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Characterization of Top Three nonfatal Occupational Injuries, 2012-2014

Levent Onat
University of Alabama at Birmingham

CHARACTERIZATION OF TOP THREE NONFATAL OCCUPATIONAL INJURIES, 2012-2014

by

LEVENT ONAT

SELVUM PILLAY, COMMITTEE CHAIR
DONALD S. BURKE
RUSSELL L. GRIFFIN
HAIBIN NING
BUNYAMIN OZAYDIN

A DISSERTATION

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CHARACTERIZATION OF TOP THREE NONFATAL OCCUPATIONAL INJURIES, 2012-2014

LEVENT ONAT

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ABSTRACT

Characterization of nonfatal occupational contact with object or equipment injuries, falls on same level injuries, and overexertion injuries involving outside sources that are considered as top three occupational injuries comprise this study. The injury data from 2012 to 2014 have been obtained from the National Electronic Injury Surveillance System - Occupational Supplement (NEISS-Work) which collects the data from a national probability-based sample of U.S. Hospital Emergency Departments (EDs). The data for selected variables were queried for the three most-occurring injury categories by using Work-Related Injury Statistics Query System (WORK-RISQS). Worker demographics and their impacts on injury characteristics have been analyzed for treatment year, gender, age, injury source and the industry group. The results have been interpreted from safety engineering and safety management standpoints to help reduce occupational injuries.

Keywords: Occupational injury, NEISS-Work, contact with an object or equipment, struck by, overexertion, falls, OSHA, emergency department

DEDICATION

Every challenging work requires self-effort as well as the guidance of those people who are very close to our hearts. I dedicate this work to my wife, Melike Dizbay-Onat, for her endless love, support, and encouragement to help turn my life-long dream into a reality.

I also dedicate this work to my beloved father, Yilmaz, and mother, Gulay Onat, strong and gentle souls who raised me and taught me to believe in myself and to be an honest and hardworking human being before I become anything else.

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INTRODUCTION

Human life and health are precious and there are many institutions, companies, organizations, and people working daily to make sure human health is well maintained and human life protected.

The data on workplace injuries and the accuracy of that data has always been a major concern to the people who work in health and safety field suc as environmental, health and safety engineers and government agencies, such as OSHA [1]. While circulating effective occupational health and safety legislation, policy-makers rely on data. Researchers also count on data to find the root causes occupational injuries and illnesses to develop methods to prevent, control and eliminate them. Quality of data and the analysis of that data are vital to support the current efforts to improve the health and safety of workers [1].

More than 80% of the increase in life expectancy over the past 100 years in North America is attributed to advances in public health [2]. Even though, the reduction of exposures to hazardous work environments has been one of the biggest achievements in public health, they continue to cause a large preventable burden of injury and illness in working adults, such as about one-quarter of injuries resulting in activity limitation among U.S. adults are work related [3]. In order to reduce the number of occupational injuries, implementing primary prevention measures with substitution,

engineering, and development of interventions in job design, work practices, and work organization is necessary [4].

In this study, three nonfatal occupational injuries, which are work-related over-exertion injuries involving outside sources, falls on same level injuries and contact by object or equipment injuries, have been examined by evaluating the data from Occupational Supplement of the National Electronic Injury Surveillance System (NEISS-Work) and Bureau of Labor Statistics (BLS) Survey of Occupational Injury and Illnesses (SOII) databases for the years between 2012 and 2014.

The Work-Related Injury Statistics Query System (Work-RISQS) has been used to interactively access the NEISS-Work data. This National Institute for Occupational Safety and Health (NIOSH) surveillance data on nonfatal work-related injuries treated in EDs are being maintained with the collaboration of the Consumer Product Safety Commission (CPSC). Results represent "national estimates" of the number of ED-treated injuries. Employed Labor Force (ELF) data is obtained from the BLS's Current Population Survey with the number of injuries to calculate "national rate estimates" of injuries per full-time equivalent worker [5].

There are number of studies in the published literature that have analyzed different injury databases other than NEISS-Work, such as the study of J.M. Williams et.al. where they used an ED-based injury surveillance system (EDBISS) for rural EDs [6]. They have documented that many workers suffered injuries on the job and also reported that occupational injuries accounted for 12.5% of all injuries. The mean age of patients injured on the job was 33.8 years (range, 16-77 years), compared with a mean age of 27.7 years for all the injured patients. Males accounted for 67% of the work-related

injury visits, compared with 57% of all the injury visits. The most common mechanisms of occupational injuries were: overexertion (20%); falls (16%); struck by object (13%) [6]. In a study of injury-related ED visits in Connecticut between 2000 and 2004, one quarter (24.8%) of these injuries were from falls, and hence was the overall leading cause of injury-related ED visits, followed by contact with object injuries (13.9%) and overexertion injuries (10.5%) [7]. In another study that looked at nonfatal occupational injuries, researchers analyzed the National Ambulatory Medical Care Survey (NHAMCS) data and suggested that African Americans had a higher rate of nonfatal occupational injuries that were treated in EDs than Caucasians: 4.2/100 workers vs. 3.5/100 workers, respectively [8].

Data

In this study, three nonfatal occupational injuries, work-related overexertion injuries involving outside sources, falls on same level injuries, and contact by object and equipment injuries, have been examined by evaluating two large injury and illness databases: NEISS-Work and BLS SOII for the years between 2012 and 2014 for the selected worker demographics.

National Electronic Injury Surveillance System - NEISS

To help reduce injuries, researchers study injury databases available to them. The NEISS database is one of them and its primary purpose is to collect data on consumer product-related injuries in the U.S. It was originally created by the Consumer Product Safety Commission (CPSC) by stratifying all hospitals in the United States based on the following three baseline variables: geographic location, hospital size, and

emergency room volume. From this pool, 101 sample hospitals were designated through a process of randomized selection, and data from each hospital were assigned statistical sample weights to create a national probability sample of hospitals in the United States and its territories. Locations of all 101 NEISS hospitals are shown in Figure 1. Patient information and injury characteristics are collected from each hospital for every emergency visit related to the injury. Traffic accidents (e.g., automobiles, motorcycles, planes, and trains), intentional, non-accidental injuries (e.g. assault), occupational injuries, or other injuries previously treated at a given hospital are not reported in the NEISS database [9].

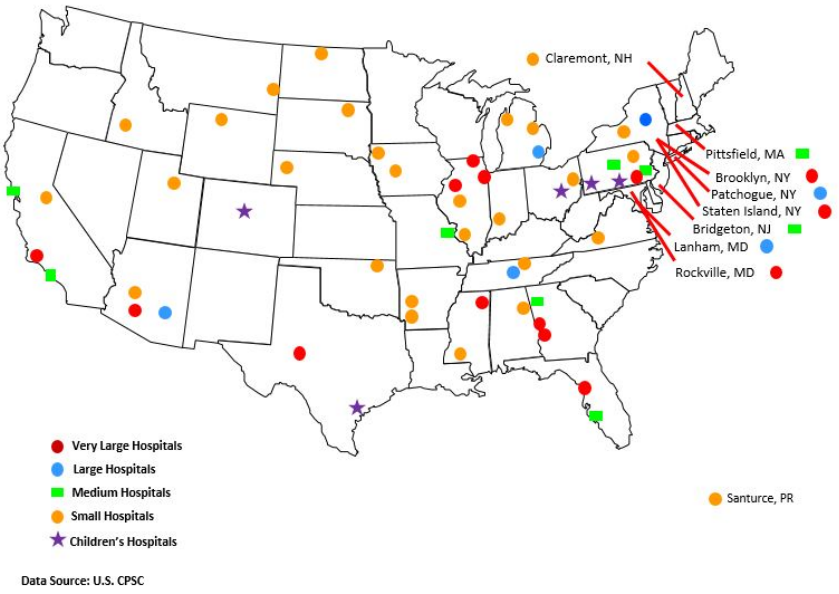

Figure 1. U.S. Consumer Product Safety Commission NEISS Hospitals [10]

Occupational Supplement to NEISS (NEISS-Work)

NEISS-Work is the occupational supplement to the NEISS that does not require consumer product involvement [11]. NEISS-Work only accounts for nonfatal

occupational injuries and illnesses treated in U.S. hospital EDs—roughly estimated to be 34% of work-related cases requiring medical treatment [12]. It is a national stratified probability sample of hospitals in the U.S. and its territories that have a minimum of six beds and operate a 24-hour emergency department (ED). The occupational injury hospital sample is a 2/3 subset of the hospital sample used by CPSC to capture product-related injuries which were selected from approximately 5,300 hospitals after stratification by total number of annual ED visits. Technically, only 67 geographically distributed sample hospitals capture work-related injuries every day of the year. Work-relatedness and case codes are recorded by the hospital abstractors from the medical records and each case is assigned a statistical weight based on the inverse probability of selection. National estimates are calculated by summing weights for all cases or the selected set of cases. Statistical weights are adjusted annually within a sample year to account for hospital mergers, closings, or withdrawals from NEISS-Work resulting in fewer than 67 hospitals reporting information and for incomplete reporting by taking into account the number of U.S. hospitals and their total number of ED visits as determined by a census of U.S. hospitals one year prior to the data year [11].

Bureau of Labor Statistics (BLS)

The government agency tasked with collecting and reporting on occupational injuries and illnesses is the Bureau of Labor Statistics in the U.S. Department of Labor (DOL) [13]. BLS data have also been examined in this study, in addition to NEISS-Work, since it provides the industry information. According to the data from the BLS, 141 occupational deaths of workers aged 19 years and under occurred in 2004 alone [14]. Emergency medical services personnel treat 22 million patients a year [15]. Each

year in the United States, more than 90 million injured patients are cared for in hospital EDs [16]. BLS collects injury and illness information annually through the Survey of Occupational Injuries and Illnesses (SOII). BLS sends the SOII to a sample of over 175,000 employers throughout the country and across most industries. Employers complete the SOII using information directly from their OSHA recordkeeping logs [13]. It has been reported that undercounting the number of injury and illness incidents in the workplace by the BLS SOII has been questioned in the literature by estimating it from 20% to 70% of all cases. However, other research and analysis concluded that the size of the undercount is actually small [13].

Variables

Several variables have been analyzed to determine their impact on injury characteristics. Treatment year is the calendar year in which the patient first received medical treatment in an emergency department for the injury. Injuries are queried according to the date of first treatment in an ED, one calendar year at a time. Age group defines the range of ages of workers that are injured in years and they are mostly grouped by five-year age ranges. There are no age restrictions for cases captured in NEISS-Work. More specifically, age groups are defined as 14 and under, 15-17,18-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70 and over. Sex has been considered as another variable and defined as the distinction between male worker and female worker. A worker's sex is reported in hospital data as “Male,” “Female,” or “Not stated.” In any given year's data, sex parameters for queries are All, Male, and Female. To determine the connection between the injury characteristics and worker demographics, we examined the part of the body affected as another variable. It is defined

as the region or part of the body most seriously injured during the incident. The three injury categories that have been analyzed in this study are the event variables. The event has been defined as the way the injury was produced or inflicted, as coded in the BLS OIICS. To determine what type of object, substance, person, bodily motion, or exposure directly produced or inflicted the injury, the source of injury has been analyzed for each event as coded in the BLS OIICS. The industry is defined by BLS using the North American Industry Classification System (NAICS) which is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy [17].

Top Three Nonfatal Occupational Injury Categories

This research work is divided into three distinct objectives composed of interrelated topic areas which will be published as separate journal papers. In this study, work-related overexertion injuries involving outside sources, falls on same level injuries and contact by object or equipment injuries have been examined by analyzing NEISS-Work data. Figure 2 shows percentages of occurrences of these nonfatal occupational injuries that were reported to NEISS-Work sample EDs for the years of 2012 through 2014. Data shows that these three types of injuries (overexertion 26.8%; falls 15.5%; contact with object or equipment 36.8% in average) were the most occurring injuries among the other injury categories for ten consecutive years from 2004 to 2014.

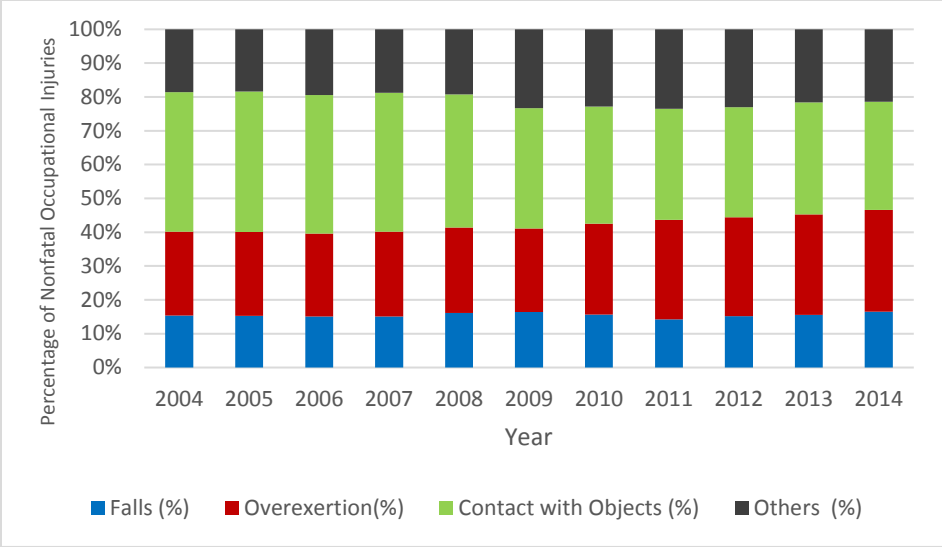

Figure 2. Distribution of NEISS-Work occupational injury data from 2004 through 2014 (in percentages).

Contact with Objects and Equipment

OSHA Directorate of Training and Education explains that contact with object or equipment injuries are produced by forcible contact or impact between the injured person and an object or piece of equipment. When the impact alone creates the injury, the event is considered as contact. These hazards are sub-categorized as follows: contact with flying object, contact with falling object, contact with swinging object, and contact with rolling object [18]. Workers injured from contact with other persons, animals, or weapons, regardless of intent, are excluded from this category. This category also excludes: falls, slips, trips, transportation incidents, fires, and explosions; injuries by persons or animals, regardless of intent; injuries by weapons, regardless of intent; exposure to hot or cold objects or substances; contact with electric current; exposure to noxious, toxic, and allergenic substances; exposures to infectious agents; and injuries resulting from overexertion [19].

