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A Survey Of Shoulder Injuries In Commercial Truck Drivers Using A Retrospective Medical Record Review

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A SURVEY OF SHOULDER INJURIES IN COMMERCIAL TRUCK DRIVERS USING A RETROSPECTIVE MEDICAL RECORD REVIEW

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A DISSERTATION

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ABSTRACT

Introduction: Musculoskeletal injuries in the occupational setting have significant impact on the worker, employer, and healthcare system. Commercial truck drivers (CTD) experience some of the highest rates of injury, missed days of work, and workers' compensation costs compared with other workers. In this population, back injuries occur most commonly, followed by shoulder injuries which require 5 times more days away from work. Commercial truck drivers are significantly impacted by shoulder injuries; however, little is known about the unique mechanisms of injury, specific injuries, or possible preventative measures among this group of workers.

Methods: A retrospective medical record review was completed to investigate musculoskeletal disorders of the shoulder among a group of CTDs between the ages of 21 and 65. One hundred and thirty participants (N = 130) were identified for the study. Demographic, anthropometric, and injury data were collected using inclusion/exclusion criteria.

Results: A majority of injured CTDs were male (97%), white (66%), between 36-45 years of age (34%), and obese (59%). These commercial truck drivers were most often injured during a fall (35%) or while using chains, tarps, or straps (31%). The most common musculoskeletal disorders were unspecified sprains/strains (58%), and 58% of these drivers were 45 years old or younger. Only 9% had to be referred to a surgeon. Rotator cuff tears (24%) were the second most common documented musculoskeletal disorder but 74% of these drivers were 46 years of age or older and 94% had to be referred. A statistically significant association was found between the age of the commercial truck drivers and the musculoskeletal disorder (p = 0.001) with an increased risk of developing rotator cuff tears as they age (p =0.005).

Conclusions: This study highlights the impact falls and the use of chains, tarps, and straps have on the development of musculoskeletal disorders of the shoulder in commercial truck driver. Also, in this group, age was associated with musculoskeletal disorders particularly rotator cuff injuries. Future research is needed to expand on this new knowledge and evaluate intervention research.

Keywords: commercial truck driver, musculoskeletal disorder, mechanism of injury, shoulder injury, occupational health

DEDICATION

In America, the commercial truck driver is critical to the economy and the way of life we all take for granted. This work is often thankless, but without it we would not be able to go to the store and buy our favorite bag of potato chips, order all of our household items from Amazon, or more importantly when people are admitted to the hospital they may not have access to the critical life-saving items that are transported by truck. The commercial truck driver touches far more in our lives; than we could ever imagine. The work of the commercial truck driver is demanding, and many times, their bodies pay the price. For this, I want to say thank you, and I dedicate this dissertation to the commercial truck drivers across America.

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First and foremost, I would like to thank the chair of my committee, Dr. Karen Heaton. Over these past five years, Dr. Heaton has been helping me through this process in more ways; than I can count. Like a lighthouse, whether the waters are calm or rough, she is always there guiding me thru. She has been an amazing mentor and confidante. Without her guidance and leadership, I would not have been able to accomplish all that I have, not only with this dissertation but also my professional career. She has taught me to "Trust the Process." I would also like to thank the rest of my committee, Dr. Allison Jones, Dr. Pariya Wheeler, Dr. Sean Gallagher, and Dr. David Brown. You all have been instrumental in my successes and advancement thru this dissertation. You each brought a critical key to this team, and this teamwork was critical to my success.

This dissertation would not have been possible without the cooperation of Dr. Raju and Dr. Bruce Romeo and Anthony Ritchie of Alabama Comp. Dr. Raju worked with me initially on this dissertation and past scholarly work, which laid a strong foundation to build on. Dr. Romeo and Mr. Ritchie were instrumental to the success of this dissertation by allowing me to work in their extremely busy occupational health clinic and accessing their electronic medical records.

There are several others that have been instrumental in my success in this program, and I would be remiss if I did not thank them; Dr. Doreen Harper and Dr. Linda Moneyham. Eleven years ago, I met with Dr. Harper about the potential of changing careers and becoming a registered nurse. Without her input and guidance at this time of my life, I may have never made the first step on my nursing journey. Since that time Dr. Harper has mentored me as I became a registered nurse, earned an MSN as a clinical nurse leader, a second MSN as a family nurse practitioner, and now as I earn a PhD. Dr. Moneyham has supported me over these past five years by helping me balance my professional and educational career within the UAB School of

Nursing. She has helped me be a successful PhD student while also growing and advancing as a faculty member.

While everyone I have thanked above was critical to my education, professional growth, and success, none of this would have ever been possible if not for my amazing and loving wife, Tonya Jones Combs. She has been a part of my life for 15 years and is my true love and rock. Many years ago, in a career that was going well, she saw I was not happy and not working at my full potential. In her mind, she saw me accomplishing greater things; than I could even imagine. As the story goes, she is the reason I am here today. Not only because she supports me in more ways, than I can count she is the one that introduced me to Dr. Doreen Harper. My wife is an amazing hairstylist, entrepreneur, and leader. She was talking to Dr. Harper one morning and mentioned my name and how she thought I could be happier and could be doing more. She told Tonya about this new program at the UAB School of Nursing and how I would be a great fit. When Tonya came home, we talked and later in the week; I talked to Dr. Harper. If there is one thing I know, there is not a person alive that could have said no to both these two ladies and as they say the rest was history. Over the past five years, Tonya has been a friend, wife, mentor, and inspiration. She started her own business and expanded to 4 locations. When things got difficult for me in work or school, all I had to do was look to my side and see her and know that I will make it thru even the toughest of spots.

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LIST OF ABBREVIATIONS

BLS	Bureau of Labor Statistics
BMI	Body Mass Index
CTD	Commercial Truck Driver
ICF	International Classification of Functioning, Disability, and Health
MOI	Mechanism of Injury
MSD	Musculoskeletal Disorder
NIOSH	National Institute for Occupational Safety and Health
NORA	National Occupational Research Agenda
OFCM	Occupational Functionally Conceptual Model
OSHA	Occupational Safety and Health Administration
ROM	Range of Motion
WHO	World Health Organization

CHAPTER 1

The purpose of this chapter is to introduce the problem, significance, background, study aims, theoretical framework, and research design related to the proposed study. This information will justify the study and provide an introduction to the major topics that will be researched.

COMMERCIAL TRUCK DRIVERS

Commercial truck drivers (CTD) are one of the largest employment groups in the United States. In 2015, the BLS reported that there were 1,797,700 individuals employed as heavy/tractor-trailer truck drivers in the United States (BLS, 2015b). The trucking industry is significantly affected by the cost of worker compensation claims; in fact, workers in this group had the highest average cost per worker compensation claim for all age groups and all occupational sectors (Davis, Dunning, Jewell, & Lockey, 2014). This work is notable for being mostly sedentary with intermittent periods of physical exertion during the loading, unloading, and securing of cargo (BLS, 2015b). Commercial truck drivers operate many different types of vehicles, including those with flatbed trailers, adding physical work to the driver due to the use of heavy chains and tarps to secure the freight on the trailer.

Commercial truck drivers experience injuries and illnesses involving days away from work at rates of 355.4 incidences per every 10,000 full-time workers (BLS, 2015b). This incidence rate is 3.5 times higher than that for all other occupations (BLS, 2016), and is higher than the rate for other hazardous occupations, such as construction and extraction (168.9 incidences/10,000 full-time workers), healthcare practitioners and technical workers (92.9 incidences/10,000 full-time workers), and farming, fishing, and forestry (147.8 incidences/10,000 full time workers) (BLS, 2015a). Musculoskeletal disorders (MSD) are among the most common reasons for CTD work absences. The incidence rate of MSDs per 10,000 full-time workers among heavy/tractor-trailer truck drivers is three times higher than that of all occupations, 108 and 31, respectively (BLS, 2016). In 2014, sprains and strains (151.4) were the most common MSD among heavy and tractor-trailer truck drivers, while pain due to soreness (56.9) was second. The back was the most commonly injured area of the body (61.2) followed by the shoulder (51.4) (BLS, 2015a).

The National Institute for Occupational Safety and Health (NIOSH) developed a National Occupational Research Agenda (NORA) to guide the development of research within their respective occupational groups. In 2009, the NORA report was published and included four strategic research goals for the Transportation, Warehousing, and Utilities sector (which includes CTDs). These goals were: 1) reduce lost-workday occupational traumatic injury and fatality rates; 2) reduce the incidence and severity of work-related musculoskeletal injuries; 3) improve health and reduce premature mortality through workplace programs and practices; and 4) identify, evaluate, and reduce chemical, biological, and physical occupational hazards and exposures (NORA Transportation Warehousing and Utilities Sector Council, 2009). Therefore, studies of MSDs among CTDs are both timely, highly significant, and aligned with NIOSH research initiatives.

Much of the prior research in CTDs has focused on healthcare status, access to healthcare, lower back injuries, fatigue, vibration, and injuries related to vehicular accidents (Apostolopoulos, Sonmez, Shattell, Gonzales, & Fehrenbacher, 2013; Blood, Rynell, & Johnson, 2011; Bovenzi, 2009; Cann, Salmoni, & Eger, 2004; Shibuya, Cleal, & Kines, 2010; Sieber et al., 2014). However, few studies have examined MSDs, and many of these studies did not investigate injuries to the shoulder specifically (Beek, Frings-Dresen, van Dijk, Kemper, & Meijman, 1992; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014). Past studies have shown that CTDs are significantly impacted by MSDs to the back and shoulder (Beek et al., 1992; Ben-Ami & Korn, 2018; Bhimani, 2014; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014). Injuries to the shoulder are commonly due to overexertion or repetitive motion (Reiman, Pekkala, Vayrynen, Putkonen, & Forsman, 2014) and most (51%) occur in drivers with less than one year of work experience (McCall & Horwitz, 2005). Commercial truck drivers have increased risks for developing partial or total disability related to occupational MSDs of the shoulder (Smith & Williams, 2014). Given the frequency and severity of shoulder injuries in CTDs, further research on the cause and nature of these injuries is needed to help decrease healthcare costs, decrease long-term disability, and improve recovery.

PROBLEM STATEMENT

Commercial truck drivers experience MSDs at rates three times higher than that of all other occupations (BLS, 2015a). Among CTDs, the shoulder is the second most commonly affected area of the body, CTDs with MSDs of the shoulder miss a significant amount of work, and incur higher financial cost compared to those among other professions (Davis et al., 2014). Even though the incidence and overall costs of shoulder injuries are higher among CTDs compared to other occupations, to date, no research has characterized occupational-acquired shoulder injuries in CTD.

BACKGROUND

While there is limited research explicitly investigating shoulder injuries in CTDs, past research has consistently shown that incidence rates of MSDs of the shoulder is second only to MSDs of the back in this group of workers (Beek, Frings-Dresen, van Dijk, Kemper, & Meijman, 1992; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014; USDOL, 2013). A study of ergonomic risks and discomfort of CTDs while performing everyday tasks outside of the cab indicated that the shoulder is associated with the most complaints of physical discomfort (Reiman et al., 2014). The mechanisms of injury (MOI) most commonly associated with shoulder discomfort or injury were overexertion, repetitive motion, and falls from height (BLS, 2016). Injuries were most often reported during unloading cargo at the delivery site (McCall & Horwitz, 2005; Reiman et al., 2014). Commercial truck drivers also experienced an increased risk of developing partial or total disability related to occupational MSDs (Smith & Williams, 2014). Davis et al. (2014) reported that CTDs had a higher number of workman's compensation claims related to the shoulder and that these claims had a 20% higher mean cost compared to those of any other profession. Davis et al, (2014) found that the trucking industry sector had the highest average cost per worker compensation claim for all age groups and all occupational sectors. A unique finding in the research was that 51% of all injuries happened to workers with less than one year of experience (McCall & Horwitz, 2005) suggesting a potential focus area for future research.

The second most common injury reported by CTDs was to the shoulder (11%) with each incident leading to an average of 46 missed days of work (BLS, 2015a). Although work-related back injuries were found to be two and half times more likely to occur than shoulder injuries, shoulder injuries required five times as long to recover, compared to back injuries. The most common type of shoulder injury was either a sprain or strain, and the mechanism or event with the highest incidence was overexertion or body reaction (BLS, 2016).

Although research investigating shoulder injuries in CTDs is limited, there is a significant amount of research that has been completed in many different occupations. The shoulder was one of the two most commonly injured regions of the body in construction workers (Borstad et al., 2009; Soares, Jacobs, Minna, & Mika, 2012). Between 17.8% and 55.6% of all MSD complaints from construction workers are related to the shoulder (Borstad et al., 2009; Soares, Jacobs, Minna, et al., 2012). In this group, shoulder discomfort was more common when work was performed above shoulder level, and there was some evidence that the type of foundation the worker was standing on may have caused a difference in discomfort (Phelan & O'Sullivan, 2014). Electricians often work with their arms raised above shoulder height, which is similar to CTDs working with flat-bed trailer. In this population, the shoulder was the most commonly reported body region associated with pain (Trotta, Ulbricht, & Silva, 2014). In 2014, the second most common MSD among the nursing workforce was related to the upper extremity (Bhimani, 2014). Taxi drivers and custodial workers are also at an increased risk for MSDs of the shoulder, and the most common MOI for custodial workers were sprains/strains related to overexertion (Asundi, Harbin, Shenoy, Garcia, & Olson, 2011; Bulduk, Bulduk, Süren, & Ovali, 2014).

There has been significant research investigating back injuries in CTDs and when compared to the lack of research investigating shoulder injuries in CTDs despite the impact it is critical to further invesitage. Also there is significantly more research investigating shoulder injuries is other professions which highlights the significant gap in the research related to CTDs and the need for in-depth and specific research targeting this population.

STUDY PURPOSE

The purpose of this study was to 1) describe mechanisms of shoulder injury 2) types of shoulder injuries and 3) identify factors that are associated with shoulder injuries among a group of CTDs seen in one occupational health clinic. This will be accomplished by addressing the following aims and research questions.

SPECIFIC AIMS, HYPOTHESIS, AND RESEARCH QUESTIONS

AIM 1: Determine the common characteristics of shoulder injuries among a group of commercial truck drivers.

Hypothesis 1: The most common shoulder injury among CTDs will involve the rotator cuff, and the most common MOI will be related to body reaction and overuse.

RQ 1.1: What are the most common diagnoses of shoulder injuries among commercial truck drivers?

RQ1.2: What are the most common mechanisms of shoulder injury among commercial truck drivers?

AIM 2: Determine factors associated with shoulder injuries among a group of commercial truck drivers.

Hypothesis 2: Commercial truck drivers using equipment related to flatbed trailers will be at increased risk for shoulder injury compared to those that use box trailers.

RQ 2.1: What work environment factors are associated with increased risk of developing shoulder injuries?

RQ 2.2: What demographic and anthropometrics are associated with increased risk of developing shoulder injuries?

CONCEPTUAL FRAMEWORK

The framework that guided this study was the Occupational Functionality Conceptual Model (OFCM) (Combs & Heaton, 2016). The OFCM created a framework that allowed the researchers to best organize and describe the variables associated with MSDs of the shoulder in CTDs. The model organized the variables and descriptors of MSDs of the shoulder using four different domains: occupational, physical, environmental, and psychological.

Combs and Heaton (2016) outlined these domains, i.e., physical, occupational, environmental, and psychological, and defined Occupational Functionality as:

The qualities of being suited to serve an occupational purpose efficiently and effectively within the physical, occupational, environmental, and psychological demands of that unique work setting.

The OFCM as a Framework

The area of overlap of the four domains within OFCM is fluid and ever-changing. The OFCM relationship to individual injury will change over time for each worker, based on the unique injury and the influence each domain had on it specifically. For example, a worker who has to secure cargo on a flatbed trailer has increased demands from the environmental and occupation aspects of the OFCM so there would be more overlap of those two areas compared to the physical and psychological domains. If this individual was compared to someone who has a history of shoulder surgery due to a fall from a flatbed trailer, there might be more influence from the psychological and physical domains resulting in changes in this individual's OFCM relationship. An example of the proposed conceptual model can be seen in Figure 1.

Figure 1: The Occupational Functionality Conceptual Model

The OFCM was the best model for this proposed study because it allowed the researcher to investigate MSDs of the shoulder by taking into account the occupational, environmental, physical, and psychological domains and how they interact together to result in an MSD. This model also allowed for the investigation of the pertinent variables required to address the AIMs and research question of the proposed study.

DEFINITIONS

General Terms

Commercial truck driver (CTD) is an individual who operates tractor-trailers and other large vehicles to transport cargo over various distances.

National Institute for Occupational Safety and Health (NIOSH) is the United States federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness (Center for Disease Control and Prevention, 2017).

National Occupational Research Agenda (NORA) is a partnership program to stimulate innovative research and improved workplace practices (Center for Disease Control and Prevention, 2017).

Occupational Safety and Health Administration (OSHA) is an agency in the U.S Department of Labor with the mission to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education, and assistance (United States Department of Labor, 2017).

United States Department of Labor (USDOL) is a cabinet-level department of the U.S. federal government responsible for occupational safety, wage and hour standards, unemployment insurance benefits, re-employment services, and some economic statistics.

Independent Variables

Demographics consisted of age, gender, race, height, weight, and BMI.

Mechanism of injury was the method by which damage (trauma) to skin, muscles, organs, and bones happens.

Date of injury was the date the injury occurred.

Date of release/referral was the date the occupational healthcare provider released the participant to full work duty or referred them to an orthopedic surgeon.

MRI was whether or not a CTD required an MRI as part of the plan of care.

Referral for surgery is the date the occupational healthcare provider referred the patient to a surgeon to perform surgery.

Referral/Release was the total amount of work days missed from the date of injury until the date of release or referral to an orthopedic surgeon.

Dependent Variables

Musculoskeletal Disorder was the exact diagnosis of the injury that occurred in the shoulder of the participant.

SUMMARY

Very little is known about shoulder injuries in CTDs. To inform preventative and restorative interventions, research was done to better understand the factors related to MSDs of the shoulder in CTDs. This chapter introduced the problem, significance, background, theoretical framework, and research questions for the study. In the following chapter, a comprehensive literature review provides the foundation for the multiple components of this study; background, design, methods, and analysis.

CHAPTER 2

The purpose of chapter two is to review the literature relevant to the concepts of interest in the study. The central outcome concept of this study is MSDs of the shoulder. The conceptual framework of the study guided the literature review of the concepts through four domains related to occupational functionality and injury (occupational, physical, environmental, and psychological). The review of the literature provided a rationale for the proposed study. This research will help create new knowledge related to MSDs of the shoulder in CTDs by describing the MOI and types of MSDs of the shoulder among CTDs and by identifying factors associated with shoulder injuries in this group.

CONCEPTUAL FRAMEWORK

The framework that guided this dissertation is an adaptation of the biopsychosocial model. The name of this adapted framework is the Occupational Functionality Conceptual Model (OFCM) (Combs & Heaton, 2016). The OFCM created a framework that allowed the researchers to best organize and describe the variables associated with MSD of the shoulder in CTDs. The model organized the variables and descriptors of MSDs of the shoulder using four different domains: occupational, physical, environmental, and psychological. Although OFCM has not been used in past research, the foundation it was developed from has been used extensively in research.

