To the Graduate Council:

I am submitting herewith a dissertation written by Jeffrey Scott Oakley entitled "An Analysis of Injury/Illness Events Among Warehouse and Transportation Workers Performing Lifting Tasks Within the Food Distribution Industry." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Human Ecology.

Susan M. Smith, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Interim Vice Provost and
Dean of The Graduate School

AN ANALYSIS OF INJURY/ILLNESS EVENTS AMONG WAREHOUSE AND TRANSPORTATION WORKERS PERFORMING LIFTING TASKS WITHIN THE FOOD DISTRIBUTION INDUSTRY

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Jeffrey Scott Oakley
August 2000

DEDICATION

This dissertation is dedicated to
my parents

Joe Pat Oakley and Judith Ann Oakley,

my grandmother

Livy Mae Oakley,

and

my wife

Amanda Hargrove Oakley

ACKNOWLEDGMENTS

Many people have helped me along the way in this educational endeavor, but first I would like to thank my wife, Amanda Oakley, for helping me in my undergraduate education and also encouraging me in my graduate and doctoral education. I love you very much. Thanks for all of your dedication and support.

I also have to acknowledge my two dogs, Raleigh and Maggie. Raleigh barked every five minutes to try to tell me how to write and Maggie sat under my computer desk while I typed every word. I am sorry I accidently kicked you while you were under my computer desk.

I would like to thank Dr. Susan Smith for helping me these three years and teaching me how to appreciate research. I would also like to thank my committee members: Dr. Tyler Kress, Dr. Paula Zemel, and Dr. Bill Wallace.

This degree would not have been possible if it were not for my mentors and professors from Murray State University, especially Dr. David Kraemer, Dr. Bassam Atieh, and Dr. Mark Friend. I also have to thank my professors from Auburn University, Dr. Robert Thomas, Dr. Leo Smith, and Dr. James Hool. I would also like to thank Dr. Magsoodloo and comment that I still get nightmares when I think about those daily problems that you made us figure out. Thanks.

I also would like to acknowledge my mentor, teacher, friend, and colleague Dr. Henry Walter and also his wife. Thanks for all of your help. You have been a good role model and friend.

I would also like to thank the cast, director, and writer of the Broadway play *Rent* for giving me the inspiration to go back to school and to pursue my passion – teaching. Thanks and always "No Day But Today!"

ABSTRACT

The purpose of this study was to analyze the frequency of injury/illness events among workers who perform lifting tasks for a food distribution company located in the Southeast United States. The study was conducted to determine how the frequency of lifting, number of hours worked in one month, work shift, conditions such as temperature, different job categories, and body mechanics are associated with the development of injuries and illnesses.

The study design was a retrospective study of those workers employed at a food distribution company utilizing data that were previously documented. The study population used included warehouse and transportation workers in the job categories of driver, picker, loader, and stocker. Following analysis of data with demographic information, it was concluded that no difference was found in injury/illness events reported during the three highest months of production and other months of the year for workers in a food distribution company located in the Southeast United States for the years 1996-1999.

The food distribution company warehouse division studied had a significantly higher incidence rate and cost associated with the injury/illness events than the transportation division. The warehouse divisions' incidence rate was found to have 3.84 more injury/illness events for each 200,000 hours worked than the national average for food distribution companies, and cost associated with the injury/illness events was $453,744 higher than the national average.

While there was a significant difference among workers in the normal, refrigerated, and frozen temperature conditions, the overriding factor for this study was job category and length of employment rather than temperature conditions. Stockers reporting an injury/illness event was found to have worked five times longer prior to experiencing an injury than loaders. Loaders experienced an injury after an average of only 9 months of employment, while stockers experienced an injury after an average of 48 months of employment. The rate of reported injury/illness events for loaders were 4.856 more injury/illness events reported than stockers. It was concluded that loaders and stockers lifted over three times the recommended weight per lift and pickers lifted over two times the recommended weight per lift using the NIOSH lifting equations.

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CHAPTER I

INTRODUCTION

Increased insurance and workers' compensation costs, loss of productivity, decreased morale, and lost workdays can result from employee injuries and illnesses. Determining and understanding the causal factors of these injuries and illnesses can be the first steps in preventing and reducing injuries and illnesses (Plavner, 1999). Analyzing previous injuries and illnesses can provide valuable information about essential risk factors for work related injuries and illnesses (Courtney, Bordorf, Sorock, & Herrick, 1997).

The food distribution industry supplies food products that are vital to the service sector of the United States economy. To be successful, the industry must maintain a continuous process of supplying, warehousing, and shipping food products. The food distribution industry is a rapidly growing and changing industry striving to meet the challenges of just-in-time delivery. Meeting the challenge of just-in-time delivery requires the food distribution and warehousing industry to move, store, ship, and transfer its goods and products rapidly. Employees serving as warehouse and transportation workers are required to undertake and carry out many tasks requiring lifting and to maintain a rapid work pace in the food distribution industry. Few in-depth studies have been conducted assessing the injuries/illnesses reported by warehousing and transportation food distribution workers compared to those working in the meat packing and automobile manufacturing industry.

Work related injuries and illnesses reported by employees in the United States can be categorized as either acute traumatic injuries or chronic musculoskeletal disorders (Murphy, 1996). The occupational illnesses most frequently reported to the Occupational Safety and Health Administration (OSHA) are "disorders associated with repeated trauma" (Hansen, 1993, p. 42). The food distribution industry is characterized by employees conducting many repeated activities including continuously lifting and moving of food products from trucks to warehouses. These food products are usually lifted five or six times between the time the products leave their initial loading point and the point at which the food products are eventually sold to a consumer. According to the Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics of the U.S. Department of Labor (1999) in 1998, there were approximately six million injuries and illnesses on the job with approximately 705,800 cases reported as a result of overexertion or repetitive motion (Bureau of Labor Statistics, 1999). Lifting and moving products, many weighing over 50 pounds, are the daily activities for warehouse and transportation workers in the food distribution industry. Lifting activities such as these have been reported to result in overexertion, leading to an injury/illness. According to the industry average, 52 percent of overexertion injuries reported involved lifting. Pushing and pulling objects resulted in 13.2 percent of injuries reported. Carrying objects accounted for 9.8 percent of the injuries reported by the Bureau of Labor Statistics in 1998 (BLS, 1999).

Food distribution employers are continuously challenged to maximize productivity and efficiency, while minimizing employee injuries and illnesses. This is particularly true in the identification of risk factors associated with back and wrist injuries. While many studies have been conducted to research lifting in specific industrial settings such as the meat packing and automobile manufacturing industries, few have focused on the food distribution warehouse and transportation workers. Research studies analyzing previous injuries and illnesses have helped to target the significant risk factors and generate measures to control the specific risk.

Purpose of the Study

The purpose of this study was to analyze the frequency of injury/illness events among workers who perform lifting tasks for a food distribution company located in the Southeast United States. The study was conducted to determine how the frequency of lifting, number of hours worked in one month, work shift, conditions such as temperature, different job categories, and body mechanics are associated with the development of injuries and illnesses. The study also assessed the frequency of injuries and illnesses within each department, job category, and shift. The most frequently occurring injuries and illnesses were analyzed to determine if there were significant differences between department, job category, and shift.

Research Questions

The following research questions were developed to address the purpose of the study:

1. Do the three months of production reporting the greatest number of hours

reflect the months also reporting the greatest frequency of injury/illness rates for workers performing lifting tasks in a food distribution company located in the Southeast United States?

2. Is there a difference in the cost of injuries/illnesses and/or the rate of injury between workers performing lifting tasks at a specific food distribution company in the Southeast United States and the reported average for workers in the United States food distribution industry?

3. Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company located in the Southeast United States?

4. Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs of picking, stocking, and loading for a food distribution company located in the Southeast United States?

Need for the Study

Workers in many occupations requiring lifting activities are at risk for a variety of injuries and illnesses. Previous studies by Grieco, Motini, De Vito, and Sias determined that the injury and illness rate for food industry workers was significantly higher for workers performing repetitive movements within frozen temperatures than for normal temperatures (Grieco, Molteni, De Vito, & Sias, 1998). The purpose of this study was to analyze the frequency of injury/illness events among workers who perform lifting tasks for a food distribution company located in the Southeast United States. The study will determine how the frequency of lifting, number of hours worked in one month, work shift, conditions such as temperature, different job categories, and body mechanics are associated with the development of injuries and illnesses.

Further research focusing on the need to identify risk factors for the food distribution industry was indicated because of the high number of injuries and illnesses reported for this industry. The studies published by the National Institute of Occupational Safety and Health (NIOSH) in 1997 report that workers in the trucking and courier services have an incidence rate for overexertion disorders almost three times higher than the average rate for all private industries (Bernard, 1997). Statistics published by the National Safety Council report that the grocery and related products in the wholesale trade division have an incidence rate of 10.6 while the industry average has an average of 8.6 for 1998 (National Safety Council, 1999). The trucking and warehousing division also was reported to have an incidence rate of 10.0 which was higher than the industry average of 8.6 for 1998 (NSC, 1999). As the service sector continues to expand in the United States, the food distribution industry is projected to remain one of the fastest growing industries. Due to the continuing success of this industry, the food distribution companies must increase production and meet just-in-time delivery demands of clients, as customers demand rapid delivery of quality produce (Nahmias, 1993).

Low back pain has been the most common and complex ailment of the workplace and affects both males and females of all ages, races, professions, education levels, and social status. It has been estimated that eight out of ten people will experience some kind of back pain in their lifetime. It has been documented that in heavy industry where lifting is involved, one out of every five people is affected by back injuries on a regular basis (Khalil, Abdel-Moty, Rosomoff, & Rosomoff, 1993).

The back is rarely injured by lifting a single load, but rather by cumulative trauma. A single event can produce the injury; however, the cumulative effect of bending, twisting, excessive sitting, or excessive standing (bad posture) increases the likelihood of the injury (MacLeod, 1995). The cumulative trauma or lifting with bad posture can be prevented in many cases by redesign of the workplace environment and the adoption and use of appropriate rest periods, stretching and flexibility exercises during a shift, and rotation of motions during a work period.

Back injuries caused by repetitively lifting heavy loads have resulted in many incidents and is most likely to occur when weight is lifted farther away from the body. Research has indicated that lifting performed in awkward situations (due to poorly designed equipment, bad tool design, bad workplace design, and lack of education) and farther from the body can put an undue amount of strain and cumulative trauma on the spine (Andersson & Chaffin, 1991).

The increased cost of health care and lost work time has increased the need to study and research back and musculoskeletal injuries from lifting (Department of Health and Human Services, 1990).

Assumptions

The basic assumptions made regarding this study were:

1. The data from the OSHA 200 logs, workers' compensation records, and accident reports used for analysis were accurate.
2. The employee data provided on the cases stocked, picked, and transported and labor hours worked were accurate.

Delimitations

For the purpose of this study the following delimitations were formulated:

1. This study was delimited to retrospective data associated with hourly workers at a food distribution company in the Southeast United States. The data included accident/injury data only on the workers that reported an injury/illness event. The data included information about hours worked, headcount, and amount of cases stocked, picked, or transported for all workers (reported an injury/illness event or not).
2. The period for the data collection was delimited to the calender years 1990-1999.
3. This study was delimited to warehouse and transportation workers in the food distribution industry. The warehouse workers performed stocking, picking, or loading activities. The transportation workers performed

driving, unloading, and stocking activities.

4. The workers in the study group were hourly workers who received an hourly rate and incentive pay per item loaded.

Limitations

The study was limited in the following ways:

1. The study data analyzed for this study were limited to the data recorded on the OSHA 200 logs, accident reports, and company records. These records were completed by different individuals. Data were limited by the accuracy of entered numerical and written reports and may have included inconsistencies and omissions. This research was limited to the data that could be extracted from written records. The study included all individuals employed for any part of the ten year period, but was not a cohort of all employees for ten years, due to turnover. Employees entered the population and exited the population within these ten years.

Definitions of Terms

This section operationally defines the terms used in this study.

1. Cumulative Trauma (also called Repetitive Motion) – trauma that occurs over time. This type of trauma is usually characterized by a continuous amount of force over a long period of time. This normally does not involve

necessarily the exact same task, but involves the same motion or muscle groups.

2. Musculoskeletal Injuries – injuries involving the musculoskeletal system. These injuries are usually characterized by the upper extremity (neck, shoulder, elbow, hand, and wrist), lower extremity (feet, legs, and buttocks), and back (spine). These injuries are categorized as fractures, dislocations, sprains, and strains.

3. OSHA 200 Log – a form required by companies to report occupational injuries and illnesses.

4. Work-Related – occupational injuries that occur at or as a result of one's occupation.

5. Workers' Compensation – insurance that a worker receives if one becomes injured at work and must require time off work for the loss. Workers' compensation will give monetary allowances to the individual injured.

6. Injury/Illness Event – an accident which was reported to the safety department and the employee received medical treatment.

7. Temperature Conditions – the temperature at which a worker performs his or her work throughout a shift. It consists of three levels: 1) normal, which is a temperature environment which varies with the outside temperature, 2) refrigerated, which is constant at around 44° Fahrenheit, and 3) frozen, which is also constant at around 22° Fahrenheit.

Summary

The purpose of this study was to analyze the frequency of injury/illness events among workers who perform lifting tasks for a food distribution company located in the Southeast United States. The National Safety Council reported that the grocery and related products in the wholesale trade division have an incident rate of 10.6, while the industry average has an average of 8.6 in 1998 (NSC, 1999). The trucking and warehousing division also reported higher incidence rates than the industry average for injuries and illnesses with a incidence rate of 10.0. The need for this research was indicated by the high injury and illness rates reported by the food distribution industry and the importance of identification of risk factors. Lifting activities were reported as routine tasks by warehouse and transportation workers of the food distribution industry. The research focused on the frequency of injury/illness events associated with lifting activities reported for a food distribution company.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

A literature review was conducted to assess the lifting related activities and related injuries and illnesses of warehouse workers in the food distribution industry. The literature review consisted of related published research focusing on the physical health effects of occupational lifting, as well as effects of workshift schedules and temperature conditions, including the methodology. The literature review focused on the content and methodology related to the determinates of health effects from lifting tasks. A theoretical and biomechanical model was also developed to serve as a framework for this study.

Research and Literature Related in Content

Injury/illness events

For any type of physical work, the relationship between workload and work capacity is affected. Many types of injuries and illnesses, such as strains/sprains and overexertion, were associated with exceeding these limits. Many factors were considered in injury/illness events such as sex, age, body dimensions, and state of health. Temperature and cold weather were reported to reduce physical performance from numbness of the hands, thus making dropping a box more common. The lowered body temperature could also cause more injury/illness events (Astrand & Rodahl, 1986). Lifting activities seem to contribute to the occurrence of an overexertion type of injury/illness event. According to the industry average, 52 percent of overexertion injuries involved lifting. Pushing and pulling objects resulted in 13.2 percent of injuries. Carrying objects accounted for 9.8 percent of the injuries (BLS, 1999).