When the injury is created more because of crushing between objects, the event is considered as caught. Caught-in and between injury category is one of the subcategories of contact with objects or equipment. OSHA lists "caught-in and between" accidents as one of the big four workplace hazards which is one of the subcategories of contact with object or equipment injuries. Jepsen et.al. reported in 2011 that the most common caught-in and between accidents are workers being caught in machinery. Others include buried in a trench and pinned between equipment and another solid object [20]. Approximately 75% of contact with- fatalities involve heavy equipment such as trucks or cranes [21]. BLS OIICS categorizes other injuries as violence and other injuries by persons or animals, transportation incidents, fires and explosions, exposure to harmful substances or environments [19].

Fall on Same Level Injuries

Falls, slips, and trips are all a major cause of preventable injuries in the workplace; fall and fall-related injuries are a major cause of disability and personal and professional impairment [22].

Falls, slips, and trips include falls on the same level, falls and jumps to lower levels, falls and jumps that were curtailed by a personal arrest device, and slips and trips that do not result in a fall. It also includes other non-transport-related falls resulting in drowning or other nonimpact injuries [19]. Fall injuries occur when worker drops due to gravity and hits a surface at the same or lower level [7]. According to National Safety Council (NSC), falls, slips, and trips account for over 8 million hospital ED visits (21.3%). Occupational fall injuries are more severe than other injuries causing longer loss-time which costs about $70 billion annually in compensation and

medical expenses [23]. According to the National Floor Safety Institute, falls, slips and trips account for 1 million visits to EDs each year, which is 12% of all fall injuries and they are the primary cause of fatal occupational injuries. Falls from elevation are approximately 40% of compensable fall cases and about 10% of occupational fatalities. Falls on the same level are approximately 60% of compensable fall cases. The injuries types are reported in a wide range from a small bruise to serious fractures or even death [24].

Mohamed et.al reported that NIOSH, OSHA, and the Center for Construction Research and Training are promoting a national campaign to prevent workplace falls, since falls are the leading cause of occupational injuries and deaths in construction [7]. According to BLS, falls accounted for 5% of the job-related fatalities for women compared to 11% for men [23]. Lombardi et al. (2011) studied work-related falls from ladders and they found that among workers approximately 20% of fall injuries involve ladders [16].

Overexertion Injuries Involving Outside Sources

Overexertion involving outside sources was the leading event or exposure with 408,760 cases reported in 2012 BLS News Release [25]. Overexertion happens when the load exceeds the limits of the human joint system while handling the load by lifting, carrying, pushing or pulling. The activities like lifting, repeated bending at the waist, bending at the waist with twisting, pushing/pulling, carrying, reaching, long term sitting or standing, sitting while absorbing vibration through the body could cause overexertion. Overexertion causes damage to muscle(s), tendon(s), ligament(s), and cartilage, joint or peripheral nerve(s), often resulting in sprains, strains, and pain.

Aging and loss of body flexibility, poor physical condition, and being overweight are some personal factors that have been linked to overexertion injuries. Even though overexertion injuries can result from different activities, lifting objects have been reported as the most common cause [26, 27].

Gray S. et al. reported that between the years 1999 and 2013, overexertion involving outside sources was ranked first as a leading cause of disabling injury at fitness facilities by using Victorian Emergency Minimum Dataset (VEMD) through the Victorian Injury Surveillance Unit (VISU). Injuries due to overexertion were most common overall (36.2% of all cases) [28]. Libscomb et.al. has studied union carpenters who worked in the State of Washington between 1989 and 2003. He concluded that overexertion injuries from manual materials handling activities were responsible for the largest burden of back injuries among these carpenters [29].

Using information obtained from NEISS, Brian R. Waterman et al. found that about 2 million people in the U.S. went to EDs for low back pain between 2004 and 2008, accounting for about 3% of all ED visits [9].

In another study, Reichard A. et.al. studied occupational injuries among emergency medical technicians by analyzing NEISS-work and concluded that nonfatal injuries were primarily associated with stress on some part of the body from motion or overexertion (33%) [30]. According to Marcin et.al. overexertion injuries are the most common cause of workers' compensation claims [31].

Methods

The data has been derived from NEISS-Work in this study by using Work-RISQS which is an interactive query tool to obtain estimates for the number of nonfatal occupational injuries treated in EDs. Work-RISQS is developed by NIOSH where users may interactively query worker demographic characteristics, the nature of the injury, and incident circumstances for ED-treated nonfatal occupational injuries from 1998 through the present to obtain national estimates.

For the work injury to be part of NEISS-Work, the patient needs to visit a NEISS-Work sample ED where work-relatedness is recorded in the ED chart. NEISS hospital coder abstracts and submits the case to CPSC to be reviewed. NIOSH reviews all cases and finalizes the data. The data collected through NEISS-Work are based on a national hospital sample with a statistical weight assigned to each case. By summing the statistical weight for all cases within the hospital sample, the national estimate of the number of work-related injuries treated in all U.S. hospital EDs is produced. For Work-RISQS, the 95% confidence interval is calculated by taking random samples of all U.S. hospitals which obtained an injury estimate that falls within the confidence interval range at least 95% of the time. Rates for Work-RISQS are calculated by dividing the Work-RISQS estimate by the selected worker population number. The number of workers is obtained from the Employed Labor Force (ELF) query system.

Occupational Injury and Illness Classification System (OIICS)

Injury classifications are coded in the system as they are defined in BLS OIICS. 1998-2011 data use OIICS v.1.01 for event and source codes. 2012 to present data

use OIICS v.2.01 for event and source codes. To use the coded data, standalone and web-based graphical coding tree interfaces that are searchable, which also include descriptive details, are used for this study. Injury classifications between 1998-2011 with event and source codes are defined in BLS OIICS v.1.01 as: 0-Contact with objects and equipment, 1-falls, 2-bodily reaction and exertion, 3-exposure to harmful substances and environments, 4-transportation accidents, 5-fires and explosions, 6-assaults and violent acts, 9-other events or exposures, and 9999-nonclassifiable. Injury classifications from 2012 and onward with event and source codes are defined in BLS OIICS v.2.01 as: 1-violence and other injuries by persons or animals, 2-transportation incidents, 3-fires and explosions, 4-falls, slips, trips, 5-exposure to harmful substances or environments, 6-contact with objects and equipment, and 7-overexertion and bodily reaction. Each main classification has its own subclassifications.

Since this study is only focused on three injury categories, overexertion injuries involving outside sources, falls on same levels, and contact with object and equipment, events will be selected from the tree for analysis. Main subcategories will also be examined for this study (Figure 3).

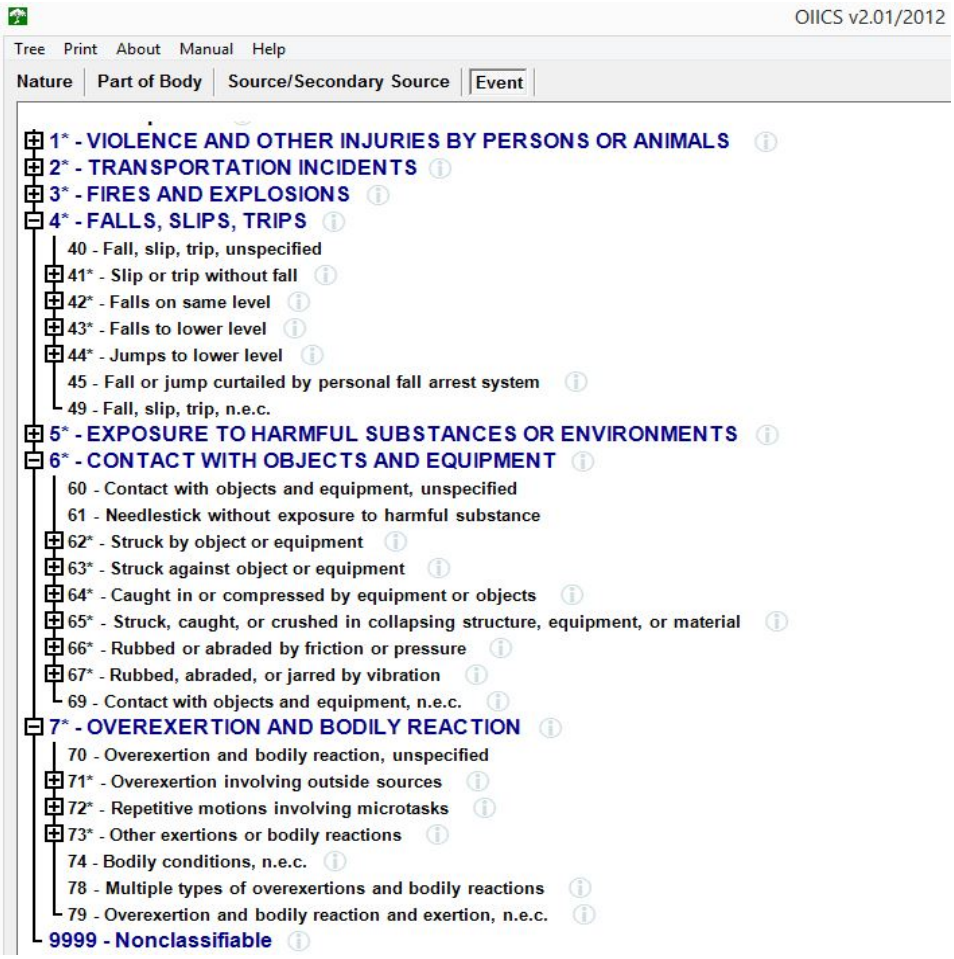

Figure 3. Main subcategories for top three injury categories

Rate estimates and confidence interval

The variance of NEISS-Work rate estimates is calculated by pooling the variances for the injury estimate and the worker population estimate. In general, the variance in the injury estimate is large with respect to the variance in the worker population estimate. The confidence bounds, expressed as an amount to be subtracted or added to the injury rate, are (Equation 1):

$$\pm R_{FTE} \times \sqrt{cv_x^2 + cv_{FTE}^2} \times 1.96 \qquad \text{Equation 1}$$

where:

R_{FTE} = Rate of injury per FTE

CV^2_x = Coefficient of variation of the injury estimate = (95% Work-RISQS estimate confidence interval/1.96)/Work-RISQS estimate

CV^2_{FTE} = Coefficient of variation of the employment FTE estimate = (ELF estimate standard error/ELF estimate)

Equation 2 below is used as the variance estimating formula:

$$\sigma_x^2 = \sum_{h=1}^{m} \frac{r_h}{r_h - 1} \sum_{i=1}^{r_h} \left(\frac{N_h}{n_h} \frac{n'_h}{r_h} \right)^2 (x_{hi} - \bar{x}_h)^2 = \sum_{h=1}^{m} \frac{r_h}{r_h - 1} \sum_{i=1}^{r_h} (wgt_{hi} x_{hi} - wgt_{\bar{x}_h}$$

Equation 2

where:

m = Number of strata in the sample during the given time period

N_h = Number of hospitals in the sampling frame for stratum h

n_h = Number of hospitals selected for the sample for stratum h

n'_h = Number of in-scope hospitals in the sample for stratum h

r_h = Number of hospitals participating in stratum h for the given time period

X_{hi} = Number of work-related cases for a specific type of injury reported by hospital i in stratum h for the given time period

wgt_{hi} = Weight of hospital i in stratum h

Equation 3 shows the number of work-related cases for a specific type of injury reported by hospital i in stratum h for the given time period

$$\bar{x}_h = \frac{\sum_{i=1}^{r_h} x_{hi}}{r_h}$$

Equation 3

Weight of hospital i in stratum h is calculated with the Equation 4

$$wgt\bar{x}_h = \frac{\sum_{i=1}^{r_h} wgt_{hi} x_{hi}}{r_h}$$

Equation 4

The 95% confidence interval (Equation 5), expressed as an amount to be subtracted or added to the national estimate, is then calculated as:

$$\pm \sqrt{\sigma_x^2} \times 1.96$$

Equation 5

where:

σ_x^2 = Variance of the injury estimate x

X = Injury estimate

To minimize issues with negative variances, r_h is calculated as a fractional r_h value where r_h equals the sum of the number of months that all hospitals within a strata reported during the calendar period divided by 12 months.

The confidence interval does not account for biases in the estimates that arise from the way in which data are collected or defined, the ability to identify all occupational cases, or mistakes in data collection or coding.

Limitations

Since NEISS-Work data represents only nonfatal occupational injuries and illnesses treated in EDs, this surveillance perspective is restricted by the type of injuries

treated in emergency departments, neglecting injuries treated in other medical locations. NEISS-Work is not controlled by the type of employer or industry or employer size [12].

The other limitations that are considered were the OIICS for events and source codes. OIICS v.1.01 were used for 1998-2011 NEISS-Work data and OIICS v.2.01 from 2012 to present. Comparisons between event and source have not been recommended between years that cross this break [11]. 2015 and onward data will not be examined in this study, since 1998-2014 NEISS-Work data include illnesses that began at work (e.g. heart attacks and strokes) where data 2015 onwards do not capture most illnesses. The small number of hospitals in the NEISS-Work sample contributes to large confidence intervals [11]. The recent data between 2012 and 2014 have been analyzed to eliminate this limitation. Due to the limitation of the interpreting and reporting results for the data before 2011 with OIICS v.1.01 for event and source codes and between 2012 and 2014 with OIICS v.2.01, comparisons between event and source should not be made between years that cross this break. Therefore, scope of this study was limited to three-year period. Because of the categorical differences, we wouldn't be able to recategorize a wide range of years of data within the scope of this study. The goal of this study was to get a high-level information that the data reflect in order to see the trend for the most recent years available.

NEISS-Work is designed to produce national estimates and is not suitable for regional, state, or local injury estimates.

The following types of cases are excluded from NEISS-Work data:

- Injuries to active-duty military (Air Force, Army, Coast Guard, Marines, National Guard, Navy, or Reserve Officers' Training Corps [ROTC])
- Injuries of institutionalized persons, such as those in prisons or psychiatric institutions
- From 2015 onwards, illnesses are excluded. Prior to 2015, occupational illnesses (excluding common illnesses such as cold and flu) were included.
- Drug and alcohol screenings
- Revisits to EDs for injuries previously treated in EDs

Inaccurate information in the medical records might happen due to the information given by the worker or person recording the information at the hospital which effects the accuracy of the data in terms of work-relatedness [11]. BLS SOII data is limited to the number of surveys which does not specify ED visits and only includes occupational injuries involving days away from work reported by selected number of employers. Thus, survey estimates excluded many employers and, by definition, numerous cases that required medical treatment (beyond first aid) or restricted work duties but did not result in days away from work.