The Foundation of OFCM

International Classification of Functioning, Disability, and Health

The concepts of fitness for duty and injury are closely related. Historically, the fitness of a worker to perform a specific job or task has been poorly defined. The World Health Organization (WHO) established the International Classification of Functioning, Disability, and Health (ICF) to create a framework and common language to understand better and measure health and disability (Center for Disease Control and Prevention, 2012). The ICF model conceptualizes functioning and disability within four domains: body functions and structures, activities and participation, and environmental factors. Examples of these domains and components are presented in Table 1 (Center for Disease Control and Prevention, 2012; World Health Organization, 2014).

Table 1: ICF domains and component examples

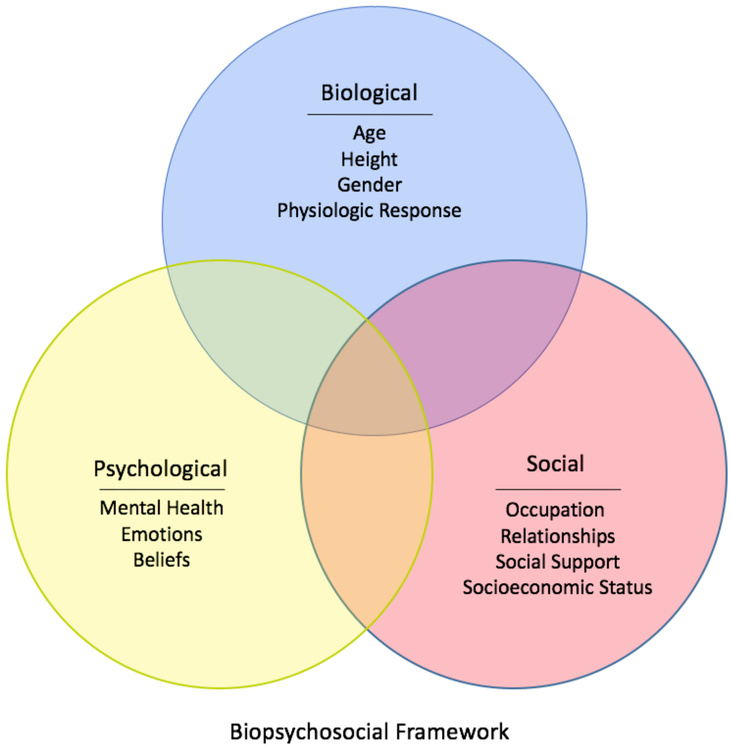
Body Function		Activities/Participation	
Mental function	Cardiovascular	Learning knowledge	Self-care
Sensory function	Respiratory	General tasks	Domestic life
Voice/speech	Neuromusculoskeletal	Communication	Mobility
Body Structure		**Environmental**	
Nervous system	Skin	Technology	Support
Eyes/ears	Bones/joints	Natural environment	Relationships
Vocal cords	Cardiac system	Attitudes	Manmade environment

The ICF model has been used as a framework for guiding clinical practice and research in many different populations for various conditions (Goldstein, Cohn, & Coster, 2004; Guptill, 2008; McDougall, Wright, Schmidt, Miller, & Lowry, 2011; Rosenbaum & Stewart, 2004; Tempest & McIntyre, 2006). Another study utilized the ICF model as a framework for research related to MSDs in musicians (Guptill, 2008). The ICF has been used to guide research in the changes of quality of life in those experiences chronic conditions (McDougall et al., 2011). The ICF is not just used in research but also in the development of evidence-based practice when working with a pediatric patient in a physical therapy practice and patients who suffer from disabilities related to a stroke (Goldstein et al., 2004; Tempest & McIntyre, 2006).

The Biopsychosocial Model

The Biopsychosocial Model was first published in 1977 as an alternative way of looking at medical care, which at that time was described as Biomedicine (Engel, 1977). George Engel felt that the Biomedical Model of care was restricted because it was built on the premise that medical conditions and illness were the result of one cause and did not take into account advances in behavioral science. George Engel believed that medical conditions and illnesses were the results of not one particular cause but influences from three different domains; 1) biological, psychological, and social (Engel, 1977). The seminal publication by Engel did not include a diagram of the model, but a rendering of the model can be seen in Figure 2 (Green & Johnson, 2013).

Figure 2 - The Biopsychosocial Framework



The Biopsychosocial Model was developed as a healthcare model, but it has been used extensively in research and had a significant impact on the scientific community. Since the seminal work was published in 1977, the Biopsychosocial Model, as described by George Engel, has been cited over 3,500 times (Fava & Sonino, 2017). In research, the Biopsychosocial Model takes an epidemiological approach to research design by investigating biological, psychological, and social factors impacting illness and injury. Epidemiology is the understanding of patterns or causes of health or disease conditions. It provides a perspective for researchers to better describe injury and MSD are one of the conditions that can be adequately investigated using epidemiological principles.

There are many examples of how the Biopsychosocial Model has been used in medicine but it has effectively been used in relation to pain and MSDs (Covic, Adamson, Spencer, & Howe, 2003; Gatchel, Peng, Peters, Fuchs, & Turk, 2007; George et al., 2017; Green & Johnson, 2013; Mathew, Ravichandran, May, & Morsley, 2001; Widerstrom-Noga, Finnerup, & Siddall, 2009). In 2007, the Biopsychosocial Model was used as a guide in the care and plan for future research in patients living with chronic pain and patients dealing with pain and depression secondary to rheumatoid arthritis (Covic et al., 2003, Gatchel et al., 2007). Three studies use the Biopsychosocial Model as a framework for research and care of patients with back injuries. Mathew et al. (2001) looked at the impact all three domains had on spinal cord injury patients and those with complaints of somatic pain. Widerstrom-Noga et al. (2009) used the biopsychosocial model to investigate more effective ways to assess and treat pain in spinal cord patients. Green and Johnson (2013) used the biopsychosocial model as a framework to investigate the associations between smoking and low back pain.

The Occupational Functionality Conceptual Model

The P.I. performed a concept analysis to determine what occupational functionality was and how it was best defined (Combs & Heaton, 2016). By using the concept analysis method defined by Walker and Avant (2011), it was found that there were four main defining attributes within the concept of occupational functionality. Occupational functionality is a holistic, multidisciplinary concept that encompasses four separate and overlapping domains: physical, occupational, environmental, and psychological. These domains are used in the OFCM.

Physical

The physical domain of OFCM is built on the understanding that the body of the worker is an integral part of understanding their ability to be functional at a job. This domain is the understanding of the worker's physical abilities in healthy, injured, and recovered states and takes into account any aspect of the physical body that may affect the worker (e.g., acute injury; chronic medical conditions; range of motion; strength) (Center for Disease Control and Prevention, 2012).

Occupational

The occupational domain uses an occupational perspective to understand specific physical and mental requirements and limitations on a worker in a unique or particular setting (Njelesani, Tang, Jonsson, & Polatajko, 2012). This domain is required to understand that a person may have a disability; however, the manner in which disability is assessed within the worker's unique occupational setting is the only way to determine functionality. It is crucial not to assume that a healthy person can do a job, or a person with a disability may not be functional on the job.

Environmental

The environmental domain was best described by Tomey and Sowers (2009) as the interaction between the worker and the environment, specifically in the work setting. This domain investigates the environment as an ever-changing and multi-faceted variable. The environment in a particular spot in a factory or office is not the only one of concern; this domain takes into account every environment a worker may come across (e.g., the car ride to work, walk across campus, clothing needed for the job).

Psychological

Psychologic evaluation is critical to defining an individual's workability or fitness for duty (Hannula, Lahtela, Jarvikoski, Salminen, & Makela, 2006). The worker's state of mind is crucial and should not be ignored. The psychological domain of work is often left out of any evaluation scale for occupational health when assessing fitness for duty, yet this aspect is integral and irreplaceable. Historically, the psychological domain of occupation looks primarily at job stress. However, this domain is much bigger than this, and emphasizes assessing not just stress but also areas such as post-traumatic stress disorder, job desire, enjoyment, satisfaction, efficacy, and sense of worth.

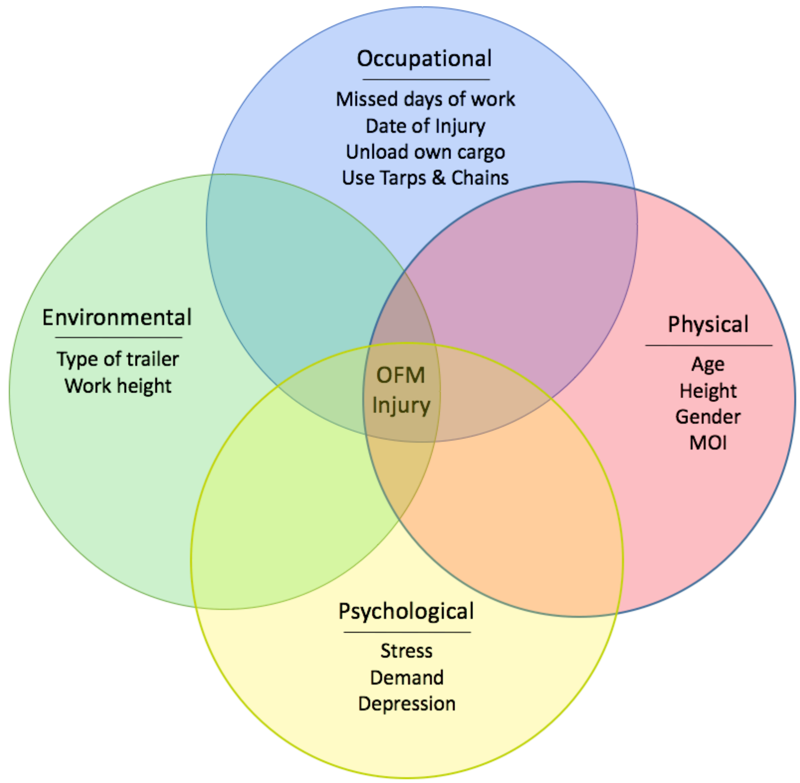
Combs and Heaton (2016) outlined these domains, i.e., physical, occupational, environmental, and psychological, and defined Occupational Functionality as:

> *The qualities of being suited to serve an occupational purpose efficiently and effectively within the physical, occupational, environmental, and psychological demands of that unique work setting.*

The OFCM as a Framework

The area of overlap within OFCM is fluid and ever-changing. Every worker will have different stresses and strains from the four domains of the OFCM at different times throughout the workday. Regarding CTDs, they may have more physical requirements when lifting and securing cargo, which would lead to more overlap from that domain. When driving, they may have decreased physical stress but increased psychological stress. This would result in less overlap from the physical domain but more from the psychological. This is the same as in the components of the IFC and the Biopsychosocial model. The OFCM relationship to individual injury will change over time for each worker and based on the unique injury and the influence each domain had in it specifically. An example of the proposed adapted concept is seen in Figure 3.

Figure 3: The Occupational Functionality Conceptual Model



The OFCM is the best model for this proposed study because it allows a researcher to investigate MSDs of the shoulder by taking into account the occupational, environmental, physical, and psychological domains and how they interact together to result in an MSD. This model also allows for the investigation of the pertinent variables required to address the AIMs and research question of the proposed study (Figure 3).

EPIDEMIOLOGIC BASIS AND CONCEPTS OF INTEREST

The Shoulder Joint

Anatomy

It is essential to understand the anatomy and function of the shoulder in order to review the literature relevant to MSDs in this population. The shoulder is a complex joint that is made up of 4 joints: sternoclavicular, acromioclavicular, scapulothoracic, glenohumeral (Oatis, 2009; Skinner & McMahon, 2014; Thompson, 2010). The most commonly injured and researched joint is the glenohumeral joint. The shoulder is made up of three bones, nine muscles, and eight ligaments (Skinner & McMahon, 2014). Often in research when the term "shoulder" is used, it is referring to the glenohumeral joint, and this will be true for this proposed study. The shoulder is a ball and socket joint that allows for the largest range of motion (ROM) found in the body. However, this range of motion leads to increased instability, as well. The supporting structures of the glenohumeral joint that work to maintain stability are the labrum, capsule, three glenohumeral ligaments, coracohumeral ligament, and the surrounding musculature (Oatis, 2009; Skinner & McMahon, 2014; Thompson, 2010).

The humerus and the glenoid cavity of the scapula form the glenohumeral joint. The glenoid cavity is small in size when compared to the humeral head with only about 1/3 of the surface area (Oatis, 2009) which allows the shoulder to have the greatest range of motion in the body (Thompson, 2010). The glenoid cavity is surrounded by a piece of circular cartilage, called the labrum, creating a larger surface area in which the humeral headrests. The labrum improves stability by increasing the surface area for articulation in the joint (Oatis, 2009). The rotator cuff is the main muscle group responsible for the motion of the glenohumeral joint. It is composed of the supraspinatus (abduction and forward flexion), infraspinatus (external rotation), teres minor (external rotation), and subscapularis (internal rotation) (Thompson, 2010). These four muscles create a capsule around the glenohumeral joint, creating stability and allowing motion.

Motion

The shoulder moves in all three planes of movement (sagittal, horizontal, and frontal) and six different motions (flexion, extension, abduction, adduction, internal rotation, and external rotation). The motion, average ROM, and muscle groups are listed in Table 2 (Oatis, 2009; Skinner & McMahon, 2014; Thompson, 2010).

Table 2: Average Range of Motion of the Shoulder and Associated Muscles

Motion	Degrees of Movement	Muscle	Plane of Movement
Flexion	0-180	Anterior Deltoid, Pectoralis Major	Sagittal
Extension	0-60	Latissimus Dorsi, Posterior Deltoid	Sagittal
Abduction	0-180	Deltoid, Supraspinatus	Frontal
Horizontal Adduction	0-50	Subscapularis, Pectoralis Major	Frontal
Internal Rotation	0-70	Subscapularis	Horizontal
External Rotation	0-90	Infraspinatus, Teres Minor	Horizontal

Biomechanics

The CTD works in a unique environment and often deals with many different environmental demands that cause physical stress or strain (e.g., loading and unloading cargo, using tarps and chains to secure the cargo, pushing and pulling heavy weights). Many of these activities require them to work with their arms at or above shoulder level. The cabs of the trucks are elevated, and as the driver enters and exits the vehicle, he/she must use concentric and eccentric contractions of the shoulder while maneuvering two or three steps. The trailers in which the CTDs use vary in size and shape but the height of the trailer floor can be between 47" to 50" above ground level, depending on the type of trailer.

The height of the cab and trailer requires CTDs to work with their shoulder at or above shoulder height. Elevating the arm to shoulder height or above increases stress and load of all muscles that cross the shoulder joint (Antony & Keir, 2010; Au & Keir, 2007; Blache, Desmoulins, Allard, Plamondon, & Begon, 2014). When the arm raises from 30° to 90°, shoulder muscle activity increases by 84% (Antony & Keir, 2010). Blache et al. (2014) showed that the supraspinatus and infraspinatus muscle force decreased as the arm moved from shoulder level to eye level, while the subscapularis muscle force increased. The peak joint reaction force occurs when the shoulder is abducted to 90°, which is when the abductor muscles must generate increase force to counteract the weight of the upper extremity (Oatis, 2009).

Commercial truck drivers often have to secure and cover their cargo, which requires them to work with tarps, chains, and straps. The tarps and chains can weigh up to 100lbs each. Lifting can increase the amount of load on the shoulder and increase muscle fatigue (Oatis, 2009; Soares, Jacobs, Moriguchi, et al., 2012). Physiologic fatigue affects shoulder muscle function, joint range of motion, and adaption (Fuller, Lomond, Fung, & Cote, 2009; McDonald, Tse, & Keir, 2015). As the shoulder becomes fatigued, the amount of flexion during tasks decreased while abduction increased (Blache et al., 2014). Muscle activity and joint range of motion were significantly affected by tasks that required pushing and pulling when fatigued (McDonald et al., 2015). During activities that required the arm to be above shoulder height, the muscle that elevated the shoulder became fatigued quicker than the other muscles of the shoulder (Fuller et al., 2009).

Musculoskeletal Disorders

Musculoskeletal disorders are impactful worldwide. More than 1.7 billion individuals are affected by MSDs across the globe and MSDs are the second most common reason for disability, and have the fourth most significant impact on overall health compared to other diseases (Global Burden of Disease Study 2013 Collaborators, 2015). In the U.S., a report completed by a group within the National Institute of Arthritis and Musculoskeletal and Skin Diseases found that in 1990, 37.9 million people suffered from at least one chronic MSD (Lawrence et al., 1998). Lawrence et al. (1998) as also estimated that by 2020, the number of those affected in the U.S. would be approximately 59.4 million people. The same group published a follow-up study in 2008 and showed that 46.4 million individuals reported having arthritis diagnosed by a medical provider (Helmick et al., 2008). The increase from 1998 to 2008 is noteworthy, considering the inclusion of all chronic MSDs in addition to arthritis in Lawrence's report.

Demographics and MSDs of the Shoulder

In the U.S., research related to MSDs has shown that the low back and upper extremities are consistently among the most common areas of the body affected by MSDs (National Research Council, 2001). Other surveys have shown that shoulder pain can affect upwards of 26% of the general population (Linaker & Walker-Bone, 2015). Women have a higher risk of developing MSDs when compared to men (de Zwart, Frings-Dresen, & Kilbom, 2001; Treaster & Burr, 2004; Walker-Bone, Palmer, Reading, Coggon, & Cooper, 2004; Wijnhoven, de Vet, & Picavet, 2006a, 2006b). According to Walker-Bone et al. (2004), 10.9% of women and 9.7% of men had signs and symptoms related to MSDs of the shoulder in the general population. Women (45%) also have a higher prevalence of chronic musculoskeletal pain than men (39%) ($p < 0.01$) (Wijnhoven et al., 2006a).

In addition to gender, age has consistently been shown to have a strong relationship with the incidence of MSDs (Wijnhoven et al., 2006a). Joint pain increases with age, but plateaus within 65 to 74 years of age. In a study published in 2015, approximately 18.7 million of those ages 18 and older reported shoulder pain, and that rate of chronic pain increases slightly for those ages 45 and older (United States Bone and Joint Initiative, 2015). Another estimate of the general population found that 62.4% of men and women between ages 51 and 61 years of age reported having one or more MSDs and that 41% of injuries reported resulted in a work disability (Yelin, Trupin, & Sebesta, 1999). A program following individuals with chronic illnesses and injuries found that 7.75% of those individuals received assistance due to an MSD; this increased to 16.9% for those between 50 and 60 years of age and 23.9% for those between 60 and 65 years of age (National Research Council, 2001).