The incidence rate for the grocery and related products in the wholesale trade division was 10.6 compared to 8.6 for the industry average for 1998. The trucking and warehousing divisions incidence rate was 10.0 for 1998 (NSC, 1999). Groups of workers from the areas of these divisions (warehouse and transportation) encompass the food distribution company of this study, and the incidence rates for both divisions were above the industry average incidence rates.

Cumulative trauma disorders

Excessive lifting and other strenuous tasks result in cumulative trauma disorders cased by cumulative stress to a particular part of the body. This stress (or trauma) accumulated over time will eventually lead to symptoms. The Bureau of Labor Statistics (BLS) defines cumulative trauma disorders as an illness rather than an injury, because it occurs over time and not as a result of one incident. These injuries and illnesses are also known as repetitive strain injuries, repetitive motion injuries, wear and tear injuries, or overuse injuries (BLS, 1999). NIOSH determined that trauma was induced when "job demands. . . repeatedly exceed the biomechanical capacity of the worker. Sources of trauma are workplace tasks or non-work-related activities that cause repetitive and continuous strain and contribute to the onset of injuries affecting the musculoskeletal system" (Peate & Lunda, 1997).

Cumulative trauma disorders were reported to be one of the most costly and preventable occupational conditions in the United States. Cumulative trauma disorders were reported to have increased over 1,000 percent in the past 10 years – from 26,000 in1983 to 302,000 in 1993. "The federal government estimates that such trauma costs the American economy more than $20 billion in workers' compensation claims and $80 billion in absenteeism and reduced productivity annually" (American College of Occupational and Environmental Medicine, 1997, p. 1).

Sprains, strains, and carpal tunnel syndrome (CTS) are injuries that could be a result of cumulative trauma (Peate et al., 1997). There has been much controversy about the work-relatedness of these injuries, since both occupational and non-occupational activities (leisure activities) tend to cause or aggravate these types of injuries (Kroemer, 1992; McGorry & Courtney, 1995). If employees work only eight hours a day, then the opportunity exists to either work another job or perform an activity that could increase the risk of cumulative trauma disorders or musculoskeletal disorders. The same concept could also be true of working on the night shift or evening shift, in the sense that the entire day was free.

Cumulative trauma injuries are the fastest growing type of occupational injury. The causes of these injuries were "controversial, multifactorial, and elusive" (Hess, 1997, p. 116). These injuries were based on work as well as non-work activities (Sandler, 1998). Personal factors such as age, gender, prior injuries, health history (acute and chronic injuries and illnesses), hobbies (sports), and pregnancy are factors that effect cumulative trauma injuries (Kroemer, 1992; Hess, 1997; Hansen, 1993).

Musculoskeletal injuries

Musculoskeletal injuries and back pain are major health problems that affect millions of people in all occupations, especially occupations that require strenuous lifting. Some studies have shown that 80 percent of the population will be affected at some time by a musculoskeletal injury (Khalil et al., 1993). Musculoskeletal injuries are categorized as fractures, dislocations, stains, and sprains. Most of the injuries are from overstretching or overexertion of some part of the muscle. Normally the overexertion is associated with the back muscles (Kelsey, 1982). Musculoskeletal injuries were found to be associated with factors related to the job/task and personal characteristics. Job/task factors include the load weight, environment, frequency of lifts, task or job design, and also psychological factors. Personal factors affecting injury included age, gender, and strength (capacity). These three personal factors were reported to affect the levels of fatigue, posture, trauma, emotional stress, congenital defects, genetic factors, and physical fitness. These factors have not only determined the job risk, but also the level or risk of musculoskeletal injuries (Isernhagen, 1988).

Musculoskeletal injury has been found to be caused by either acute trauma or cumulative trauma. Acute trauma is associated with the application of force which exceeds the tolerance of the body during an infrequent act. This trauma is normally combined with large amounts of force such as lifting an extremely heavy object.

Cumulative trauma is associated with repeated application of force to the body that will lower the tolerance of the structure to sustain the same amount over time, until eventually the structure fails. The lifting of objects over time has been found to cause cumulative trauma, "wear and tear," and muscle fatigue (Salvendy, 1997). Sustained or frequent exertion has been found to cause muscle fatigue and then progresses to the musculoskeletal injury. The muscle fatigue from overuse causes inflamation of tendons, synovia, bursa, and joint structures. This process increases the discomfort and pain which causes functional limitations (Andersson et al., 1991).

Back injuries

Back injuries were found to be a major concern and cost to employers, as well as the leading musculoskeletal problem. It was estimated that 6.5 million people were bedridden in the United States because of back injuries, and new cases of back injuries were found to occur at a rate of approximately 1.5 million per month. The escalating number of back injuries costs employers millions a year and removes many able bodied workers from the workforce (Khalil et al., 1993).

Low back pain was the most common and complex ailment of the workplace reported to affect both males and females of all ages, races, professions, education levels, and social status. It has been estimated that eight out of ten people will experience some kind of back pain in their lifetime (Khalil et al., 1993). It has been documented that in heavy industry that requires excessive lifting, one out of every five people was affected by back injuries on a regular basis. Approximately 60 percent of the back injuries required approximately one thousand dollars of medical treatment and were usually resolved within a week. However, 10 percent of the back injury cases required 30 or more visits to a medical provider (California Workers' Compensation Institute, 1997). Workplaces have been recommended to focus on root causes and ergonomic design to achieve the prevention, instead of rehabilitation, for back injuries. Injuries involving the spine (vertebrae) or back (muscles and tendons) were the most costly to the employer as compared to other types of injuries (Kelsey, 1982).

There were basically two main types of back injuries reported. These were: (1) injuries to the spinal vertebrae and (2) injuries to the muscles and tendons of the back (Kelsey, 1982). The back is rarely injured by lifting a single load, but rather by cumulative trauma. While a single event was reported to have produced the injury, the cumulative effect of bending, twisting, excessive sitting, or excessive standing (bad posture) have been reported to increase the likelihood of the injury (MacLeod, 1995). The injuries from the cumulative trauma or excessive bad posture were reported to be prevented in many cases by redesign of the workplace environment and the adoption and use of appropriate rest periods, stretching and flexibility exercises during a shift, and rotation of motions during a work period.

Most back injuries have been caused by lifting repetitive heavy loads. Most back injuries were reported to occur when weight was lifted farther away from the body. Lifting performed in awkward situations (due to poorly designed equipment, bad tool design, bad workplace design, and lack of education) and farther from the body have been found to put an undue amount of strain and cumulative trauma on the spine (Andersson et al., 1991).

Back injuries have been found to be so prevalent that the National Institute for Occupational Safety and Health developed guidelines for lifting to try to prevent the amount of back injuries in the workplace. The back injuries were not decreased, so the guidelines were revised. These lifting guidelines are excellent tools if used properly (Waters, Putz-Anderson, Garg, & Fine, 1993).

Upper extremity musculoskeletal injuries (neck, shoulder, elbow, hand, and wrist)

Injuries to the upper extremities are also very often plagued by lifting activities. Overexertion and repetitive motion of a particular part of the body leads to sprains, strains, and other more serious disorders, such as carpal tunnel syndrome (which is a painful disease characterized by the inflammation of the nerves and tendons within carpal tunnel in the wrist). Although the back was affected most by lifting activities, the shoulder, according to the Bureau of Labor Statistics in 1999, was affected in 47,861 overexertion injuries (BLS, 1999).

Repetitive motions such as typing, tool use, and repetitively assembling, placing, grasping, or moving objects continuously throughout the day were reported to affect the elbow, hands, and wrists. There were 92,576 injuries and illnesses that were affected by such repetitive motion in 1994. Most of these injuries (55 percent) affected the wrist (Bernard, 1997).

The injuries to the upper extremities were found to be from overuse of the muscles and tendons. Lifting of heavy loads or constant lifting was found to cause the muscles and tendons to become fatigued. Arthritis and ligament stress were found to be problems that occur to the upper extremity from overuse (Ranney, 1997).

Lower extremity (feet, legs, and buttocks)

Injuries to the lower extremity (feet, legs, and buttocks) are rarely associated with lifting activities. While fractures occur frequently to the lower extremity from slips and falls, overuse or cumulative trauma have been found not to occur as often as the back or upper extremity. Lower extremities were found to be stronger and not as susceptible to all of the repetitive motion (Praemer, Furner, & Rice, 1992).

Research and Literature Related in Methodology

Workshift schedule

With the advent of the industrial revolution and discovery of electricity, manufacturers engaged workers to work around the clock (Glazner, 1992). Around 27 percent of the United States population work at an occupation where shift work is scheduled. The shift work percentage has increased steadily as companies try to gain an edge by producing more products and covering all the possible shifts. The food distribution industry is one of the industries that consistently work in shifts. In order to accomplish the demand of supplying, stocking, and transporting food products, workers have been reported to frequently work overtime to accomplish this high demand.

The workshift schedule was determined to maximize performance of the employee, while reducing the amount of injuries and illnesses. It has been reported that in individuals who have worked too long, fatigue and possible injury or cumulative trauma has resulted. Wood's study (1997) focused on 20 women and the optimal work rest schedules during repetitive jobs. The results were analyzed using the analysis of variance. Results indicated that the longer a worker performed a task, the more fatigue was generated on the body (Wood, Fisher, & Andres, 1997).

The rationale for having three shifts per day has been supported for many years in industries and service centers that are open 24 hours a day such as health care, food distribution, and power generation industries (Smith, Folkard, Tucker, & Macdonald, 1998). Every shift and hour must be covered by an employee of the company. The morning, afternoon, and night shifts with different health problems were correlated with working at the different times, because the bodies were in a different routine and body rhythm. Since a large number of people are engaged in this kind of shift work, the health impact is of great concern to employers (Taylor, Briner, & Folkard, 1997).

A straight shift is defined as the type of work schedule that does not change from week to week, and the employee works on days only or on nights only. In Gold's study (1992), 878 registered nurses, licensed practical nurses, and staff were administered a questionnaire that concluded that rotators reported accidents or errors twice as much as for day or evening nurses. The results were analyzed in EPISTAT and SAS and univariate and multivariate analyses. Rotators also were found to have 2.5 times the amount of near-miss accidents (Gold, Rogacz, Bock, Tosteson, Baum, Speizer, & Czeisler, 1992).

Research and Literature Related in Methodology and Content

Study design

A study of risk factors for back injuries was performed by Gardner, Landsittel, and Nelson (1999) for retail merchandise store workers to determine which risk factors were associated with strain or back injuries. The workers performed significant manual material handling responsibilities including daily lifting and movement of merchandise. Workers were divided into two physical work requirement categories of higher physical work category and lower physical work category. The higher category had an injury rate of 3.64 per 100 person years to 1.82 per 100 person years with the workers in the low physical work category. Males also had a much higher injury rate of 3.67 compared to 2.34 for females, which was confounded by higher physical work requirements for men in the higher physical work category of stocker/receiver. The injury rate ratio was determined for short versus long duration employment and was computed to be 3.53 (95 percent confidence interval 2.90, 4.30). For medium versus long duration it was 1.38 (95 percent confidence interval 1.18, 1.62). The major finding of this study indicated that workers with the greatest physical work requirements and those with the shortest duration of employment were found to be at the highest risk for back injury (Gardner, Landsittel, and Nelson, 1999).

Theoretical and Biomechanical Models

The study of occupational injuries and illnesses as well as lifting activities have produced many different types of models, both theoretical and biomechanical, that will help to describe how injuries and illnesses occur. The theoretical models of injuries and illnesses have been used for hazard identification, hazard control, risk management, and accident investigation. Many different models have been used to attempt to figure out the mystery of injuries and illnesses at the workplace.

One model is the worker-equipment-environment interaction. This model illustrates this interrelationship and demonstrates how an accident can intervene between the systems and the task as shown in Figure 2-1. This model explains the many factors that produce an accident, which is called the system approach to accidents.

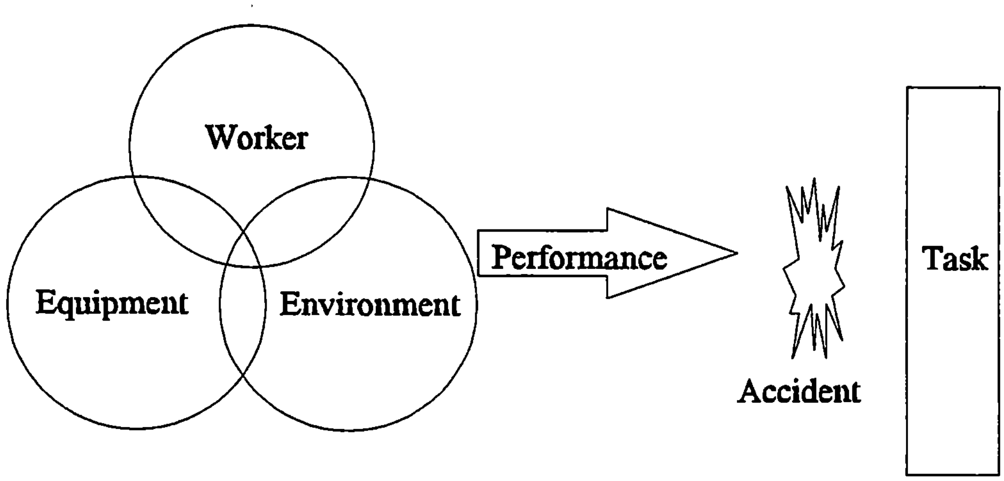

Figure 2-1. System Approach to Accidents (NSC, 1992, p. 65)

Chaffin added that there were two different types of injury mechanisms that are common in industry. Figure 2-2 illustrates Chaffin's view on the injury mechanisms. These injury mechanisms are either a sudden force /impact trauma, or volitional activity/ overexertion trauma. The mechanism of injury is one of these two types.

Many statistical analyses (epidemiological studies) have been performed on different injuries and illnesses, especially of musculoskeletal systems, in industries and have concluded that certain physical activities produce more than a random number of injuries to a particular anatomical region. According to Chaffin and Andersson (1991), "the large number of workers who are disabled because of low back pain associated with manual labor has resulted in concerted efforts to relate the biomechanical aspects of such labor to resulting tissue injury. In this regard, the acts of lifting, pushing, and pulling heavy loads in various postures have been biomechanically modeled to predict resulting forces and moments" (Andersson et al., 1991, p. 215).

Event		Trauma Type		Typical Medical Outcomes
Sudden Force	→	Impact Trauma	→	Contusions, Lacerations, Fractures, Amputations, Joint Subluxations, Concussion, etc.
Volitional Activity	→	Overexertion Trama	→	Tendonitis, Tenosynovitis, Myofascial Disorders, Nerve Entrapment Disorders (CTS), Low Back Pain, etc.