Objectives

Objectives of this research are to:

- Characterize nonfatal occupational overexertion injuries involving outside sources by analyzing NEISS-Work data and recommend safety engineering and safety management-based solutions to help reduce occupational injuries.

- Characterize nonfatal occupational falls on same level injuries by analyzing NEISS-Work data and recommend safety engineering and safety management-based solutions to help reduce occupational injuries.
- Characterize nonfatal occupational contact with object and equipment injuries by analyzing NEISS-Work data and recommend safety engineering and management-based solutions to help reduce occupational injuries.

Intellectual Merit: Determining appropriate preventive actions by focusing on the right areas will help reduce the number of workers injured and may result in financial savings for companies, government organizations, etc. Products of this research will be of broad interest to a diverse group of health and safety professionals, including environmental, health and safety managers, responsible officials, and academicians who study occupational health and safety. Characterization of top three occupational injuries for demographics and industry types will help to determine which variables they need to focus on to reduce occupational injuries at workplaces when training their employees and developing and implementing safety programs.

Broader Impacts: The broad and societal impact of the research is on worker safety, improving the quality of people's lives and ultimately leading to an injury-free work environment.

ORGANIZATION OF THE WORK

The main focus of this research is to study the top three nonfatal occupational injuries that were treated in EDs in the United States by focusing on the relationship between the worker demographics and the sources of the injuries and thereby discuss how the results can be interpreted in terms of safety engineering and safety management perspectives to reduce workplace injuries. The three main aspects of this study are nonfatal occupational injuries treated in EDs which occurred due to a contact with object or equipment, nonfatal occupational fall on same level injuries treated in EDs, or nonfatal occupational overexertion injuries which involved outside sources. This dissertation includes a literature review which gives background information about the subject material, three interconnected manuscripts which are consistent with the objectives, and a general conclusion that summarizes the whole work. Manuscript 1 explores the connections between the worker demographics, the industry, and selected variables for the injury category of contact with object or equipment. Manuscript 2 studies how the fall on same level injuries have been impacted by varying worker demographics and the impacts of them on the main industry categories. Manuscript 3 analyses the types of sources that were involved in the overexertion injuries of workers and the impact of the selected variables including worker demographics on nonfatal occupational overexertion injury characteristics. All three injury categories have been studied from safety engineering and safety management perspective to suggest improvements to help reduce worker injuries.

CHARACTERIZATION OF NONFATAL OCCUPATIONAL CONTACT WITH OBJECT AND EQUIPMENT INJURIES, 2012-2014

by

LEVENT ONAT, SELVUM PILLAY

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ABSTRACT

Introduction: The purpose of this study is to examine occupational nonfatal contact with object injuries treated in emergency departments (EDs) in the United States. *Method*: Data has been derived from National Electronic Surveillance System-Occupational Supplement (NEISS-Work) from 2012 to 2014. *Results*: Nonfatal occupational contact with object and equipment injuries that are treated in EDs (36.8%) were among the top three occupational injury categories for three consecutive years. Knives and cutters have been the source of the injuries that caused the highest number of injuries among both male and female workers. The highest risk group was the workers who were between 20 and 24 years old. The lowest risk groups of workers were 55 and older and 19 and younger. While both genders injured their fingers and heads the most, hand injuries for male workers and foot injuries for females were the third highest. The mining industry, agriculture-forestry-fishing industry, construction industry, and transportation industry had the highest injury rates per 100 full-time equivalent (FTE). Overall, the rates slightly changed over the three-year period. However, in transportation/warehouse/ utility industry the injury rate per 100 FTE for females had a significant drop (3 times). *Conclusions*: This study shows that workers' demographics had a significant impact on the number of contact with object or equipment injuries. The close relationship between worker demographics and injury characteristic needs to be considered at the engineering design stage of the work tools, work platforms, walking-working surfaces, and equipment to have the most significant impact on the injury prevention efforts. *Practical Applications*: Engineering designs, safety training, and behavioral safety management practices,

which include the effects of worker demographics on occupational injury rate, will be useful tools to help reduce worker injuries.

Keywords: Occupational injury; national electronic injury surveillance system-occupational supplement (NEISS-Work); contact with object; struck by; OSHA; emergency department

1. INTRODUCTION

Occupational Safety and Health Administration (OSHA) Directorate of Training and Education explains that contact with object or equipment injuries are produced by forcible contact or impact between the injured person and an object or piece of equipment [1]. An accident event is considered as contact when the impact alone causes the injury. These hazards are categorized as contact with flying object, contact with falling object, contact with swinging object, or contact with rolling object [1]. According to Bureau of Labor Statistics (BLS) Occupational Injury and Illness Classification System (OIICS), this injury category excludes falls, slips, trips, transportation incidents, fires, and explosions; injuries by persons or animals, regardless of intent; injuries by weapons, regardless of intent; exposure to hot or cold objects or substances; contact with electric current; exposure to noxious, toxic, and allergenic substances; exposures to infectious agents; and injuries resulting from overexertion [2].

Contact with object or equipment accidents occur when objects or equipment such as machinery, flying debris, or work tools hit a person directly [3]. Potential hazards that might cause this type of injuries are tools or loose parts, such as cutters, screwdrivers left on shelves or tables at workplace, objects such as ladders that are leaning against walls, racks or equipment, breaking or broken glass, metal chips and particles from machines, or

someone swinging a tool without looking [3]. Approximately 75% of contact with fatalities involve heavy equipment, such as trucks or cranes [4]. BLS OIICS categorizes contact with object and equipment injuries with 9 subcategories with classification codes from 60 to 69 with multiple subcategories [2]. This study focuses on the main injury category while investigating the impact of worker demographics on the rate and number of injuries for the study period. The National Safety Council (NSC) reported the total cost of unintentional work-related injuries as $188.9 billion which includes productivity losses of $86.7 billion, medical costs of $52.3 billion and administrative expenses of $34.2 billion, employers' uninsured cost of $10.5 billion, damage to motor vehicles of $2.4 billion, and fire losses of $2.8 billion in 2012, where the cost of struck by injuries only were $4.64 billion [5]. To provide a different perspective and contribute to the efforts of reducing occupational injuries by addressing some of the gaps, we studied NEISS-Work to analyze contact with object or equipment injuries.

2. METHODS

NEISS-Work data was used to investigate the demographic and trend analysis of nonfatal occupational contact with object and equipment injuries treated in EDs for the selected period for treatment year, age group, sex, part of the body affected, event, and industry group by analyzing. When the patient visits a NEISS-Work sample ED for the work injury, a NEISS hospital coder abstracts and submits the case to the Consumer Product Safety Commission (CPSC) to be reviewed. All cases are reviewed and finalized by the National Institute for Occupational Safety and Health (NIOSH) [6].

The Work-Related Injury Statistics Query System (Work-RISQS) was developed by NIOSH which collaborated with CPSC to collect the data through NEISS-Work. In

this study, this system was used as the interactive data access system to the surveillance data. More specifically, it allowed us to query interactively on worker demographic characteristics, nature of the injury, and incident circumstances for ED-treated nonfatal occupational contact with objects injuries to obtain national estimates. The 95% confidence intervals were calculated by taking random samples of all U.S. hospitals that obtained an injury estimate that falls within the confidence interval range at least 95% of the time [7].

BLS OIICS defines the injury classifications codes [8]. OIICS v.1.01 presents data between 1998-2011, and OIICS v.2.01 present 2012 data use for event and source codes. OIICS v.2.01 injury classification system was used in this study since the data between the years 2012 and 2014 have been analyzed.

The query system was used to select the variables including treatment year, age group, part(s) of the body affected, events, and sex for the studied injury category and the years. The systems allowed only one year to be queried at a time. Therefore, injuries were queried for one calendar year at a time. Age groups were selected as 15 and over at preset 5-year age groups. "National rate estimates" of injuries per full-time equivalent worker (FTE) for all industry groups was calculated using the employed labor force (ELF) data which is obtained from the BLS's Current Population Survey (CPS) [9]. Rates for Work-RISQS were calculated by dividing the Work-RISQS estimate by the selected worker population number. Obtained data were exported to excel and results have been analyzed and presented with tables and plots for the selected injury category.

3. RESULTS

Contact with objects and equipment injuries have been estimated as the highest occurring injury category among top three injury categories for three consecutive years during the study period (Figure 1). The number of contact with object injuries per year has changed slightly and percentages of total annual estimates have shown 0.5% change compared to 2012 (Table 1). Lipscomb et al. also reported that contact with object injuries from 1998 to 2005 changed slightly during that period [10]. However, Lipscomp et al.'s estimated number of injuries compared to this study were significantly lower. More specifically, in 2005, it has been estimated that 229,100 (95% CI 184,800 - 273,400) contact with object injuries occurred, when in 2012 it has been estimated as 905,300 (95% CI 729,600 – 1,081,000). This shows a significant increase (3.95 times) in the number of contact with object injuries between 2005 and 2012 which suggests that despite all preventative efforts more people are getting injured due to contact with object injuries compared to previous years.

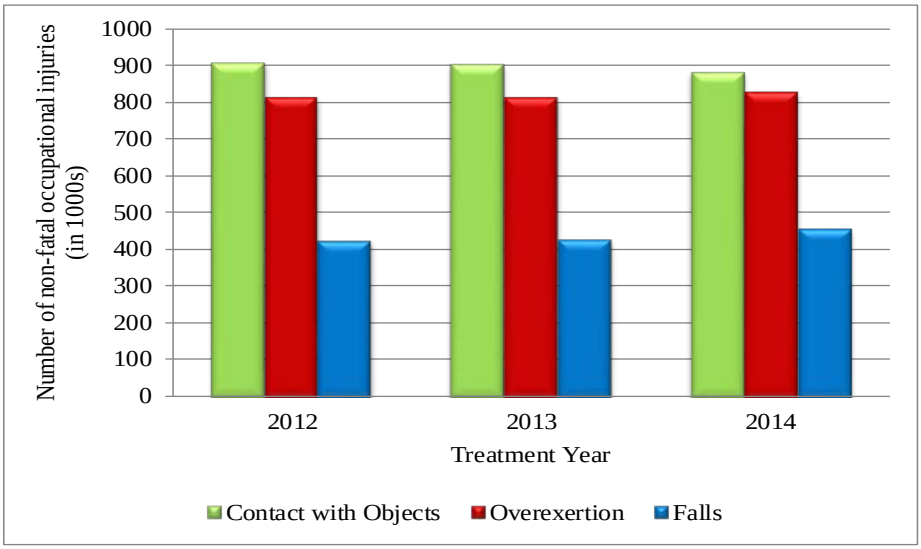


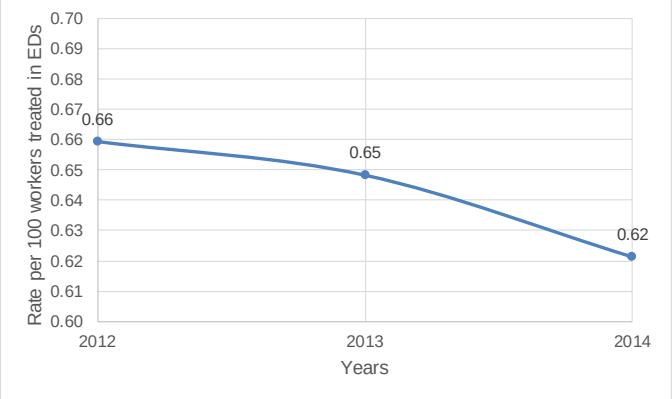
Figure 1. Distribution of NEISS-Work nonfatal occupational injury data from 2012 through 2014 (in percentages).

Table 1. Yearly estimate of number of nonfatal occupational contact with object injuries treated in U.S. emergency departments, 2012 – 2014

Year	Number of injuries/illnesses	95% CI	Percent of total annual estimate
2012	905,300	1,081,000 - 729,600	32.60%
2013	903,900	1,087,600 - 720,200	33.10%
2014	881,200	1,019,000 - 743,400	32.00%

Estimated injury rates (0.66 and 0.65) for the years 2012 and 2013 have minimally changed by decreasing slightly (0.62) in 2014 per 100 workers treated in EDs (Figure 3) which also supports the idea that existing efforts to prevent injuries did not make a big impact on keeping the workforce safer.

Figure 2. Yearly injury rate per 100 FTE of nonfatal occupational contact with object injuries treated in U.S. emergency departments, 2012 – 2014



According to BLS's data for nonfatal occupational injuries and illnesses requiring days away from work for 2012 also supported our results and estimated that 23% of total injuries were contact with object injuries with an injury rate of 25.5 [11]. In this study, subcategories of the contact with object injury category have been estimated, including over 40 subcategories that were listed in OIICS; the top seven most occurring injury subcategory did not change during the years studied (Figure 2). The results revealed that

contact injuries largely fell under the subcategories of contacts with unspecified objects and equipment (20.70%), injuries by unspecified handheld object or equipment (10.16%), rubbed or abraded by foreign matter in the eye (5.73%), struck by unspecified falling object or equipment (5.73%), struck by unspecified objects or equipment (5.41%), and struck again stationary objects (5.21%). In 2014, the percentage of injuries by slipping or swinging objects held by the worker was also high in addition to the estimated injury subcategories listed above.