Mechanism of Injury and MSDs of the Shoulder

Two characteristics of injury are essential to understand and describe MSDs: 1) mechanism of injury (MOI) and 2) specific diagnosis of the MSD. The most common MOI for MSDs is a fall (32%) (Center for Disease Control and Prevention, 2010). The second most common MOI is to be struck by an object, which accounted for 15% followed by overexertion (11%) in a study of ambulatory care visits to physician offices in the U.S. (Center for Disease Control and Prevention, 2010). The most common tissues to be injured or develop a disorder are the tendons, muscles, or ligaments (Kumar, 2001). An injury or disorder involving the tendon or muscles is described as a strain and an injury/disorder to the ligament in described as a sprain. The most common types of MSDs seen in physician offices are sprains and strains, of which, one-third of all MSDs were to the shoulder (Center for Disease Control and Prevention, 2010).

Occupation and MSDs of the Shoulder

Musculoskletal disorders can impact an individual's occupation and ability to work. Approximately 28 million people in the US between the ages of 18 and 64 reported that having a musculoskeletal condition resulted in lost work days in the previous 12 months and are the most common condition associated with lost work days (National Research Council, 2001). The annual estimated cost attributable to individuals with an MSDs is an approximate $213 billion (National Research Council, 2001). This takes into account both direct (e.g., worker's compensation, medical payments, legal expenses) and indirect costs (e.g., replacement employees, lost productivity, absenteeism).

LITERATURE REVIEW

The purpose of this literature review was to explore MSDs of the shoulder in CTDs in order to develop a foundation of understanding that will help address the AIMs of the proposed study. The findings of this literature review will be discussed using the four domains of the OFCM as an organizing structure.

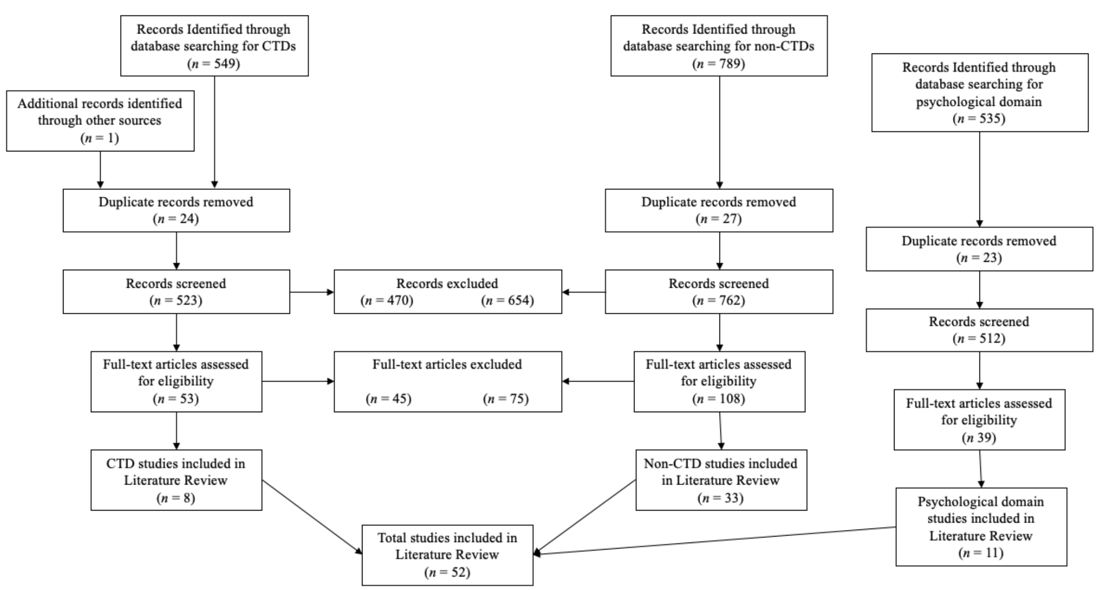
Search Strategy

The literature related to MSDs and CTDs was identified by using three databases: PubMed, CINAHL, and SCOPUS. The inclusion criteria for this literature search required the publication to be (1) peer reviewed, (2) written in the English language, and (3) published within the last ten years. An initial search included the keywords "shoulder injury" and "commercial truck driver," which resulted in no citations. The date range was expanded include the last 25 years and keywords were adjusted to include "shoulder," "injury," "musculoskeletal disorder," "truck driver," "commercial driver," and "long haul." Using the revised criteria, the search yielded 549 articles. Duplicates were removed (n = 24) and article titles and abstracts were reviewed for inclusion and exclusion criteria. The remaining 53 articles were then reviewed in depth. Only eight articles were found to address MSDs that included the shoulder in the CTD population, including a report from the U.S. BLS (2014) found during a secondary search of Google Scholar.

Due to the limited search results regarding CTDs and MSDs, a new search using the search terms "shoulder injury," "work-related," "occupation," and "occupational" was completed using the same inclusion criteria to find studies of shoulder MSDs in non-CTD occupational settings. This search resulted in 789 articles. Duplicates were removed (n = 27) and the titles and abstracts were reviewed to verify the articles addressed MSDs in the occupational setting, and 108 articles remained. These articles were reviewed to verify that they specifically addressed shoulder injuries within the occupational setting, leaving 33 articles that related to MSDs of the shoulder within the occupational setting. In total, 41 articles were identified for inclusion in the literature review.

Additionally, there were limited results regarding MSDs of the shoulder in the working population and psychological factors. In order to investigate the psychological domain of the OFCM a new search was completed using the search terms "shoulder injury," "work-related," "occupation," "occupational," and "pain"; along with "depression," "anxiety," "stress," and "psychological." The same inclusion criteria previously discussed was used. This search resulted in 535 articles. Duplicates were removed (n = 23) and the titles and abstracts were reviewed to verify the articles addressed relationships between psychological factors and either MSDs or musculoskeletal pain, and 39 articles remained. These articles were reviewed to verify that they specifically addressed psychological factors and either MSDs or musculoskeletal pain, leaving 11 articles. In total, 11 articles were identified for inclusion in the literature review. When all were combined 52 articles were included in the literature review.

Figure 4. Literature Review Flow Chart



Review of Literature

The literature review represents the current and relevant literature related to the concepts of the proposed study. The literature is organized using the conceptual framework of the proposed study, the OFCM. The literature will be discussed in the context of the occupational, physical, environmental, and psychological domains of the OFCM.

Occupational Domain

Commercial Truck Drivers. Musculoskeletal disorders have a significant impact on CTDs. Research has shown that between 21% - 42% of CTDs have reported an MSD in the last 12 months (Apostolopoulos et al., 2013; Smith & Anderson, 2017). While the research investigating injuries in CTDs is limited, the body of work available consistently reports that shoulder injury is second in incidence of injury only to the back (Beek et al., 1992; BLS, 2016; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014; Spielholz et al., 2008). An early, seminal study of 534 CTDs in England showed that of all MSDs assessed using the Periodic Occupational Health Survey, over 70% of the CTDs complained of pain originating in the spine, and 28% complained of pain in the shoulder (Beek et al., 1992).

A study of reported shoulder injuries within a large goods transport company in Denmark (McCall & Horwitz, 2005) showed that, within the CTD population, falls from height were the most common mechanisms of injury. Stepping off of an edge was the trigger for these falls 33% of the time. A unique finding in the research was that 51% of all injuries happened to workers with less than one year of experience (McCall & Horwitz, 2005). Ergonomic risks and discomfort of CTDs while performing common tasks outside of the truck cab were investigated. The right shoulder was associated with the most complaints of physical discomfort while the left shoulder was associated with the third most common complaints (Reiman et al., 2014). The mechanism of injury most commonly associated with shoulder discomfort was overexertion and repetitive motion and was most often reported during unloading cargo at the delivery site (Reiman et al., 2014).

Several studies have highlighted the financial implications of shoulder injuries by analyzing associated workers' compensation claims and disability reports. At the same time that the shoulder was associated with one of the highest incidence rates of work-related injury claims; these claims were some of the costliest (Davis et al., 2014; Smith & Williams, 2014). Commercial truck drivers had a higher incidence of injury to the shoulder than workers in non-trucking populations. They also had an increased risk of developing partial or total disability related to occupational MSDs (Smith & Williams, 2014). Davis et al. (2014) reported that the CTD had a higher number of claims related to the shoulder, and these claims had a 20% higher mean cost compared to any other profession. The commercial driver industry sector had the highest average cost per worker compensation claim for all age groups and all occupational sectors (Davis et al., 2014).

Non-CTD Occupations. The shoulder is one of the two most commonly injured regions of the body in construction workers (Borstad et al., 2009; Soares, Jacobs, Minna, et al., 2012). Complaints of shoulder pain are common in construction workers: a prospective study of 240 construction workers found that 17.8% complained of shoulder pain over a period of 2 years (Borstad et al., 2009). Another study found that 55.6% of construction workers have experienced an MSD of the shoulder during their careers (Soares, Jacobs, Minna, et al., 2012). In construction workers, shoulder discomfort was more common when they worked above shoulder level, and there was some evidence that the type of foundation the worker was standing on may have caused a difference in discomfort (Phelan & O'Sullivan, 2014). It is possible that the difference in discomfort could be contributed to the shoulder muscles compensating while on different work platforms. The muscles in the shoulder compensate and change forces in different ranges of motion, specifically, the deltoid muscle has different forces while a worker stands on a ladder versus a stable platform (Phelan & O'Sullivan, 2014).

Injury prevention was evaluated in two of the studies, and it was found that the use of occupational health services, such as job training and screening at the initiation of a job (Soares, Jacobs, Minna, et al., 2012) and preventative exercise programs (Borstad et al., 2009) may be useful in decreasing complaints and MSDs of the shoulder. When construction workers received occupational health services, such as education on work posture, performance, or tools, there was a statistically significant decrease in the incidence of MSDs to the shoulder or arm ($p = 0.024$) (Soares, Jacobs, Minna, et al., 2012).

Electricians often work with their arms raised above shoulder height, and for these workers, the shoulder was the most common body region to experience pain (12.69%) (Trotta et al., 2014). Interestingly, taller utility workers experienced less pain unloading and loading ladders when compared to shorter workers doing the same activity; this was the result of the increased force required to pull items above shoulder height (Soares, Jacobs, Moriguchi, et al., 2012). The force required during the simulated task of pulling an object is increased with changes in elevation (Soares, Jacobs, Moriguchi, et al., 2012) and this represents daily tasks performed by electricians in the field (Moriguchi, Carnaz, Miranda Junior, Marklin, & Gil Coury, 2012).

Shoulder injuries have a significant impact on workers in many different settings, not just those requiring work above shoulder height or who use heavy machinery. Musculoskeletal disorders of the shoulder have also been found to have an impact on nurses, taxi drivers, intervention educators, and computer users (Bhimani, 2014; Kathy Cheng, Cheng, & Ju, 2013; Linaker & Walker-Bone, 2015; Waehrer, Leigh, & Miller, 2005; Wigaeus Tornqvist, Hagberg, Hagman, Hansson Risberg, & Toomingas, 2009). In 2014, it was shown that the second most common MSD within the nursing workforce was related to the upper extremity (Bhimani, 2014). Shoulder injuries in nurses were explained by the pushing and pulling of patients. Within this study of nurses, 48% acknowledged having an MSD, yet they did not initially report it because they felt it was a minor injury (Bhimani, 2014). Taxi drivers are also at an increased risk for MSDs of the shoulder. A study completed by Bulduk et al. (2014) found that taxi drivers had an increased risk of exposure for MSDs of the neck, shoulder, and arm. One potential cause of this increase was described as the required strength to care for and carry passengers luggage and goods. In China, early interventional educators are teachers taking care of children at the age of 6. In this population, 25% complained of back pain, and 19.7% complained of shoulder pain (Kathy Cheng et al., 2013).

While these professions are different, they highlight the significance of shoulder injuries across occupational settings. Manufacturing workers that require high workload have an increased risk for developing MSDs of the upper limb when compared to those that have a low workload (OR = 3.2, 95% CI: 1.1 – 9.4) (Häkkänen, Viikari-Juntura, & Martikainen, 2001). There are some professions where MSDs of the shoulder are less common. W. T. Davis, Fletcher, and Guillamondegui (2014) investigated MSDs in surgeons and discovered that MSDs of the shoulder and elbow (9%) were the fourth most common area of the body injured behind the back/spine (37%), hand (22%), and neck (19%). This just highlights that different professions require different loads on certain parts of the body, and this must be taken into account when investigating MSDs in the occupational setting. Professions that require less physical load such as professional computer workers are still affected by MSDs of the shoulder (41/100 person-years) along with the neck (67/100 person-years) and arm/hand (47/100 person-years) (Wigaeus Tornqvist et al., 2009).

In studies that investigated mixed occupational groups, the shoulder was still a common body region affected by MSDs (Asundi et al., 2011; Bovenzi, 2014; Hegmann et al., 2014; Herin, Vézina, Thaon, Soulat, & Paris, 2012; Nordander et al., 2009). A study of custodial staff found that the most common mechanism of injury seen in MSDs of the shoulder was sprains/strains related to overexertion (Asundi et al., 2011). Also, workers in occupational settings required to perform repetitive tasks within a constrained environment were more at risk of developing MSDs of the shoulder than workers in nonrestrictive environments and had more mobility (Herin et al., 2012; Nordander et al., 2009).

Several mechanical factors have been shown to be related to MSDs of the shoulder. In patients with chronic shoulder pain, 24% were seen to have constraints in movement, and 24% experienced a physical space constraint when having to apply forceful movement (Herin et al., 2012). Workers in occupational settings that require whole body vibration, lifting greater than 15kg for more than 45 minutes during work days, or working with hands above their head more than 60 minutes during workdays have been shown to experience significantly more shoulder pain (Bovenzi, 2014). Beach, Senthilselvan, and Cherry (2012) investigated the workers' compensation claims related to the shoulder and found that in workers required were required to lift weights heavier than 10 kg more then two hours in a workday had a significant increase in shoulder injuries (OR = 2.62, 95% CI: 1.54 – 4.45). Messias, de Andrade, Artero, and Nóbrega (2017) investigated the unique mechanical stresses placed on sugarcane workers using kinematic analysis of simulated work movements and discovered that this population is at increased risk for the development of MSDs of the shoulder due to increase in shoulder flexion and abduction throughout the workday.

Occupational Domain Summary. This section has shown that there is a significant association between MSDs of the shoulder and specific occupational groups. Commercial truck drivers have an increased risk to develop MSDs of the shoulder, and the costs of these MSDs is significantly higher than other parts of the body. These findings are also consistent with those in other occupations, such as construction workers, electricians, and nurses. The next section will explore findings related to the physical domain of the OFCM.

Physical Domain

Age. The potential for a MSD to develop in the shoulder increases as the worker ages (Andersen et al., 2002; Davis et al., 2014; Leroux, Brisson, & Montreuil, 2006; Smith & Anderson, 2017; Smith & Williams, 2014; Soares, Jacobs, Moriguchi, et al., 2012). Specifically, workers over the age of 45 are at an increased risk (Andersen et al., 2002; Leroux et al., 2006). In one study of worker compensation claims of CTDs 67% of all claimants were between 45 and 64 years of age (Smith & Anderson, 2017) and those between 35 and 55 years of age had an increased rates of time of lost work (OR = 1.48, 95% CI: 1.31-1.68) and increased medical costs (OR = 1.55, 95% CI: 1.36-1.76) (Smith & Williams, 2014). Older age is also associated with increased cost of worker compensation claims; a separate study showed that worker compensation claims had higher financial costs between the ages of 45 and 64 with 1.6% of all claims being more than $600 compared to only 0.9% of those between 35 and 44 and 0.5% between 25 and 34 (Davis et al., 2014). Shoulder injuries were associated with the highest cost per claim among any age group and location, with those between 55 and 64 years of age having an average cost per claim of just over $15,000 (Davis et al., 2014).

Height. In addition to age, the physical height of the worker has been shown to be associated with MSDs of the shoulder (Borstad et al., 2009; Hagberg & Wegman, 1987; Soares, Jacobs, Moriguchi, et al., 2012; Svendsen et al., 2004). A study of construction workers found that the height of a worker predicted shoulder pain (Borstad et al., 2009). Taller construction workers required less workforce ($p = 0.05$) when pushing and pulling items from at or above shoulder height which could lead to less risk of developing MSDs of the shoulder (Soares, Jacobs, Moriguchi, et al., 2012). The damage to the shoulder for shorter individuals can be cumulative; a study investigating multiple worker populations highlighted the role of height in shoulder injury, reporting that the development of rotator cuff tendinopathy is significantly related to long-term work with the arms above shoulder height (OR = 1.29, 95% CI: 1.02-1.60)) (Svendsen et al., 2004).

Gender. In the occupational setting women experience an increased risk of developing a MSD, compared to men (Andersen et al., 2002; Andersen et al., 2003; Davis et al., 2014; de Zwart et al., 2001; Leroux et al., 2006; Nordander et al., 2009; Smith & Anderson, 2017; Smith & Williams, 2014). A study of plant workers found that being female was a risk factor for developing neck and shoulder pain with pressure tenderness and had a prevalence portion ratio of 1.8 up to 2.26 when compared to men. This highlights that women developed almost twice as often as men (Andersen et al., 2002; Leroux et al., 2006). The female gender has also been shown to increase medical costs (OR = 1.34, 95% CI: 1.07-1.66) and days away from work (OR = 1.18, 95% CI: 0.95-1.46) (Smith & Williams, 2014). Women have higher risks for developing MSDs in specific regions of the body, such as the neck (OR = 1.90, 95% CI: 1.75-2.08), shoulder (OR = 1.43, 95% CI:1.30-1.57), elbow (OR = 1.23, 95% CI:1.02-1.47), or wrist (OR = 1.31, 95% CI: 1.09-1.58) (de Zwart et al., 2001). The type of work may affect the risk of MSDs in female workers. A study of multiple worker groups showed that consistent with previous findings (Andersen et al., 2002; Leroux et al., 2006; Smith & Williams, 2014), females had an increased incidence of MSDs compared to men, 34% to 29% respectively, but the mean difference increased even more when looking at work described as repetitive and constrained (Nordander et al., 2009).

Obesity. One of the studies found that workers who were overweight had an increased risk to develop MSDs (Herin et al., 2012). While this is only a single study, it is essential due to the increased rates of obesity among CTDs (Apostolopoulos et al., 2013; Birdsey et al., 2015), suggesting that CTDs may be at an even higher risk of MSDs.

Mechanism of Injury. The current literature shows that the most common activities related to MSDs of the shoulder are falls and overexertion (Asundi et al., 2011; Beek et al., 1992; BLS, 2016; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014; Spielholz et al., 2008). A study investigating MSDs of the shoulder within a diverse sample of workers found that the most common MOI resulting in MSDs of the shoulder was over-exertion, followed by falls (Asundi et al., 2011). A study investigating all work compensation claims in commercial truck drivers and statistics from the Bureau of Labor and Statistics showed that, as the study by Asundi et al. (2011), the most common MOI resulting in MSDs was overexertion (BLS, 2016; Davis et al., 2014; Smith & Williams, 2014). McCall and Horwitz (2005) did show that falls were the most common MOI of MSDs in CTDs. However, this study investigated only injuries that happened directly around or on the truck, and it may not have taken into account MSDs that develop over time. Vibration is associated with CTDs who experience shoulder pain (Bulduk et al., 2014). Many studies use workers' compensation claims to evaluate MOIs. However, a separate study used surveys to discuss the concerns that CTDs have in developing MSDs, and the top two concerns were developing MSDs by overuse and from falling (Spielholz et al., 2008). This is important because CTDs have personal concerns which seem to reflect an internal understanding of the most common MOIs that are supported by research.