Figure 2-2. Two Different Types of Injury Mechanisms Common in Industry (Chaffin, 1987, p.2)

Herrin, Chaffin, and Mach proposed that several distinct groups of factors need to be considered simultaneously in the prevention of musculoskeletal disorders related to manual material handling. These factors, which define a manual material handling system, were the worker characteristics, material/container characteristics, and work practices. From this research, the findings were conclusive that when manually lifting loads, the loads should be symmetrically balanced in front of the body. This led to the development of the NIOSH lifting equations (National Institute for Occupational Safety and Health, 1981). Because manual lifting was so prevalent and has been the cause of many injuries and illnesses, this approach to lifting analysis and modeling was developed for the warehouse food distribution workers. Both the 1981 and 1991 NIOSH lifting equations were used for the analysis.

The basic equation for the 1981 NIOSH lifting guide is 90(H)(V)(D)(F). The complete mathematical equation is incorporated in Appendix A. The H represents the horizontal variable, which was determined by how many inches the load was away from the centerline of the body. The V represents the vertical variable, which was determined by the distance in inches the load was from the floor at the start of the lift. The D represents the distance variable, which was the distance in inches that the load was lifted. The F represents the frequency variable, which was the frequency the load was lifted per minute (NIOSH, 1981).

The 1991 NIOSH lifting guide added origins and destinations and also the amount of twist involved with the lifting task to the equation. The complete mathematical equation and instructions for completing the 1991 NIOSH lifting guide is provided in

Appendix B. The basic equation is 51(HM)(VM)(DM)(AM)(FM)(CM). The HM represents the horizontal modifier, which was calculated by the distance the load was from the centerline of the body at the start of the lift and the distance from the centerline of the body at the destination of the lift. The VM represents the vertical modifier, which was calculated by the distance the load was from the floor at the beginning of the lift and the distance the load was from the floor at the end of the lift. The DM represents the distance modifier, which was the distance the load was lifted. The AM represents the angle modifier, which was the angle of twist at the origin of the lift and then the angle of twist at the destination of the lift. The FM represents the frequency modifier, which was the frequency of the lift by minute. The CM represents the coupling modifier, which was categorized by good, fair, or poor (Waters et al., 1993).

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to analyze the frequency of injury/illness events among groups of workers who perform lifting tasks for a food distribution company located in the Southeast United States. The design and methods used to collect and analyze the research data has been described in this chapter. The research design, study population, data tabulation, management of data, and statistical analysis used to analyze the research questions have been included in this chapter.

Research Design

The research design used for this project was a retrospective study. The study utilized data previously documented and maintained to meet OSHA, workers' compensation, and accounting requirements. The data were extracted, coded, and entered into two computerized databases. Data were extracted from OSHA 200 logs, accident reports, workers' compensation records, accounting spreadsheets, and food distribution company records. No individual employee names or identification numbers were used in the results generated for data analysis. Two computerized databases were created. One database contained data related to employees that received an injury or illness and reported to management from the years 1990-1999. Table 3-1 lists the variables coded

Table 3-1. Table of Variables Coded into the Databases

Employee Injury/illness Database 1990-1999		Monthly Headcount, Hours Worked, and Performance Data Totals Database 1996-1999	
Age	Tests Conducted	Month	Headcount (T)
Date Employed	Injury Type	Year	Total Hours (T)
Gender	Injury Code	Headcount (D)	Miles Driven (T)
Job Category	Body Part	Overtime Hours (D)	Routes (T)
Department	Injury Event	Total Hours (D)	Cases a Day (T)
Date of Injury	Lifting Task*	Cases Received (D)	
Lost Time*	Body Mechanic	Cases an Hour (D)	
Days Lost	Object	Headcount (N)	
Restricted*	Weight of Object	Overtime Hours (N)	
Workers Comp*	Stock/Pick/Load	Total Hours (N)	
See Doctor*	Temperature	Cases Shipped (N)	
Diagnosis		Cases an Hour (N)	

* These variables were coded either yes or no.
(D) denotes day shift.
(N) denotes night shift.
(T) denotes transportation.

into the two databases. The second database included the monthly totals of hours, cases received and shipped, and the head counts per department for all employees (reporting an injury or not) for the years 1996 -1999. The data could only be obtained for the years 1996-1999.

Study Population

This study was designed to assess frequency of lifting, number of labor hours worked in a month, work shift, conditions such as temperature, different job categories, and body mechanics to determine how these factors affect frequency of injuries and illnesses reported among workers in a food distribution company. The retrospective study addressed the population of workers who reported an injury/illness event from the years 1990-1999. Hours worked, headcounts, and other variables were collected from the years 1996-1999. This data for the entire population of workers (reporting an injury or not) was not available for the years 1990-1995. The population of all workers averaged 207 workers per year. The data used for analysis were provided by a food distribution company in the Southeast United States and approved by The University of Tennessee Institutional and Departmental Review Board for Human Studies.

The data analyzed included injury/accident data previously reported for company health records by hourly warehouse and transportation workers. The reported injury data represented workers who were 99 percent male and only one percent female within the group of warehouse workers and transportation drivers reporting injuries. Gender was not included in any analysis due to such a low number of females. The workers included in the study normally worked an eight hour shift in the daytime or the nighttime with overtime when required. The employees reporting injuries performed manual material lifting; unloaded material from trucks to store in the warehouse, removed material from the warehouse, and loaded material on trucks for delivery. The day workers stocked the warehouse shelves with delivered goods, and the night workers picked the products from the warehouse shelves to put on trucks for delivery. The three job categories for all warehouse workers (stockers, pickers, and loaders) within the food distribution company included in the study were analyzed.

Warehouse workers

Within the warehouse division, there were three job categories of stockers, pickers, and loaders. Each job category performed a different function related to receiving, warehousing, and transporting food products. Stockers took the products from the trucks and stocked them in the warehouse. The products were delivered by forklift to an area of the warehouse. The stockers took the products and placed them on either the first or second shelves from the floor. A forklift took the unstocked products and put them on the top shelves. The top shelves were used for storage, and the food products were placed on the bottom two shelves (bottom shelves used for picking). The pickers selected products from the two bottom shelves and placed them on a cart. A full cart was taken to the appropriate truck for loading by the pickers. The loaders took the items off carts and loaded a semi-truck for delivery to the customer. While each group of workers did not perform the same job or task, each involved lifting activities. The lifting tasks involved moving a wide range of goods ranging widely in weights, sizes, and shapes. The average weight of the material moved by employees within a food distribution industry was estimated by plant management to be around 25 pounds. A common lifting task involved a standard size of 60 pound commercial packaged canned goods called 6/10 cases, which was commonly lifting by warehouse workers.

Each group of warehouse workers (stockers, pickers, and loaders) performed their work under three different temperature conditions. The first group of workers worked in a room temperature environment (normal) which did not stay constant, but was determined by the temperature outside. The normal temperature environment fluctuated with the temperature outside. The second group of workers worked in a refrigerated environment. This refrigerated environment stayed constant throughout the day at 44° Fahrenheit. The third group of workers worked in a frozen environment. This environment was 22° Fahrenheit. Groups of workers studied were permanently assigned to one of these environments for their entire workshift. Each group of workers wore clothing suitable for the different temperature conditions present in their work area to achieve their personal comfort level.

Biomechanical model

The lifting analysis and modeling for the three categories of warehouse workers' lifts have been illustrated in Figure 3-1. A stocker loaded the products from a pallet to the warehouse rack (bottom shelf or second shelf). The bottom shelf was four inches off of the floor on a pallet. The top shelf was four foot four inches (52 inches) off of the floor.

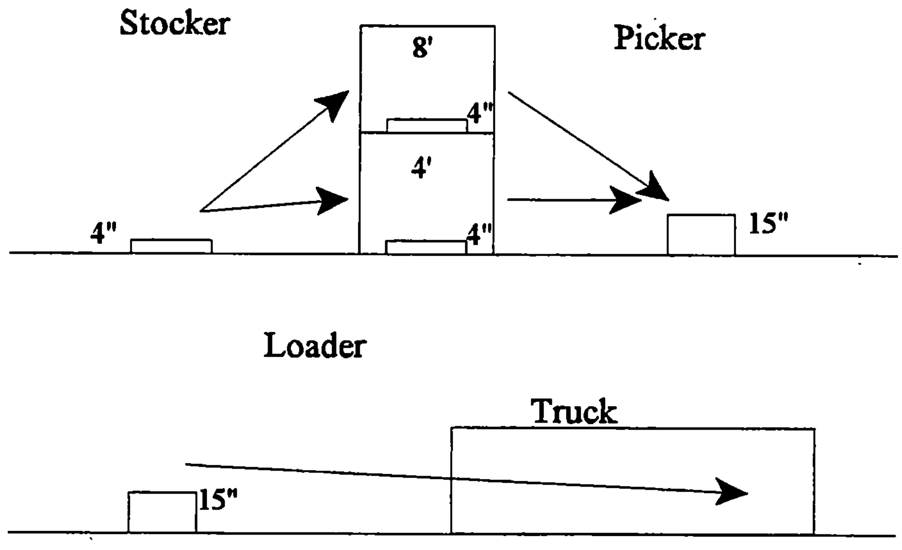

Figure 3-1. Model of Lifting Tasks by Job Category (Stocker, Picker, and Loader)

The picker performed the opposite task of a stocker, in that the product was taken off of the rack to a cart which was fifteen inches off the floor. The loader took the products off of the cart and loaded the truck for delivery to the customers. Information on how the biomechanical models were calculated is provided in Appendices A and B.

Transportation workers

The study included transportation workers (drivers) who delivered produce and other goods in large trucks to the customers. The drivers performed unloading and stocking activities when reaching customer locations, in addition to their driving responsibilities. Most goods were unloaded using a two wheeled dolly.

Data Tabulation

Information was gathered from OSHA 200 logs, workers' compensation records, and accident investigation reports for the injury/illness data of the workers who reported an injury/illness event for the years 1990-1999. Accounting records and company performance records (labor hours worked and amount of cases of goods that were received from suppliers and shipped to customers) were used to gather information for the entire population of workers (both injured and not injured) for the years 1996-1999. The accounting records and company performance records were consistent and assumed accurate. The injury/illness data gathered from the OSHA 200 logs, workers' compensation records, and accident investigation reports were completed by different individuals. This resulted in some records missing information.

Two computerized databases were constructed from the extracted data without employee names or identification numbers. The first database included only information associated with the workers' reported injuries and illnesses for the years 1990 through 1999. The second database coded the totals of cases received by the suppliers and shipped to the customers by all workers, head count, and labor hours worked for each department by all workers, job category, and type of work environment by group working in frozen, refrigerated, or normal temperature conditions by month.

Management of Data

All data entry from company records were completed at a secure office at the company. The records were kept in a locked office while coding the data, and returned back to the appropriate company representative when the database was complete. The computerized databases created for analysis contained no names of individuals, companies, or identification numbers. All information was analyzed as group data.

Statistical Analysis

The group data were analyzed using the Statistical Program for Social Sciences (SPSS) version 10.1. Data were first tabulated and analyzed using descriptive statistics (mean, frequency, and percentages) of demographic information about the population. The variables included frequencies of injury/illness events by shift, job category, division, body part, type of injury/illness, cause of injury/illness, and duration of employment. The results of this descriptive analysis are found in Chapter IV. The analysis of the variables was conducted using inferential statistics using the appropriate parametric or non-parametric statistic depending on characteristics of the specific data.

Parametric tests performed in this study including t-tests, analysis of variance (ANOVA), and linear regression, were conducted on continuous data such as the cases stocked per month, cases shipped per month, and labor hours worked per month to determine if there was a significant difference between these variables and reporting an injury/illness event. The t-test compared means of two groups to determine if they were equal. If the p value was less than .05, this test indicated that the means of the groups were significantly different. The ANOVA was used to determine whether there was a significant difference between two or more means using the same p value of .05 (Gay & Airasian, 2000). Confidence intervals were included in the ANOVA analysis. Three linear regression analyses were conducted to assess how injury/illness events on the day shift, night shift, and transportation divisions were predicted by the amount of overtime hours worked in a month and the amount of cases stocked, loaded, or transported (SPSS, 1997). Table 3-2 lists the parametric statistics used for the study.

Non-parametric tests performed in the study included the chi square analysis, odds ratio, Kruskal-Wallis test, and Mann-Whitney test for nominal data. These tests were used for determining the significance in injury/illness events and the variables of temperature, shift, job category, and division of work (warehouse and transportation). The chi square analysis was used to test whether a significant difference existed between an observed number of injury/illness events and an expected number of injury/illness events (Ferguson & Takane, 1989). The expected number of injury/illness events for the temperature, shift,

Table 3-2. List of Parametric Statistical Analyses Performed on Specific Variables

Type of Statistical Test	Statistical Test Performed	Variables
Parametric	T-test	Cases stocked per month
	Analysis of Variance (ANOVA)	Cases picked and loaded per month
		Cases per hour on day shift
		Cases per hour on night shift
		Drivers' cases loaded per month
		Drivers' cases per day
		Drivers' miles driven
		Overtime hours worked per month day shift
		Overtime hours worked per month night shift
		Drivers' hours worked per month
	Linear Regression	Overtime hours worked per month day shift and cases stocked per month
		Overtime hours worked per month night shift and cases loaded per month
		Hours worked per month for drivers and cases loaded per month

job category, and division of work (warehouse and transportation), was given the percentage of employees working in the appropriate category. The odds ratio was used to examine the strength of association between exposure of variables (temperature, job category, and shift) and the injury/illness events. The higher values following analysis using the odds ratio indicate a stronger association. The number 1.0 in the odds ratio determines the variable that is used to compare to the others. A value of more than one determines how many more times that association is from the comparative variable. There has been much debate about odds ratio studies that have confidence intervals that include 1.0 or less than 1.0. The concern expressed by previous studies is whether such studies simply show no significant difference or can be seen as useful estimates of association (Bernard, 1997). Confidence intervals were also computed to determine significance for the odds ratio.

The Kruskal-Wallis test was performed to test the difference in the ranks of three or more groups. A chi square was calculated to determine if there is a significant difference between the groups for the test. The Mann-Whitney test was performed to test if there is a significant difference in the ranks of two groups (Gay et. al., 2000). The level of significance chosen for this study was p=.05. Table 3-3 lists the non-parametric statistics used for the study.