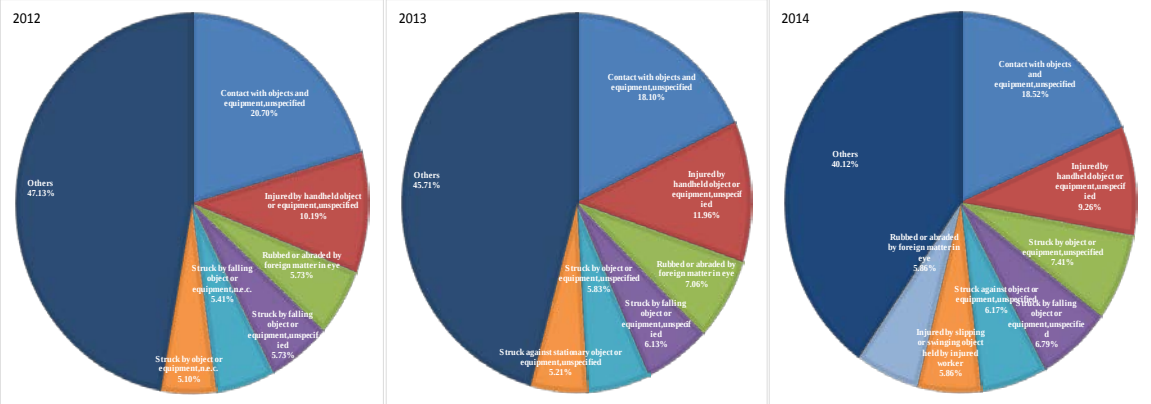


Figure 3. Distribution of the number of nonfatal occupational contact with object injury subcategories in NEISS-Work for 2012 through 2014

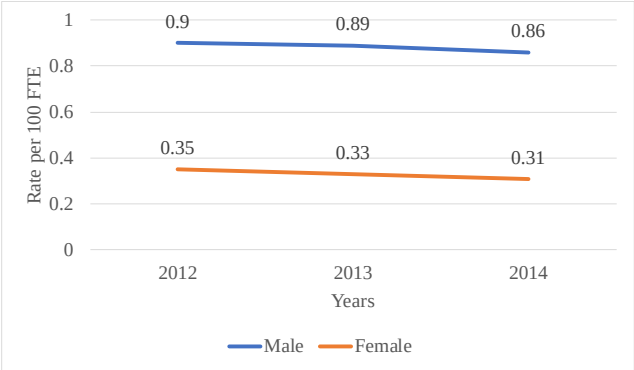
Even though the overall contact with object injury rates and number of injuries did not show a significant difference during those three years, male and female workers experienced a significantly different number of injuries (Table 2) While the injury rates per 100 FTE for men were 0.90, 0.89 and 0.86 in 2012, 2013, and 2014, respectively, the rates were very low for women (0.35, 0.33 and 0.31, respectively). This means men obtained injuries more than twice the times women did. In addition to that, the percentage of men's injuries compared to the total annual estimate has increased from 10.30% to

25.10% within two years, indicating that men continued to have more and more injuries each year.

Table 2. Estimates of the number of male and female workers injured from nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014

	2012			2013			2014		
Sex	Number of injuries/illnesses	95% CI	Percent of total annual estimate	Number of injuries/illnesses	95% CI	Percent of total annual estimate	Number of injuries/illnesses	95% CI	Percent of total annual estimate
Male	699,800	561,900 - 837,700	10.30%	704,500	555,500 - 853,500	25.80%	691,300	576, 300 - 806,300	25.10%
Female	205,500	165,400 - 245,600	6.4%	199,400	160,800 - 238,000	7.30%	189,900	162,000 - 217,800	6.90%

Figure 4. Estimates of the number of male and female workers injured from nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014



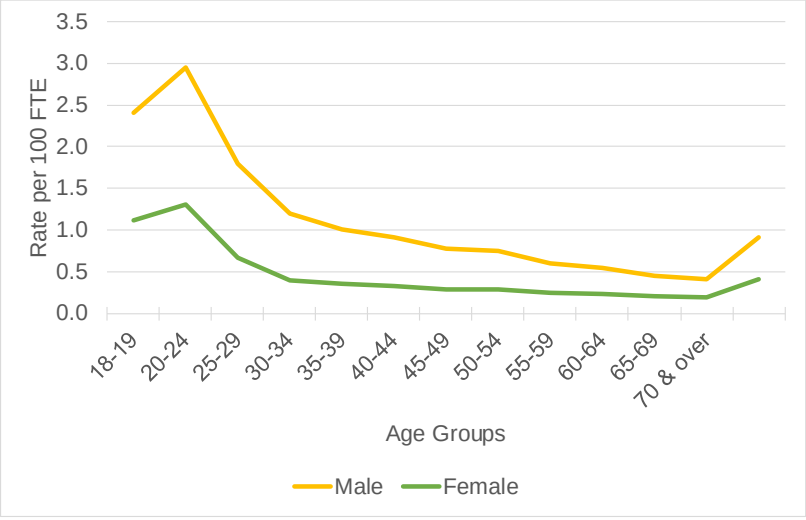
Overall, the workers who were within 20-24 years of age had the highest number of injuries occurred, 146,700 (95% CI 118,200 – 175,200) in 2012 (Table 3). The number of injuries decreased with increasing age. On the other hand, our results showed that employees who were between 18-19 years old had the highest injury rate per 100 FTE. Even though the change in the number of full-time workers was minimal between the age groups, the injury rate has decreased with increasing age. Male workers were more susceptible to contact with object injuries than female workers. They had 3.9 times higher the number of injuries, 112,000 (95% CI 89,400 – 134,600), then female workers, 34,600

(95% CI 27,000 – 42,200). The injury rate for males was 2.9 where it was 1.3 for females in 2012.

Table 3. Nonfatal occupational contact with object and equipment injuries treated in emergency departments in 2012 by age and sex

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
15-17	7.1	±2.4	3.4	±1.2	10.5	±3.1	0.4%
18-19	30.3	±7.5	12	±3.8	42.3	±10.6	1.5%
20-24	112	±22.6	34.6	±7.6	146.7	±28.5	5.3%
25-29	102.3	±18.6	25.6	±5.6	127.9	±22.3	4.6%
30-34	90.9	±20.8	22.9	±5.3	113.9	±25.5	4.1%
35-39	77.9	±14.9	20.4	±4.9	98.3	±18.2	3.5%
40-44	71.9	±16.1	20	±4.1	91.9	±19.5	3.3%
45-49	70.5	±15.9	20.8	±5.5	91.3	±20.9	3.3%
50-54	55.5	±12.9	17.9	±4.3	73.4	±16.2	2.6%
55-59	42.3	±8.7	15	±3.6	57.3	±11.5	2.1%
60-64	21.9	±4.9	7.9	±1.8	29.8	±6.3	1.1%
65-69	8.2	±2.4	2.7	±1.2	10.9	±2.9	0.4%
70 & over	7.4	±1.9	2.1	±1.2	9.5	±2.6	0.3%

Figure 5. Nonfatal occupational Contact with object and equipment injuries treated in emergency departments in 2012 by age and sex



Similar to the previous year, the highest number of injuries occurred for all workers between 20-44 years of age, 147,600 (95% CI 116,100 – 179,700) in 2013. Despite

that, due to the lower number of younger workers in the workforce and relatively high number of injuries, workers who were 18-19 years old had the highest injury rate (1.5) per 100 FTE. The number of injuries and the injury rate decreased with increasing age. Female workers were at a lower injury risk compared to male workers for all age groups. For both male and female workers, the highest number of injuries have been estimated for the age group of 20 – 24 year-old with an injury rate of 1.0. It is estimated as 113,400 (95% CI 86,000 – 140,800) for male workers (1.8 rate per 100 FTE) and 34,200 (95% CI 28,000 – 40,400) for female workers (0.6 rate per 100 FTE) (Table 4). The injury rate for male workers (2.8) was more than double the rate (1.2) for female workers for the workers who were 18-19 years old.

Table 4. Nonfatal occupational contact with object and equipment injuries treated in emergency departments in 2013 by age and sex

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
15-17	6.5	±2.7	3.7	±1.3	10.2	±3.1	0.004
18-19	29.2	±7.4	11.1	±3.1	40.2	±9.9	1.50%
20-24	113.4	±27.4	34.2	±6.2	147.6	±31.5	5.40%
25-29	104.2	±20.8	26.8	±6.8	131	±25.7	4.80%
30-34	90.1	±20.6	21.4	±5.0	111.5	±24.3	4.10%
35-39	77	±15.8	15.4	±3.4	92.4	±17.4	3.40%
40-44	71.4	±15.2	19.5	±6.3	90.9	±20.7	3.30%
45-49	65.9	±14.9	18.5	±4.1	84.5	±17.7	3.10%
50-54	60.6	±13.9	20.5	±4.6	81.1	±17.8	3.00%
55-59	42.9	±9.9	15.6	±4.9	58.5	±13.3	2.10%
60-64	25.2	±5.7	7.3	±2.0	32.5	±6.9	1.20%
65-69	10.2	±3.2	3.2	±1.3	13.4	±3.7	0.50%
70 & over	7.2	±2.5	2	±0.9	9.3	±3.0	0.30%

Figure 6. Nonfatal occupational Contact with object and equipment injuries treated in emergency departments in 2013 by age and sex

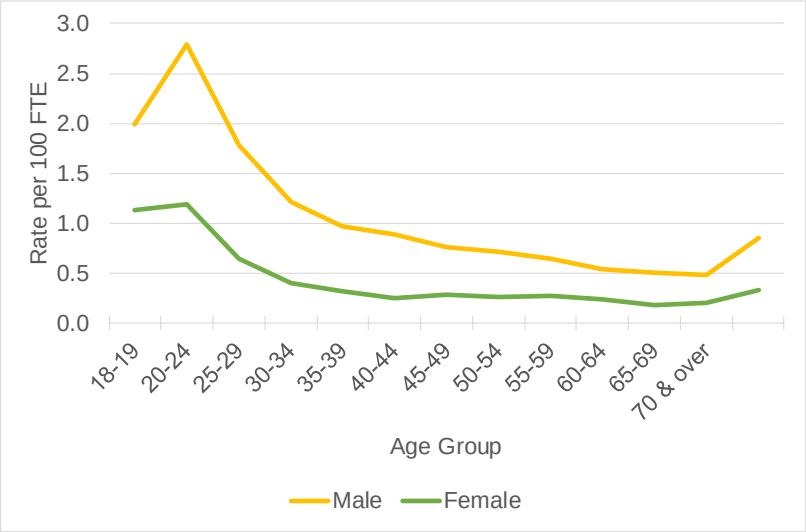
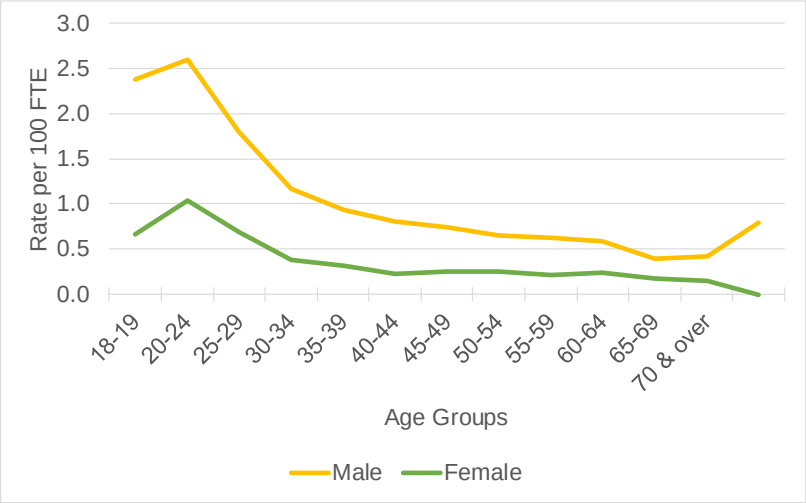


Table 5 shows the same trend for the three consecutive years that the highest number of injuries occurred for all workers within 20-24 years of age 155,700 (95% CI 127,900 – 185,300) in 2014. But the 18-19 age group had the highest injury rate (1.4). For male employees, the highest number of injuries, 118,200 (95% CI 96,200 – 140,200), occurred for the workers who were between the ages of 20-24 years, with 37,500 (95% CI 29,800 – 45,200) for females. Like the years 2012 and 2013, due to less number of workers (11,976,606 FTE for 20-24 age group and 2,001,155 FTE for 18-19 age group in 2014), the injury rate was higher for the employees who were younger than 20 years old. Male workers still had the highest risk with the injury rate of 2.6 per 100 FTE compared to their female counterparts with the injury rate of 1.0 per 100 FTE. The older employees had less injuries compared to younger employees in 2014.

Table 5. Nonfatal occupational Contact with object and equipment injuries treated in emergency departments in 2014 by age and sex

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
15-17	8.2	±2.5	2.2	±1.2	10.4	±2.7	0.004
18-19	28	±7.2	9.6	±2.3	37.6	±8.0	1.40%
20-24	118.2	±22.0	37.5	±7.7	155.7	±27.8	5.70%
25-29	102.7	±18.6	25.9	±5.8	128.6	±22.0	4.70%
30-34	88.6	±16.0	21.3	±3.2	109.9	±17.3	4.00%
35-39	71.6	±12.2	14.9	±3.7	86.5	±14.0	3.10%
40-44	69.4	±12.6	17.7	±4.1	87	±14.8	3.20%
45-49	60.2	±10.0	17.8	±3.2	78	±12.0	2.80%
50-54	59.2	±11.7	16.1	±2.9	75.3	±13.1	2.70%
55-59	47.4	±10.3	15.5	±3.6	62.9	±13.2	2.30%
60-64	21.2	±5.1	6.9	±1.6	28.2	±5.7	1.00%
65-69	9.3	±2.5	2.5	±1.4	11.8	±3.4	0.40%
70 & over	7	±2.1	0	0	8.7	±2.5	0.30%

Figure 7. Nonfatal occupational Contact with object and equipment injuries treated in emergency departments in 2014 by age and sex



Workers younger than 20 years old having fewer injuries than the workers who were between 20 and 59 years old was a compelling finding which needs to be studied in more depth to explain the science behind it. In the literature, the majority of studies on nonfatal injuries showed that young workers had a higher injury rate than the overall rate

[12, 13]. Also, 63 published, peer-reviewed studies reported that 25-years-old' and younger workers' nonfatal injuries between 1940 and 2002 had higher injury rate than older workers [14]. Some studies suggested that age-work injury association plays a critical role in reducing occupational injuries [15].

The distribution of parts of the body affected for all employees treated in EDs did not change significantly over the study period (Table 6). Injuries most often involved workers' hands (including fingers), heads, lower arms and feet for all three years from 2012 to 2014. Upper arm, neck, and upper leg injuries were among the lowest number of injuries.

Table 6. Estimates of body parts injured of nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014.

