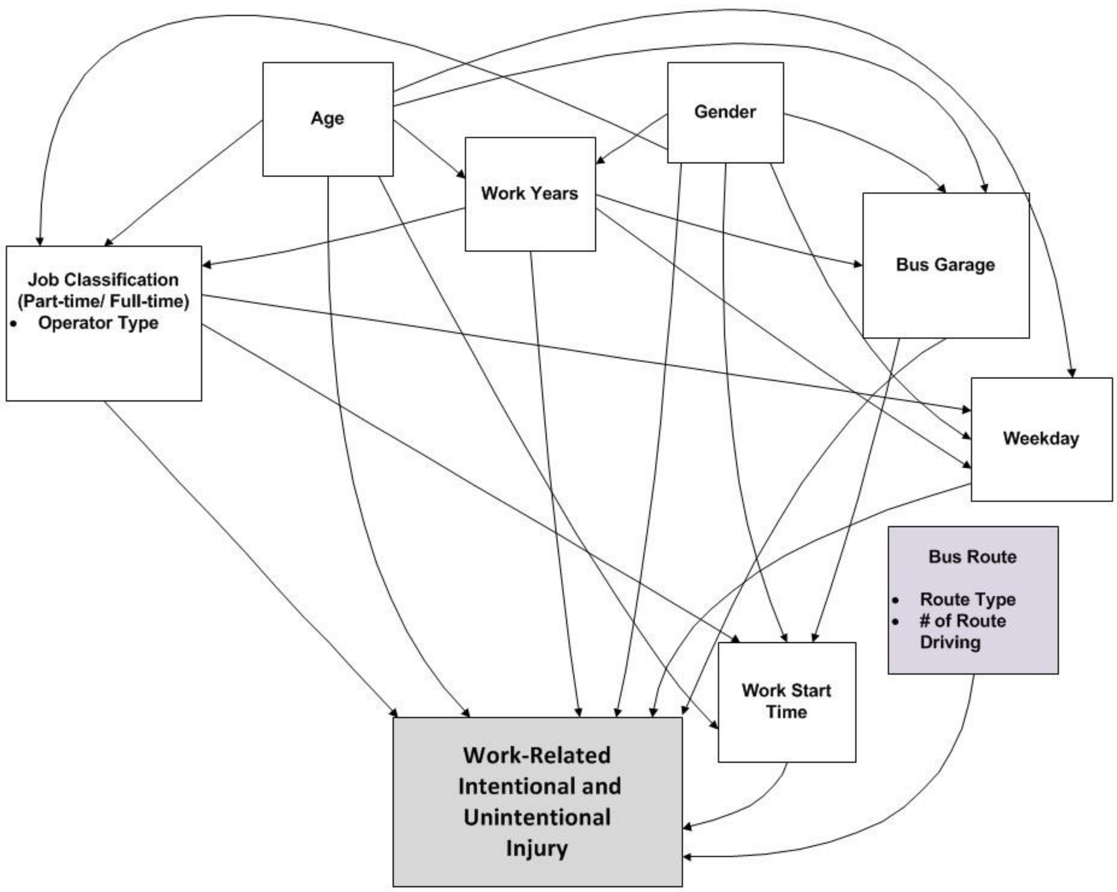

Figure 9. Directed Acyclic Graph (DAG) for Weekday: Minnesota Bus Operator Study, 2006-2012