Table 3-3. List of Non-Parametric Statistical Analyses Performed on Specific Variables

Type of Statistical Test	Statistical Test Performed	Variables
Non-Parametric	Chi Square	Job category (picker, loader, stocker, and driver)
		Division (warehouse and transportation)
		Months of the year
	Odds Ratio	Shift (day and night)
		Temperature conditions (normal, refrigerated, and frozen)
		Job category for warehouse workers (picker, loader, and stocker)
	Kruskal Wallis Test (Chi Square)	Duration of employment before injury and job category
	Mann-Whitney Test	Duration of employment before injury rank between picker and driver
		Duration of employment before injury rank between picker and stocker
		Duration of employment before injury rank between picker and loader
		Duration of employment before injury rank between stocker and driver
		Duration of employment before injury rank between stocker and loader
		Duration of employment before injury rank between loader and driver

Do the three months of production reporting the greatest number of hours reflect the months also reporting the greatest frequency of injury/illness rates for workers performing lifting tasks in a food distribution company located in the Southeast Unites States?

A chi square analysis was performed on the number of injury/illness events each month to determine if there was a significant difference between the months of the year and reporting an injury/illness event. The food distribution industry was found to have workloads which vary by month, some of the months encompassing high volumes of overtime and higher workloads, and other months encompassing lower volume, less overtime, and lower workloads. The three highest months of production were selected for analysis to determine if most injuries occurred during the highest volume months. Linear regression analyses were performed on day, night, and transportation workers to determine if the analysis predicts the frequency of injury/illness events by workload and overtime hours worked.

The number of cases of goods stocked by month for all employees (injured and not injured) were analyzed by a t-test. The average number of cases stocked for months when a reported injury/illness event occurred compared to the average number of cases stocked for months when there was no injury/illness event reported. A one sample t-test was performed on the means of cases stocked per month that received an injury for a given year and that was compared with the means of the months with no reported injury/illness event. The one sample t-test was used to determine if there was a statistical significance difference between months with reported injury/illness events and those with no injuries.

An ANOVA was run to assess the number of cases picked and loaded per month. The analysis was conducted by calculating the average number of cases picked and loaded per month with no reported injury/illness events, with one reported injury/illness events, with two reported injury/illness events, and with three or more reported injury/illness events. If the p value was less than .05, then the means were statistically different. The confidence intervals were determined to calculate which means were different.

The analyses were also performed by the number of cases per hour on both the day and night shifts. ANOVA was conducted to determine if the average cases per hour were different when a reported injury/illness event occurred when there was no reported injury/illness event. Drivers were also analyzed using ANOVA in cases loaded and stocked in a month, cases per day, and miles driven in a month to determine if there was a statistical significant difference between the months when an injury/illness event was reported and months when an injury/illness event was not reported.

The day and night shifts were analyzed by ANOVA to determine if there was a statistical significant difference between the mean of the overtime hours worked per month between months with a reported injury/illness event and months without a reported injury/illness event. Drivers' hours were also analyzed by ANOVA; however, the hours were combined with regular and overtime hours. The total hours were analyzed by ANOVA to determine if there was a statistical significant difference between the mean of the total hours worked per month with a reported injury/illness event and months without a reported injury/illness event. The specific variables utilized for each parametric and non-parametric test are provided in Table 3-4.

Table 3-4. List of Statistical Analyses Performed for Research Question 1: Do the three months of production reporting the greatest number of hours reflect the months also reporting the greatest frequency of injury/illness rates for workers performing lifting tasks in a food distribution company located in the Southeast United States?*

Type of Statistical Test	Statistical Test Performed	Variables Analyzed for Research Question 1*
Parametric	T-test	Cases stocked per month
	Analysis of Variance (ANOVA)	Cases picked and loaded per month
		Cases per hour on day shift
		Cases per hour on night shift
		Drivers' cases loaded per month
		Drivers' cases per day
		Drivers' miles driven
		Overtime hours worked per month day shift
		Overtime hours worked per month night shift
		Drivers' hours worked per month
	Linear Regression	Overtime hours worked per month day shift and cases stocked per month
		Overtime hours worked per month night shift and cases loaded per month
		Hours worked per month for drivers and cases loaded per month
Non-Parametric	Chi Square	Months of the year

Is there a difference in the cost of injuries/illnesses and/or the rate of injury between workers performing lifting tasks at a specific food distribution company in the Southeast United States and the reported average for workers in the United States food distribution industry?

An incidence rate analysis was performed to compare the food industry average to the incidence rate for the food distribution company studied. The hours worked for all employees were calculated for each division (warehouse and transportation) and shift (day and night). The hours were analyzed to determine if a difference exists between the hours worked and frequency of injury/illness events. The incidence rates were calculated using the following formula:

$$\text{Incidence rate per 200,000*} = \frac{\text{number of injuries X 200,000}}{\text{number of hours worked}}$$

$$\text{Lost time incidence rate per 200,000} = \frac{\text{number of lost time injuries X 200,000}}{\text{number of hours worked}}$$

* The 200,000 used for the formula represents100 full-time workers working 40 hours a week for 50 weeks a year (NSC, 1999).

An odds ratio with confidence intervals was calculated to examine the strength of association between the shift and the frequency of injury/illness events reported.

A cost analysis was conducted on each division (warehouse and transportation) to determine the monetary cost of injury/illness events for the average food distribution industry and the food distribution company studied. The national safety council estimates $10,488 per injury calculated for the year 1998 (NSC, 1999). The cost analysis for part of body injured was performed to itemize each injury to a cost value. The specific variables utilized for the non-parametric odds ratio test is provided in Table 3-5.

Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company located in the Southeast United States?

The groups of worker injuries/illnesses were analyzed for those working in normal, refrigerated, and frozen temperatures. These groups were analyzed by frequency and type of job category. The hours worked in each group were calculated. The incidence rate per 200,000 hours was calculated, and an odds ratio with confidence intervals was calculated to examine the strength of the association between the groups of employees working in different temperatures and the frequency of injury/illness events reported. The odds ratio was performed to address whether a significant difference or association exists between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company in the Southeast United States. The specific variables utilized for the test is provided in Table 3-6.

Table 3-5. List of Statistical Analyses Performed for Research Question 2: Is there a difference in the cost of injuries/illnesses and/or the rate of injury between workers performing lifting tasks at a specific food distribution company in the Southeast United States and the reported average for workers in the United States food distribution industry?*

Type of Statistical Test	Statistical Test Performed	Variables Analyzed for Research Question 2*
Non-Parametric	Odds Ratio	Shift (day and night)

Table 3-6. List of Statistical Analyses Performed for Research Question 3: Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company in the Southeast United States?*

Type of Statistical Test	Statistical Test Performed	Variables Analyzed for Research Question 3*
Non-Parametric	Odds Ratio	Temperature conditions (normal, refrigerated, and frozen)

Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs picking, stocking, and loading for a food distribution company located in the Southeast United States?

Jobs performed by warehouse workers, including jobs categorized as picking, stocking, and loading, were analyzed by lifting task, task before injury, and length of employment before reporting an injury/illness event. Kruskal-Wallis test and Mann-Whitney tests were performed to determine if there was a significant difference between the job categories (picker, stocker, loader, and driver) and the length of employment before reporting an injury/illness event. The Kruskal-Wallis test was conducted to determine if there was a difference between the job categories (picker, stocker, loader, and driver), and the Mann-Whitney test was conducted to determine which individual job categories were significantly difference from another. The following non-parametric statistical tests were performed to address whether a significant difference or association was found between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs of picking, stocking, and loading for a food distribution company in the Southeast United States. The specific variables utilized for each test is provided in Table 3-7.

The biomechanical models for pickers, stockers, and loaders were calculated using both the 1981 and 1991 NIOSH lifting equations to determine how well these equations had predicted the risk on these three job categories. The hours worked were calculated for each job category. The incidence rate per 200,000 hours were calculated, and an odds

Table 3-7. List of Statistical Analyses Performed for Research Question 4: Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs of picking, stocking, and loading for a food distribution company in the Southeast United States?*

Type of Statistical Test	Statistical Test Performed	Variables Analyzed for Research Question 4*
Non-Parametric	Chi Square	Job category (picker, loader, stocker, and driver)
		Division (warehouse and transportation)
	Odds Ratio	Job category for warehouse workers (picker, loader, and stocker)
	Kruskal Wallis Test (Chi Square)	Duration of employment before injury and job category
	Mann-Whitney Test	Duration of employment before injury rank between picker and driver
		Duration of employment before injury rank between picker and stocker
		Duration of employment before injury rank between picker and loader
		Duration of employment before injury rank between stocker and driver
		Duration of employment before injury rank between stocker and loader
		Duration of employment before injury rank between loader and driver

ratio with confidence intervals was calculated to examine the strength of the association between job category and frequency of injury/illness events reported.

Summary

This chapter described the research design, study population, data tabulation, management of data, and statistical tests utilized in this study. The study design was a retrospective study of those workers employed at a food distribution company utilizing data that were previously documented and maintained to meet OSHA and accounting requirements. The study population used for this study included drivers, pickers, loaders, and stockers, and there was an average of 207 workers per year. The variables of the study were analyzed using both parametric and non-parametric tests. The parametric data was analyzed by ANOVA, t-tests, and linear regression. The non-parametric data was analyzed by chi square, odds ratio with confidence intervals, Kruskal-Wallis test, and Mann-Whitney tests.

CHAPTER IV

ANALYSIS OF THE DATA

Introduction

This study examined the injury/illness events that were reported by warehouse and transportation workers performing lifting tasks for a food distribution company. Chapter IV presents the findings and analysis of the injury/illness data. Demographic information describing the injury/illness events and discussion of descriptive data were presented. The research questions were discussed, analyzed, and statistically tested at the .05 level of significance.

Data Analysis

Demographic information

A total of 263 injury/illness events were reported by workers at the food distribution company studied in the Southeast United States between the years 1990 and 1999. The population studied included two divisions of employees (warehouse and transportation) at the food distribution company. The warehouse and transportation employees worked one of two shifts, either a day or a night shift. The warehouse division employed an average of 92 warehouse workers (44.5 percent of all workers) during the ten year period. An average of 27 workers (29 percent) were employed on the day shift and 65 workers (71 percent) were employed on the night shift. The transportation division employed an average of 115 drivers (55.5 percent of all workers). Drivers performed driving, unloading, and stocking activities. The day shift reported 137 injury/illness events (52.1 percent) compared to126 injury/illness events (47.9 percent) reported for workers on the night shift for the ten year period. The results of the frequency of injury/illness events reported by each shift for the years 1990-1999 are provided in Table 4-1.

The food distribution population of warehouse and transportation workers included four categories of jobs within the warehouse and transportation divisions. The job categories were pickers, loaders, stockers, and drivers. The warehouse division employed pickers, loaders, and stockers, and the transportation division employed drivers. Pickers reported the higher number of workers in the warehouse division with an average of 35 workers. Loaders reported an average of 25 workers and 32 workers for stockers. Drivers reported an average of 115 workers. See the results in Table 4-2. Over the 10 year period, drivers reported the most injuries with 126 injury/illness events (47.9 percent) and employed the highest number of total employees. Pickers reported the second highest category of those injured with 72 injury/illness events (27.4 percent). The results are provided in Table 4-3.

A descriptive analysis of coded data provided by the part of the body most often injured indicated that the back was the part of the body most frequently injured. Sixty-one injury/illness events (23.2 percent) involved the back. Ankle injuries were the second highest injury reported, with 34 injury/illness events (12.9 percent). Injuries and illnesses

Table 4-1. Frequency of Injury/Illness Events Reported by Shift for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Shift	Frequency	Percent
Day	137	52.1
Night	126	47.9
Total	263	100.0

Table 4-2. Average Number of Workers per Year by Job Category for the Warehouse and Transportation Workers at the Food Distribution Company

Job Category	Frequency	Percent
Picker	35	16.9
Loader	25	12.1
Stocker	32	15.5
Driver	115	55.5
Total	207	100.0

Table 4-3. Frequency of Injury/Illness Events Reported by Job Category for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Job Category	Frequency	Percent
Picker	72	27.4
Loader	36	13.7
Stocker	29	11.0
Driver	126	47.9
Total	263	100.0

associated with the leg were the third highest, with 27 injury/illness events (10.3 percent). The results are provided in Table 4-4.

An analysis of the type of injury/illness events indicated that strains/sprains were the injury/illness event most frequently reported. This type of injury involved an injury to multi-body parts. One hundred twenty-six strains/sprains (47.9 percent) were reported by the food distribution industry in the years 1990 through 1999. The second most frequent injury/illness events were contusions or bruises. Seventy-one occurrences (27.0 percent) of all reports were contusions and bruises. The third and fourth highest categories of injury/illness events were fractures and lacerations, each with 21 occurrences (8.0 percent). The results are provided in Table 4-5.

The analysis of the cause of injury/illness found overexertion to be the most frequent with 79 injury/illness events (30.0 percent) of the reported 263 cases. The second cause was found to be slip/trip/fall from the same elevation with 48 injury/illness events (18.3 percent). The third highest cause was caught in/on/under/between with 45 occurrences (17.1 percent). The results are provided in Table 4-6.

When accident reports were analyzed to assess length of employment, it was found that the length of employment prior to an injury/illness event was extremely short, with 74 percent of the injury/illness events occurring before the first year of employment was completed. Seventeen percent of the injury/illness events reported occurred within the first month of employment. Over half (54 percent) of the injury/illness events were reported to occur prior to the first six months of employment being completed. A graphic representation of injuries/illnesses reported and the length of employment

Table 4-4. Body Part of Injury/Illness Events for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Body Part	Frequency	Percent
Back	61	23.2
Ankle	34	12.9
Leg	27	10.3
Fingers	22	8.4
Multiple	16	6.1
Wrist	15	5.7
Arm	13	4.9
Shoulder	12	4.6
Chest	10	3.8
Foot	10	3.8
Hand	9	3.4
Face	6	2.3
Head	6	2.3
Toes	5	1.9
Abdomen	4	1.5
Groin	4	1.5
Neck	4	1.5
Thigh	2	.8
Eye	1	.4
Trunk	1	.4
Other	1	.4
Total	263	100.0

Table 4-5. Type of Injury/Illness Events for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Type	Frequency	Percent
Sprain/Strain	126	47.9
Contusion	71	27.0
Fracture	21	8.0
Laceration	21	8.0
Multiple	10	3.8
Other	5	1.9
Puncture	3	1.1
Foreign Body	8	.8
Hernia/Rupture	2	.8
Carpal Tunnel	1	.4
Concussion	1	.4
Total	263	100.0

Table 4-6. Cause of Injury/Illness Events for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Cause	Frequency	Percent
Overexertion	79	30.0
Slip/Trip/Fall (Same Elevation)	48	18.3
Caught In/On/ Under/Between	45	17.1
Struck By	35	13.3
Slip/Trip/Fall (Elevation)	27	10.3
Struck Against	15	5.7
Contact With	10	3.8
Other	3	1.1
Bodily Reaction	1	.4
Total	263	100.0

reported for each employee prior to injury are provided in Figure 4-1.

Do the three months of production reporting the greatest number of hours reflect the months also reporting the greatest frequency of injury/illness rates for workers performing lifting tasks in a food distribution company located in the Southeast United States?