Part(s) of body	2012				2013				2014			
	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**
Head	200.8	±13.5	7.20%	**13.99**	203.1	±15.4	7.40%	**14.57**	195.9	±9.6	7.10%	**13.81**
Neck (inc. cervical vertebrae)	6.7	±1.6	0.20%	**0.49**	7.5	±1.9	0.30%	**0.54**	7	±2.1	0.30%	**0.49**
Arm,upper	2.7	±1.1	0.10%	**0.20**	3.9	±1.6	0.10%	**0.28**	4	±1.4	0.10%	**0.28**
Arm,lower (inc. elbow & wrist)	62.5	±9.4	2.70%	**5.36**	75.1	±9.6	2.80%	**5.39**	76.4	±7.5	2.70%	**5.39**
Hand	448.8	±24.4	16.20%	**32.69**	435.2	±23.4	16.00%	**31.22**	425.9	±20.9	15.50%	**30.03**
Trunk (inc. shoulders)	34.2	±2.9	1.20%	**2.49**	34.2	±3.6	1.30%	**2.45**	34.7	±3.4	1.20%	**2.45**
Leg,upper	8.5	±2.3	0.30%	**0.62**	9.4	±2.2	0.30%	**0.67**	7.9	±1.9	0.30%	**0.56**
Leg,lower (inc. knee or ankle)	59.3	±6.3	3.34%	**4.32**	66	±6.4	2.40%	**4.73**	60.2	±5.5	2.20%	**4.25**
Foot	68.3	±9.9	2.40%	**4.97**	67.2	±11.0	2.50%	**4.82**	67.7	±9.7	2.40%	**4.77**

Table 7 shows the body parts affected for male and female workers. Fingers were the most commonly injured body part among two sexes. When finger, hand, and eye were the top three most common injured body parts for male workers, unlike men, finger, head, and foot were the top three for female workers during the study period. However, men were more at risk compared to women. More specifically, the rate per 100 FTE for male workers who injured their fingers have been estimated at 31.6 with the number of injuries at 246,500 (95% CI 189,700 – 303,300). Alternatively, the rate per 100 FTE for female workers was 13.8 with the number of injuries at 81,900 (95% CI 65,400 – 98,400). In addition to the rate differences between sexes on injured body parts, other

than the fingers, the number of other body parts injured varied between men and women. Moreover, when hands were the second highest injured body part (12.2 per 100 FTE) among men, women did not have to go to EDs for hand injuries. Likewise, women sought medical attention for foot injuries that were caused by contact with an object or equipment, but men did not. Overall, the injury rates for body parts did not change significantly for either sex even though there was a slight increase in 2013.

Table 7. Estimates of body parts injured of nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014 for female and male workers

		2012				2013				2014			
Sex	Part(s) of body	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**
Male													
	Head	164.3	±9.7	5.90%	**35.7**	165.6	±9.7	6.10%	**21.0**	159.2	±7.4	5.80%	**19.8**
	Neck (inc. cervical vertebrae)	4.3	±1.3	0.20%	**0.6**	4.5	±1.4	0.20%	**0.6**	3.9	±1.4	0.10%	**0.5**
	Arm,upper	2.2	±0.9	0.10%	**0.3**	3.4	±1.4	0.10%	**0.4**	3.3	±1.3	0.10%	**0.4**
	Arm,lower (inc. elbow & wrist)	58.7	±8.1	1.20%	**7.5**	58.9	±8.3	2.10%	**7.5**	59.8	±6.4	2.20%	**7.4**
	Hand	340.5	±18.9	12.20%	**75.3**	340.5	±18.5	12.40%	**43.2**	335.7	±18.2	12.20%	**41.7**
	Trunk (inc. shoulders)	25.3	±2.4	0.90%	**5.1**	23.1	±2.8	0.90%	**2.9**	25	±2.6	0.90%	**3.1**
	Leg,lower (inc. knee or ankle)	67.8	±5.6	1.70%	**9.3**	51.5	±5.9	0.90%	**6.5**	23.4	±5.1	0.90%	**2.9**
Female													
	Head	35.6	±4.9	1.30%	**6.0**	36.9	±7.6	1.30%	**6.1**	36.2	±4.4	1.40%	**5.9**
	Neck (inc. cervical vertebrae)	20.1	±3.8	0.70%	**3.4**	20.3	±4.1	0.80%	**3.4**	20.4	±3.1	0.70%	**3.3**
	Arm,lower (inc. elbow & wrist)	2.4	±1.0	0.10%	**0.4**	3	±1.0	0.10%	**0.5**	3.1	±1.0	0.10%	**0.5**
	Trunk (inc. shoulder)	9.4	±1.0	0.30%	**1.6**	14.2	±1.5	0.30%	**1.3**	7.2	±1.4	0.20%	**1.2**
	Leg,lower (inc. knee or ankle)	12.7	±1.6	0.50%	**2.1**	14.6	±1.4	0.60%	**2.4**	11.1	±1.2	0.40%	**1.8**
	Foot	15	±1.8	0.20%	**2.5**	16.2	±2.0	0.60%	**2.7**	16.5	±1.9	0.60%	**2.7**

The sources of the nonfatal occupational injuries that were caused due to a contact with object or equipment between 2012 and 2014 have been shown in Figure 5. Injuries that were caused by knives were the most commonly occurring injuries for three consecutive years with increasing numbers from 2.10 to 2.30, total annual estimate. More specifically, the number of contact with object or equipment injuries caused by knives that were unspecified were 57,200 (95% CI 46,500 – 67,900) in 2012, 61,900 (95% CI 51,600 – 72,200) in 2013, and 63,400 (95% CI 53,800 – 73,000) in 2014. Moreover, box cutters and razor knives were specified as the source of the contact with object injuries have been estimated at 37,000 in 2012 and 2014 and 39,600 in 2013, in addition to the numbers above, which makes the knives the number one object category causing contact with

object and equipment injuries. Knives were followed by machinery, chips/particles, doors (except garage and vehicle) and nails/brads, tacks, nuts, and bolts/washers. The injuries that were caused by knives have shown 8.7% increase in 2013 and 2.5% increase in 2014. Even though there is no information about how the injury occurred in the database, these results indicate that safety engineers/professionals need to focus more on the design of the cutters used and/or the cut resistant gloves worn while performing the job tasks, and the training provided to the employees needs to be improved if necessary.

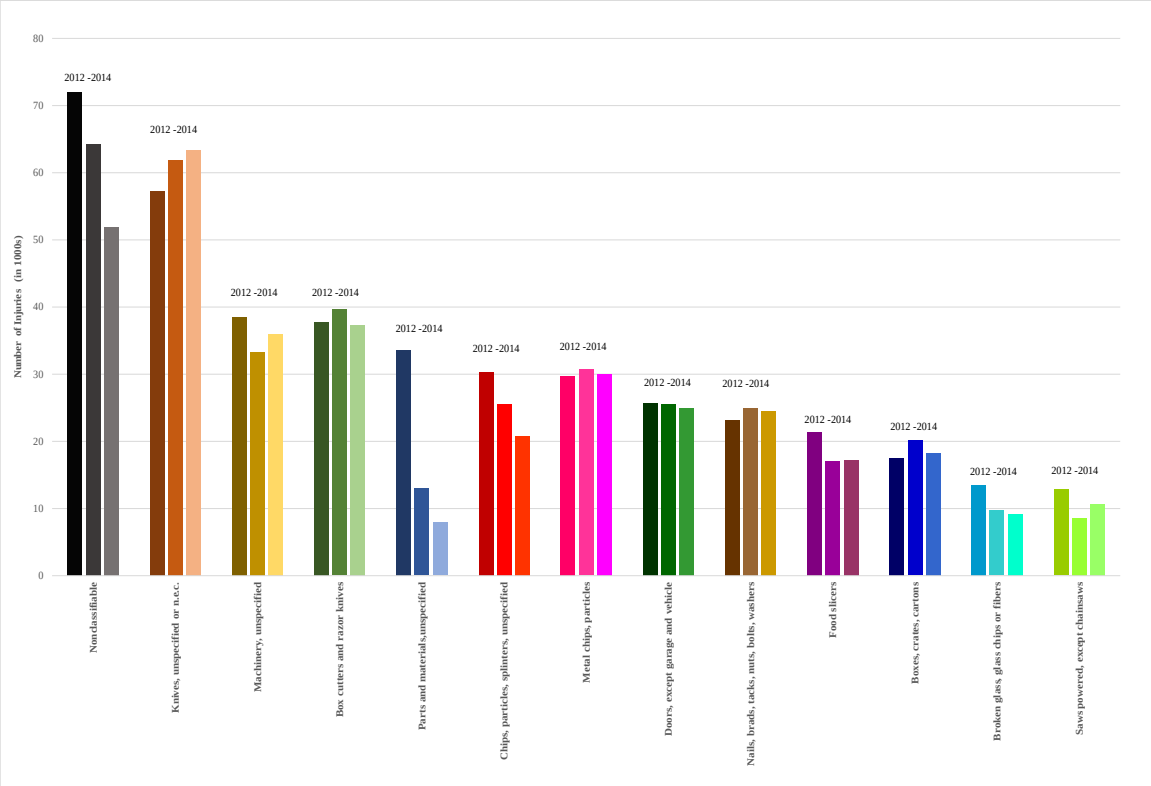


Figure 8. The Source distribution of the nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014

The objects and equipment that caused the highest number of injuries for male and female workers during the studied years have been estimated and shown in Figure 5. Nonfatal contact with object injuries caused by knives showed a small but steady increase (0.7%) from 2012 to 2014, where it also showed an increase for female workers with

fluctuating numbers (Figure 5a). Even though machinery (Figure b) was the second leading cause of the injuries for male workers followed by metal chips/particles and parts (Figure c), doors except for garage and vehicle was the second leading cause of nonfatal occupational contact with object injuries for female workers which were 4.7 times higher than male worker injuries caused by doors (Figure 5d). Figure 5c and Figure 5d show the clear differences between two sexes in terms of the source of the injury at the workplace for the contact with object and equipment injury category. In other words, the estimated numbers calculated out of the NEISS-Work database for the years 2012 – 2014 show that both sexes do not experience injuries in the same way.

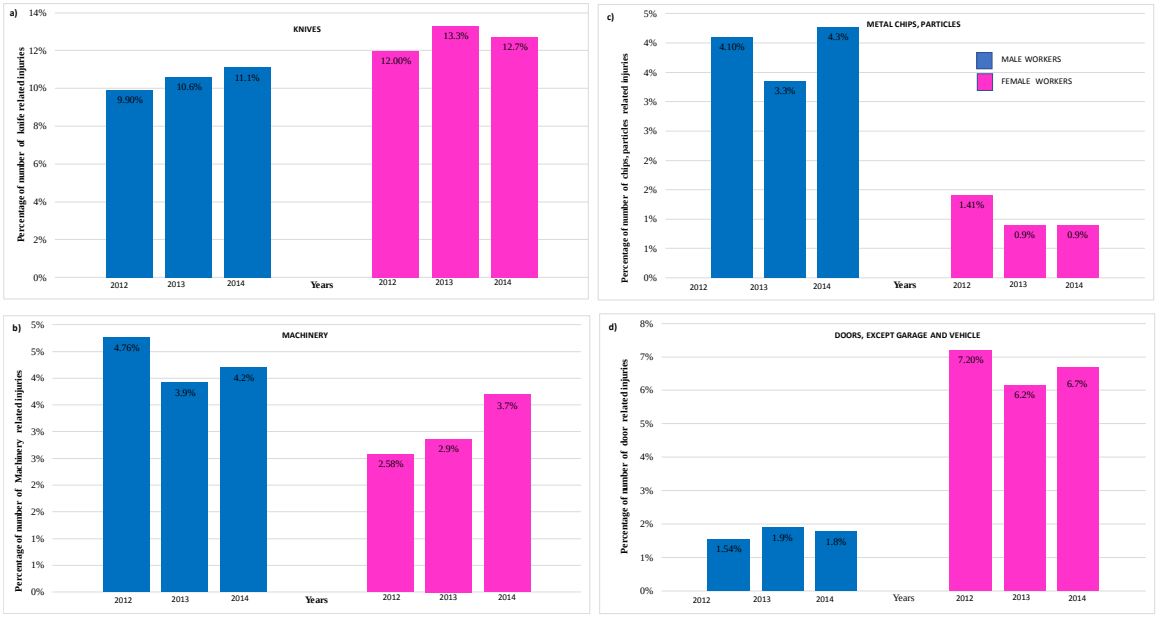


Figure 9. Sources that have caused the highest number of nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments for male and female workers, 2012 – 2014. a) Knife related injuries b) Machinery c) Metal chips, particles d) Doors, except garage and vehicle

Age groups for the source of the nonfatal occupational contact with object or equipment injuries have also been estimated for this study. Even though knife/cutter involved injuries were the most occurring injuries among others, the number of injuries and

the rate of injury decreased with increasing age and, more interestingly, no injuries which involved knife/cutter reported for the age groups of 60 and up (Figure 6).

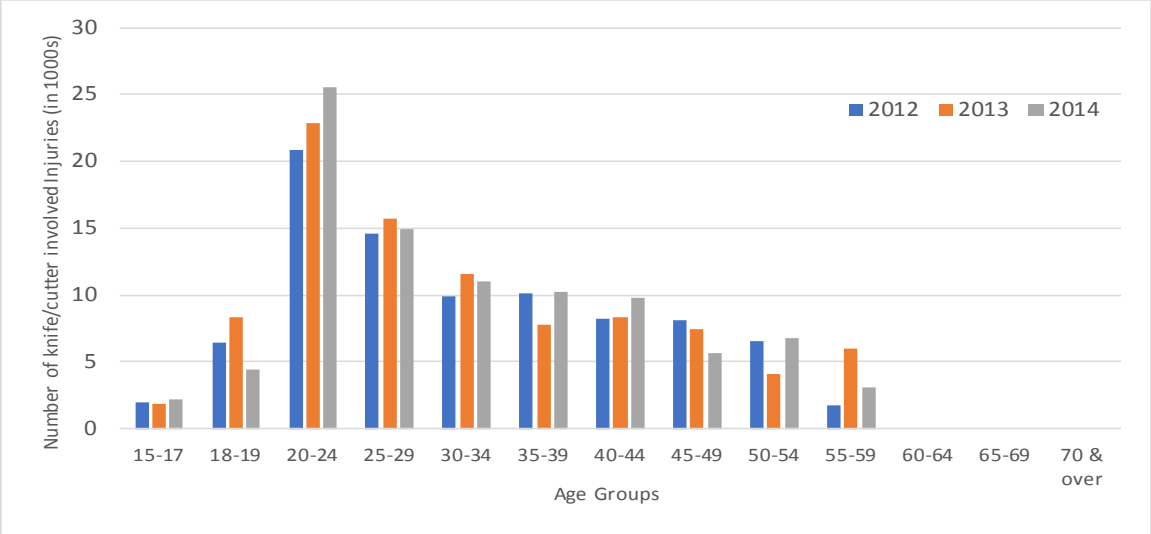


Figure 10. Workers' age distribution of nonfatal occupational contact with object injuries that involved a knife/cutter, 2012 – 2014.

Floors, walkways and stairs were the leading source causing injuries for these age groups. More specifically, workers who fell into the age group of 20-24 and younger, got injured while using a knife/cutter more than any other age groups three consecutive years and number of injuries and injury rate per 100 FTE increased from 2012 to 2014 (0.18, 0.20 and 0.21, respectively). Even though there was a significant difference between the injury rates per 100 FTE (0.18 for 20-24 age group and 0.33 for 18-19 age group and 0.01 for 50-54 age group due to the number of workers in the workforce), the number of workers younger than 20 years old experienced several knife/cutter involved injuries very close to older workers who were between 50 and 59 years old (6,400 (95 CI 5,300-7,500)).