Physical Domain Summary. This section has highlighted the effects that the physical aspects of a worker can have on the risk of developing MSDs in an occupational setting. An individuals age, gender, height, and weight can all have an impact on the development of MSDs in the occupational setting. The MOI is a physical action that is the cause of an MSD, and the most common MOI of MSDs of the shoulder are falls and overexertion. The next section will explore findings related to the environmental domain of the OFCM.

Environmental Domain

Above Shoulder Height. Occupational settings that require a worker to elevate their arms higher then shoulder height can increase the risk for the development of MSDs of the shoulder (Hagberg & Wegman, 1987; Soares, Jacobs, Moriguchi, et al., 2012). Shoulder tendonitis has been shown to be more prevalent in workers who work with their arm at or above shoulder height (OR = 11, 95% CI: 2.7-48) (Hagberg & Wegman, 1987). Working surfaces that required increased shoulder elevation was associated with increased stress on the shoulder by requiring increased force while pulling objects (Soares, Jacobs, Moriguchi, et al., 2012).

Handling/Assistive Lifting. While there is no research within the CTD population investigating injury and cargo handling, there were two studies that investigated medical staff and the relationship between MSDs and poor lifting techniques and lack of assistive devices (Bhimani, 2014; Dennerlein et al., 2017). During an interview, nurses felt the lack of available lifting devices led to an increased risk of injury to their back and shoulders (Bhimani, 2014). An interventional study of patient care technicians found that improved patient handling techniques decreased the incidence of MSDs to the back and shoulder ($p < 0.01$) (Dennerlein et al., 2017).

Preventative/Rehabilitative Services. Overall, the literature suggests that education and prevention services are effective in decreasing the risk for developing MSDs of the shoulder (Cheng & Hung, 2007; Dennerlein et al., 2017; Ludewig &

Borstad, 2003; Soares, Jacobs, Minna, et al., 2012). An early study showed that exercise programs prescribed to individuals who were identified to have decreased shoulder ROM decreased complaints about shoulder pain and had an increased shoulder satisfaction score when compared to a control group (Ludewig & Borstad, 2003). The use of rehabilitative services designed by athletic rotator cuff principles and specific job activities improved the return to work rate when compared to a control group ($p = 0.01$) (Cheng & Hung, 2007).

Environmental Domain Summary. The section highlighted findings related to the environmental aspects of the occupational setting where MSDs develop. The occupational environment can have significant impacts on worker risk of developing shoulder MSDs. In environments where the workers have to utilize work height above shoulder height will have an increased risk of developing MSDs of the shoulder. The environment can have protective measures as well. In working environments that utilized assistive equipment and educational and preventative services, the risk of developing MSDs of the shoulder was decreased.

Psychological Domain

Depression/Anxiety and Pain. Individuals with increased depression and anxiety have been shown to have an association with increased levels of pain (Liu et al., 2018; Sato et al., 2018; J. A. Smith et al., 2017). A large cross-sectional study (N = 5397) of individuals following an acute injury found that individuals reporting higher levels of depression required more narcotics for pain control than those with decreased levels of depression ($p < 0.0001$) (J. A. Smith et al., 2017). A similar finding was also present in older adults with osteoarthritis. The level of opioid supply for an older patient with depression was significantly higher than those without depression (IRR 1.5, 95% CI 1.1-2.3) (Liu et al., 2018).

Depression/Anxiety and MSDs. Depression and anxiety not only have an impact on the experience of pain but has also been associated with MSDs (Ben-Ami & Korn, 2018; Li, Moreland, Peek-Asa, & Yang, 2017). Ben-Ami and Korn (2018) found that undergraduate students who were diagnosed with increased levels of depression were more likely to report backaches (OR = 2.69, 95% CI 1.54-4.69). A study evaluating college athletes found that student-athletes who experience anxiety symptoms had increased MSD incident rates when compared to those who had no symptoms of anxiety (RR= 2.3, 95% CI 2.0-2.6) (Li et al., 2017).

Stress and Injury. Several research articles showed an association between increased stress and the development of an MSD (Bedno et al., 2014; Ben-Ami & Korn, 2018; Clouser, Bush, Gan, & Swanberg, 2018; Julia, Catalina-Romero, Calvo-Bonacho, & Benavides, 2016; Kim, Min, Min, & Park, 2009; Nakata et al., 2006; Wang & Delp, 2014). A study investigating the relationship between backaches and stress among undergraduate students found that those students who reported back pain also reported higher levels of stress (OR = 2.39, 95% CI 1.22 - 4.69). Clouser et al. (2018) recently found that Latino farmworkers who experienced increased work stress had a significantly increased risk of developing an MSD (OR 6.70, 95% CI 1.84–24.31). A study of military personnel showed that those individuals reporting more than usual personal stress (OR = 1.56, 95% CI 1.16-1.67) and reporting more than usual work stress (OR = 1.54, 95% CI 1.3-1.81) were more likely to develop an MSD (Bedno et al., 2014).

Julia et al. (2016) completed a large prospective cohort study in Spain (N=16,693) and investigated psychological risk factors and the incidence of occupational MSDs and discovered that women reporting unfavorable levels of psychological demands had increased incidences of occupational MSDs (RR = 2.20, (95% CI 1.08-4.47). Wang and Delp (2014) showed that taxi drivers who reported experiencing low levels of stress had a decreased risk ratio for developing MSDs (0RR = 0.89, 95% CI 0.51-1.56). Japanize men who work in a manufacturing setting are at increased risk for developing MSDs when they experience high workload (OR = 1.55, 95% CI 1.24-1.98) and high cognitive demands (OR 1.31, 95% CI 1.03-1.67) (Nakata et al., 2006). Interestlingly, Nakata et al. (2006) also found that women showed similar results with high workload and MSDs (OR – 1.76, 95% CI 0.83-3.75). Kim et al. (2009) discovered similar findings in Korea during an investigation of job-demand and the impact it has on developing MSDs. Men and women both experienced increase risk for MSDs when they have high job demand; Men (OR = 1.71, 95% CI 1.13-2.59), Women (OR 2.11, 95% CI 1.18-3.78).

Psychological Domain Summary. This section has shown that depression, anxiety, and stress can have a significant impact on the personal perception of pain and the potential for injury. This increased perception of pain could increase potential work related complaints resulating in increased worker compensation claims. While many of these studies did not investigate the working population, they do highlight the relationship between psychological factors and pain/injury.

SUMMARY

Musculoskeletal disorders have a significant impact not just on the general population but also the worker. Although research shows that MSDs of the shoulder are among the most commonly reported in CTDs, little is known about the MOIs and the MSD themselves. This is true even though there is research that shows the MSDs of the shoulder are among the most common, require significant time away from work, and are among the most expensive to care for (Davis et al., 2014). Current research can be found investigating MSDs of the shoulder in occupations other than CTDs; i.e., construction workers, electricians, nurses, taxi drivers. This research supports the impact that MSDs of the shoulder can have on a worker and highlights the gap in research in the CTD population. Therefore, the purpose of this study is to describe mechanisms of injury, types of shoulder injuries among CTDs, and identify factors that are associated with shoulder injuries in this group. The OFCM will help guide the proposed study by creating a framework for investigating the occupational, physical, and environmental domains of MSDs. A quantitative research design will be used to address the aim of the proposed study effectively. In order to answer the research questions of this proposed study, the most efficient and effective method of quantitative research will be a retrospective cross-sectional methodology.

This chapter developed support for the proposed study by discussing the epidemiology, concepts of interest, conceptual framework, and literature review. Chapter three will outline and describe the research methods that will be utilized to answer the research questions of the proposed study.

CHAPTER 3

As highlighted in Chapter Two, there are significant gaps in the literature related to MSDs of the shoulder in CTDs. This study addressed these gaps using a quantitative retrospective cross-sectional study. The purpose of this chapter is to discuss the methodological components of the study, including the plans for sampling, data collection, data analysis, and human subjects' protection. The study investigated the following aims and research questions:

AIM 1: Determine the common characteristics of shoulder injuries among a group of commercial truck drivers.

RQ 1.1: What are the most common diagnoses of shoulder injuries among commercial truck drivers?

RQ1.2: What are the most common mechanisms of shoulder injury among commercial truck drivers?

AIM 2: Determine factors associated with shoulder injuries among a group of commercial truck drivers.

RQ 2.1: What work environment factors are associated with increased risk of developing shoulder injuries?

RQ 2.2: What demographic and anthropometrics are associated with increased risk of developing shoulder injuries?

STUDY DESIGN

This study was a retrospective cross-sectional study investigating MSDs of the shoulder in CTDs. This methodology has also been utilized in other research investigating MSDs. Past research has utilized retrospective studies to investigate workers' compensation claims in commercial truck drivers (Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014). A study of CTDs utilized past workers compensation claims to investigate MSDs within an individual company (McCall & Horwitz, 2005). A similar design was also utilized in the state of Washington, however, this study investigated just claims filed by CTDs (Smith & Williams, 2014). Therefore, this design was justified for the stated purpose in the CTD population.

SAMPLING

Setting

All data collection was conducted at an occupational health clinic in a large city in the southeast that services several trucking companies. The CTDs were seen in this clinic due to an injury in the work setting, and these injuries were all reportable to OSHA. The clinic has utilized an electronic medical record for 15 years. These two facts allowed both ease of access to the data and consistency across all the patient medical records. The clinic agreed to allow access to the site and the medical records. A letter of support from the physician and practice manager was received (Appendix A). The University of Alabama at Birmingham IRB approved the study before the onset of data collection (Appendix B).

Recruitment

This study employed a retrospective medical record review. Therefore, no direct recruitment of participants took place. Records of past patient visits were reviewed to determine which cases met the inclusion criteria of the study. This approach represents convenience sampling.

Sample

The sample consisted of CTDs who were evaluated at the occupational health clinic for a shoulder injury. Nonprobability convenience sampling was used (Polik & Beck, 2017). Since this sample was comprised of only CTDs in a large city in the southeast, the study does have limited generalizability; however, when using a retrospective design investigating a specific population, it is the most appropriate method. This sampling method is also supported by the past research mentioned earlier. Historically, CTDs are a transient population, and convenience samples have been shown to be effective methods for data collection (Beek et al., 1992; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014). After accessing electronic medical records, the investigator used ICD 9 codes to identify individuals who presented to the clinic with a shoulder injury. Only ICD-9 codes were used due to drastic changes in ICD-10 coding, and the occupational health clinic had just initiated ICD-10 coding, and there may have been increased chances of error in both healthcare provider use and data collection. Once this search was completed, the inclusion and exclusion criteria were applied to add cases to the database.

Tabachnick and Fidell (2013) recommend two methods for calculating sample sizes. The first does not take into account effect size ($N \geq 50 + 8(10) = 130$) and the other uses Cohen's f2 in its calculation ($N \geq (8/0.15) + (10 - 1) = 62$). In order to be most conservative in the sampling approach, the larger suggested sample size was used ($N = 130$). Thus using methods described in Tabachnick and Fidell (2013), the anticipated sample size was no smaller than 130. This was adequate to have sufficient statistical power and effect sizes for all analyses, including logistic regression.

A set of inclusion and exclusion criteria was used to select participants. Inclusion criteria: CTDs, ages 18 - 65 years old, all genders and races, individuals presenting with a work-related shoulder injury. Exclusion criteria: Previous history of shoulder surgery in the injured shoulder, a fracture related to the current injury, injuries related to a commercial vehicle accident, injuries that are found not to be related to work.

Human Subjects' Protection

Informed consent was not obtained because there was no direct contact with participants, and it was not feasible to obtain informed consent. The CTD population is transient and can be difficult to contact, especially when taking into account the length of time from when the CTDs were seen in the clinic. Due to potential changes in contact information, addresses, or employment, it was not a reasonable or feasible expectation to obtain informed consent. This was described in detail in the approved IRB application (Appendix B).

The protection of human subjects was accomplished by de-identifying all data when the data were extracted from the medical records. All data that were collected were stored in a securely locked drawer at the occupational health clinic until all data were extracted and documented on the data collection forms. Once this process was completed, all of the data collection forms were transferred to the researcher's office on campus and will be secured in a locked drawer. The data were housed on a secure USB drive that was also stored in a locked drawer. All data entry into the data set was done on a secure computer within the UAB system.

DATA COLLECTION

This section describes procedures for data collection by focusing specifically on the variables of interest, data collection, and study timeline.

Variables

The key variables of this study were age, gender, race, height, weight, body mass index (BMI), equipment, MOI, radiology, date of injury, date of release, referral for surgery, days of work missed (Independent) and MSD (Dependent). These are common variables used in research with the goal of describing injury. This is supported by past research with commercial truck drivers (Beek et al., 1992; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014). The variables that were examined in the proposed study, conceptual and operational definitions, and the level of measurements are found in Table 3.

Table 3: Variables, Levels of Measurement, and Definitions

Conceptual Definition	Level of Measurement	Operational Definition	Measurement
Age	Ratio	Age in years at the time of injury	Mean, Range, SD
Age	Ordinal	21-35 yo, 36-45 yo, 46-55 yo, 56-65 yo	Frequency and %
Gender	Nominal	Male, Female, Transgender	Frequency and %
Race	Nominal	Caucasian, African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Or *Other*	Frequency and %
Height	Ratio	Height of participant in inches	Mean, Range, SD
Height	Ordinal	70” or Less, 71” or More	Frequency and %
Weight	Ratio	Weight of participant in pounds	Mean, Range, SD
Weight	Ordinal	100-199 lbs, 200-299 lbs, 300-399 lbs.	Frequency and %
BMI	Nominal	Underweight (< 18.5, normal Weight (18.5-24.99), Overweight (25-29.99), Obesity 1 (30-34.99), Obesity 2 (35-39.99), Morbid Obesity (40 or >)	Frequency and %
BMI	Ratio	Numerical Body Mass Index	Mean, Range, SD
Equipment	Nominal	Tarps, Chains, Straps, None	Frequency and %
Mechanism of injury	Nominal	Specific cause of injury as reported in the medical record	Frequency and %
MSD	Nominal	Specific ICD-9 codes listed in the medical record and from reports	Frequency and %
Radiology	Nominal	Yes/No, What radiology was order when ordered	Frequency and %
Referral for surgery	Nominal	Yes/No, Date provider referred to a surgeon for operative management	Frequency and %
Days of work missed	Ratio	Days between Date of injury and Date of release	Mean, Range, SD

Collection

Data were collected via reviewing medical records selected from a list of MR numbers that were related to specific ICD-9 codes for shoulder injuries (Table 4).

Medical records were reviewed if there were office visits documented within 2007-2015. During this time frame, the clinic had a consistent electronic medical record system. To maintain consistency, the researcher stopped data collection at the point the clinic started using ICD-10 codes, which were at the beginning of 2016.

Table 4: Common ICD-9 Codes for the Shoulder

840.4	Rotator Cuff Sprain
840.7	Superior Glenoid Labrum Lesion
840.9	Sprain Shoulder non-specific
959.2	Injury Shoulder and upper Arm non-specific

A general data collection form was used to document the de-identified data finding the medical records (Appendix C). A data set was created in Microsoft Excel, and all documented data on the collection forms was entered into the database using the randomized participant number. All data was collected and documented in the collection form by one individual. To prevent incorrect data collection, a schedule was developed that allowed for sufficient breaks to try and decrease researcher fatigue. There were also steps in place to assess quality assurance. At the beginning of the next day of data collection, a sample of the completed data collection forms were evaluated a second time by comparing them to the companion medical records to assess for data consistency. These reviews were documented to support the quality and rigor of the work performed. Once all data were de-identified and documented on the data collection forms, the data were entered into the database. In order to continue to ensure the quality of the data, all data collection forms were checked a second time on a separate day to verify data in the database matches the data collected on the collection forms. A 10% audit will be completed as a second step in order to determine the accuracy of the transfer of data onto the data collection forms and into the database.

Timeline

As medical records were reviewed for patients that meet the inclusion criteria, the data were extracted from the medical record and documented onto the collection forms and then placed into the data set. It took approximately 1 minute to review each medical record to verify whether the patient is a CTD, and then it took approximately 10 minutes to review the medical record and extract all pertinent variables. The goal for completion of data collection was December 7, 2018. The process of cleaning data was complete by December 20, 2018, at which point the data analysis began. The process of data analysis was completed by January 18, 2019.

RELIABILITY AND VALIDITY

This study was a retrospective study and does not utilize any form of an instrument that requires reliability and validity testing. The process of establishing reliability and validity in this study was accomplished in the procedures of the study itself. Reliability is the degree to which an assessment tool produces stable and consistent results. In order to maintain reliability throughout the data collection process, the investigator utilized a schedule that allowed for sufficient breaks to try and decrease investigator fatigue. The investigator also completed EMR training within the occupational clinic to ensure the investigator has a clear and working understanding of the EMR for data extraction. Validity refers to how well a study measures what it is supposed to study. For this study, validity was accomplished by collecting a random sample of the medical records used for data collection and were evaluated a second time at the beginning of a work day to assess the data for consistency. The completed quality assurance reviews were documented to show members of the dissertation committee and to support the quality of the work performed.

DATA ANALYSIS

This section discusses the data analysis plan and is accomplished by addressing missing data, describing common statistical methods found in related research, and explaining the process for data analysis in this proposed study.

Missing Data

In order to address missing data, it was essential to understand what types of missing data were present. There are three forms of missing data that are common in research: missing completely at random, missing at random, and missing not at random (Table 5) and there are three standard methods for addressing missing data in a research study (Table 6) (Perkins et al., 2017; Polit & Beck, 2012).

Table 5: Types of Missing Data

Type	Description
Missing completely at random (MCAR)	When the probability that the data are missing is not related to either the specific value which is supposed to be obtained or the set of observed responses
Missing at random (MAR)	When the probability that the responses are missing depends on the set of observed responses but is not related to the specific missing values which are expected to be obtained
Missing not at random (MNAR)	When the characters of the data do not meet those of MCAR or MAR

Table 6: Ways to address Missing Data

Method	Description
Listwise Deletion	Delete all data from any participant with missing values
Pairwise Deletion	Pairwise deletion eliminates information only when the particular data-point needed to test a particular assumption is missing.
Regression Substitution	Use multiple-regression analysis to estimate a missing value
Random Forest	Imputation model that can accommodate nonlinearities and interactions and does not require a particular regression model to be specified

Once the data were collected and entered into the dataset, all data were cleaned. Any missing data were investigated and assessed to establish what type of missing data they were as explained in Table 5. In the occupational clinic, many of the variables were required in workers compensation claims, and due to this fact, it was expected the most likely form of missing data was missing completely at random. Once the missing data are assessed, the most appropriate method of addressing missing data was chosen (Table 6). Assuming a majority of the data is present in the medical records and any missing data can be defined as MCAR, then a likely option for addressing the missing data would be to use the listwise approach. The risks of using listwise deletion are the potential of decreasing statistical power due to the smaller sample size and may be biased if the data are not MCAR. If the data collection does not follow the expected path and listwise deletion becomes no longer applicable, then missing data will likely be addressed pair-wise deletion or random forest as shown in Table 6.