An analysis of workload data per month by volume was conducted for the food distribution company studied. Appendix C (Tables C-1 through C-10) provids the results of the parametric tests for the workload data per month. The three highest volume months were identified as March, June, and September. These months had the most cases received, stocked, and shipped for the years 1996-1999. It was found that the most overtime was also consistently worked these three months of the year for the years 1996-1999. A chi square analysis was performed to determine if the injury/illness events were significantly different between all twelve months. The chi square analysis was performed and concluded that there was no significant difference between the months of the years reporting an injury and the frequency of injury/illness events reported at the .05 level of significance. The p-value for this test was .191. The results of the chi square analysis are provided in Table 4-7.

An analysis of the twelve months for the ten year period determined that the highest month of injuries was found to be April, with 32 injury/illness events reported. Figure 4-2 displays injury/illness events charted by month for the years 1990-1999. The three months with the highest number of injury/illness events were September, April, and

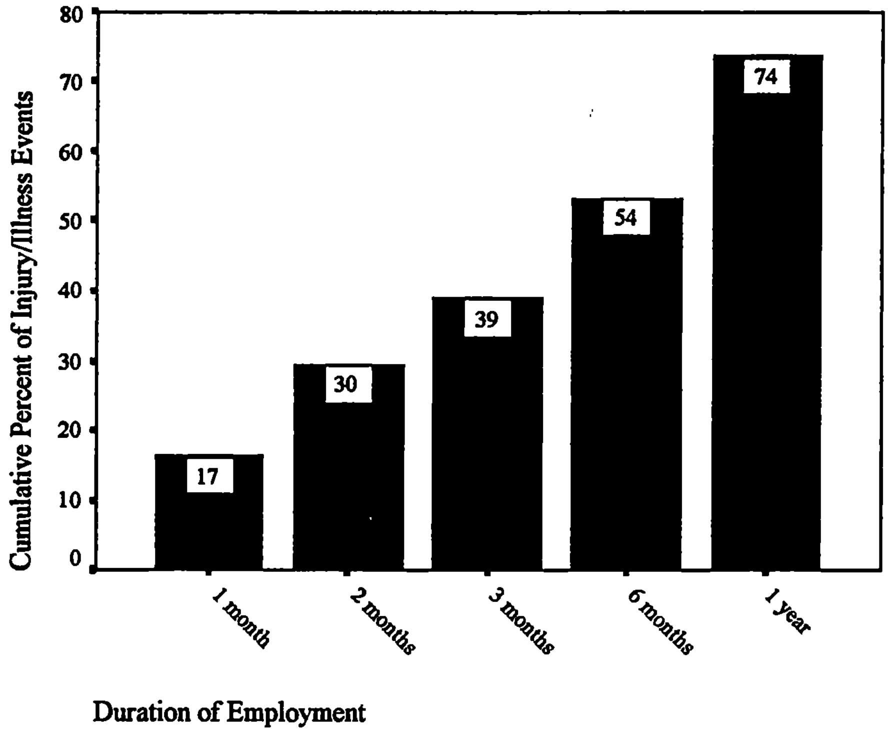

Figure 4-1. Injury/Illness Events in Cumulative Percent by Duration of Employment Reported the First Year of Employment for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Table 4-7. Chi Square Analysis of Injury/Illness Events Reported by Month for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Job Category	Observed	Expected	Residual
January	13	21.9	-8.9
February	19	21.9	-2.9
March	22	21.9	.1
April	30	21.9	8.1
May	16	21.9	-5.9
June	22	21.9	.1
July	17	21.9	-4.9
August	24	21.9	2.1
September	32	21.9	10.1
October	23	21.9	1.1
November	24	21.9	2.1
December	21	21.9	-.9
Total	263		
Chi Square = 14.825 p = .191			

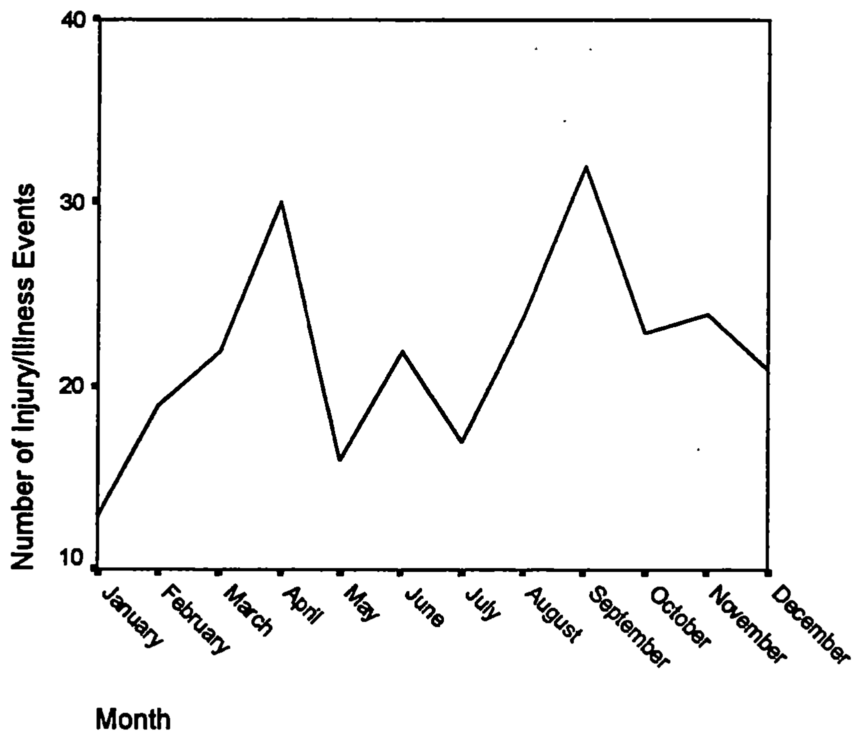

Figure 4-2. Average Number of Injury/Illness Events by Month for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

August/November (recorded the same number of injury/illness events) for the years 1990-1999. Figure 4-3 displays the injury/illness events charted by month for the years 1996-1999. September, April, and February were the months found to have the highest number of injury/illness events reported for the years 1996-1999. September reported the most injury/illness events and recorded a high workload and overtime hours worked.

A linear regression analysis was performed to determine if the variables of overtime hours worked and cases stocked per month would predict injury/illness events by the day shift for the warehouse workers. The linear regression calculated a .974 level of significance with a R^2 value of .001, which only explains less than one percent of the variability. There was no difference in overtime hours worked and cases stocked per month in the ability to predict an injury/illness event for the years 1996-1999. The results of the linear regression analysis for the day shift are provided in Table 4-8.

A linear regression analysis was also calculated for the night shift of warehouse workers and the transportation division. The linear regression for the night shift calculated a .021 level of significance; however, a R^2 value explains only 15 percent of the variability. The overtime hours increased during the months when an injury/illness event occurred; however, the increase of overtime hours was only .001. The results of the linear analysis for the night shift are provided in Table 4-9.

The transportation division linear regression analysis calculated a .353 level of significance with a R^2 value of .045, which explains less than five percent of the variability. No significant difference was found in the hours worked and cases loaded per month and the ability to predict injury/illness events. The results of the linear analysis for the

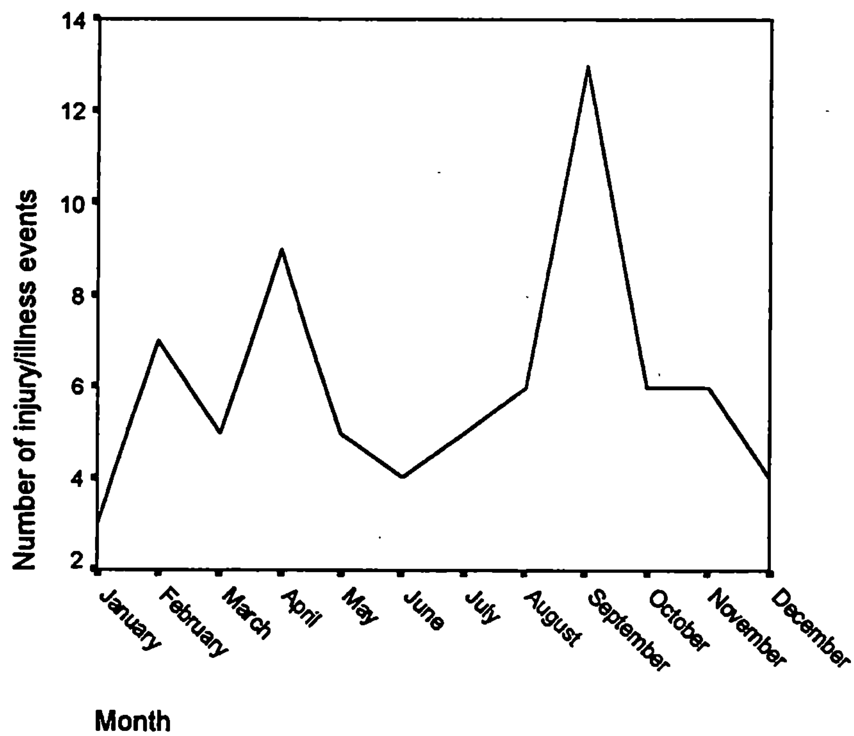

Figure 4-3. Average Number of Injury/Illness Events by Month for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1996-1999

Table 4-8. Linear Regression of Overtime Hours and Cases Stocked to Predict Injury/Illness Events by the Day Shift for the Warehouse Workers at the Food Distribution Company for the Years 1996-1999

	X^2	df	R^2	Sig.
Model	.053	2	.001	.974

Variables	B	SE	df	Sig.	Exp (B)
Overtime hours	.001	.002	1	.838	1.001
Cases stocked	.000	.000	1	.851	1.000

X^2 = chi square
df = degrees of freedom
R^2 = proportion of the total variation
Sig. = significance
SE = standard error of the estimate
B - Exp (B) = (Slope) ratio between the vertical change and the horizontal change

Table 4-9. Linear Regression of Overtime Hours and Cases Loaded to Predict Injury/Illness Events by the Night Shift for the Warehouse Workers at the Food Distribution Company for the Years 1996-1999

	X^2	df	R^2	Sig
Model	7.739	2	.158	.021

Variables	B	SE	df	Sig.	Exp (B)
Overtime hours	.001	.001	1	.040	1.001
Cases loaded	.000	.000	1	.025	1.000

X^2 = chi square
df = degrees of freedom
R^2 = proportion of the total variation
Sig. = significance
SE = standard error of the estimate
B - Exp (B) = (Slope) ratio between the vertical change and the horizontal change

transportation division are provided in Table 4-10.

Is there a difference in the cost of injuries/illnesses and/or the rate of injury between workers performing lifting tasks at a specific food distribution company in the Southeast United States and the reported average for workers in the United States food distribution industry?

The incidence rates were calculated for the job categories of pickers, stockers, loaders, and drivers. The incidence rate was computed per 100 employees and allows a comparison of the level of injury/illness prevention between the company and the industry average. The grocery and related products in the wholesale trade division have been reported to have an incidence rate of 10.6 for the year 1998 (NSC, 1999). The calculation of the incidence rate of the warehouse division (pickers, stockers, and loaders) of the food distribution company studied resulted in an incident rate of 14.44, which was higher than the food distribution industry average. The National Safety Council estimate for injuries was $10,488 per injury calculated for the year 1998 (NSC, 1999). There were 263 injury/illness events for the years 1990-1999 for the food distribution company. The cost of injury/illness events for the past ten years calculates to be $2,758,344 using the estimate for 1998.

Warehouse workers

The incidence rate for the warehouse division was calculated to be 14.44. This rate was higher than the average for the food distribution industry of 10.6. The lost

Table 4-10. Linear Regression of Hours and Cases Loaded to Predict Injury/Illness Events by the Transportation Division at the Food Distribution Company for the Years 1996-1999

	X^2	df	R^2	Sig
Model	2.084	2	.045	.353

Variables	B	SE	df	Sig.	Exp (B)
Hours	.000	.000	1	.363	1.000
Cases stocked	.000	.000	1	.213	1.000

X^2 = chi square
df = degrees of freedom
R^2 = proportion of the total variation
Sig. = significance
SE = standard error of the estimate
B - Exp (B) = (Slope) ratio between the vertical change and the horizontal change

workday rate for the food distribution company studied was actually lower than the average. The cost of the injuries from 1990-1999 for the warehouse division calculated to be $1,436,856, which was $453,744 more than the average food distribution company paid out for injuries over the past ten years, assuming the average cost of injury to be $10,488 (NSC, 1999). The results of the incidence rates and cost analysis are provided in Table 4-11.

Transportation workers

The transportation division of the food distribution company had an incidence rate of 10.2 compared to the industry average of 10.0. The amount of injury/illness events that resulted in lost time was lower than the industry average, with 3.79 compared to 5.4. The incidence rate when calculated in cost for the ten year period was $1,321,488. This was calculated to be $37,757 more than the average transportation company over the past ten years, assuming the average cost of injury to be $10,488 using National Safety Council estimates for the year 1998 (NSC, 1999). The results are provided in Table 4-12.

Each injury/illness event that occurred in the workplace resulted in several costs. These costs to the company include: payment for medical services for the injury/illness, providing income to workers when they are away from work, costs of injury-related paperwork, costs associated with accident investigation, as well as other related costs. Each of these costs increases the financial burden to the company. The total cost of the past ten years was averaged and estimated to be $2,758,344, using estimates of $10,488 per injury from the National Safety Council. The National Safety Council estimates that

Table 4-11. Incidence Rates and Cost Analysis for the Warehouse Division at the Food Distribution Company Compared to the Food Distribution Industry Average

	Average for Food Distribution Industry	Food Distribution Company Studied
Incidence Rate	10.6	14.44
Lost Workday Rate	6.2	6.1
Average Cost of Injuries for 10 Years*	$983,112	$1,436,856
Cost Difference		$453,744

* Assuming average cost of injury to be $10,488 (NSC, 1999).

Table 4-12. Incidence Rates and Cost Analysis for the Transportation Division at the Food Distribution Company Compared to the Food Distribution Industry Average

	Average for Food Distribution Industry	Food Distribution Company Studied
Incidence Rate	10.0	10.2
Lost Workday Rate	5.4	3.79
Average Cost of Injuries for 10 Years*	$1,283,731	$1,321,488
Cost Difference		$37,757

* Assuming average cost of injury to be $10,488 (NSC, 1999).

the average injury costs $10,488. The five highest costs for the parts of the body injured are multiple body parts ($21,500), head ($20,614), leg ($13,214), knee ($12,252), arm or shoulder ($10,726), and lower back (10,833) (NSC, 1999). By using this itemized cost analysis, the total cost for the last ten years was calculated to be $2,610,862. However, this cost was less than the $2,758,344 calculated by using $10,488 per injury. The analysis displayed how expensive these injury/illness events can be for a company. During the past ten years, the cost of injury/illness events for the food distribution company studied was projected to be over 2.5 million dollars. The results of a cost analysis by part of the body affected are provided in Table 4-13.