Workers' ages showed a similar pattern for both genders for 20-24-year-old workers for having the highest number of injuries from knives/cutters (Figure 7). Female workers had a significantly lower number of injuries compared to male counterparts. According to BLS, the number of FTE in 2012 were 1,028,896 for men and 303,252 for women who were between 18-19 years old. Therefore, our study shows that female workers were more at risk with the 0.99 per 100 FTE injury rate compared to male workers with the injury rate of 0.52 per 100 FTE. Female workers between 15 and 17 years old and who were older than 55 did not experience injuries that were caused by knives/cutters for three consecutive years. In addition, the age groups of 18-19, 45-49 had zero injuries in 2014.

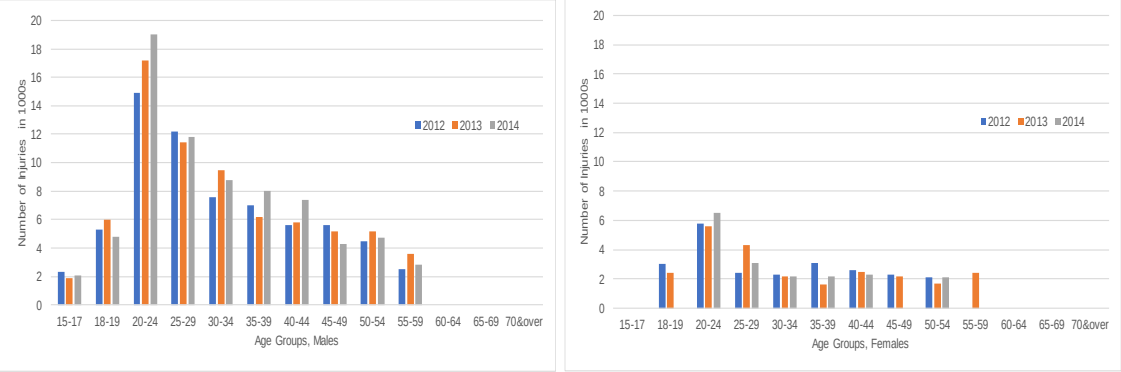


Figure 11. Workers' age distribution of nonfatal occupational contact with object injuries involving a knife/cutter for male workers and female workers, 2012 – 2014.

Rates per 100 FTE for nonfatal occupational contact with object and equipment injuries treated in EDs by the industry as the workers' primary job showed that the mining industry had the highest rates for both male (41%) and female (59%) workers for three consecutive years (Table 8). Rates for both male (66.0, 60.4 and 58.1) and female (162.7, 139.3 and 132.0) workers decreased with years in the mining industry. Estimated injury rates for both male (25%) and female (18%) workers in the agriculture, forestry,

and fishing industry category had the second highest numbers and did not change significantly from 2012 to 2014. In the transportation industry, the rate per 100 FTE for female workers was 3.75 times higher than male workers for 2012, where it significantly dropped in 2013 and 2014. Injury rate per 100 FTE female workers was approximately 3 times higher than male workers in the construction industry. Other than the instances stated above, injury rates per 100 FTE did not change significantly between 2012 and 2014.

Table 8. The estimated rate of nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014 for female and male workers by the industrial group.

		Rate per 100 FTE		
Industry Group	Sex	2012	2013	2014
Agriculture, forestry, fishing	Male	37.9	38.7	36.4
	Female	44.0	45.2	40.2
Mining	Male	66.0	60.4	58.1
	Female	81.0	70.0	66.0
Construction	Male	8.6	8.3	7.6
	Female	29.0	26.7	24.2
Manufacturing	Male	6.2	6.1	5.9
	Female	4.8	4.7	4.3
Trade	Male	6.3	6.4	6.1
	Female	2.7	2.7	2.4
Transportation/ warehouse/ utililities	Male	11.7	11.6	11.0
	Female	43.8	12.0	11.5
Services	Male	2.1	2.1	2.0
	Female	2.3	0.6	0.6
Health, social services	Male	16.1	16.1	15.8
	Female	1.5	1.4	1.3

Female workers were 3 times more at risk compared to their male counterparts in the construction industry and their risk to get injured due to contact with object or equip-

ment was doubled in the mining industry and it was slightly higher in the agriculture industry (19%) categories (Figure 8). The rate per 100 FTE in other industry categories remained similar and did not show a significant change throughout the years studied.

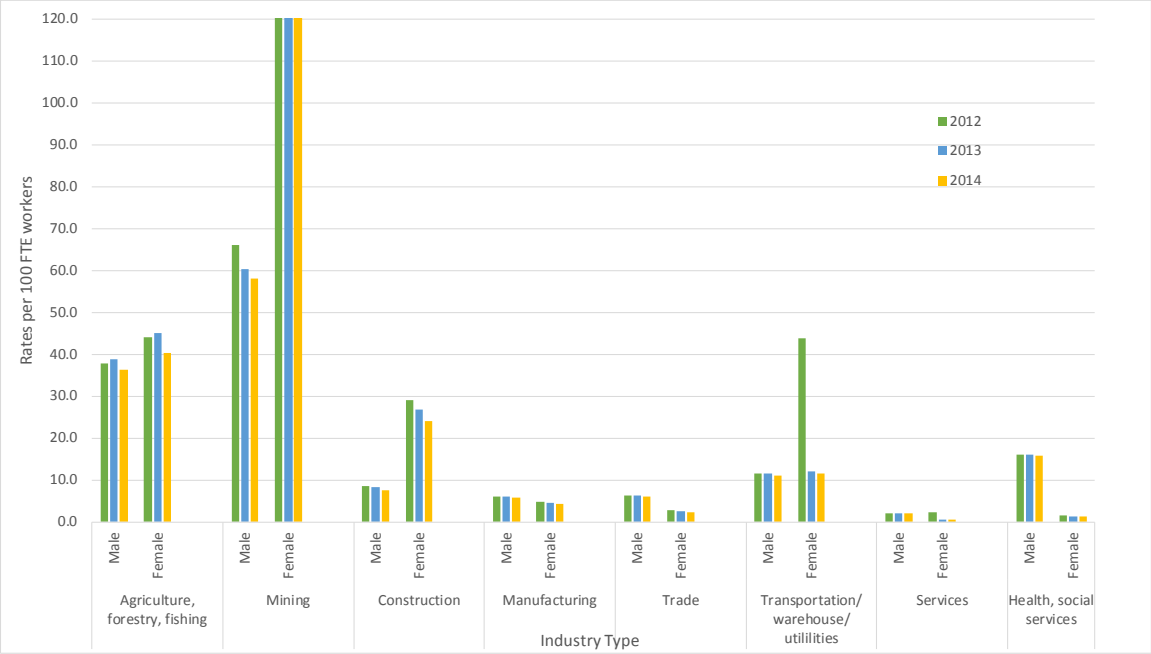


Figure 12. The estimated rate of nonfatal occupational contact with object and equipment injuries treated in U.S. emergency departments, 2012 – 2014 for female and male workers by the industrial group.

4. DISCUSSIONS

This study showed that contact with object and equipment injuries remained as the highest occurring nonfatal occupational injuries treated in EDs among other injury categories during the study period for three years and existing regulations, enforcement, and employers' and employees' efforts to reduce the number of injuries did not make a significant impact. Male workers continued to have more injuries with increasing numbers compared to female workers. Overall, it has been found that younger workers who were

between 20 and 24 years old were the highest risk group and 25-29 workers placed second. 19-year-old and younger workers experienced 1/3 lesser number of injuries than the young workers between 20 and 25 years old. But the injury rate per 100 FTE was higher for the workers in this age group due to the number of workers in this age group in the workforce. This is a highly significant finding since it has been consistently reported in the literature that workers who were younger than 25 years old had the highest injury rate [14]. Even though our study showed a similar trend in terms of the injury rate, the highest number of injuries should also be carefully considered. Therefore, the reason for the high injury rates among the certain age group of young workers may not only be occurring most frequently because of them being young and inexperienced. It has also been found that both sexes have injured their fingers (male injury rate 31 per 100 FTE and female 13 per 100 FTE) the most followed by hand and eye injuries for males and head and foot injuries for females. But while males were injuring their hands at a rate of 12 per 100 FTE, females experienced zero hand injuries. On the other hand, males experienced zero foot injuries where females injured their foot at 2.3 rate per 100 FTE. This leads to a conclusion that differences between males and females in terms of the injury estimates should be taken into consideration very carefully in order to achieve an effective reduction at injury rates. The study showed that a knife/cutter was the source of most of the injuries. On another note, females tend to have 4 times more injuries involving doors, except garage and vehicle compared to males, where males got injured 4 times more due to contact with metal chips/particles. This study also showed even with different injury rates (0.52 per 100 FTE for 19 and younger and 0.05 per 100 FTE for 50 and older), regardless of their sex, the youngest workers (19 and younger with 5,300 (95% CI 3,400 – 7,200)) and the

oldest workers (50 and older 4,500 95% CI 2,900 – 7,100)) had the lowest number of injuries that were caused by cutters/knives.

The results showed the distinctive relation between the injury rate per 100 FTE workers' sexes and the type of the industries which may be due to the type of work or assigned tasks, the work environment, type of tools being used, and, more importantly, the training provided. Female workers who worked in agriculture, mining, construction, and transportation/warehouse industries were more at risk. Manufacturing, trade, services, and health industries were where male workers were getting injured more compared to females. In the industries, the work tools, equipment, working surface heights, and workstations are usually designed for the average size of males [16]. Male and female workers often have physical differences and their anthropometric measurements are different which may cause female workers to conduct work tasks differently from male workers. This leads female workers to be tasked with very different physical demands compared to male counterparts [16]. Some studies in the literature suggests that sex differences in human behavior may cause injury and deaths from injury and also suggests that the sex difference in aggressiveness, violence, crime, sexual behavior, occupational preferences, personality, and diseases may have been contributing to the injury rate differences between male and female workers [17].

5. CONCLUSION

While the best ergonomic shape and safety features of work tools continue to be designed by engineers and the existing safety measures improved and enforced at workplaces, the NEISS-Work injury data suggest that age and sex play a very important role in the number of nonfatal occupational injuries and the sources that caused those injuries

treated in EDs. The analysis of contact with object or equipment injuries showed that cutters/knives were the main sources of worker injuries. Even though the data do not explain how the injury occurred, injuries involving knives at work were most likely due to not using the tool correctly or to not using a properly designed cutter/knife for the task or to not using the proper personal protective equipment (PPE), such as cut resistant gloves. There are a variety of industrial knives designed ergonomically and cut-resistant industrial gloves engineered using different materials in the market. This study also suggests that materials engineers and safety engineers need to be closely studying the injury sources and their close relationship with injury characteristics and worker demographics. An improved design of an industrial knife and a cut-resistant glove which was engineered by using more appropriate material and design can help reduce or even eliminate future workplace injuries. Worker demographics at workplaces need to be determined by safety engineers/ professionals and workplace risk assessments (RA), job safety analysis (JSA) and job hazard analysis (JHA), and safety training need to be revised and improved by considering the impact of the age and the sex of the workers and the industry to help prevent or eliminate any possible occupational injuries. Engineering designs should be reconsidered for the higher risk groups. Instead of using the same methods for all workers, if the safety training and safety engineering designs are revised and by closely monitoring incident and demographic characteristics of the worker groups that have higher injury risk, the injury rate may be reduced.

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CHARACTERIZATION OF NONFATAL OCCUPATIONAL FALL ON SAME LEVEL INJURIES, 2012-2014

by

LEVENT ONAT, SELVUM PILLAY

Submitted to Accident Analysis and Prevention

Format adapted for dissertation

ABSTRACT

Introduction: The purpose of this study is to examine occupational nonfatal same level fall injuries treated in emergency departments (EDs) in the United States. *Method*: Data has been derived from National Electronic Surveillance System-Occupational Supplement (NEISS-Work) from 2012 to 2014. *Results*: Fall injuries (15.5%) were among the top three occupational injury categories and fall on same level injuries accounted for more than 63% of all fall-related injuries. The increase in the number of injuries have been noted for both female and male workers and injury rates for female workers have been estimated higher than male workers. Female workers had the highest injury rates at older ages (50-59 years old) compared to their male counterparts (25-34 years old). Knees, heads, and lower trunks were the most often injured body parts for both female and male workers. The mining industry, the agriculture, forestry, and fishing industry, and the construction industry all had the highest injury rates for both sexes. However, female workers had significantly higher injury rates (5 to 15 times) for these industry groups. *Conclusions*: This study shows that despite existing federal regulations and requirements, occupational fall on same level injuries increased during the study period. The differences between male and female workers' demographic injury characteristics were significant and need to be taken into consideration when incident prevention plans, engineering controls, and training are being developed and implemented. *Practical Applications*: Developing and implementing injury prevention programs and safety management plans supported by the applicable engineering controls and related safety train-

ing, which considers the demographic findings, will support the efforts of reducing occupational injuries.

Keywords: Occupational injury; national electronic injury surveillance system-occupational supplement (NEISS-Work); fall on same level; OSHA; emergency department

1. INTRODUCTION

Falls are one of the main causes of injuries that are preventable which lead to disability and personal and professional impairment at workplaces [1]. Hospital emergency departments (EDs) receive more than 90 million injured patients' visits every year in the United States [2]. Emergency medical services (EMTs) personnel treat 22 million patients a year [3]. National Safety Council (NSC) reported that falls account for over 8 million of those ED visits, representing the leading cause of visits (21.3%). In terms of severity, fall injuries were the leading injury category among others, and work-related accidents cost employers approximately $70 billion including compensation and medical expenses annually [4]. Williams et al. reported that occupational injuries accounted for 12.5% of all injuries and falls accounted for 16% of all occupational injuries [5]. One-quarter (24.8%) of all injuries were due to falls by being the overall leading cause of injury-related ED visits [6]. The National Floor Safety Institute also reported that falls account for approximately 1 million visits to EDs each year, which is 12% of all injuries. Falls do not constitute a primary cause of fatal occupational injuries but instead represent the primary cause of lost days from work [7].