Common Statistical Methods and Advantages/Disadvantages

Assessment of Normality

Groups within the data were evaluated to determine if the data were normally distributed and if variances were similar. In order to assess if a sample has a normal distribution, it must be assessed for normality or normal distribution among groups. The Shapiro-Wilks test was used to verify that assumption of normality. If the Shapiro-Wilks test is significant, typically p-value < 0.05, then the null hypothesis was rejected, and it was assumed that the data are not normally distributed. Once the data were tested for normality, it then was assessed for homogeneity of variance by running the Levene's test. The Levene's test is used to test if two different groups have equal variances. If the Levene's test was significant, typically p-value < 0.05, then the null hypothesis was rejected, and it was assumed that there was a variance in the two groups, and they did not meet requirements for homogeneity of variance. If groups were shown to have normality and homogeneity of variance, then parametric statistical tests were preferred, but in the event, groups do not have both, normal distribution and homogeneity of variance, then non-parametric statistical tests will be the tests of choice.

Descriptive Statistics

In past research investigating MSDs in CTDs, the most common statistical methods used were descriptive statistics: Mean, SD, frequencies, and proportion (Apostolopoulos et al., 2013; Beek et al., 1992; Chen et al., 2015; Davis et al., 2014; McCall & Horwitz, 2005; Reiman et al., 2014; Smith & Anderson, 2017; Smith & Williams, 2014). Descriptive statistics are used to describe the basic features of data in a study and provide a descriptive summary of the population and the data collected. Descriptive statistics are the first step in virtually all quantitative data analysis. The main advantage of descriptive statistics is that it is the only way to describe the population in the study. Descriptive statistics characterize the participants and the concepts being investigated.

Parametric Statistics

Parametric test procedures have strict population parameters and work off the assumption that data are normally distributed. There are several parametric tests that are routinely used in research, and they are described more in-depth below.

The Pearson correlation evaluates the linear relationship between two continuous variables. A relationship is linear when a change in one variable is associated with a proportional change in the other variable. Pearson correlation also shows if there is a negative or positive relationship between the two variables. Pearson's correlation has been used regularly in past research when assessing association between two continuous variables (Beek et al., 1992; Chen et al., 2015; Davis et al., 2014; McCall & Horwitz, 2005; Reiman et al., 2014; Smith & Anderson, 2017; Smith & Williams, 2014). While it can show an association, the main disadvantage is that it does not show cause and effect.

Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more nominal, ordinal, interval, or ratio-level independent variables. Logistic regression is used in many different research studies and of those similar to the proposed study the most common form is simple logistic regression (Armijo-Olivo, Woodhouse, Steenstra, & Gross, 2016; Beek et al., 1992; Borstad et al., 2009; Bovenzi, 2014; Kathy Cheng et al., 2013; Smith & Anderson, 2017). The main advantages of logistic regression are that it can be used with categorical data and show the best fit between the dependent and independent variables. Like discussed above, one disadvantage of logistic regression is the lack of ability to show cause and effect.

Non-Parametric Statistics

Non-parametric test procedures do not have population parameters, measure data on any scale (ratio, interval, ordinal, or nominal) and work off the assumption that data does not have normality. There are several non-parametric tests that are routinely used in research, and they are described more in-depth below.

The Spearman correlation evaluates the relationship between two continuous or ordinal variables within a group that does not maintain normality. The Spearman correlation coefficient is based on the ranked values for each variable rather than the raw data. Spearman's correlation can be seen as the non-parametric replacement for Pearson's correlation. As is with many non-parametric tests, the main advantage is that it can be used when groups do not have normality. Disadvantages of all non-parametric tests are the lack of efficiency when compared to parametric tests and the difficulty to compute.

Chi-squared is used to determine if there is a significant relationship between two categorical variables. Chi-squared can show an association between two categorical variables, but the main disadvantage of Chi-squared is that it does show cause and effect. It also requires an additional test to be reported appropriately, Cramer's V. Cramer's V calculates the effect size, which shows the strength of an association once Chi-squared as determined statistical significance. (Beek et al., 1992; Chen et al., 2015; Davis et al., 2014; McCall & Horwitz, 2005; Reiman et al., 2014; Smith & Anderson, 2017; Smith & Williams, 2014).

Additional Statistical Methods

All of the statistical methods previously mentioned could have been used in this proposed study. There is one statistical method that has recently shown to be useful in similar research that could be of benefit: Association Rules. Association rule analysis is a data mining technique used in analyzing categorical data and provides rules for two or more variables that frequently occur together. Association Rules are if/then statements that help uncover relationships between variables created by analyzing data for frequent if/then patterns and using the criteria support and confidence to identify the most important relationships (Agrawal, Mielinski, & Swami, 1993; Agrawal & Srikant, 1994). While association rules were initially developed for consumer market-based analysis, they are often successfully applied to other research areas, including healthcare. For example, Ivancevic et al. (2015) helped identify risk factors associated with early childhood caries, Pham et al. (2016) assessed the black cloud versus white-cloud phenomenon in apheresis medicine, and (Kost, Littenberg, & Chen, 2012) was able to show disease-specific co-occurrences using Association Rules. Most recently, association Rules has been used to show an association between MOI and MSDs in long-haul truck drivers (Combs, Heaton, Raju, Vance, & Sieber, 2018). As described above with Chi-squared, there will be additional tests to support the significance of Association rules. The support and confidence must be reported with the lift. The confidence shows the rate at which consequents will be found and is an indication of how often the rule has been found to be true. The lift value of an association rule is the ratio of the confidence of the rule and the expected confidence of the rule and shows how effective the rule is in finding consequents.

The Mann–Whitney U test is a non-parametric test of the null hypothesis that it is equally likely that a randomly selected value from one sample will be less than or greater than a randomly selected value from a second sample. It is the non-parametric statistical method of choice when a t-test cannot be used since there is no normality in the data. The Mann-Whitney U will show the median between 2 groups, and it can also work with two groups of different sizes. This was an advantage in the study because some of the sub-groups were compared (those that require surgery versus those that did not) did not have equal numbers or meet the criteria for normality.

Planned Data Analysis

Once the data were cleaned and ready for analysis, the next step was to analyze the data according to the AIMs of the proposed study.

AIM 1: Determine the common characteristics of shoulder injuries among a group of commercial truck drivers

AIM 1 was accomplished by first analyzing the data using descriptive statistics. The continuous variables (age, height, weight, and days of work missed) were described in relation to MOIs and MSDs by calculating the mean and standard deviations of each variable. The categorical variables (gender, race, BMI, Equipment, MOI, MSD, radiology, and referral for surgery) were described in relation to MOIs and MSDs using frequency distribution and proportions. Both of these techniques are common first steps in descriptive data analysis and support in research of MSDs in many different worker populations (Apostolopoulos et al., 2013; Armijo-Olivo et al., 2016; Beek et al., 1992;

Borstad et al., 2009; Bovenzi, 2014; Chen et al., 2015; Davis et al., 2014; McCall & Horwitz, 2005; Reiman et al., 2014; Smith & Anderson, 2017; Smith & Williams, 2014).

AIM 2: Determine factors associated with shoulder injuries among a group of commercial truck drivers.

AIM 2 was accomplished by comparing all paired continuous variables using either parametric (Pearson's correlation) or non-parametric tests (Spearman's Correlation) once the Shapiro-Wilks and Leven's tests were used to test the assumption of normality and homogeneity of variance. All paired categorical variables were investigated by using Chi-squared, and all variables using Association Rules. Cramer's V was calculated to assess the effect size of all chi-squared results, while, support and confidence were calculated to assess Association Rules results. Once initial bivariate inferential statistics were analyzed, and paired variables were assessed for associations. Next, all variables that were shown to have an association with MSDs at the bivariate level were included in a multivariate model. The use of Pearson's Correlation, Chi-squared, and logistic regression has been supported by past research when examining MSDs in many different populations (Apostolopoulos et al., 2013; Armijo-Olivo et al., 2016; Beek et al., 1992; Borstad et al., 2009; Bovenzi, 2014; Chen et al., 2015; Davis et al., 2014; McCall & Horwitz, 2005; Reiman et al., 2014; Smith & Anderson, 2017; Smith & Williams, 2014). As described above Association rules have not been used as often, but it is supported in healthcare research and has successfully been used in a study investigating MSDs of long-haul truck drivers that are in press (Combs et al., 2018).

SUMMARY

The purpose of this chapter was to discuss the methodological components of the proposed study, including the plans for sampling, data collection, and data analysis. In order to accomplish the aims of the proposed study, quantitative design utilizing a retrospective cross-sectional method was the most appropriate approach for design, data collection, and analysis. Therefore, the researcher achieved the aims and research questions of the purpose study by working in collaboration with a large occupational health clinic investigating CTDs that presented for evaluation of a work-related MSD of the shoulder between 2007 and 2015. Following the described methods and procedures the investigator collected, cleaned, and analyzed the data to determine common characteristics of shoulder injuries among commercial truck drivers and the factors that may be associated with them. The next chapter presents the findings from these analyses.

CHAPTER FOUR

The purpose of this study was to describe mechanisms and types of shoulder injuries among CTDs and to, identify factors that are associated with shoulder injuries in CTDs. The findings of this study are addressed below in the following order: sample and setting characteristics, missing values, descriptive statistics in the study, correlations among the study variables, analysis of AIM 1, analysis of AIM 2, additional analyses, and a summary.

DATA ACCESS AND MANAGEMENT

A convenience sample of 130 CTDs was selected during a retrospective medical record review. The medical record review was conducted at an occupational health clinic in a large city in the southeast and was reviewed by the primary investigator for eligibility. Over 500 records were reviewed, and 134 records were related to CTDs with MSDs of the shoulder. Of these records, 2 had electronic files that were illegible and thus removed from the sample. Two more were missing more than half of the data. After the exclusion of these four records, 130 records met all inclusion and exclusion criteria and were retained for analysis.

MISSING VALUES

There were very little missing data noted during the data collection process. One participant had no record for height or weight; two other participants had no record of weight. In order to address these issues, the pairwise deletion was used. As discussed in Chapter 3, two power analyses were completed as suggested by Tabachnick and Fidell (2013); one suggested a sample size of N=62 and the other a sample size of N=130. Due to the limited amount of missing data, there is little to no concern about the loss of power in the study.

ASSUMPTION OF NORMALITY

The first step in data analysis was to assess whether the use of parametric or non-parametric methods was appropriate. Shapiro-Wilk tests were conducted on all continuous variables in order to determine whether the distributions of age, height, weight, BMI, and referral/release were significantly different from a normal distribution. All five variables were found to not have a normal distribution. The results are presented in Table 7.

Table 7: Shapiro-Wilk Test Results

Variable	W	p
Age	0.96	< .001
Height	0.98	.041
Weight	0.97	.012
BMI	0.97	.018
Referral/Release	0.64	< .001

The first of the two required assumptions were not present; thus, non-parametric methods were chosen. As a result, the Leven's Test was not used as it was not required to assess for homogeneity of variance since no variable was found to be normally distributed.

CHARACTERISTICS OF SAMPLE AND INJURIES

All categorical and continuous demographic and MSD characteristics are summarized in Table 8. A majority of all participants were White (*n* = 86, 66%) and Male (*n* = 126, 97%). Individuals who were between the ages of 36-45 (*n* = 44, 34%) made up the largest age group followed by ages 56-65 (*n* = 36, 27%) and ages 46-55 (*n* = 26, 20%) with an average age of all participants was 45 years old with a range of 21-65. Over half of the participants were categorized as Obese (*n* = 77, 59%) and weighed between 200-299 lbs. (*n* = 83, 64%) moreover, an average of 224 lbs. (Range - 126 – 375). The height of the sample was divided using a medium split resulting in individuals who are 70" or less making up 53% of the sample (*n* = 69) with an average height of 70.29" (Range – 63" – 77"). Out of all of the participants, 43% were required to get an MRI, and 38% had to be referred to an orthopedic surgeon for surgical evaluation. All participants were assessed for the number of days between the date of injury and the date they were either released to full duty or referred to an orthopedic surgeon. On average this occurred on day 11, but there was a very wide range between one day and 131 days.

Table 8: Frequency Table for All Variables (N = 130)

Variable					
Gender				*n*	%
Male				126	96.92
Age – Categorical				*n*	%
21-35				24	18.46
36-45				44	33.85
46-55				26	20.00
56-65				36	27.69
Age - Continuous	*n*	*M*	*SD*	*Min*	*Max*
	130	45.85	11.53	21	65
Race				*n*	%
White				86	66.15
African American				40	30.77
Other				2	1.54

Hispanic				2	1.54
Weight – Categorical				*n*	%
100-199				37	28.46
200-299				83	63.85
300-399				7	5.38
Missing				3	2.31
Weight - Continuous	*n*	*M*	*SD*	*Min*	*Max*
	127	224.27	45.09	126	375
Height – Categorical				*n*	%
70" or Less				69	53.08
71" or More				60	46.15
Missing				1	0.77
Height - Continuous	*n*	*M*	*SD*	*Min*	*Max*
	129	70.29	2.66	63	77
BMI – Categorical				*n*	%
Normal Weight				11	8.46
Overweight				39	30.00
Obese				77	59.23
BMI - Continuous	*n*	*M*	*SD*	*Min*	*Max*
	127	31.94	5.76	19.9	48.7
MOI				*n*	%
Chain, Tarp, Strap				41	31.54
Fall				45	34.62
Handling Cargo				14	10.77
Using Equipment				24	18.46
Other				6	4.62
Referral				*n*	%
Yes				50	38.46
No				80	61.54
MRI				*n*	%
Yes				56	43.08
No				74	56.92
MSD				*n*	%
Rotator Cuff				31	23.85
SLAP Lesion				14	10.77

Unspecified Sprains/Strains				75	57.69
Other				10	7.69
Referral/Release	*n*	*M*	*SD*	*Min*	*Max*
	130	11.73	16.48	1	131

FINDINGS BY RESEARCH AIMS

Aim 1

The goal for the first aim of this study was to determine the common characteristics of shoulder injuries among a group of commercial truck drivers. This was accomplished by answering two research questions.

Research Question 1.1

What are the most common diagnoses of shoulder injuries among commercial truck drivers? Frequencies and percentages were calculated for each categorical variable (Table 9), and summary statistics were calculated for each continuous variable (Table 10) split by MSD.

Frequencies and Percentages. The four MSDs documented in this study were unspecified stains/strains, rotator cuffs injuries, Superior Labrum Anterior to Posterior (SLAP) lesions, and *others*. The most common diagnosis, unspecified sprains/strains, was found in 75 participants (58%). The second most common diagnosis was rotator cuff injuries (n = 31, 24%). The two least frequently recurring MSDs were SLAP lesions (n = 14, 11%) and *other* (n = 10, 7%).

The largest group of CTDs were diagnosed with an unspecified strain/sprain (n = 75). This is the only diagnosis to be associated with the female gender (5%). A majority of these individuals were between the ages of 36 and 45 (39%). A total of 60% of these individuals were obese, and 53% were 71” or taller. The most common MOI of these CTDs was the use of chains, tarps, and straps (35%). Only 3% of these individuals required an MRI, and only 9% eventually needed to be referred.

Commercial truck drivers diagnosed with rotator cuff injuries (*n* = 31) were all male and primarily white (74%) and between the ages of 56 and 65 (39%). They could best be described as obese (70%) with a majority of them were 70” or shorter (61%). The most common MOI for individuals with rotator cuff injury was due to a fall (42%), and all of them needed an MRI with 94% of them being referred to an orthopedic surgeon.

Those CTDs diagnosed with a SLAP Lesion (*n* =14) were also all male with a majority of them being white (57%) and between the ages of 36-45 (36%). Exactly half of this group was 70” and shorter while 57% were classified as obese. The most common MOI found in SLAP lesions were falls (43%), followed by the use of equipment (29%). Similar to participants with rotator cuff tears, 100% of these individuals required an MRI, and 86% were referred to an orthopedic surgeon.

Only 10 CTDs received a diagnosis classified as *other*. These individuals were all male, and 60% were white, and 50% were between the ages of 36 and 45. These individuals were most commonly classified as overweight (50%), and 60% of them were 71” or taller. These individuals were most commonly injured from a fall (40%). While 90% of these individuals did receive an MRI, only 20% were eventually referred to an orthopedic surgeon.

Table 9: Frequency Table for Categorical Variables

Variable	Rotator Cuff	SLAP Lesion	Unspecified Sprains/Strains	Other
Gender				
Male	31 (100%)	14 (100%)	71 (95%)	10 (100%)
Female	0 (0%)	0 (0%)	4 (5%)	0 (0%)
Age - Categorical				
21-35	3 (10%)	3 (21%)	14 (19%)	4 (40%)
36-45	5 (16%)	5 (36%)	29 (39%)	5 (50%)
46-55	11 (35%)	3 (21%)	12 (16%)	0 (0%)
56-65	12 (39%)	3 (21%)	20 (27%)	1 (10%)
Race				
White	23 (74%)	8 (57%)	49 (65%)	6 (60%)
African American	8 (26%)	4 (29%)	24 (32%)	4 (40%)
Other	0 (0%)	1 (7%)	1 (1%)	0 (0%)
Hispanic	0 (0%)	1 (7%)	1 (1%)	0 (0%)
Weight - Categorical				
100-199	7 (23%)	4 (29%)	21 (29%)	5 (50%)
200-299	22 (73%)	10 (71%)	46 (63%)	5 (50%)
300-399	1 (3%)	0 (0%)	6 (8%)	0 (0%)
Height - Categorical				
70” or Less	19 (61%)	7 (50%)	39 (53%)	4 (40%)
71” or More	12 (39%)	7 (50%)	35 (47%)	6 (60%)
BMI - Categorical				
Normal Weight	2 (7%)	0 (0%)	8 (11%)	1 (10%)
Overweight	7 (23%)	6 (43%)	21 (29%)	5 (50%)
Obese	21 (70%)	8 (57%)	44 (60%)	4 (40%)
MOI				
Chain, Tarp, Strap	9 (29%)	3 (21%)	26 (35%)	3 (30%)
Fall	13 (42%)	6 (43%)	22 (29%)	4 (40%)
Handling Cargo	3 (10%)	1 (7%)	10 (13%)	0 (0%)
Using Equipment	5 (16%)	4 (29%)	13 (17%)	2 (20%)
Other	1 (3%)	0 (0%)	4 (5%)	1 (10%)
Referral				
Yes	29 (94%)	12 (86%)	7 (9%)	2 (20%)
No	2 (6%)	2 (14%)	68 (91%)	8 (80%)
MRI				
Yes	31 (100%)	14 (100%)	2 (3%)	9 (90%)
No	0 (0%)	0 (0%)	73 (97%)	1 (10%)

Summary of Continuous Variable. The average age of individuals with an unspecified sprain/strain was 44 years old, and they were on average 70.2” tall, weighed 223 lbs. with a BMI of 31.96. These individuals also had about 11 days between the day of injury and release or referral. Those CTDs that experienced a rotator cuff tear were about the same height (70.35”), weight (234 lbs.) when compared to those with unspecified sprains or strains. However, they were on average older (51 yo) with a higher BMI (33.17), and there was a decrease in the days between injury and referral/release (5.5 days).