The incidence rate of injury/illness events for warehouse workers reported for the years 1996-1999 was higher during the night shift compared with the day shift. The incidence rate was found to be 10.68 per 200,000 hours for the day shift and 15.68 per 200,000 hours for the night shift. The odds ratio calculated that a warehouse employee on the night shift was 1.538 (.643, 3.682) times more likely to report an injury/illness event than a warehouse employee on the day shift. There have been debates about odds ratio studies that have confidence intervals that include 1.0, and whether such studies simply show no significant difference or can be seen as useful estimates of associated risk (Bernard, 1997). The results of the analysis by shift are provided in Table 4-14.

Table 4-13. Cost Analysis for Part of Body Injured for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Body Part	Frequency	Percent	Cost per Body Part Injured*	Cost
Back	61	23.2	$10,833	$660,813
Ankle	34	12.9	$6,345	$215,730
Leg	27	10.3	$13,214	$356,778
Fingers	22	8.4	$6,427	$141,394
Multiple	16	6.1	$21,490	$343,840
Wrist	15	5.7	$6,427	$96,405
Arm	13	4.9	$10,726	$139,438
Shoulder	12	4.6	$10,726	$128,712
Chest	10	3.8	$6,547	$65,470
Foot	10	3.8	$5,495	$54,950
Hand	9	3.4	$6,427	$57,843
Face	6	2.3	$5,990	$35,940
Head	6	2.3	$20,614	$123,684
Toes	5	1.9	$5,495	$27,475
Abdomen	4	1.5	$6,598	$26,392
Groin	4	1.5	$8,983	$35,932
Neck	4	1.5	$14,756	$59,024
Thigh	2	.8	$8,983	$17,966
Eye	1	.4	$5,990	$5,990
Trunk	1	.4	$6,598	$6,598
Other	1	.4	$10,488	$10,488
Total	263	100.0		$2,610,862

* Cost per body part injured data was calculated by the National Safety Council using body part specific average cost data (NSC, 1999)

Table 4-14. Warehouse Workers Incidence Rates by Shift at the Food Distribution Company with Odds Ratios and 95% Confidence Intervals for the Years 1996-1999

Work Shift	No. of Injuries	Hours	Incidence Rate per 200,000 Hours	Odds Ratio	95% Confidence Interval	
Day	7	131,048	10.68	1.00*		
Night	31	395,313	15.68	1.538	0.643	3.682
Total	38	526,361	14.44			

* Day shift was chosen as the comparison for the odds ratio.

Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company located in the Southeast United States?

The groups of workers analyzed were permanently assigned to a type of job involving different temperature conditions (normal, refrigerated, and frozen). The number of injury/illness events for the period 1990-1999 was 174 in the normal environment, 29 in the refrigerated environment, and 60 in the frozen environment. The frequencies of injury/illness events and the temperature conditions are provided in Table 4-15.

The drivers also worked in the different temperature conditions, and reported having an injury/illness event within a specific temperature condition. However, because drivers were not permanently assigned to a temperature condition, the drivers were not included in this analysis by temperature. The frequencies of injury/illness events and temperature conditions by job category are provided in Table 4-16.

The incidence rate calculated per 200,000 hours was found to be 9.91 for the frozen environment, 23.75 for the cooler environment, and 17.35 for the normal environment. The odds ratio calculated that it was 3.028 (.935, 9.801) more likely for an employee to report an injury/illness event in the refrigerated environment than the frozen environment. It was also calculated that an employee in the normal environment was 1.908 (.893, 4.076) times more likely to report an injury/illness event than an employee in the frozen environment. There have been debates about odds ratio studies that have confidence intervals that include 1.0 and whether such studies simply show no significant difference or can be seen as useful estimates of associated risk (Bernard, 1997). The results of the odds ratio analysis for temperature condition are provided in Table 4-17.

Table 4-15. Frequency of Injury/Illness Events and the Different Temperature Conditions for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Temperature Condition	Frequency	Percent
Normal	174	66.2
Refrigerated	29	11.0
Frozen	60	22.8
Total	263	100.0

Table 4-16. Frequency of Injury/Illness Events and Different Temperature Conditions by Job Category for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Job Category	Temperature Conditions			Total
	Normal	Refrigerated	Frozen	
Picker	40	12	20	72
Loader	23		13	36
Stocker	16	5	8	29
Driver	95	12	19	126
Total	174	29	60	263

Table 4-17. Warehouse Workers Incidence Rates by Different Temperature Conditions at the Food Distribution Company with Odds Ratios and 95% Confidence Intervals for the Years 1996-1999

Temperature Condition	No. of Injuries	Hours	Incidence Rate per 200,000 Hours	Odds Ratio	95% Confidence Interval	
Frozen	12	242,126	9.91	1.00*		
Refrigerated	5	42,109	23.75	3.028	.935	9.801
Normal	21	242,126	17.35	1.908	.893	4.076
Total	38	526,361	14.44			

* Frozen temperature condition was chosen as the comparison for the odds ratio.

Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs of picking, stocking, and loading for a food distribution company located in the Southeast United States?

A chi square analysis was performed on the job categories to determine if there was a significant difference in the job categories and the reporting of injury/illness events. An analysis was run to generate the expected number calculated representing the percent employed at that job category. The chi square test, using the .05 level of significance, found a significant difference between the job categories of pickers, stockers, loaders, and drivers. The p-value for this test was less than .001. The results are provided in Table 4-18.

A chi square analysis was also performed on the warehouse and transportation division. The chi square test, using the .05 level of significance, concluded that there was a significant difference between the divisions (warehouse and transportation) and the reporting of injury/illness events. This test was performed using the expected number of warehouse injury/illness events to be 44.5 percent (the number of employees in the warehouse division) and 55.5 percent expected for transportation. The results are provided in Table 4-19.

The majority of the workers in the food distribution company studied were involved with a task related to lifting. Workers lifted, lowered, pushed/pulled, or carried food products throughout their shift. Of the injury/illness events analyzed for the ten year period, 163 (62 percent) of the workers were performing a type of task involving lifting

Table 4-18. Chi Square Analysis of Injury/Illness Events Reported by Job Category for Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Job Category	Observed	Expected*	Residual
Picker	72	44.4	27.6
Loader	36	31.8	4.2
Stocker	29	40.8	-11.8
Driver	126	146.0	-20
Total	263		
Chi Square = 23.755 p<.001			

* The expected numbers were generated from the percentage of workers employed in the job categories.

Table 4-19. Chi Square Analysis of Injury/Illness Events Reported by Division at the Food Distribution Company for the Years 1990-1999

Division	Observed	Expected*	Residual
Warehouse	138	118.5	19.5
Transportation	125	144.5	-19.5
Total	263		
Chi Square = 5.852 p<.016			

* The expected numbers were generated from the percentage of workers employed in the division.

Table 4-20. Frequency of Injuries/Illnesses Reported Associated with a Lifting Task for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Lifting Task	Frequency	Percent
No	100	38.0
Yes	163	62.0
Total	263	100.0

when the injury/illness event was reported. The data analysis is provided in Table 4-20. The highest frequency of lifting tasks reported was actual lifting. The second was pushing or pulling an object, and the third was lowering an object. The data analysis is provided in Table 4-21.

Drivers reported the most injury/illness events twice as much when they were performing some type of lifting task. Drivers had 42 injury/illness events associated without a lifting activity and 84 injury/illness events with a lifting activity. Stockers reported 15 injury/illness events while performing lifting tasks and 14 injury/illness events while not performing a lifting task. The data analysis is provided in Table 4-22. Loaders reported a greater number of injury/illness events associated with lifting than any other task. Pickers had a high lowering task and reported 18 injury/illness events associated with the task of lowering. The data analysis is provided in Table 4-23.

The job categories (pickers, stockers, loaders, and drivers) were analyzed by a Kruskal-Wallis test to determine if a significant difference in the ranks of the categories by length of employment before reporting an injury/illness event. The test calculated a chi

Table 4-21. Frequency of Injuries/Illnesses Reported by Task Being Completed before Injury for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Task Before Injury	Frequency	Percent
Lifting	76	28.9
Push/Pull	37	14.1
Lowering	34	12.9
Carrying	11	4.2
Repetitive Motion	1	.4
Other (non-lifting)	104	39.5
Total	263	100.0

Table 4-22. Frequency of Injuries/Illnesses Reported by Job and Lifting Task for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

	Lift Task		
Job Category	No	Yes	Total
Picker	29	43	72
Loader	15	21	36
Stocker	14	15	29
Driver	42	84	126
Total	100	163	263

Table 4-23. Frequency of Injuries/Illnesses Reported by Workers by Task for the Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990 - 1999

Job Category	Task Before Injury						Total
	Push/ Pull	Lifting	Lowering	Carrying	Repetitive Motion	Other	
Picker		25	18			29	72
Loader		17	4			15	36
Stocker		8	4	2		15	29
Driver	37	26	8	9	1	45	126
Total	37	76	34	11	1	104	263

square of 20.390 and a p value of less than .001. There was a significant difference between the length of employment before reporting an injury/illness event and the different job categories. The mean rank calculated that loaders have the lowest rank and stockers have the highest rank. The results of the Kruskal-Wallis test are provided in Table 4-24.

Each job category was compared to the other job categories individually by the Mann-Whitney test. The Mann-Whitney test calculated that loaders and pickers were significantly different than drivers and stockers based upon length of employment before reporting an injury/illness event. Mann-Whitney test results are provided in Tables 4-25, 4-26, 4-27, 4-28, 4-29, and 4-30. Loaders were employed the least amount of days before reporting an injury/illness event with a mean of 288 days (9 months). Stockers and drivers were employed 1,445 days (48 months) and 1,501 days (50 months) before reporting an injury/illness event, respectively. The average number of days for each job category before reporting an injury/illness event are provided in Table 4-31.

Table 4-24. Kruskal-Wallis Test of Injury/Illness Events Reported by Job Category for Warehouse and Transportation Workers at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank
Stocker	13	102.69
Loader	22	55.14
Picker	49	65.90
Driver	76	93.46
Chi Square = 20.390 $p<.001$		

Table 4-25. Mann-Whitney Test of Length of Employment before Injury/Illness Event Reported by Pickers and Drivers at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank	Sum of Ranks
Picker	49	50.09	2454.50
Driver	76	71.31	5420.50
Mann-Whitney U = 1229.5 $p = .001$			

Table 4-26. Mann-Whitney Test of Length of Employment before Injury/Illness Event Reported by Pickers and Loaders at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank	Sum of Ranks
Picker	49	37.49	1837.00
Loader	22	32.68	719.00
Mann-Whitney U = 466.0 $p = .354$			

Table 4-27. Mann-Whitney Test of Length of Employment before Injury/Illness Event Reported by Pickers and Stockers at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank	Sum of Ranks
Picker	49	28.32	1387.50
Stocker	76	43.50	565.50
Mann-Whitney U = 162.5 p = .007			

Table 4-28. Mann-Whitney Test of Length of Employment before Injury/Illness Event Reported by Drivers and Loaders at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank	Sum of Ranks
Driver	76	54.76	4162.00
Loader	22	31.32	689.00
Mann-Whitney U = 436.0 p = .001			

Table 4-29. Mann-Whitney Test of Length of Employment before Injury/Illness Event Reported by Drivers and Stockers at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank	Sum of Ranks
Driver	76	44.38	3372.50
Stocker	13	71.31	632.50
Mann-Whitney U = 446.50 p = .581			

Table 4-30. Mann-Whitney Test of Length of Employment before Injury/Illness Event Reported by Loaders and Stockers at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean Rank	Sum of Ranks
Loader	22	14.14	311.00
Stocker	13	24.54	319.00
Mann-Whitney U = 58.0 p = .004			

Table 4-31. Average Number (Mean) of Days of Employment before Injury/Illness Event Reported by Job Category (Loader, Picker, Stocker, and Driver) at the Food Distribution Company for the Years 1990-1999

Job Category	N	Mean	Standard Deviation
Loader	22	288.4	554.25
Picker	49	403.1	700.9
Stocker	13	1,445.5	2,350.1
Driver	76	1,501.9	2,670.9

The biomechanical models for the three warehouse job categories (picker, stocker, and loader) were calculated to determine how well the 1981 NIOSH lifting equation and 1991 NIOSH lifting equation would predict the risk for these three job categories. Appendix A gives the assumptions and instructions that were used to calculate the 1981 NIOSH lifting calculations. Based on the 1981 NIOSH lifting calculations, all three job categories had an action limit that were below 15 lbs. The average weight lifted for these job categories was 25 lbs. Based on the calculations, all of these jobs were at risk for injuries. The results of the 1981 NIOSH lifting equations are provided in Table 4-32.

Table 4-32. 1981 National Institute for Occupational Safety and Health (NIOSH) Lifting Calculations for the Job Categories of Warehouse Workers at the Food Distribution Company

	Stocker		Picker		Loader	
	Lift to Bottom Rack	Lift to Top Rack	Lift from Bottom Rack	Lift from Top Rack	Lift to Truck Bottom	Lift to Middle of Truck
H_1	18"	18"	18"	18"	15"	15"
V_2	4"	4"	4"	52"	14"	14"
D_3	10"	48"	10"	38"	14"	34"
F_4	4	4	4	4	6	6
F_{max4}	12	12	12	12	12	12
AL_5	14.80 lbs	11.29 lbs	14.80 lbs	12.15 lbs	13.82 lbs	11.92 lbs
MPL_6	44.40 lbs	33.86 lbs	44.40 lbs	36.45 lbs	31.47 lbs	35.75 lbs

Note: The equations and explanations are defined in Appendix A.
$_1$ H = horizontal variable
$_2$ V = vertical variable
$_3$ D = distance variable
$_4$ F and F_{max} = frequency variable
$_5$ AL = action limit
$_6$ MPL = maximum permissible limit

The 1991 NIOSH lifting calculations also have been calculated to determine how this equation would predict the risk for the three job categories of warehouse workers. The recommended weight limits were all less than 12 lbs. The lifting indexes were calculated to be 2.15 and 3.55 times the recommended weight limit. The results of the1991 NIOSH lifting equations are provided in Table 4-33.

The incidence rate per 200,000 hours was 5.43 for stockers, 18.13 for pickers, and 21.71 for loaders. The odds ratio calculated that pickers were 3.846 (1.390, 10.643) times more likely to report an injury/illness event than stockers. The odds ratio also calculated that loaders were 4.856 (1.608, 14.667) times more likely to report an injury/illness event than stockers. The results of the odds ratio analysis for job category are provided in Table 4-34.

Summary

This chapter provided findings and analysis of the injury/illness events reported to the food distribution company from the years 1990-1999. The demographic and descriptive information of the injury/illness events have been included in this Chapter. The statistical tests and significance are summarized in Tables 4-35, 4-36, 4-37, and 4-38.