Falls are categorized as falls on the same level, falls and jumps to lower levels, falls and jumps that were curtailed by a personal arrest device, slips and trips that do not result in a fall, and non-transport-related falls resulting in drowning or other nonimpact injuries

[8]. Falls on same level incidents, which were reported as nearly 60% of all compensable fall cases, may cause all levels of injuries ranging from minor contusions to more serious injuries or even death [9]. The most common primary source of same level fall injuries are floors, walkways, or ground surfaces [7]. They were the second highest injury that caused disabling workplace injuries with $7.94 billion in 2011 as reported by NSC. The research about fall on same level injuries is very limited. In addition to the limited number of research in this area, the focus of that research was very narrow. For example, Shishlov et al. studied nonfatal construction industry fall-related injuries treated in U.S. EDs [10]. Even though this type of study can be helpful for specific industries, there is also a need to examine the injuries in a broader perspective. Therefore, this study focused on and investigated the demographic characteristics of fall on same level injury categories including affected body parts and industry groups since nonfatal occupational fall on same level injuries treated in EDs have not been comprehensively investigated.

Researchers have studied injuries by analyzing different injury databases or surveys, such as Bureau of Labor Statistics (BLS) statistical data and the Occupational Supplement of National Electronic Injury Surveillance System (NEISS-Work) [1, 2, 10-14]. NEISS-Work accounts for nonfatal occupational injuries and illnesses treated in U.S. hospital EDs, and occupational injuries that require medical treatment are roughly estimated to be 34% [7]. In this study, the data were derived from NEISS-Work database where injuries are not recorded, requiring consumer product involvement for the years of 2012, 2013 and 2014. It is a nationally stratified probability sample of hospitals in the U.S. and its territories that have a minimum of six beds and operate 24-hour EDs. 67 geographically distributed sample hospitals have been chosen within approximately 5,300

rural and urban U.S. hospitals after stratification by total annual ED visits. Occupational injuries are recorded by hospital employees every day of the year after identifying the case as an occupational injury case, where each case is assigned a statistical weight [15].

This study examines and evaluates the demographic and trend analysis of nonfatal occupational fall on same level injuries treated in EDs for the selected period of treatment years, age group, sex, parts of the body affected, event, and industry group. The outcome of this study provides useful information for the injury prevention efforts of health and safety professionals to determine which variables should be focused on to develop and implement more effective prevention plans and engineering controls at workplaces.

2. METHODS

We examined and evaluated the demographic and trend analysis of nonfatal occupational fall on same level injuries treated in EDs for the selected period for treatment year, age group, sex, part of the body affected, event, and industry group by analyzing NEISS-Work data. In order for the work injury to be part of NEISS-Work, the patient needs to visit a NEISS-Work sample ED where work-relatedness was recorded in an ED chart. NEISS hospital coder abstracts and submits the case to Consumer Product Safety Commission (CPSC) to be reviewed. The National Institute for Occupational Safety and Health (NIOSH) reviews all cases and finalizes the data. [15].

Work-Related Injury Statistics Query System (Work-RISQS) was used in this research as the interactive data access system to the surveillance data. It was developed by NIOSH which collaborated with CPSC to collect the data through NEISS-Work. Work-RISQS allowed us to query interactively on worker demographic characteristics, nature of the injury, and incident circumstances for ED-treated nonfatal occupational fall on

same level injuries to obtain national estimates. The 95% confidence intervals were calculated by taking different random samples of all U.S. hospitals that obtained an injury estimate of falls within the confidence interval range at least 95% of the time [16].

Injury classifications are coded in the system as they are defined in BLS OIICS [17]. 1998-2011 data use OIICS v.1.01 for event, and source codes 2012 to present data use OIICS v.2.01 for event and source codes. Since the recent data between the years 2012 and 2014 have been analyzed, OIICS v.2.01 injury classification system was used in this study.

All variables that are examined in this study, treatment year, age group, part(s) of the body affected, events, and sex, have been selected through the query system for the studied injury category and the years. Injuries were queried for one calendar year at a time since the systems allowed only one year to be queried at one time. Age groups were selected as 15 and over at pre-set 5-year age groups. The employed labor force (ELF) data obtained from the BLS's Current Population Survey (CPS) has been used in this study to calculate "national rate estimates" of injuries per full-time equivalent worker (FTE) for all industry groups [18]. Rates for Work-RISQS were calculated by dividing the Work-RISQS estimate by the selected worker population number. Obtained data were exported to Excel and results have been analyzed and presented with tables and plots for the selected injury category.

3. RESULTS AND DISCUSSIONS

The results showed that the number of nonfatal occupational fall injuries treated in EDs (434,200 in average) and their percentage (15.8%) were among the top three injuries with overexertion and contact with object or equipment injuries from 2012 to 2014 (Fig-

ure 1, Figure 2). Figure 1 and Figure 2 also show the rise in occupational fall injuries during the study period. More specifically, fall injuries increased 1.3% from 2012 to 2014. Even though this may look like a small percentage, it shows that 31,600 more nonfatal occupational fall injuries have been reported to the EDs in 2014 compared to 2012. Researchers studying BLS data have similarly found that the percentage of overall fall injuries, including "fall on same level", "fall to lower level", "jump to lower level", and other fall-related events increased incrementally from 19.8% in 2006 to 22.3% in 2010 [19]. BLS Survey of Occupational Injuries and Illness (SOII) data for the study period also shows that fall injuries are among top three nonfatal occupational injuries. Fall injuries were 25.5% – 27.4% of all injury types where fall on same level injuries had the highest rate among all other fall injury subcategories (19 per 10,000FTE) [20-22].

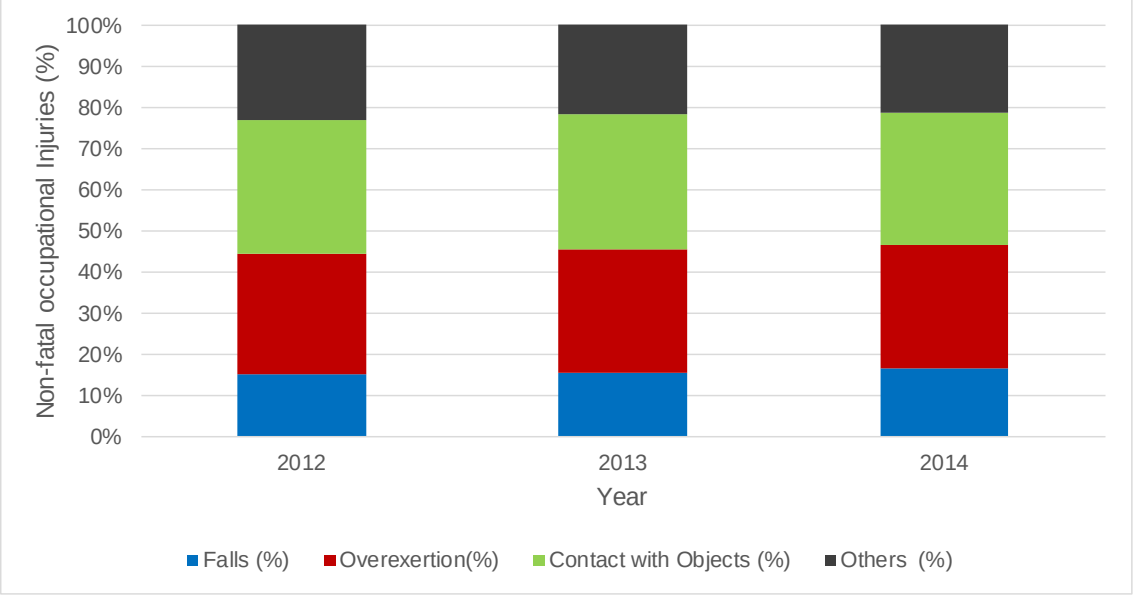


Figure 1. Distribution of NEISS-Work nonfatal occupational injury data from 2012 through 2014 (in percentages).

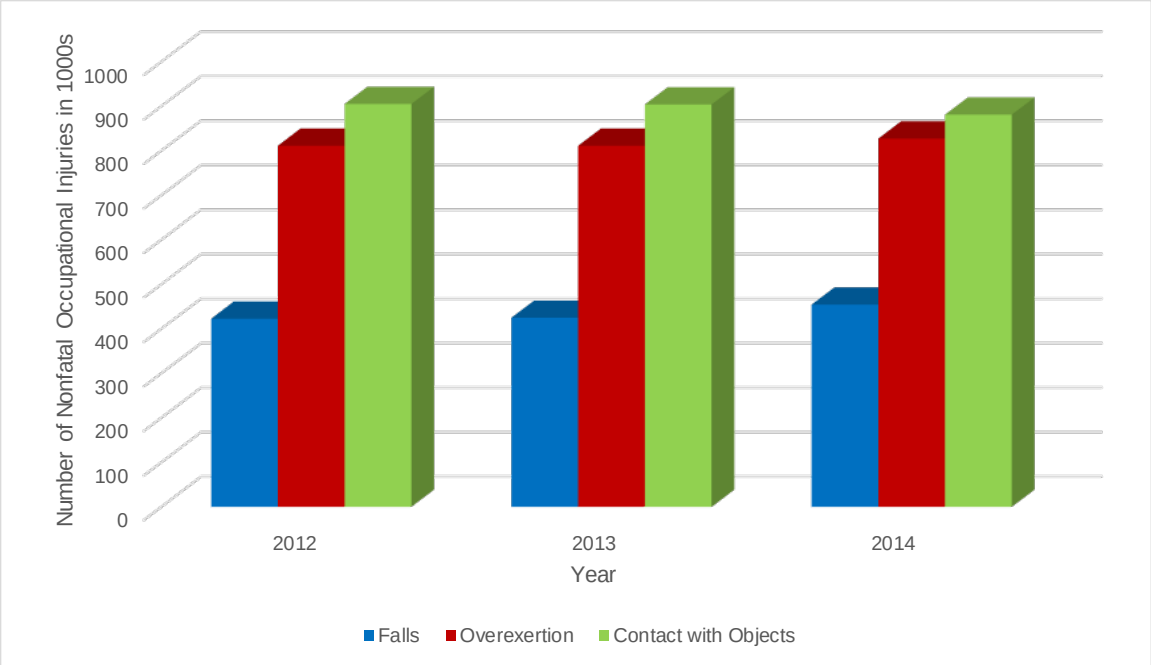


Figure 2. Distribution of the number of nonfatal occupational injuries in NEISS-Work from 2012 through 2014 (in 1000's).

Fall on same level injuries have been calculated as the most often occurring injury category among all other fall injury categories for three consecutive years (Figure 3). They occurred 40% more than other fall-related injury categories. The number of falls to lower level injuries, 108,300 (95% CI 87,800 – 128,800), were the second leading injury category. Yeoh et al. published a study showing a similar pattern for the percentage of fall on same level injuries documented at BLS for prior years. They increased from 12.8% in 2006 to 15% in 2010 [19]. Their results suggested that fall on same level related occupational injuries contribute to more than 14% of overall occupational injuries. In another study, it has been reported that the one half million fall events ranked third among emergency department treated incidents in 1998. Among the falls, 63% were falls on the same level and 33% were falls to a lower level [7].

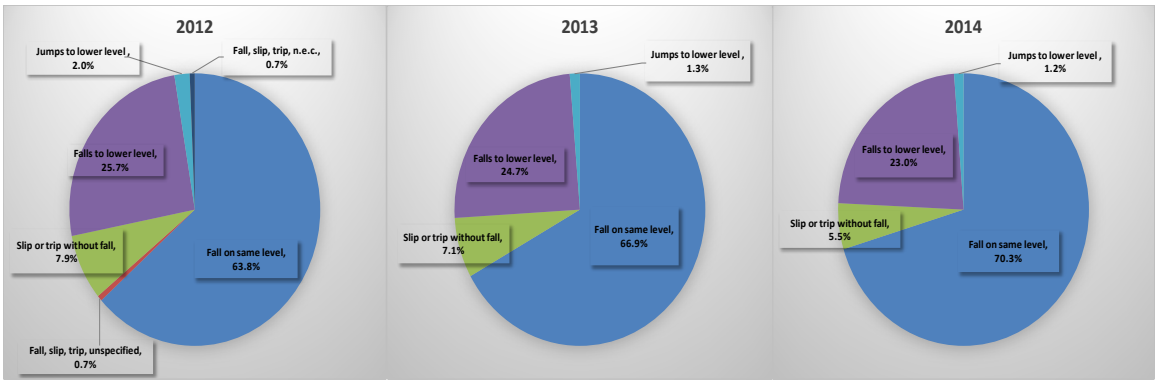


Figure 3. Distribution of the number of nonfatal occupational fall injury subcategories in NEISS-Work for 2012 through 2014.

Using the records from NEISS-Work, nonfatal occupational fall on same level injuries were estimated at a 19% increase in the number of injuries from 2012 to 2014 (Table 1). The highest estimated number of fall on same level injuries, 319,600 (95% CI 272 600 – 366,600), occurred in 2014.

Table 1. Yearly injury and rate estimate of nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014.

Year	Number of injuries/illnesses	95% CI	Percent of total annual estimate
2012	268,400	214,700 - 322,100	9.70%
2013	282,500	230,500 - 334,500	10.30%
2014	319,600	272,600 - 366,600	11.60%

The injury rates have been estimated at 0.19, 0.20, and 0.23 per 100 workers treated in EDs for the years 2012, 2013, and 2014, respectively (Figure 4). This result also showed the increasing nonfatal occupational fall on same level injuries.

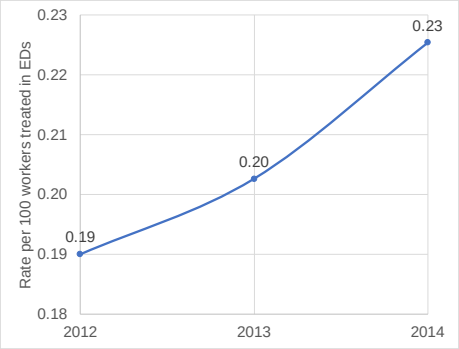


Figure 4. Nonfatal occupational fall on same level injury rates per 100 workers.

Estimates of workers injured due to nonfatal occupational fall on same level injuries treated in EDs showed a similar increasing trend for both sexes (Table 2). Male workers had 5.72% more injuries in 2013 and 17.07% more injuries in 2014 compared to previous years where the change in female worker injuries was not at the same rate as male workers (4.40% in 2013, 6.67% in 2014). However, female workers experienced more injuries compared to male workers each year. While the difference in the estimated number of injured female vs. male in 2012 and 2013 was 31,000, this number dropped 48% in 2014. On the other hand, due to the increase in the number of male workers in the workforce, injury rates for males were 0.15, 0.16, and 0.19, while it was 0.25, 0.26, and 0.27 for females in 2012, 2013, and 2014, respectively. In short, the significant increase in male worker injuries in 2014 caused the reduction of the difference in the number of female and male worker injuries, while increasing number of male workforce balanced the injury rate. BLS revealed that falls accounted for 5% of the job-related fatalities for female workers compared to 11% for male [4].