The observations for CTDs that experienced a SLAP lesion appeared similar to those with unspecified sprains/strains. The average age was 45 years old, and they were on average 70.14” tall and weighed 219 lbs. with a BMI of 31.28. They did have a slight increase in the days between injury and ate of release/referral (13.5 days). The diagnosis with the fewest observations was labeled as *other*, and these CTDs were younger (37 years old) and weighed less (209 lbs.) with a smaller BMI 29.10). Commercial truck drivers with diagnoses did experience many more days between their injury and date of release /referral (38.5 days).

Table 10: Summary Statistics Table for Interval and Ratio Variables Split by MSD

Variable	*n*	*M*	*SD*
Age			
Rotator Cuff	31	51.68	10.24
SLAP Lesion	14	44.93	10.92
Unspecified Sprains/Strains	75	44.77	11.48
Other	10	37.10	9.27
Height			
Rotator Cuff	31	70.35	2.39
SLAP Lesion	14	70.14	2.35
Unspecified Sprains/Strains	74	70.20	2.90
Other	10	70.90	2.18

Weight			
Rotator Cuff	30	234.53	44.95
SLAP Lesion	14	219.07	32.75
Unspecified Sprains/Strains	73	223.05	47.26
Other	10	209.60	43.44
BMI			
Rotator Cuff	30	33.17	5.80
SLAP Lesion	14	31.28	4.21
Unspecified Sprains/Strains	73	31.96	6.08
Other	10	29.10	4.56
Referral/Release			
Rotator Cuff	31	5.52	8.44
SLAP Lesion	14	13.50	13.38
Unspecified Sprains/Strains	74	10.38	10.22
Other	10	38.50	39.65

Research Question 1.2

What are the most common mechanisms of shoulder injury among commercial truck drivers? Frequencies and percentages were calculated for each categorical variable (Table 11), and summary statistics were calculated for each continuous variable (Table 12) and split by MOI.

Frequencies and Percentages. There were 5 MOIs documented in this study. The MOI most commonly reported was injury due to a fall (n = 45, 35%). Falls accounted for only 3% more than the second most common MOI, the use of chains, tarps, and straps (n = 41, 32%). Using equipment accounted for 18% ($n = 24$) of the MOIs while handling cargo accounted for 11% ($n = 14$) and MOIs labelled as *other* only accounted for 4% ($n = 6$).

Injuries due to falls most often happened to men (98%) who were white (67%), and a majority were between the ages of 36-45 (38%). These individuals were primarily labeled as obese (69%) and were 70” or less (53%). Forty nine percent of the injuries resulting from falls were unspecified sprain/strains. In these individuals, 51% required an MRI, and 53% were referred to an orthopedic surgeon.

The second most often documented MOI was the use of chains, tarps, and straps. These MOIs, as with falls, primarily happened to men (95%) who were white (73%) and they were most often between the ages of 36-45 (44%). 56% of those injured due to the use of chains, tarps, and chains were 71” or taller, and 69% were obese. The most common injury resulting from the use of chains, tarps, and straps were unspecified sprain/strains (63%). In these individuals, only 37% required an MRI, and 37% were referred to an orthopedic surgeon.

A majority of the individuals who were injured while using the equipment on the job were white (58%), male (96%), and between the ages of 56-65 (33%). They were also most often labeled as obese (54%) and 70” or shorter (67%). The most common MSD related to the use of equipment were unspecified sprains/sprains (54%). Half of these CTDs required an MRI, but only 38% required a referral.

The two smallest groups of MOIs were handling cargo and those labeled as *other*. These injured due to handling cargo were all male, and a majority were white (64%) and between the ages of 21-35 (57%). Just under half of these individuals were labeled as obese (46%) while just over half were 70” or shorter (54%). Handling cargo most often resulted in unspecified sprains/strains (71%) with 29% requiring an MRI and 29% resulting in a referral to an orthopedic surgeon. Those injuries labeled as *other* were also all male with a majority are white (67%) and between the ages of 46 and 55 (50%). Individuals injured due to MOIs labeled as *other* were most often labeled as overweight (83%) and were 70” or less (67%). Mechanisms of injury most often resulted in unspecified sprains/strains (67%) with 33% requiring an MRI and 17% resulting in a referral to an orthopedic surgeon.

Table 11: Frequency Table for Nominal Variables

Variable	Chain, Tarp, Strap	Fall	Handling Cargo	Using Equipment	Other
Gender					
Male	39 (95%)	44 (98%)	14 (100%)	23 (96%)	6 (100%)
Female	2 (5%)	1 (2%)	0 (0%)	1 (4%)	0 (0%)
Age - Categorical					
36-45	18 (44%)	17 (38%)	2 (14%)	6 (25%)	1 (17%)
56-65	14 (34%)	12 (27%)	2 (14%)	8 (33%)	0 (0%)
46-55	5 (12%)	10 (22%)	2 (14%)	6 (25%)	3 (50%)
21-35	4 (10%)	6 (13%)	8 (57%)	4 (17%)	2 (33%)
Race					
White	30 (73%)	30 (67%)	9 (64%)	13 (54%)	4 (67%)
African American	10 (24%)	12 (27%)	5 (36%)	11 (46%)	2 (33%)
Other	1 (2%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Hispanic	0 (0%)	2 (4%)	0 (0%)	0 (0%)	0 (0%)
Weight - Categorical					
100-199	6 (15%)	11 (24%)	7 (54%)	9 (38%)	4 (67%)
200-299	31 (79%)	30 (67%)	6 (46%)	14 (58%)	2 (33%)
300-399	2 (5%)	4 (9%)	0 (0%)	1 (4%)	0 (0%)
Height - Categorical					
70” or Less	18 (44%)	24 (53%)	7 (54%)	16 (67%)	4 (67%)
71” or more	23 (56%)	21 (47%)	6 (46%)	8 (33%)	2 (33%)
BMI - Categorical					
Obese	27 (69%)	31 (69%)	6 (46%)	13 (54%)	0 (0%)
Overweight	10 (26%)	13 (29%)	3 (23%)	8 (33%)	5 (83%)
Normal Weight	2 (5%)	1 (2%)	4 (31%)	3 (12%)	1 (17%)
Referral					
Yes	15 (37%)	21 (47%)	4 (29%)	9 (38%)	1 (17%)
No	26 (63%)	24 (53%)	10 (71%)	15 (62%)	5 (83%)
MRI					

Yes	15 (37%)	23 (51%)	4 (29%)	12 (50%)	2 (33%)
No	26 (63%)	22 (49%)	10 (71%)	12 (50%)	4 (67%)
MSD					
Rotator Cuff	9 (22%)	13 (29%)	3 (21%)	5 (21%)	1 (17%)
SLAP Lesion	3 (7%)	6 (13%)	1 (7%)	4 (17%)	0 (0%)
Unspecified Sprains/Strains	26 (63%)	22 (49%)	10 (71%)	13 (54%)	4 (67%)
Other	3 (7%)	4 (9%)	0 (0%)	2 (8%)	1 (17%)

Summary Statistics

The two most common MOIs recorded in the study were falls and the use of chains, tarps, and straps. Those CTDs that were injured during a fall were on average 46 years old, 70.3" tall, weighed 232 lbs with a BMI of 33.08. Falls resulted in the CTD to experience about 12 between their date of injury and date of release/referral. The CTDs that were injured using chains, tarps, and straps were similar in every way. These CTDs were on average 47 years old, 70.6" tall, weighed 231 lbs with a BMI of 33.08. They did experience two fewer days between the date of injury and date of release/referral compared to falls (10 days).

The use of equipment accounted for almost 19% of all MOIs. The CTDs injured due to the use of equipment were on average 47 years old, 69.8" tall, weighed 220 lbs. with a BMI of 31.8. There were about 11 days between the date of the reported injury and the date of release/referral. The handling of cargo only accounted for about 11% of the reported MOIs. The CTDs injured while handling cargo were younger than all other MOIs (37 years old), and they weighed less (195 lbs.) with a smaller BMI (28.8). They were about the same height (69.8") with a similar amount of days between the date of injury and date of release/referral (10 days). The CTDs that were injured due MOIs labeled were also younger with an average age of 43 years old, and these CTDs weighed the less (188 lbs.) and had the smallest BMI (26.4). They did, however, have an increase in the days between the date of injury and the date of referral/release (18 days).

Table 12: Summary Statistics Table for Interval and Ratio Variables Split by MOI

Variable	*n*	*M*	*SD*
Age			
Chain, Tarp, Strap	41	47.05	11.02
Fall	45	46.93	10.69
Handling Cargo	14	37.71	13.89
Using Equipment	24	47.17	11.89
Other	6	43.17	8.59
Height			
Chain, Tarp, Strap	41	70.66	2.49
Fall	45	70.29	2.79
Handling Cargo	13	69.85	3.02
Using Equipment	24	69.79	2.43
Other	6	70.67	3.27
Weight			
Chain, Tarp, Strap	39	231.90	40.24
Fall	45	232.87	47.63
Handling Cargo	13	195.69	46.39
Using Equipment	24	220.12	42.19
Other	6	188.67	27.64
BMI			
Chain, Tarp, Strap	39	32.62	5.13
Fall	45	33.08	5.94
Handling Cargo	13	28.82	5.89
Using Equipment	24	31.80	5.96
Other	6	26.43	1.77
Referral/Release			
Chain, Tarp, Strap	40	10.00	10.65
Fall	45	12.82	23.31
Handling Cargo	14	10.14	14.30
Using Equipment	24	11.88	8.92
Other	6	18.17	17.34

Aim 2

Determine factors associated with shoulder injuries a group of commercial truck drivers. This will be accomplished by first assessing variables for associations among the study variables and then answering two research questions.

Preliminary Associations Among Study Variables

Once all descriptive data analyses were complete, all variables were assessed for any associations present between them. This was accomplished by assessing associations between categorical to categorical variables, continuous to continuous variables, and continuous variables to categorical variables.

The first step was to look for associations between all categorical variables. A majority of the variables are categorical, and all categorical variables were analyzed for the association by running Chi-Square (x^2) tests between each variable, along with Cramer's V (φ_c) tests to assess for effect size. All of the results for Cramer's V are documented in Table 13.

There were 11 pairs of categorical variables with a statistically significant association. Of those 1 had a Cramer's V between 0.3 and 0.5 which denotes a medium effect size, and four had a Cramer's V greater than 0.5 which denotes a large effect size (Table 13). The remaining six variables were all below 0.3, which represents a small effect size.

Gender was found to have a statically significant association with BMI ($p < 0.01$) but was found to have a small effect size. Age had a statistically significant association with multiple variables: Race ($p < 0.01$), BMI ($p < 0.05$), MOI ($p < 0.01$), and MSD ($p < 0.05$). These also had a small effect size. However, the effect size between age and MSD (φ_c – 0.29) approached a medium effect. BMI was also associated with the MOI ($p < 0.01$) and had a medium effect size (φ_c – 0.31). Referral to an orthopedic surgeon was associated with MRI ($p < 0.01$) and MSD ($p < 0.01$) and they both had a large effect size; φ_c – 0.68 and φ_c – 0.79 respectively. The variable MSD was statistically associated with MRI ($p < 0.01$) with a very large effect size (φ_c – 0.95).

Table 13: Cramer's V Effect Size (φ_c) for Chi-Squared Categorical Variables

	Gender	Age	Race	Height	Weight	BMI	MOI	Referral	MRI	MSD
Gender	-	0.168	0.127	0.167	0.183	0.273*	0.099	0.141	0.155	0.153
Age		-	0.224**	0.840	0.179	0.239**	0.284*	0.244	0.171	0.290**
Race			-	0.084	0.136	0.133	0.172	0.088	0.025	0.166
Height				-	0.291*	0.141	0.167	0.072	0.064	0.205
Weight					-	0.519*	0.236	0.129	0.143	0.144
BMI						-	0.312*	0.135	0.043	0.149
MOI							-	0.172	0.171	0.162
Referral								-	0.685*	0.794*
MRI									-	0.954*
MSD										-

* - p<0.01; ** - p<0.05

All categorical variables were also assessed for relationships by running association rules. There were thirteen relationships present using association rules, and these are reported in Table 14. Individuals who were described as having a normal body weight were found to have a greater chance of not being referred to an orthopedic surgeon (Lift – 1.32). CTDs that were injured by handling cargo were almost three times more likely to be between the ages of 21-35 (Lift – 2.97). Commercial truck drivers who were between 21-35 years of age were more likely not to be referred to an orthopedic surgeon (Lift – 1.25) while those who were between 46-55 years of age were more likely to have an MRI ordered (Lift – 1.33) and be referred (Lift – 1.42). Those CTDs that diagnosed with a rotator cuff tear were found to have an increased chance of being equal or less than 70” tall (Lift – 1.12), be described as obese (Lift – 1.15), and between 200-299 lbs. (Lift – 1.12). Rotator cuff injuries had increased chances of requiring an MRI (Lift – 2.31) and being referred to an orthopedic surgeon (Lift – 2.46). Similar to those diagnosed with a rotator cuff tear those that diagnosed with a SLAP lesion showed increased chances of having an MRI ordered (Lift – 2.27) and being referred to an orthopedic surgeon (Lift – 2.31).

Table 14: Association Rules

Antecedent		Consequent	Support	Confidence	Lift
Normal Weight	=>	Referral - No	0.07	0.82	1.32
Handling Cargo	=>	21-35 yo	0.06	0.54	2.97
21-35 yo	=>	Referral - No	0.14	0.78	1.25
Using Equipment	=>	70” or less	0.13	0.67	1.25
46-55 yo	=>	Referral	0.11	0.54	1.42
46-55 yo	=>	MRI - Yes	0.12	0.58	1.33
Rotator Cuff	=>	70” or less	0.14	0.60	1.12
Rotator Cuff	=>	Obese	0.17	0.70	1.15
Rotator Cuff	=>	Referral - Yes	0.22	0.93	2.46
Rotator Cuff	=>	MRI – Yes	0.23	1.00	2.31
Rotator Cuff	=>	200-299 lbs.	0.17	0.73	1.12
SLAP Lesion	=>	Referral - Yes	0.09	0.86	2.27
SLAP Lesion	=>	MRI - Yes	0.11	1.00	2.31

The second step was to assess all associations among the continuous variables. This was accomplished by using Spearman correlation, which is a non-parametric test. A Spearman correlation analysis was conducted among Age, Height, Weight, BMI, and Referral/Release, and these results are reported in Table 15. Cohen's standard was used to evaluate the strength of the relationships, where coefficients between .10 and .29 represent a small effect size, coefficients between .30 and .49 represent a moderate effect size, and coefficients above .50 indicate a large effect size (Cohen, 1988).

A significant positive correlation was observed between Height and Weight (r_s = 0.35, $p < .001$). The correlation coefficient between Height and Weight was 0.35, indicating a moderate effect size. A significant positive correlation was also observed between Weight and BMI (r_s = 0.90, $p < .001$). A significant negative correlation was observed between Weight and Referral/Release (r_s = -0.20, p = .023); however, it had a small effect size. Another statistically significant negative correlation was discovered between BMI and Referral/Release (r_s = -0.19, p = .029), but this also had a small effect size.

Table 15: Spearman Correlation Matrix: Age, Height, Weight, BMI, and Referral/Release

Variable	Age	Height	Weight	BMI	Days Till Referral/Release
Age	-	0.03	0.17	0.14	-0.08
Height		-	0.35*	-0.00	-0.01
Weight			-	0.90*	-0.20**
BMI				-	-0.19**
Referral/Release					-

* - p<0.01; ** - p<0.05

The final step to assess all variables describing CTD characteristics for an association was to investigate relationships between the continuous variables and the dependent variable. Because the dependent variable, MSD, has four categories, this process was accomplished by running a simple multinomial regression analysis. These results are reported in Table 16. There was no statically significant association between the MSDs and either height, weight, or BMI. However, the results of the multinomial logistic regression model between Age and MSD were significant ($\chi^2 = 15.50$, $p = .001$) suggesting that Age had a significant effect on the odds of observing at least one response category of MSD. There was also a statistically significant association between Referral/Release and MSD ($\chi^2 = 25.67$, $p < .001$).

Table 16: Multinomial Logistic Regression Table with MSD predicted by Age, Height, Weight, BMI, Days Till Referral/Release

Variable	X^2	*p*	R^2
Age	15.50	0.001	0.05
Height	0.68	0.877	0.00
Weight	2.92	0.404	0.01
BMI	4.28	0.233	0.02
Referral/Release	25.67	0.001	0.09

Research Question 2.1

What work environment factors are associated with increased risk of developing shoulder injuries?

The environmental factors were documented and addressed in the MOI variable. As shown in Table 13, there was no relationship found between MOI and the dependent variable MSD. Also, when evaluating association rules, there were no categories within MOI that were shown to be associated with any category of the MSDs (Table 14). The MOI was found to have a statistically significant association with both age ($p < 0.01$) and BMI ($p < 0.01$) (Table 13). The effect size was small between MOI and age (φc – 0.284), but it was medium between MOI and BMI (φc – 0.312) (Table 10). An association between MOI and age was also discovered when using association rules, CTDs injured while handling cargo were almost three times more likely to be between the ages of 21 and 35 (Lift – 2.97) when compared to other age groups (Table 14).

Research Question 2.2

The second research question of AIM 2 is: What demographic and anthropometrics are associated with increased risk of developing shoulder injuries?

The only demographic or anthropometric variable found to have an association with MSD was age (Table 13). This association was present in both the categorical variable for age (X^2 – 18.89, $p < 0.05$) and the continuous (X^2 – 15.5, $p = 0.001$). While there was no statistically significant association discovered between any of the other demographic or anthropometric variables and MSDs, as evident due to a Lift greater than 1 and a Confidence greater than or equal to 0.6, association rules showed that CTDs with a rotator cuff injury were more often 70" or shorter (Confidence – 0.60, Lift – 1.12) and obese (Confidence – 0.70, Lift – 1.15) (Table 14).

While they are not demographic or anthropometric variables it is important to note that MSDs did have a very strong association with two other variables: MRI ($p <$ 0.01, φc – 0.954) and Referral ($p < 0.01$, φc – 0.794) (Table 13). Association rules also supported that there was an association between MSDs and both MRI and referral. Commercial truck drivers diagnosed with a rotator cuff injury are just over two times more likely to require an MRI (Lift – 2.31) and to be referred to an orthopedic surgeon (Lift –2.46) (Table 14). This was also found to be the case with those diagnosed with a SLAP lesion. These individuals were also just over two times more likely to require an MRI (Lift – 2.27) and to be referred to an orthopedic surgeon (Lift –2.31) (Table 14).