Table 4-33. 1991 National Institute for Occupational Safety and Health (NIOSH) Lifting Calculations for the Job Categories of Warehouse Workers at the Food Distribution Company

	Stocker		Picker		Loader	
	Lift to Bottom Rack	Lift to Top Rack	Lift from Bottom Rack	Lift from Top Rack	Lift to Truck Bottom	Lift to Middle of Truck
$H_{origin1}$	18"	18"	18"	18"	15"	15"
$V_{origin2}$	4"	4"	4"	52"	14"	14"
H_{dest1}	18"	18"	15"	15"	10"	10"
V_{dest2}	4"	52"	14"	38"	0"	48"
D_3	10"*	48"	10"*	10"*	14"	34"
$A_{origin4}$	60	60	60	60	0	0
A_{dest4}	60	60	60	60	0	0
F_5	4	4	4	4	6	6
$Coupling_6$	Poor	Poor	Poor	Poor	Poor	Poor
RWL $Origin_7$	8.29 lbs	7.11 lbs	8.29 lbs	8.60 lbs	7.66 lbs	7.05 lbs
RWL $dest_7$	8.29 lbs	7.38 lbs	10.88 lbs	11.62 lbs	10.12 lbs	10.40 lbs
Index $origin_8$	>1 (3.01)	>1 (3.52)	>1 (3.01)	>1 (2.91)	>1 (3.26)	>1 (3.55)
Index $dest_8$	>1 (3.01)	>1 (3.39)	>1 (2.30)	>1 (2.15)	>1 (2.47)	>1 (2.40)

* The Distance factor was 0", but for the calculation 10" was used. D>10 is assumed according to NIOSH.

Note: The equations and explanations are defined in Appendix B.

1 H = horizontal modifier at origin or destination of lift
2 V = vertical modifier at origin or destination of lift
3 D = distance modifier
4 A = angle modifier at origin or destination of lift
5 F = frequency modifier
6 Coupling = Coupling modifier
7 RWL = recommended weight limit at origin or destination of lift
8 Index = lifting index at origin or destination of lift

Table 4-34. Warehouse Workers Incidence Rates by Job Category at the Food Distribution Company with Odds Ratios and 95% Confidence Intervals for the Years 1996-1999

Job Category	No. of Injuries	Hours	Incidence Rate per 200,000 Hours	Odds Ratio	95% Confidence Interval	
Stocker	5	184,226	5.43	1.00*		
Picker	21	231,599	18.13	3.846	1.390	10.643
Loader	12	110,536	21.71	4.856	1.608	14.667
Total	38	526,361	14.44			

* Stockers were chosen as the comparison for the odds ratio.

Table 4-35. Summary of Statistical Analyses Results for Research Question 1: Do the three months of production reporting the greatest number of hours reflect the months also reporting the greatest frequency of injury/illness rates for workers performing lifting tasks in a food distribution company located in the Southeast United States?

Statistical Test Performed	Variables Analyzed for Research Question 1	Results (P value)
T-test	Cases stocked per month	p = .916
Analysis of Variance (ANOVA)	Cases picked and loaded per month	p = .211
	Cases per hour on day shift	p = .245
	Cases per hour on night shift	p = .502
	Drivers' cases loaded per month	p = .380
	Drivers' cases per day	p = .045*
	Drivers' miles driven	p = .517
	Overtime hours worked per month day shift	p = .899
	Overtime hours worked per month night shift	p = .108
	Drivers' hours worked per month	p = .830

* denotes statistical significance

** while this analysis seems to be significant, the R^2 value explains only 15 percent of the variability.

Table 4-35 (continued).

Statistical Test Performed	Variables Analyzed for Research Question 1	Results (P value)
Linear Regression	Overtime hours worked per month day shift and cases stocked per month	p = .974 R^2 = .001 (explains less than 1 percent)
	Overtime hours worked per month night shift and cases loaded per month	p = .021** R^2 = .158 (explains only 15 percent)
	Hours worked per month for drivers and cases loaded per month	p = .353 R^2 = .045 (explains less than 4 percent)
Chi Square	Months of the year	p = .191

* denotes statistical significance

** while this analysis seems to be significant, the R^2 value explains only 15 percent of the variability.

Table 4-36. Summary of Statistical Analyses Results for Research Question 2: Is there a difference in the cost of injuries/illnesses and/or the rate of injury between workers performing lifting tasks at a specific food distribution company located in the Southeast United States and the reported average for workers in the United States food distribution industry?

Statistical Test Performed	Variables Analyzed for Research Question 2	Results (P value)
Odds Ratio	Shift (day and night)	day = 1.00 night = 1.538 (.643, 3.682)

* denotes statistical significance

Table 4-37. Summary of Statistical Analyses Results for Research Question 3: Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company located in the Southeast United States?

Statistical Test Performed	Variables Analyzed for Research Question 3	Results (P value)
Odds Ratio	Temperature conditions (normal, refrigerated, and frozen)	frozen = 1.00 refrigerated = 3.028 (.935, 9.801) normal = 1.908 (.893, 4.076)

* denotes statistical significance

Table 4-38. Summary of Statistical Analyses Results for Research Question 4 Continued: Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs of picking, stocking, and loading for a food distribution company located in the Southeast United States?

Statistical Test Performed	Variables Analyzed for Research Question 4	Results (P value)
Chi square	Job category (picker, loader, stocker, and driver)	$p < .001$*
	Division (warehouse and transportation)	$p = .016$*
Odds Ratio	Temperature conditions (normal, refrigerated, and frozen)	frozen = 1.00 refrigerated = 3.028 (.935, 9.801) normal = 1.908 (.893, 4.076)
	Job category for warehouse workers (picker, loader, and stocker)	stocker = 1.00 picker = 3.846 (1.390, 10.643) loader = 4.856 (1.608, 14.667)
Kruskal Wallis Test (Chi Square)	Duration of employment before injury and job category	$p < .001$*

* denotes statistical significance

Table 4-38 (continued).

Statistical Test Performed	Variables Analyzed for Research Question 4	Results (P value)
Mann-Whitney Test	Duration of employment before injury rank between picker and driver	p = .001*
	Duration of employment before injury rank between picker and stocker	p = .007*
	Duration of employment before injury rank between picker and loader	p = .364
	Duration of employment before injury rank between stocker and driver	p = .581
	Duration of employment before injury rank between stocker and loader	p = .004*
	Duration of employment before injury rank between loader and driver	p = .001*

* denotes statistical significance

CHAPTER V

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Findings

Based on the data collected in this study, the following findings were found.

Demographic information

1. There were a total of 263 injury/illness events reported between the years 1990 and 1999.
2. The day shift reported 137 injury/illness events compared with 126 injury/illness events reported for the night shift.
3. The warehouse division employed an average of 92 employees (44.5 percent) and the transportation division employed an average of 115 drivers (55.5 percent).
4. While making up almost 55.5 percent of the employees, drivers reported 47.9 percent (126 of the 263) of the injury/illness events.
5. While making up almost 44.5 percent of the employees, the warehouse division (pickers, loaders, and stockers) reported 53.1 percent (138 of the 263) of the injury/illness events.
6. Pickers had the highest injury/illness events of the warehouse workers with 72 occurrences reported (27.4 percent).

7. Loaders reported 36 (13.7 percent) and stockers reported 29 (11.0 percent) of the injury/illness events.

8. The most reported body part injured was the back, with 61 injury/illness events (23.2 percent).

9. Ankle injuries were the second highest body part injured, with 34 injury/illness events (12.9 percent).

10. The most reported injury/illness event was strain/sprain, with 126 occurrences (47.9 percent).

11. Contusions and bruises were reported as the second highest injury/illness event, with 79 injury/illness events (27 percent).

12. The most common cause of injury/illness events reported was overexertion, with 79 occurrences (30 percent).

13. Slips/trips/falls on the same elevation was the second highest reported, with 48 occurrences (18.3 percent).

14. Seventeen percent of the injury/illness events were reported during the first month of employment.

15. Fifty-four percent of the injury/illness events were reported by workers during the first six months of employment.

16. Seventy-four percent of the injury/illness events were reported by workers during the first year of employment.

Do the three months of production reporting the greatest number of hours reflect the months also reporting the greatest frequency of injury/illness rates for workers performing lifting tasks in a food distribution company located in the Southeast United States?

1. A chi square analysis found no significant difference between reporting an injury/illness event and the months of the year using a .05 level of significance.
2. The months of March, June, and September were found to be the three highest workload months for cases received, stocked, and shipped, as well as overtime hours worked for the years 1996-1999.
3. The months of September, April, and February reported the three highest numbers of injury/illness events reported for the years 1996-1999.
4. The linear regression analyses did not predict that an increase in injury/illness events would be associated with an increase in overtime hours worked and cases stocked for the day shift.
5. The linear regression analyses did not predict that an increase in injury/illness events would be associated with an increase in overtime hours worked and cases loaded for the night shift.
6. The linear regression analyses did not predict that an increase in injury/illness events would be associated with an increase in overtime hours worked and cases loaded for the transportation workers.

Is there a difference in the cost of injuries/illnesses and/or the rate of injury between workers performing lifting tasks at a specific food distribution company in the Southeast United States and the reported average for workers in the United States food distribution industry?

1. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found to be 14.44. The food distribution company studied was found to have 3.84 more injury/illness events for each 200,000 hours worked than the national average of 10.6 for food distribution companies.
2. The injury/illness incidence rate generated for 200,000 hours worked was found to be 10.68 for the day shift and 15.68 for the night shift. The night shift was found to have five more injury/illness events for each 200,000 hours worked than the day shift.
3. An employee on the night shift was found to be 1.538 (.643, 3.682) times more likely to report an injury/illness event than an employee on the day shift.
4. The cost calculated for the warehouse division of the food distribution company studied was found to be $453,744 more than the average food distribution company over the past ten years.
5. The injury/illness incidence rate generated for 200,000 hours was found to be 10.2 for the drivers in the transportation division, which was slightly higher than the national average of 10.0 for transportation industries. The

drivers were found to have .2 more injury/illness events for each 200,000 hours worked than the national average.

6. The cost for injury/illness workers' compensation costs was calculated for the transportation division of the food distribution company studied was $37,757 more than the average food distribution company over the past ten years.

7. The costs of injuries for the food distribution company studied were estimated to cost $2,758,344 by using $10,488 per injury and $2,610,862 by using an itemized cost per body part for the years 1990-1999.

Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers who perform lifting tasks in the normal, refrigerated, and frozen temperature conditions for a food distribution company located in the Southeast United States?

1. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found to be 9.91 for the frozen temperature condition. This was a lower rate than the normal and refrigerated temperature conditions.

2. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found to be 23.75 for the refrigerated temperature condition. The refrigerated temperature condition workers were found to have 13.84 more

injury/illness events for each 200,000 hours worked than the frozen temperature workers.

3. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found to be 17.3 for the normal temperature condition. The normal temperature condition workers were found to have 7.44 more injury/illness events for each 200,000 hours worked than the frozen temperature workers.

4. An employee who worked in the refrigerated temperature condition was found to be 3.028 (.935, 9.801) times more likely to report an injury/illness event than an employee who worked in the frozen temperature condition.

5. An employee who worked in the normal temperature condition was found to be 1.908 (.893, 4.076) times more likely to report an injury/illness event than an employee who worked in the frozen temperature condition.

Is there a significant difference or association between the number of injury/illness events reported by groups of food distribution warehouse workers performing the jobs of picking, stocking, and loading for a food distribution company located in the Southeast United States?

1. A significant difference was found between the number of injury/illness events among the employees working in the job categories (picking, loading, stocking, and driving) using a .05 level of significance.

2. A significant difference was found between the number of the injury/illness

events reported between employees in the warehouse and transportation divisions using a .05 level of significance.

3. When all injuries were reported, 62 percent (163 out of 263) of all the injury/illness events involved a lifting task prior to the injury/illness event for the food distribution company studied.
4. A significant difference between the length of employment before reporting an injury/illness event and the different job categories of picking, loading, stocking, and driving was found using the Kruskal-Wallis test.
5. A Mann-Whitney Test was performed which calculated that pickers and loaders were found to be significantly different than stockers and drivers in the length of employment before reporting an injury/illness event.
6. Loaders reporting injury/illness events were found to have worked the shortest number of days [an average of 288 days (9 months)] before experiencing an injury.
7. Pickers reporting injury/illness events were found to have worked an average of 403 days (13 months) before experiencing an injury. The average work time was longer than loaders, but shorter than stockers.
8. Stockers reporting injury/illness events were found to have worked the longest period of time prior to experiencing an injury with an average of 1,445 days (48 months).
9. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found

to be 5.43 for stockers.

10. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found to be 18.13 for pickers. Pickers were found to have 7.53 more injury/illness events for each 200,000 hours worked than the national average of 10.6 for food distribution companies. The pickers were found to have 12.7 more injury/illness events for each 200,000 hours worked than the stockers.

11. The injury/illness incidence rate generated for 200,000 hours worked for the warehouse division of the food distribution company studied was found to be 21.71 for loaders. Loaders were found to have 11.11 more injury/illness events for each 200,000 hours worked than the national average of 10.6 for food distribution companies. The loaders were found to have 16.28 more injury/illness events for each 200,000 hours worked than the stockers.

12. The 1991 NIOSH lifting calculations determined that stockers have 3.01 to 3.52 times the risk of injury based on the level of physical stress associated with a particular manual lifting task.

13. The 1991 NIOSH lifting calculations determined that pickers have 2.15 to 3.01 times the risk of injury based on the level of physical stress associated with a particular manual lifting task.

14. The 1991 NIOSH lifting calculations determined that loaders have 2.40 to

3.55 times the risk of injury based on the level of physical stress associated with a particular manual lifting task.

15. Pickers were found to be 3.846 (1.390, 10.643) times more likely to report an injury/illness event than stockers.

16. Loaders were found to be 4.856 (1.608, 14.667) times more likely to report an injury/illness event than stockers.

Conclusions

Based upon the findings of this study, the following conclusions were made.

1. No difference was found in injury/illness events reported during the three highest months of production and other months of the year for workers performing lifting tasks in a food distribution company located in the Southeast United States for the years 1996-1999.

2. The food distribution company warehouse division studied had a significantly higher incidence rate (14.44 compared to 10.2) and cost ($115,368 higher) associated with the injury/illness events than the transportation division. The warehouse divisions' incidence rate of 14.44 was found to have 3.84 more injury/illness events for each 200,000 hours worked than the national average of 10.6 for food distribution companies, and cost associated with the injury/illness events was $453,744 higher than the national average.

3. There was a significant difference in the injury/illness events reported

among warehouse workers in normal, refrigerated, and frozen temperature conditions for a food distribution company located in the Southeast United States.