ASSESSING BEST FIT MODEL

There was only one variable found in research questions one and two that were found to have a statistically significant association with MSDs, and that was age. As shown in Table 17, the multinomial logistic regression analysis with age as a continuous variable had a higher level of significance and will be evaluated more closely. For all following multinomial logistic regression using MSDs as the dependent variable the variables, unspecified sprains/strains, was selected as the reference group because this group was the largest and those that primarily did not require referral or MRIs.

MSDs Relative to Age

A multinomial logistic regression analysis was conducted to assess whether Age had a statistically significant effect on MSDs. The results of the multinomial logistic regression model were significant (χ^2 = 15.50, p = .001) and this suggests that age had a significant effect on the odds of observing at least one response category of MSD. McFadden's R-squared in used to assess the fit logistic regression models, and according to Louviere, Hensher, & Swait (2000), values greater than .2 are indicative of models with excellent fit. The McFadden R^2 value calculated for this model was 0.05. While this is lower than the suggested threshold, the overall model was significant, as a result, each predictor was examined further. Sine, there is only one independent variable this model was not assessed for interactions or multicollinearity.

There were two categories that were shown to have a statistically significant effect on MSDs (Table 17). The regression coefficient (B = -0.07) for Age in response category *other* of MSD was significant (χ^2 = 3.86, p = .049). This suggests that as Age increases by one unit, the odds of observing the injuries labeled as o*ther* relative to Unspecified Sprains/Strains would decrease by 7%. The opposite results were found with rotator cuff injuries, which were also statistically significant (χ^2 = 7.73, p = .005). Rotator cuff injuries had a positive coefficient (B = 0.06) which suggests that for every unit increase in age the odds of observing the Rotator Cuff injuries relative to Unspecified Sprains/Strains would increase by 6%.

Table 17: Multinomial Logistic Regression Table with MSD predicted by Age

Variable	Response	*B*	*SE*	χ^2	*p*	*OR*
(Intercept)	Other	0.87	1.41	0.38	.538	
Age	Other	-0.07	0.04	3.86	.049	0.93
(Intercept)	Rotator Cuff	-3.66	1.05	12.09	< .001	
Age	Rotator Cuff	0.06	0.02	7.73	.005	1.06
(Intercept)	SLAP Lesion	-1.73	1.21	2.05	.153	
Age	SLAP Lesion	0.00	0.03	0.00	.962	1.00

Note. $\chi^2 = 15.50$, $p = .001$, McFadden $R^2 = 0.05$.

While age was the only variable to have statistical significance relative to MSD, there was evidence there may be some relationship with height and BMI when assessed using association rules. Due to this finding, additional models were run to verify that there is no model that has a better fit then the one above. Height is used to calculate BMI, so they will be split between the two following models. Model 2 will investigate age and BMI as independent variables, and Model 3 will investigate age and height.

MSDs Relative to Age and BMI

Model 2 used multinomial logistic regression analysis to assess for any significant effect Age and BMI had on MSDs using the same process as the previous model. There was a statistically significant association between age and BMI. However, there was a small effect size (Table 13). Due to this lack of moderate or strong effect size, there will not be a concern with interactions between the two variables.

This model did have a statistically significant effect on MSDs (χ^2 = 16.36, *p* = .012); however, when the model was investigated further, only age had any statistical impact within the model. Just as in the previous model, age had statistically significant effects on rotator cuff tears (χ^2 = 5.93, *p* = .015) (Table 18).

Table 18: Multinomial Logistic Regression Table with DxFinal predicted by Age and BMI

Variable	Response	*B*	*SE*	χ^2	*p*	*OR*
(intercept)	Other	2.95	2.22	1.77	.184	19.11
Age	Other	-0.07	0.04	3.34	.067	0.94
BMI	Other	-0.07	0.07	1.21	.271	0.93
(intercept)	Rotator Cuff	-4.37	1.65	7.00	.008	0.01
Age	Rotator Cuff	0.05	0.02	5.93	.015	1.05
BMI	Rotator Cuff	0.03	0.04	0.61	.435	1.03
(intercept)	SLAP Lesion	-0.97	1.95	0.25	.619	0.38
Age	SLAP Lesion	-0.00	0.03	0.00	.995	1.00
BMI	SLAP Lesion	-0.02	0.05	0.16	.686	0.98

Note. $\chi^2(6)$ = 16.36, *p* = .012, McFadden R^2 = 0.06.

MSDs Relative to Age and Height

Using the same process as in the previous two models, Model 3 used multinomial logistic regression to assess for any significant effect age and height has on MSDs. There was no statistically significant association between age and height, so there is no concern for interaction or multicollinearity.

Just as in the last two models, the results for Model 3 were significant (χ^2 = 16.45, *p* = .012) but just as in Model 2 the only variable to have any statistically significant impact on MSD was age (Table 19). Age was found to significantly impact rotator cuff injuries (χ^2 = 7.31, p = .007) and injuries labeled as *other* (χ^2 = 4.28, p = .038). However, Height had no statistical impact.

Table 19: Multinomial Logistic Regression Table with DxFinal predicted by Age and Height

Variable	Response	*B*	*SE*	χ^2	*p*	*OR*
(intercept)	Other	-7.96	9.18	0.75	.386	0.00
Age	Other	-0.08	0.04	4.28	.038	0.92
Height	Other	0.13	0.13	0.98	.322	1.14
(intercept)	Rotator Cuff	-5.00	6.11	0.67	.413	0.01
Age	Rotator Cuff	0.06	0.02	7.31	.007	1.06
Height	Rotator Cuff	0.02	0.09	0.06	.814	1.02
(intercept)	SLAP Lesion	-1.07	7.71	0.02	.890	0.34
Age	SLAP Lesion	-0.00	0.03	0.00	.992	1.00
Height	SLAP Lesion	-0.01	0.11	0.01	.939	0.99

Note. $\chi^2(6)$ = 16.45, p = .012, McFadden R^2 = 0.06.

ADDITIONAL ANALYSIS

The descriptive statistics of those that were required to be referred to an orthopedic surgeon were examined and also whether there was any association with MSDs. The referral variable was not shown to have any statistically significant association with MSDs (Tables 13). However, descriptive statistics (frequencies and percentages) were calculated for Gender, Age, Race, Weight, Height, BMI, MOI, MRI, and MSD split by Referral (Table 20) and some important clinical findings were present.

Commercial truck drivers that required a referral to an orthopedic surgeon were all male (n = 50) with a majority of them between the ages of 56-65 (n = 17, 34%), white (n = 35, 70%), described as obese (n = 32, 67%), and 70” or shorter (n = 29, 58%). They were primary injured during a fall (n = 21, 42%) followed by the use chains, tarps, or straps (n = 15, 30%). The most common MSD among those referred was a rotator cuff tear (n = 29, 58%).

The population of CTDs that did not require a referral had a slightly different distribution. They were also most often male (n = 76, 95%), white (n = 51, 64%), and described as obese (n = 45, 57%). However, a majority of them are between the ages of 36 - 45 (n = 29, 58%) and the height was the virtually split down the middle, 70” or less (n = 40, 51%) and 71” or taller (n = 39, 49%). They were primarily injured while using chains, tarps, or straps (n = 26, 32%) with the second being falls (n = 24, 30%). The most common MSD among those not requiring a referral was unspecified sprains/strains (n = 68, 85%).

Table 20: Frequency Table for Nominal Variables

Variable	Yes	No
Gender		
Male	50 (100%)	76 (95%)
Female	0 (0%)	4 (5%)
Age - Categorical		
21-35	5 (10%)	19 (24%)
36-45	14 (28%)	30 (38%)
46-55	14 (28%)	12 (15%)
56-65	17 (34%)	19 (24%)
Race		
White	35 (70%)	51 (64%)
Other	2 (4%)	2 (2%)
African American	13 (26%)	27 (34%)
Weight - Categorical		
100-199	13 (27%)	24 (30%)
200-299	34 (71%)	49 (62%)
300-399	1 (2%)	6 (8%)
Height - Categorical		
70” or Less	29 (58%)	40 (51%)
71” or More	21 (42%)	39 (49%)
BMI - Categorical		

Normal Weight	2 (4%)	9 (11%)
Overweight	14 (29%)	25 (32%)
Obese	32 (67%)	45 (57%)
MOI		
Chain, Tarp, Strap	15 (30%)	26 (32%)
Fall	21 (42%)	24 (30%)
Handling Cargo	4 (8%)	10 (12%)
Using Equipment	9 (18%)	15 (19%)
Other	1 (2%)	5 (6%)
MRI		
Yes	43 (86%)	13 (16%)
No	7 (14%)	67 (84%)
MSD		
Rotator Cuff	29 (58%)	2 (2%)
SLAP Lesion	12 (24%)	2 (2%)
Unspecified Sprains/Strains	7 (14%)	68 (85%)
Other	2 (4%)	8 (10%)

SUMMARY

Commercials truck drivers were most often diagnosed with unspecified sprains/strains (57%). The CTDs that were diagnosed with unspecified strains/sprains were majority male (95%) and between the ages of 36 – 45 (39%). These CTDs were majority obese (60%), and just over half were 70" or less (53%). The most commonly reported MOI by those with unspecified strains/sprains were the use of chains, tarps, or straps (35%) followed by falls (29%). These CTDs only required an MRI 3% of the time, and only 9% had to be referred to an orthopedic surgeon.

The second most common MSD reported was rotator cuff injuries. Just as with unspecified strains/sprains, CTDs with rotator cuff injuries were all male (100%) and white (74%), obese (70%), and 70" or shorter 61%). However, they were older with a majority between the ages of 56 and 65 (39%) and more often injured during a fall

(42%). An interesting difference between unspecified strains and rotator cuffs injuries is that those CTDs that had a rotator cuff injury always required an MRI, and 94% of them had to be referred to an orthopedic surgeon.

All demographic, anthropometric, and environmental (MOI) variables were assessed for the association, and only one had any statistically significant association with MSDs in CTDs, Age. Multinomial logistic regression showed that as age increased in CTDs, they had a greater chance of being diagnosed with a rotator cuff tear ($\chi 2$ = 7.73, p = .005, *OR* – 1.06). There were two other variables that were shown to have some association using association rules, Height – categorical, BMI – categorical; however, when they were placed into a multinomial logistic regression model, they had no statistically significant impact on MSDs.

While there was not a statistically significant association between the referral variable and any other variables, there were some clinical differences between those that were referred and those that were not. When compared to those that did not require a referral the CTDs that had to be referred where more often older, between 56 and 65 years of age (34%), injured during a fall (42%), and diagnosed with rotator cuff tears (58%) or SLAP lesions (24%).

CHAPTER FIVE

The purpose of this chapter is to discuss the findings of this study, limitations, and future implications. This chapter will start by discussing the demographic and anthropometric characteristics of the sample. It will be followed by discussing the findings related to the variables of interest, AIM 1, AIM 2, and all additional analyses. This chapter will conclude with a discussion of the limitations of this study, and it will end by highlighting the implications for nursing practice and future research, and a summary.

SAMPLE DEMOGRAPHIC AND ANTHROPOMETRIC CHARACTERISTICS

The CTDs in this study were almost all male (96.9%); a majority of them were white (66%), and 30.7% were African-American. Participants' ages ranged between 21 to 65 years of age (M = 45.85, SD = 11.53) and a majority of them were between the ages of 36 and 45 (33.8%) and 56 and 65 (27.7%). All of this is consistent with national data and past research regarding the CTD working population (Birdsey et al., 2015; Data USA, 2019) except race. Our study had a larger representation of African-American CTDs compared to census data and other national studies (16%) (Birdsey et al., 2015; Data USA, 2019).

The height of the CTDs in this study ranged between 62" and 77" (M = 70.29, SD = 2.66) which is consistent with past research where the height of CTDs was reported in the study (Beek et al., 1992). The average weight of the CTDs in this study was 224 lbs., ranging between 126 and 375 lbs. The majority of the CTDs were between 200 and 249 lbs. (63.8%). The average calculated BMI of the CTDs was 31.94, with a range of 19.9 – 48.7. They were largely obese (59%), followed by overweight (30%). In a national survey of over 1,000 CTDs supports this finding, Sieber et al. (2014) reported that 22.8% of all CTDs were overweight, and 68.9% were obese. Therefore the current sample had lower representation of obesity and higher representation of overweight.

VARIABLES OF INTEREST

Factors Associated with Injury

Other than the demographic and anthropometric characteristics of the sample, the other variables of interest were MOI, MRI, Referral, Injury to Date of Release/Referral, and MSD. In this study, the most commonly reported MOIs were falls (n = 45, 34.6%) followed by the use of chains, tarps, or straps (n = 41, 31.5%). The three lesser reported MOIs were the use of equipment (n = 24, 18.4%), handling cargo (n = 14, 10.7%), and those labeled as *other* (n = 6, 4.6%). The variable *other* consisted of contact with an object (n = 3) and those that did not report any MOI (n = 3). In the CTD population injury related to a fall is one of the two most commonly reported injuries, along with overexertion (Beek et al., 1992; BLS, 2016; Davis et al., 2014; McCall & Horwitz, 2005; Smith & Williams, 2014; Spielholz et al., 2008). This study is the first to examine overexertion in-depth and to break out those individuals injured while using chains, straps, or tarps and those using other equipment. This allowed for a more thorough understanding of what may happen to CTDs during times of overexertion. It can be surmised that since the use of chains, straps, and tarps would fall under the umbrella of overexertion in past studies, the findings of this study are supported by that research.

MRIs and Referrals

CTDs were often required to get an MRI for diagnostic reasons ($n = 56$, 43%) and many of them were referred to an orthopedic surgeon ($n = 50$, 38.4%). In previous studies of CTDs, none assessed whether CTDs required an MRI or a referral. One study did investigate medical claims across many different occupational sectors and reported that only 11% required surgery (Davis et al., 2014). Unfortunately, it did not give the percentage of claims that required surgery within the transportation, warehouse, and utility sector. The study did, however, show that the claims related to MSDs of the shoulder within this sector did have the highest costs per claim, especially, in those between the ages of 45 and 64 (Davis et al., 2014). Past research has highlighted the importance of utilizing MRIs to better diagnose MSDs of the shoulder in both the acute setting as well as individuals who work above shoulder height (Beckmann, Sanhaji, Chinapuvvula, & West, 2019; I. Y. Chang & Polster, 2016; Navio-Fernandez et al., 2019). These findings are not comparable to our current study; however, it does support the increased number of individuals requiring an MRI.

There were, on average, 11.7 days between the date of injury and the date of either referral or release. Commercial truck drivers were referred to a surgeon ($M = 10.74$, $SD = 20.86$) almost two days sooner than those who were released to return to full duty status ($M = 12.35$, $SD = 13.09$). These findings cannot be compared to those of past research. The typical way research evaluates lost days of work is by calculating the days between the date of injury and the date the CTDs was released to full work status. This was accomplished by using OSHA reported claims or occupational workers compensation claims. The exact days of work missed was not part of the AIMs of the study, and due to the data available for collection, it was only possible to calculate the days from injury to date of release or referral.

Musculoskeletal Disorders

The most commonly reported MSDs in this study were: Unspecified sprains/strains (*n* = 75, 57.6%), followed by rotator cuff injuries (*n* = 31, 23.8%), SLAP lesions (*n* = 14, 10.7%) and then *other* (*n* = 10, 7.7%). The variable, *other*, was made up of overuse injuries (*n* = 6) and soft tissue injuries other than rotator cuff or SLAP lesion (*n* = 4). Previous studies investigating MSDs in CTDs grouped all soft tissue injuries as sprains/strains. Therefore, this study is the first to break up soft tissue injuries to include a variable for rotator cuff tears and SLAP lesions in this worker population. While these findings are not consistent with past research showing sprains/strains to be among the most common MSDs of the shoulder experienced by CTDs (BLS, 2016; Bovenzi, 2014; Combs et al., 2018), our study provides more detailed information about specific medical diagnoses.

FINDINGS RELATED TO AIMS AND RESEARCH QUESTIONS

AIM 1

Determine the common characteristics of shoulder injuries among a group of commercial truck drivers.

Research Question 1.1

RQ 1.1: What are the most common diagnoses of shoulder injuries among commercial truck drivers? In this particular study the most commonly reported MSDs were unspecified sprains/strains (*n* = 75, 57.6%), followed by rotator cuff injuries (*n* = 31, 23.8%), SLAP lesions (*n* = 14, 10.7%) and then *other* (*n* = 10, 7.7%). This is the first study that did not group all soft tissue injuries into the general sprains/strains category but rather divided them to get a more detailed understanding of the shoulder injuries that CTDs experience.

The most common documented injury for CTDs was unspecified strains/sprains (*n* = 75, 75%). During the data collection portion of this study, it was discovered that when the CTD first presented to the clinic, the initial documented MSD was an unspecified sprain or strain 98% of the time. The actual patient diagnosis only changed after follow up visits and/or the results of an MRI. Only two (3%) of the CTDs received a final diagnosis of unspecified sprains/strains received an MRI. A majority of the CTDs diagnosed with unspecified sprains/strains were between the ages of 36 and 45 (39%) followed by 56 and 65 (25%). Almost half of these CTDs were 70" or shorter (53%). The CTDs with unspecified strains/sprains were most often injured while using chains, tarps, or straps (35%) followed by falls (29%) and only 9% of these CTDs had to be referred.

Rotator cuff injuries (23.8%) and SLAP lesions (10.7%) were the next most commonly diagnosed MSD in this population. However, those that were diagnosed with a rotator cuff tear were mostly between the ages of 56 and 65 (39%) whereas those with a SLAP lesion were between 36 and 45 years of age (36%). A higher percentage of those with rotator injuries were 70" or shorter (61%) when compared to those diagnosed with a SLAP lesion (50%). The most common MOI for both rotator cuff injuries and SLAP lesions were falls (42%, 43%) followed by the use of chains, tarps, and straps (29%, 21%). Each of these two diagnoses required an MRI to be diagnosed, and 86% of those with a SLAP lesion were referred compared to 94% of those with a rotator cuff tear.

Some differences in group characteristics were found when the two most common diagnoses, unspecified strains/sprains, and rotator cuff tears, were compared. Those with unspecified sprains/strains were younger than those with rotator cuff injuries. Seventy four percent of those diagnosed with a rotator cuff tear were 45 years of age or older with a mean age of 51.6 compared to only 43% of those with unspecified sprains and strains with a mean age of 44.7. This is an expected finding because past research has shown that there is an increased risk to develop rotator cuff injuries as people age particularly in the worker population (Andersen et al., 2002; Craig, Holt, & Rees, 2017; Davis et al., 2014; Gombera & Sekiya, 2014; Leroux et al., 2006). This was also supported in past research related to CTDs. Smith and Anderson (2017) found that over half of all CTD workers' compensation claims related to the shoulder were in workers between 45 and 64 years of age. Older age is also associated with an increased cost of worker compensation claims related to the shoulder; a separate study showed that worker compensation claims had higher financial costs between the ages of 45 and 64 (Davis et al., 2014). These cost affect both the patients and the companies they work for.

Research Question 1.2

RQ 1.2: What are the most common mechanisms of shoulder injury among commercial truck drivers? The most commonly reported MOIs were: falls (*n* = 45, 34.6%); the use of chains, tarps, or straps (*n* = 41, 31.5%); use of other equipment (*n* = 24, 18.4%); handling cargo (*n* = 14, 10.7%); *other* (*n* = 6, 4.6%). Two variables make up 67% of the most commonly reported MOIs, falls, and the use of chains, straps, tarps. Just as seen with the other variables, those who experience injuries related to falls and the use of chains, straps, and tarps were mostly male, white, obese, and between the ages of 36-45. A majority of those injured during a fall were 70" or shorter (53%), whereas, those injured using chains, tarps, and straps were more often 71" or taller (56%).

The third and fourth most common documented MOIs were the use of equipment other than a chain, tarps or strap, and handling cargo. Individuals injured while using the equipment and handling cargo had similar demographic and anthropometric results when compared to the other MOIs. However, there were two findings of note. 33% of those injured while using equipment were between the ages of 56 and 65 with a mean age of 47 and 67% of them were 70" or less. Those injured while handling cargo were primarily between the ages of 21 and 35 (57%) with a mean age of 37, and just over half were 70" or less (54%). This study is not able to justify why the age of those injured while handling cargo is lower, but past research has shown that MSDs in CTDs can be more common in the first year of work experience (McCall & Horwitz, 2005). While it is not possible to know in this study, it could be a potential explanation.

AIM 2

Determine factors associated with shoulder injuries among a group of commercial truck drivers.

Research Question 2.1

RQ 2.1: What work environment factors are associated with increased risk of developing shoulder injuries? In this study, overexertion was divided to more specifically investigate environmental factors instrumental in the mechanism causing MSDs. As described in Chapter 4, MOI was not found to have a statistically significant association with MSDs. This was an unexpected finding due to the relationships between environmental factors and occupational injury found in previous studies. There is a body of research that highlights the relationship between environment and MSDs. Work environments requiring individuals to work with their arms at or above shoulder height have increased rates of pain and MSDs in the shoulder (Moriguchi et al., 2012; Soares, Jacobs, Moriguchi, et al., 2012; Trotta et al., 2014). In the nursing population, a majority of injuries of the shoulder are related to pushing or pulling patients, which supports the impact of environmental items related to the MOIs of MSDs of the shoulder (Bhimani, 2014). This is comparable to a construction worker lifting a tool required for a task or a CTD lifting a tarp to cover cargo or throwing chains to secure freight on a flatbed trailer.

As these studies have shown, the environment plays a role in the development of MSDs of the shoulder, and even though our study did not show a statistically significant association between MOIs and MSDs, it is still critical to take the environment into account. This is the first study to investigate MOIs by environmental components such as the use of chains, tarps, and straps and the use of other equipment. While these activities did not have a statistically significant association with particular MSDs, they did make up a significant portion of the MOIs reported in this study: Chains, tarps, and straps (31.55%) and use of equipment (18.5%). This, in itself, helps better indicate how the environment impacts the MSDs of the shoulder, and it is an important finding. It is not possible to directly compare the findings related to MOIs with past research due to the definitions used for this variable.

While these environmental factors have not been investigated in CTDs the impact of environmental factors on MSDs of the shoulder has been supported in past research within other worker populations. Professions that require workers to use equipment above shoulder height can increase the stress on the shoulder and the risk of developing an MSD of the shoulder (Soares, Jacobs, Moriguchi, et al., 2012; Trotta et al., 2014). Past research has shown that lifting a ladder out of a truck at or above shoulder height increases the forces across the shoulder (Soares, Jacobs, Moriguchi, et al., 2012). When compared to CTDs, this is similar to lifting chains and tarps above shoulder height to place them on a flatbed truck.

Past research supports that falls are among the most common MOIs for CTDs (Center for Disease Control and Prevention, 2010; McCall & Horwitz, 2005). This was no different in our study; falls were the most commonly reported MOI overall. Interestingly, the only age group in which falls were the most commonly reported MOI were ages 46-55, injuries reported due to the use of equipment were the second most commonly reported in this age group. In all other age groups, falls were either the second or third most often reported MOI.

Many aspects can affect falls in the occupational setting: slippery surfaces, working from a height above ground level, or proprioception alterations (W. R. Chang, Leclercq, Lockhart, & Haslam, 2016; Leclercq, Cuny-Guerrier, Gaudez, & Aublet-Cuvelier, 2015; McCall & Horwitz, 2005; Son et al., 2014). While surface areas and working from different height may not be related to age it is important to note that as an individual gets older there is a decrease in proprioception which can increase the risk of falling (W. R. Chang et al., 2016; Shaffer & Harrison, 2007; Wingert, Welder, & Foo, 2014).

In this study, 47.6% of the CTDs were 46 years of age or older. It could be that falls in older CTDs could be related to decreased proprioception, which is a natural progression with age. While this study does not investigate this potential impact in this population the effect of aging on proprioception should be remembered as potential factors impacting falls. A study comparing proprioception and dynamic balance among different age groups found that both significantly decreased in older participants (p = 0.01) (Wingert et al., 2014). Another study had similar changes in proprioception with age; Peters, McKeown, Carpenter, and Inglis (2016) found that older participants experienced decreased anteroposterior and mediolateral postural stability decreased and increases in postural sway. While these studies do not speak directly to CTDs, they do highlight the changes of proprioception over time and since a large portion of the CTDs in this study and across national samples are older this is important to remember.

Research Question 2.2

RQ 2.2: What demographic and anthropometrics are associated with increased risk of developing shoulder injuries? Only one demographic and anthropometric variable had any statistical association with MSDs; Age. The use of association rules showed some association, not only with age but also height and BMI. Three separate multinomial logistic regression models were used to compare all three variables, and the potential impact they may have on MSDs. As each model was run, the variable that showed no statistical significance and least effect on the model was removed before the next model was tested. The multinomial logistic regression model with the best fit only included age as a dependent variable ($X^2 = 7.73$, p = .005). In this model, as age increased, so did the chance that the CTD would be diagnosed with a rotator cuff tear. This is the first study to include rotator cuff tears and SLAP lesions as MSDs of the shoulder in the CTD population. However, the impact of age on MSDs of the shoulder has been supported in past research in both CTDs and other professions (Andersen et al., 2002; Davis et al., 2014; Leroux et al., 2006; Smith & Anderson, 2017; Smith & Williams, 2014; Soares, Jacobs, Moriguchi, et al., 2012). Smith and Anderson (2017) found that 67% of all CTD worker compensation claims related to an MSD of the shoulder were between the ages of 45 and 64. It has also been shown that CTDs over the age of 45 will experience an increased risk for developing MSDs of the shoulder (Andersen et al., 2002; Leroux et al., 2006). These studies may not have individually isolated rotator cuff tears or SLAP lesions, but it can be surmised that they were part of the injuries often labeled strains/sprains.

ADDITIONAL ANALYSIS

As the descriptive data were analyzed, some potential clinically relevant findings not explicitly addressed in the research questions. These findings are related to those who had to be referred to an orthopedic surgeon. Past research has highlighted the significant financial impact of MSDs of the shoulder on CTDs. Commercial truck drivers with an MSD of the shoulder miss significant amounts of work (BLS, 2016) when compared to the other common MSDs they experience. This significant amount of time away from work is a major contributor to the financial impact on CTDs. Worker compensation claims related to MSDs of the shoulder are among some of the most costly and can have a 20% higher mean cost compared to any other professions (Davis et al., 2014; Smith & Williams, 2014). Some of this increased time away from work and increased cost could be due to those cases that have to be referred. While no study has compared worker compensation claims that have to be referred to those that do not it would make sense that those that require a referral will keep the CTD away from work longer and increase the cost of the claims.

There was no statistically significant association found between the variable referral with any other variable; however, some of the descriptive data could be clinically relevant. A higher percentage of CTDs that required a referral (68%) were between the ages of 46 and 65 compared to those that did not require a referral (39%). The most common MSD among those that required a referral where rotator cuff tears (58%) and SLAP lesion (24%) and the most common among those that did not were unspecified sprains/strains (85%). This supports the significant impact age has on the CTD population and the risk for developing MSDs of the shoulder that requires higher levels of care and negatively impact the finances of CTDs and their employers.

LIMITATIONS

All studies must be evaluated for potential limitations which must be identified and explained. Several limitations must be considered with the design of this study, including available data for collection, participant selection, and the sample size and makeup.

The first limitation of this study has to do with the data that were available for collection. The data collected for this study were not designed to be used for research purposes but rather for the care of injured CTDs. This study design was a retrospective medical record review, which limits the data collection to include only variables routinely addressed during office visits. While the data in this study were beneficial, they came with limitations. Since the collected data was not designed specifically for this study, it was impossible to obtain any information related to the psychological domain of the CTD at the time of injury, and as shown in the OFCM, this could be an important aspect that justifies further investigation. There were also variables related to the general health of the CTD and the environment that were not available that could have been beneficial. Some of these variables are chronic diseases, the type of truck driven, the type of trailer used, and loading/unloading cargo. These are just a few of the areas that would have allowed a more in-depth data analysis.

The second limitation of this study was the potential for error in the process of identifying CTDs within the EMR at the data collection site. The EMR at the occupational clinic where the data collection occurred documented the profession of a worker in the history of present illness section of the SOAP note. It is possible that in some cases, it was not stated that a worker was a CTD. This would create the opportunity for some participants to have been missed resulting in the sample not to be as diverse as it could have been.

The third limitation for this study was due to the inability to identify a sample of commercial truck drivers with MSDs other than shoulder injuries that could have been used as a comparison group. The EMR at this clinic did not have a way to search for the workers based on profession. The only way to identify CTDs was if it was stated in the medical record as part of the history of present injury. This created a potential for CTDs that were not identified, which could have decreased the sample size.

The final limitation of the study is related to the size and makeup of the sample. The sample was adequate based on the completed power analyses; however, when using categorical data, a larger sample size may have allowed for a richer analysis of the variables and the groups. This sample is made up of CTDs that work primarily in and around a large city in the southeast. The demographics may have been comparable to those of the national working population, but this is still a convenience sample of a local CTD population and would not be generalizable to the national population. This does not discount the information that was discovered but should be taken into account in the discussion of the findings and assumptions that are made.

IMPLICATIONS FOR NURSING PRACTICE

It is critical for healthcare providers, especially nurses, who have patients that are CTDs to understand the impact MSDs of the shoulder have on this population. Past research has shown that working proactively in the occupational setting can greatly benefit workers across all occupational areas. An educational program with construction workers that put into action highlighting; posture, performance, and the use of different tools; was shown to significantly decrease the incidence of MSDs to the shoulder or arm (Soares, Jacobs, Minna, et al., 2012). Borstad et al. (2009) found that the use of preventive rotator cuff strengthening exercises in construction workers could decrease the risk of developing an MSD of the shoulder.

This study has shown a statistically significant association between the age of CTDs and the development of MSDs, particularly rotator cuff injuries. Therefore, health care providers should be aware of the potential impact that age has on the development of MSDs when they encounter a CTD, particularly in those over the age of 45. Healthcare providers should be able and willing to educate CTDs on this potential increased risk for injury.

This study did not show a significant association between the MOIs and MSDs, but it is the first study to show that a large number of MSDs of the shoulder are related to the use of chains, tarps, and straps and the use of other equipment. While future research still needs to be done to develop and test an interventional plan for CTDs, healthcare providers should understand that the work environment of the CTD and the tasks they perform should be assessed for safety and potential injury risks. Just as CTDs should be educated about the potential for injury as they age, there should also be a discussion about the tasks they are required to perform while on the job. Some potential tasks that CTDs complete that should be a part of this discussion is loading/unloading cargo or securing the cargo on a flatbed truck using chains, tarps, or straps. These tasks may be required, but by discussing the risk, they could pose a CTD could potentially limit the times they have to perform the task or utilize any available assistive equipment.

IMPLICATIONS FOR FUTURE RESEARCH

Future research related to MSDs of the shoulder in CTDs should focus on two areas: developing a richer understanding of these MSDs and the development of interventions to prevent injuries. The first item should build off of the foundation the current study provides. Based on the limitations of the current study, future research should be prospective and designed using the OFCM to ensure that all potential variables are investigated across the four domains: environmental, physical, occupational, psychological. A prospective study should be completed with a larger sample size made up of a CTDs that experience an MSD of the shoulder and those who do not have any MSD. This would provide an opportunity to better analyze those who get injured and offer a comparison group to see if there are measurements that are more common in those with an MSD of the shoulder.

There should be a standard assessment tool created to address variables across all of the OFCM domains. This tool should address all of the same demographic data presented in this study but also have more specific questions related to the anthropometric measurements and work-related variables. An example of some of these potential variables could be the strength of rotator cuff, type of truck driven, type of trailer used, required to handle and secure own cargo, depression/anxiety screening, job satisfaction scores. These types of questions would give a more in-depth analysis of the CTD at the time of injury and allow for a significantly stronger foundation in which to build interventions.

The second focus of future research should be intervention studies designed to incorporate preventative measures in the workplace of the CTD in an attempt to decrease the prevalence of MSDs of the shoulder. This may be accomplished in two ways. The first would concentrate on using rotator cuff exercise programs to decrease the prevalence of rotator cuff injuries and SLAP lesions. Even though there is still a need to develop a stronger foundation as described above an interventional study could still be designed. This study suggests there is an association between age and the development of MSDs, especially rotator cuff injuries, and there is already evidence in other active occupational group's rotator cuff strengthening programs can help prevent MSDs in the shoulder (Borstad et al., 2009; Cheng & Hung, 2007). A prospective intervention study should be designed comparing a group of CTDs who do not participate in a strengthening program to a group of CTDs who do. These two groups should be followed over a period of time and assessed for any differences in the development of MSDs of the shoulder comparing the two groups. If a simple and inexpensive strengthening program were shown to help decrease the risk of developing MSDs of the shoulder in CTDs, this would have a significant impact on the CTD population and their employers.

This study also showed the prevalence of MSDs due to the use of chains, tarps, and straps. This MOI affected CTDs of all ages and the act of using tarps, chains, and straps put a significant amount of stress on the shoulder. Just as discussed above, a prospective interventional study should be designed to investigate preventive programs that could potentially decrease the prevalence of injuries related to the use of these items. Past research has supported the use of educational programs highlighting appropriate lifting and equipment used along with the use of assistive devices which could decrease the risk for developing MSDs of the shoulder (Bhimani, 2014; Borstad et al., 2009; Cheng & Hung, 2007; Dennerlein et al., 2017; Soares, Jacobs, Minna, et al., 2012). In the CTD population, these programs could highlight appropriate mechanics when completing tasks requiring chains, tarps, and straps or even the development of assistive devices unique to CTDs that could remove the strain of these required tasks.

SUMMARY

This is the first study that specifically investigated MSDs of the shoulder in CTDs. It is also the first study that utilized more specific variables when evaluating MOIs and MSDs. There were three critical outcomes of this study: the prevalence of rotator cuff tears and SLAP lesion among MSDs, the statistically significant association between age and MSDs; the prevalence of MSDs that resulted from the use of chains, tarps, and straps and equipment.

The results of this study are consistent with findings of past research by showing that, in CTDs, unspecified strains/sprains were the most commonly documented MSD. However, it is the first study to show the prevalence of rotator cuff tears and SLAP lesions as well. Past research did not investigate these diagnoses or the impact they could have on this population but instead grouped them with sprains/strains. This highlights the importance of the study in developing a better understanding of the MSDs of the shoulder in CTDs. In this population, rotator cuff tears and SLAP lesions required more costly diagnostics tests and all of the CTDs with these injuries were referred to an orthopedic surgeon. This has a significant impact on not just the CTD but their employers and family. Intervention research needs to be developed to help decrease the prevalence of these two injuries by initiating preventative programs (e.g., rotator cuff strengthening exercises, stretching protocols) as supported by current and future research.

The relationship between age and rotator cuff injuries is well established in research, but this is the first study to investigate the prevalence of rotator cuff injuries in a group of CTDs. This study confirmed a statistically significant association between age and MSDs; specifically, rotator cuff tears, which is supported by past research and highlights the importance this has on practice. Healthcare providers must be aware of this relationship, and they should work to educate their patients who are CTDs on the risks for developing rotator cuff tears as they age. The earlier CTDs understand the risk of developing rotator cuff tears, the higher the chance they can prevent them from occurring.

This study was also the first to investigate environmental factors within the MOIs that are unique to CTDs. Falls were found to be the most commonly documented MOI, which is strongly supported in past research. This study also found that almost the same number of CTDs were injured while using chains, tarps, and straps as compared to falls, which can have a significant impact on the clinical setting. This study, for the first time, shows the prevalence of injuries related to the use of chains, tarps, and straps, and this can be used in two important ways. First, this new knowledge can be used to educate patients of all ages of the potential risks that the use of chains, tarps, and straps could have on developing an MSD of the shoulder. Second, intervention research can be developed to investigate the best method for preventing injuries related to the use of chains, straps, and tarps. These could be safe handling education programs, development of assistive devices, or strengthening exercises for the torso and upper extremities.

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Appendix A

Letter of Support

Dr. Karen Heaton
Associate Professor
University of Alabama at Birmingham
School of Nursing
NB 2MO26
1720 2nd Ave South
Birmingham, AL 35294

Dear Dr. Karen Heaton,

I would like to express my strong support for your research proposal, *Shoulder injuries in long-haul truck drivers*. We would be delighted to assist with this project and look forward to our collaboration. Specifically, we will provide access to records of commercial drivers with a history of shoulder injury as a source of data for the project after your proposal is reviewed and approved by the UAB Institutional Review Board (IRB).

As the manager of a successful occupational health clinic and on behalf of Dr. Romeo, we believe this research project is important, feasible, and consistent with the goals of Alabama Comp.

Please keep us advised on the progress of the research proposal and anticipated timeline for implementation of the project.

Sincerely,

Anthony Richey
Practice Manager
Alabama Center for Occupational Medicine and Prevention

Appendix B

UAB IRB Approval

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
Institutional Review Board for Human Use

Exemption Designation
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on November 8, 2021. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator:	Heaton, Karen L
Co-Investigator(s):	Combs, Bryan P Raju, Dheeraj A
Protocol Number:	**E170222004**
Protocol Title:	*Shoulder Injuries in Long-Haul Truck Drivers Seen in Occupational Health Clinic*

The above project was reviewed on 3/16/17. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This project qualifies as an exemption as defined in 45CFR46.101(b), paragraph 4.

This project received EXEMPT review.

Date IRB Designation Issued: 3/16/17

Margie Lawson, CIP
Designated Reviewer
Chair Designee

Investigators please note:

Any modifications in the study methodology, protocol and/or consent form/information sheet must be submitted for review to the IRB prior to implementation.

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1720 2ND AVE S
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Appendix C

Data Collection Form

Participant #	
CTD	
Date of Injury	
Gender	
Age	
Race	
Height	
Weight	
BMI	
MOI	
Injury	
Work Enviroment	
Refferal	
Imaging	
Imaging Result	
Date of Release	
Days of work missed	
Notes	