4. Stockers reporting an injury/illness event were found to have worked five times longer prior to experiencing an injury than loaders. Loaders experienced an injury after an average of only 9 months of employment, while stockers experienced an injury after an average of 48 months of employment. The rate of reported injury/illness events for loaders were 4.856 more injury/illness events reported than stockers. Loaders were found to have 7.53 more injury/illness events for each 200,000 hours worked than the national average of 10.6 for food distribution companies. The warehouse workers were lifting greater amount of weight per lift than the NIOSH lifting recommendations. Loaders and stockers were lifting over three times the recommended weight per lift using the NIOSH lifting equations. Pickers were lifting over two times the recommended weight per lift using the NIOSH lifting equations.

Recommendations

Based upon the findings, conclusions, and literature review of the study, the following recommendations were made.

1. While no significant difference was found between injury/illness events reported within the three months with the highest production within the

three years studied, the association between increased workload and overtime and injury/illness events remain an important issue. A large variation in one of those years may have caused the results of this question to skew the data. The lack of availability of data reporting volumes and hours worked per profession for a greater number of years may have greatly limited the ability to further analyze this data. It is recommended that companies retain the data on cases loaded and hours worked for ten years, thus allowing a larger sample. A longitudinal retrospective study needs to be conducted on individual workers as well as on groups of workers. This type of data will allow future research to assess the possible association among hours worked, cases lifted, and the number of injury/illness events reported more effectively. The total lack of availability of data for individuals and the availability of only three years by group severely limited the ability of the research to answer this question effectively in the current study.

2. Since warehouse workers had significantly more injury/illness events than the transportation division and the national average for the food distribution industry, a comprehensive injury/illness prevention program to reduce injuries/illnesses and their cost needs to be evaluated and implemented to focus on warehouse workers.

3. While there was a significant difference among workers in the normal, refrigerated, and frozen temperature conditions, the greater number of

injury/illness events were experienced by all loaders compared to the stockers and pickers. This would indicate that loaders from all temperature conditions should receive priority training on prevention programs. In this study the employees in the frozen temperature conditions were found to have a longer work history, higher pay, and lower injury/illness rates than the workers in the normal and refrigerated temperature conditions. While other studies have found that workers in the frozen temperature conditions tend to report more injury/illness events, the overriding factor for this study was job category and length of employment rather than temperature conditions. A larger sample of each distribution (length of employment) in all temperature conditions for each job category needs to be conducted.

4. Since length of employment was such a major factor for reporting injury/illness events, new worker training needs to conducted. A special emphasis needs to be placed targeting loaders. A more in-depth job analysis needs to be performed, and common training needs to be performed for pickers and stockers in the areas common to work movement and lifting. The food distribution industry and warehousing industries may need to take a further look at how much a person needs to lift. According to the findings, a reduction of over 50 percent needs to be performed per lift for all job categories. The food distribution industry needs to look at using smaller boxes or smaller cases to reduce this weight per lift.

CHAPTER VI

THE STUDY IN RETROSPECT

Introduction

This Chapter addresses the study in retrospect. A discussion of the quality of available data within the industry, future research needs, a discussion of biomechanical models, and findings for future study are provided to assist future researchers to both replicate and improve the research topic addressed in this study.

Quality of Available Data

Injury and illness data from private organizations are very difficult to obtain and also difficult to analyze. By not collecting the information directly from employers, it is very difficult to get consistent, fully completed data. Data from companies–while not perfect–are extremely useful, regardless of these inconsistencies. An important aspect that this study had to contend with was the differences in data that were collected. The injury/illness data were collected for 10 years (1990-1999), and the production and hours worked data were collected for only 3 years (1996-1999). The production and hours worked data were not obtainable for all 10 years.

Analyzing injury/illness data are used for many aspects of safety prevention. Companies need to realize that the collection of this data is extremely important. Data need to be collected for all aspects of the work operation. Lifting has become such an important aspect of injury prevention, yet the injury/illness data collection for lifting tasks have been limited.

Future Research Needs

The literature review revealed that there was a significant difference in the amount of injury/illness events reported in workers who perform activities in frozen environments than in normal environments. The findings and conclusions of this study seem to determine that workers in frozen temperature conditions have the least amount of injury/illness events reported. After further analysis, it was concluded that the warehouse workers who work in the frozen temperature conditions are paid more and tend to be the more experienced workers.

Additional research needs to be conducted on job rotation within different temperature conditions. While this study did not show the frozen environment as the cause for the highest injury rate, in the literature it was very significant that workers in the frozen environments yield a higher injury rate. Studies need to be performed on how job rotation could be used either daily or even hourly so employees are not burdened by the same temperature.

Discussion of Biomechanical Models

The biomechanical models seem to explain why the incidence rates were more than the industry average for warehouse workers. The loads that were consistently lifted were much higher than the action limits or range from the biomechanical model. This could explain why there seems to be such a significant difference in the incidence rates.

An important concept to consider is the physical characteristics of workers. Workers should be characterized as occupational athletes. The workers at the food distribution industry studied performed lifting activities at a constant rate throughout the day. The job categories of picking, loading and stocking can be very stressful to the body. There needs to be a type of physical assessment and conditioning program to first determine if the employee can conduct the lifting tasks, and also to condition the worker to prevent injury/illness events.

The issue of overtime is a very complex part of many occupations. At various labor intensive and lifting occupations, the use of overtime can put the employee at risk for more lifting and cumulative trauma to the body. The hiring of part time workers could reduce this burden. A study evaluating the hiring of temporary employees need to be assessed instead of burdening the employee to work more overtime.

Findings for Future Study

Gardners' study indicated that workers with the greatest physical work requirement and those with the shortest duration of employment are at the highest risk for back injury (Gardner et al., 1999). This trend of injuries within a short duration of employment was found in this study. The injury/illness events were reported very early, with 74 percent of the injury/illness events arising within the first year of employment. A comprehensive study focusing on duration of employment and lifting activities needs to be conducted to determine the risk for injury/illness events for different job categories within warehousing operations. Proactive prevention training programs need to be evaluated and implemented for warehousing operations to prevent the injury/illness events from occurring.

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APPENDICES

APPENDIX A

APPENDIX A

1981 NIOSH Lifting Equation (NSC, 1992, p. 118-119)

The lifting equation established by NIOSH incorporates the major task variables that an analyst identifies and quantifies during the job study. The equation for determining the action limit (AL) and maximum permissible limit (MPL) are:

$$AL\ (lb) = 90(6/H)(1-0.01|V-30|)(0.7+3/D)(1-F/Fmax)$$

$$MPL = 3\ (AL)$$

The variables in the lifting equation are:

H = Horizontal distance measured between center of handgrasp and midpoint between ankles at the start of lift. It is assumed to be between 6 inches and 32 inches. Generally, objects cannot be brought closer to the spine than 6 inches, because of body interference, nor further than 32 inches, because objects beyond this distance cannot be reached by most people.

V = Vertical distance measured between handgrasp and floor or standing surface at the beginning of the lift. This distance is assumed to be between 0 and 70 inches, which represents the range of vertical reach for most people.

D = Vertical travel distance between origin and destination of lift. This distance is assumed to be between 10 inches and 80 inches. If the vertical travel distance is less than 10 inches, set D = 10 inches in the equation.

F = Frequency of lift or the number of lifts per minute. Frequency is assumed to be between one lift every fine minutes (F = 0.2) and frequency maximum (Fmax). For lifting less frequently than once per five minutes, set F = 0.

Fmax = Maximum frequency that can be sustained based on lifting duration. To determine Fmax, select column A or B depending upon the vertical distance (V) variable at the beginning of the lift. Next, select the time period (such as one hour or eight hours) that closely approximates the duration of the lifting period and then select the Fmax value located under the column previously selected.

Other measurements:

- Object weight – if the weight of the object varies, record the average and maximum weights. For the analyses, the object weight was averaged to be 25 lbs.
- Hand location: origin – record the horizontal (H) and vertical (V) distance measurements at the beginning of the lift.
- Hand location: destination – record the horizontal (H) and vertical (V) distance measurements at the end of the lift.
- Task frequency – record the average number of lifts per minute. Task duration such as one hour or eight hours also should be noted.

APPENDIX B

APPENDIX B

1991 NIOSH Lifting Equation (Kohn, 1997, p. 20-21)

The revised NIOSH lifting equation (1991) can be used to determine the recommended weight limit (RWL) for manual material handling tasks. To calculate the RWL for a task, one would use the following equation:

$$RWL = (LC)(HM)(VM)(DM)(AM)(FM)(CM)$$

RWL = recommended weight limit

LC = load constant, which is 51 lbs.

HM = horizontal multiplier calculated as 10/H where H is the horizontal of the hands from the midpoint between the ankles.

VM = vertical multiplier calculated as [1-(0.0075\V-30\)] where V is the vertical location of the hands from the floor, measured as the origin and destination of the lift.

DM = distance multiplier calculated as [0.82 + 1.8/D] where D is the vertical travel distance between the origin and the destination of the lift.

AM = asymmetric multiplier calculated as [1-(0.0032A)] where A is the angle of symmetry, the angular displacement of the load from the sagittal plane; measure at the origin and destination of lift.

FM = frequency multiplier as determined from NIOSH table where F is the average frequency rate of lifting measured in lifts/min; duration is defined to be either 1 hour, 2 hours, or 8 hours assuming appropriate recovery allowances.

CM = coupling multiplier as determined from NIOSH table.

Applications Manual for the Revised Lifting Equation (Waters, Putz-Anderson, & Garg, 1994, p. 4-5)

The recommended weight limit (RWL) is the principal product of the revised NIOSH lifting equation. The RWL is defined for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (e.g., up to 8 hours) without an increased risk of developing lifting-related low back pain. By healthy workers, we mean workers who are free of adverse health conditions that would increase their risk of musculoskeletal injury.

The lifting index (LI) is a term that provides a relative estimate of the level of physical stress associated with a particular manual lifting task. The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit. The LI is defined by the following equation:

$$LI = \frac{\text{Load Weight *}}{\text{Recommended Weight Limit}}$$

*Load Weight is the weight of the object to be lifting in lbs. For the purpose of the analyses the load weights was averaged to be 25 lbs.

Complete 1991 NIOSH Lifting Equation

$$RWL = 51\{(10/H)[1-(0.0075\backslash V-30\backslash)][0.82 + (1.8/D)][1-(0.0032A)](FM)(CM)\}$$

APPENDIX C

Table C-1. T-Test for Day Shift Cases Stocked Per Month and Injury/Illness Events

	Number of Injuries	Average Cases Per Month
No Injury	38	698,346
One Injury	7	691,792
t = .106, df = 43, p = .916		

Table C-2. Cases Per Hour Stocked on the Day Shift and Injury/Illness Events

	Average Cases Per Hour	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	181.0	2.611	175.7	186.2
One Injury	188.8	6.083	176.5	201.1
F (1,43) = 1.392 p = .245				

Table C-3. Night Shift Cases Picked and Loaded Per Month and Injury/Illness Events

	Average Cases Per Month	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	767,697	30,395	706,313	829,081
One Injury	658,331	41,298	574,926	741.736
Two Injuries	755,396	60,790	632,627	878,164
Three or More	730,380	105,291	517,739	943,021
F (3, 41) = 1.569 p = .211				

Table C-4. Night Shift Cases Per Hour Picked and Loaded and Injury/Illness Events

	Average Cases Per Hour	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	64.5	.548	63.4	65.6
One Injury	63.4	.744	61.9	64.9
Two Injuries	63.2	1.095	61.0	65.4
Three or More	63.1	1.897	59.3	66.9
F (3,41) = .798 p = .502				

Table C-5. Drivers Cases Loaded and Stocked and Injury/Illness Events

	Average Cases Per Month	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	756,897	31,591	693,097	820,696
One Injury	672,314	42,020	587,453	757,176
Two Injuries	776,020	61,851	651,107	900,932
Three or More	723,780	87,471	547,127	900,433
F (3,41) = 1.051 p = .380				

Table C-6. Drivers Cases Per Day Loaded and Stocked and Injury/Illness Events

	Average Cases Per Day	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	524.3	10.8	502.4	546.1
One Injury	494.1	14.3	465.1	523.1
Two Injuries	542.3	21.1	499.5	585.0
Three or More	582.3	29.9	521.9	642.8
$F(3, 41) = 2.932$ $p = .045$				

Table C-7. Miles Driven in a Month and Injury/Illness Events

	Average Miles Driven in a Month	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	474,504	22,918	428,218	520,789
One Injury	419,551	30,484	357,986	481,117
Two Injuries	469,614	44,872	378,993	560,236
Three or More	432,184	63,459	304,026	560,343
$F(3,41) = .771$ $p = .517$				

Table C-8. Day Overtime Hours and Injury/Illness Events

	Average Overtime Hours Per Month	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	314.4	30.3	253.2	375.6
One Injury	324.2	70.7	70.7	466.9
$F(1,43) = .016$ $p = .899$				

Table C-9. Night Overtime Hours and Injury/Illness Events

	Average Overtime Hours Per Month	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	1,721.2	138.4	1,441.6	2,000.8
One Injury	1,764.3	188.0	1,384.5	2,144.2
Two Injuries	2,492.8	276.8	1,933.6	3,051.9
Three or More	1,831.5	479.5	863.0	2,799.9
$F(3,41) = 2.152$ $p = .108$				

Table C-10. Transportation Hours and Injury/Illness Events

	Average Hours Per Month	Std. Error	95% Confidence Intervals	
			Lower Bound	Upper Bound
No Injury	20,157	743	18,655	21,658
One Injury	19,115	988	17,118	21,112
Two Injuries	20,310	1,455	17,370	23,250
Three or More	19,340	2,058	15,183	23,498
$F(3,41) = .294$ $p = .830$				

VITA

Jeffrey Scott Oakley, son of Joe Pat and Judy Oakley, was born October 7, 1970 in Paducah, Kentucky. In 1993, Jeff graduated from Murray State University with a Bachelor of Science in Occupational Safety and Health. He worked as a safety engineer with Battelle Memorial Institute at the Pantex Plant in Amarillo, Texas and later as a safety engineer/researcher for Battelle Memorial Institute Corporate Operations. Jeff was married to Amanda Hargrove Oakley in 1994 and has two dogs, Raleigh Abigail and Maggie May. While with Battelle, Jeff earned a Masters Degree in Industrial and Systems Engineering from Auburn University. He entered The University of Tennessee to pursue a Doctor of Philosophy Degree in 1998. While enrolled in the Doctoral Program, he worked as a graduate teaching associate for the Department of Health and Safety Sciences. In 1999, he received the Outstanding Graduate Teaching Associate for the Department. He received the Ph.D. in August, 2000 and accepted a faculty position at the University of Houston - Clear Lake in Houston, Texas. He is currently a Certified Safety Professional and a member of the American Society of Safety Engineers.