Table 2. Estimates of the number of male and female workers injured from nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014

	2012			2013			2014		
Sex	Number of injuries/illnesses (in 1,000's)	95% CI	Percent of total annual estimate	Number of injuries/illnesses (in 1,000's)	95% CI	Percent of total annual estimate	Number of injuries/illnesses (in 1,000's)	95% CI	Percent of total annual estimate
Male	118,600	94,500 - 142,700	4.30%	125,800	101,300 - 150,300	4.60%	151,700	127,600 - 175,800	5.50%
Female	149,800	118,200 - 181,400	5.40%	156,700	126,300 - 162,400	5.70%	167,900	140,200 - 195,600	6.10%

Figure 5. Injury rate per 100 FTE of male and female workers injured from nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014.

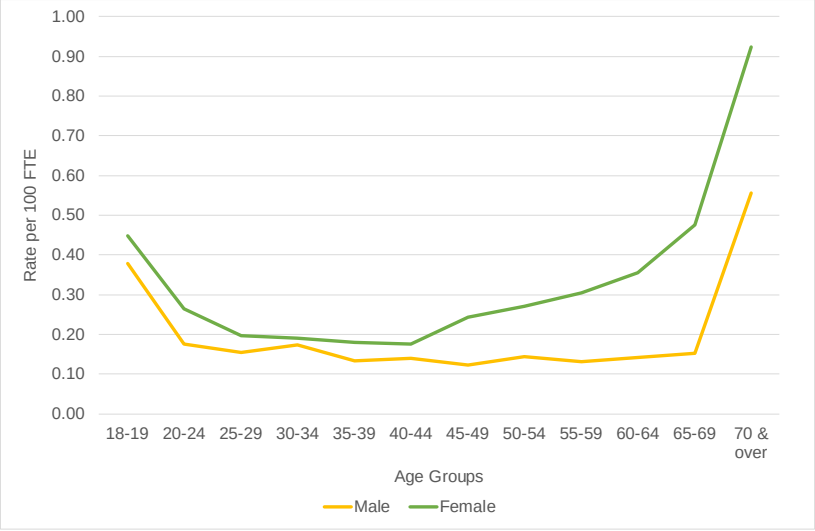
In 2012, even though the injury rate per 100 FTE was 0.20, with 16,769,757 workers at this age group, the highest number of injuries occurred for all workers within 50-54 years of age, 33,600 (95% CI 26,400 – 40,800). Moreover, the highest injury rate was 0.70 for 70 years old & over and 0.41 for the workers younger than 20 years old. Both age groups had around 1.5 – 2.0 million in the workforce while others had over 11 million FTEs. Female workers had slightly fewer injuries compared to male workers between 25-44 year-old, whereas female workers had more injuries at other age groups. On the other hand, due to fewer female FTE, injury rate per 100FTE was higher for female workers. More specifically, the rate for female workers younger than 20 years old was 0.45 per 100 FTE, while it was 0.38 for male workers. For male employees, the highest number of injuries, 15,600 (95% CI 12,400 – 18,800) with the injury rate of 0.17 per 100 FTE, occurred for the workers who were between the ages of 30-34 years when it was

estimated as 20,200 (95% CI 15,400 – 25,000) with the injury rate of 0.27 per 100 FTE for female workers for the age group of 50 – 54 year-old (Table 3). Workers who were older than 70 years old and younger than 20 years old had the highest injury rates.

Table 3. Nonfatal occupational fall on same level injuries treated in emergency departments in 2012 by age and sex.

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
18-19	3.9	±1.5	4.1	±1.6	8	±2.2	0.3%
20-24	11	±2.9	13.6	±3.7	24.6	±5.5	0.9%
25-29	13.1	±3.4	12.8	±4.1	25.9	±6.8	0.9%
30-34	15.6	±3.2	12.3	±3.3	27.9	±5.7	1.0%
35-39	11.5	±2.8	11	±2.6	22.6	±4.6	0.8%
40-44	13.1	±4.0	12.3	±2.7	25.4	±5.6	0.9%
45-49	11.6	±2.7	17.8	±4.9	29.4	±7.1	1.1%
50-54	13.4	±3.6	20.2	±4.8	33.6	±7.2	1.2%
55-59	10.1	±3.2	19.1	±4.7	29.2	±7.5	1.1%
60-64	6.9	±2.3	13.6	±3.9	20.5	±5.0	0.7%
65-69	3.1	±1.3	6.8	±2.3	9.9	±3.0	0.4%
70 & over	4.5	±1.5	4.8	±1.7	9.3	±2.7	0.3%

Figure 6. Nonfatal occupational fall on same level injuries treated in emergency departments in 2012 by age and sex



At 55-59 years of age, the highest number of injuries, 36,000 (95% CI 27,800 – 44,200), has been found for all workers in 2013 (Table 4). The injury rate has been esti-

mated at 0.25 per 100 FTE. Even though the number of injuries for male workers within 20-25 years of age was the highest, 14,900 (95% CI 10,800 – 19,000), the number of 50-54 years old male workers also reported to EDs with a high number of fall on same level injuries, 14,800 (95% CI 10,300 – 19,300). The number of female worker injuries has been estimated as 22,100 (95% CI 16,900 – 27,300) for 55-59 years of age as the highest. Similar to the previous year, despite fewer injuries, the injury rate increased for workers older than 55 years old and younger than 25 years old.

Unlike the results in 2012 (Table 3), in 2013 female workers had only fewer injuries than male workers for the age group of 25-29. The number of male worker injuries has been estimated as 14,900 (95% CI 10,800- 19,000) and female workers as 12,100 (95% CI 9,000 – 15,200).

Table 4. Nonfatal occupational fall on same level injuries treated in emergency departments in 2013 by age and sex.

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
18-19	3.3	±1.4	4.5	±1.8	7.7	±2.5	0.30%
20-24	12.3	±3.1	13.2	±2.6	25.5	±4.4	0.90%
25-29	14.9	±4.1	12.1	±3.1	27.1	±6.4	1.00%
30-34	12.8	±2.6	12.7	±2.8	25.6	±4.4	0.90%
35-39	10.4	±2.1	12.7	±3.3	23.1	±4.9	0.80%
40-44	13.4	±3.7	14.7	±3.9	28	±6.9	1.00%
45-49	13.2	±3.4	17.6	±4.3	30.9	±7.3	1.10%
50-54	14.8	±4.5	18.8	±5.2	33.6	±7.8	1.20%
55-59	13.9	±3.8	22.1	±5.2	36	±8.2	1.30%
60-64	7.3	±2.1	13	±3.2	20.3	±4.3	0.70%
65-69	4.1	±1.2	7.7	±2.9	11.7	±3.6	0.40%
70 & over	4.1	±1.7	5.4	±1.8	9.5	±3.2	0.30%

Figure 7. Nonfatal occupational fall on same level injuries treated in emergency departments in 2013 by age and sex

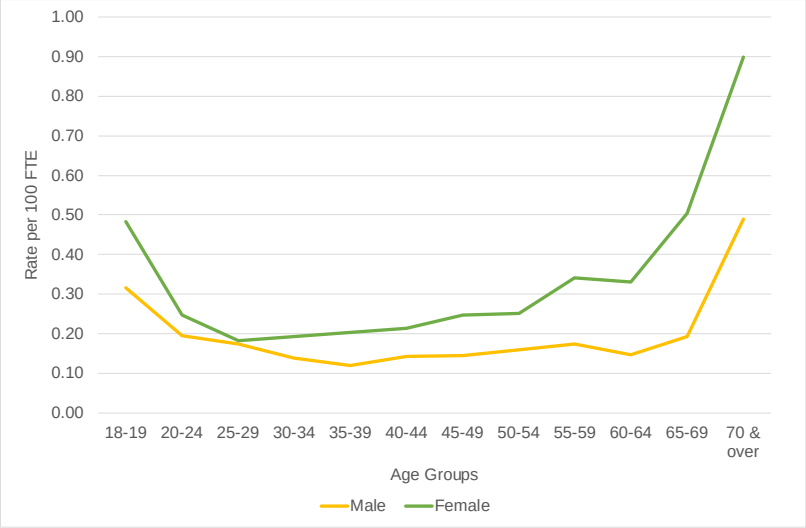
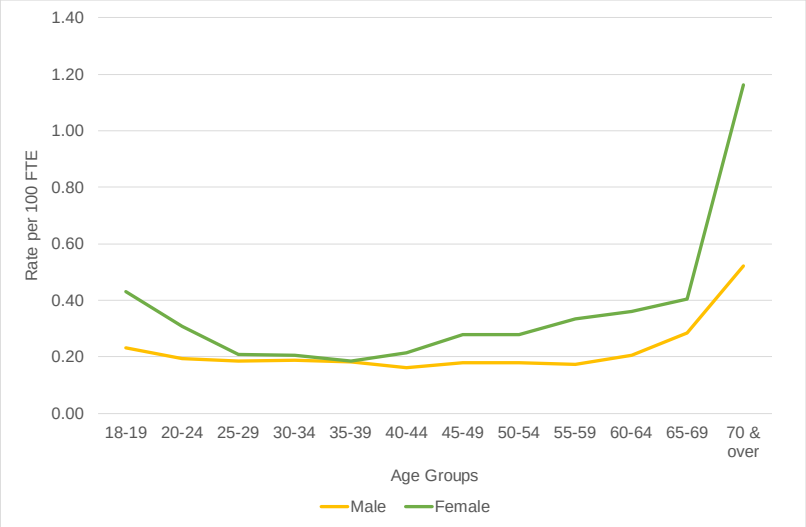


Table 5 shows that the highest number of injuries occurred for all workers within 50-54 years of age, 37,900 (95% CI 30,400 – 45,400), in 2014 with an injury rate of 0.20 per 100 FTE. For male employees, the highest number of injuries is estimated at 17,800 (95% CI 13,400 – 22,200) with an injury rate of 0.14 per 100 FTE, occurring for the workers who were between the ages of 30-34 years. Number of injuries for female workers were very close for the age groups 50-54 [21,600 (95% CI 17,100 – 26,100)] and 55-59 [21,000 (95% CI 17,100 – 24,900)]. In relation to the number of people in the workforce, the injury rate has decreased from 0.32 to 0.18 per 100 FTE from 18 years old to 44 years old and increased from 0.18 to 0.79 from 45 years old to 70 and over. Similar to the year 2012, the age group that female workers had less number of injuries compared to the male workers were between 25 and 44 years in 2014 but had higher injury rates for all age groups compared to male counterparts.

Table 5. Nonfatal occupational fall on same level injuries treated in emergency departments in 2014 by age and sex

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
18-19	2.5	±1.0	4	±1.3	6.4	±1.9	0.20%
20-24	12.8	±3.0	16.6	±4.2	29.4	±6.5	1.10%
25-29	16.3	±3.4	14.2	±4.6	30.5	±6.3	1.10%
30-34	17.8	±4.4	13.9	±3.8	31.6	±6.8	1.20%
35-39	16.4	±3.6	11.9	±2.7	28.3	±4.9	1.00%
40-44	15	±3.5	14.6	±3.4	29.6	±5.6	1.10%
45-49	16.6	±2.7	19.6	±3.9	36.2	±5.7	1.30%
50-54	16.9	±4.6	21	±3.9	37.9	±7.5	1.40%
55-59	14	±3.2	21.6	±4.5	35.6	±6.3	1.30%
60-64	11	±2.5	14.8	±3.0	25.7	±4.7	0.90%
65-69	6.3	±2.0	6.6	±2.4	12.9	±4.1	0.50%
70 & over	4.6	±1.8	7	±2.7	11.7	±4.1	0.40%

Figure 8. Nonfatal occupational fall on same level injuries treated in emergency departments in 2014 by age and sex



The distribution of parts of the body affected for all employees treated in EDs did not change significantly over the study period (Table 6). Injuries most often involved knee, head, and lower trunk injuries for all three years with increasing numbers from 2012 to 2014. Upper arm and leg injuries have been recorded as the lowest number of

injuries for 2012 and 2013. In addition to the upper arm and leg injuries, mouth (including lips, tongue, and teeth) and all parts of the body (more than 50% of the body) have also occurred as the lowest number of estimates for the year of 2014.

Table 6. Estimates of body parts injured of nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014.

Part(s) of body	2012				2013				2014			
	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**
Head	51.2	±9.2	2.80%	**3.73**	56.3	±9.4	2.10%	**4.04**	63.9	±7.6	2.30%	**4.51**
Neck (inc. cervical vertebrae)	6	±1.8	0.20%	**0.44**	6.6	±2.5	0.20%	**0.47**	8.9	±2.9	0.30%	**0.63**
Arm,upper	3.4	±1.1	0.10%	**0.25**	2.9	±0.9	0.10%	**0.21**	3	±1.3	0.10%	**0.21**
Arm,lower (inc. elbow & wrist)	35.5	±2.6	1.30%	**2.59**	35.4	±2.1	1.30%	**2.54**	38.3	±2.0	1.40%	**2.70**
Hand	13	±3.3	0.50%	**0.95**	14.8	±2.9	0.50%	**1.06**	16.3	±2.5	0.50%	**1.15**
Trunk (inc. shoulders)	78.5	±6.7	2.80%	**5.72**	82.1	±5.5	3.00%	**5.89**	96.6	±6.1	3.50%	**6.81**
Leg,upper	3.4	±1.3	0.10%	**0.25**	2.2	±0.8	0.10%	**0.16**	2.3	±1.0	0.10%	**0.16**
Leg,lower (inc. knee or ankle)	66.7	±1.9	2.50%	**4.86**	73.5	±2.1	2.70%	**5.27**	79.4	±2.5	2.90%	**5.60**
Foot	4.5	±1.5	0.20%	**0.33**	4	±1.7	0.10%	**0.29**	5.8	±1.5	0.20%	**0.41**
All parts of the body (> 50% of body	-	-	-	-	-	-	-	-	1.8	±0.8	0.10%	**0.13**

In more detail, Table 7 presents the body parts affected for male and female workers where knee injuries, head injuries, and lower trunk injuries were the most common injuries for both male and female workers for the study period. The year 2014 had the highest estimated number of injuries for these three body parts compared to the previous years, except the knee injuries for female workers in 2013. More specifically, the highest estimated number of knee injuries for male workers in 2014 was 17,000 (95% CI 13,100 – 20,900) injuries with the injury rate of 2.2 per 100 FTE and 32,500 (95% CI 23,600 – 41,400) injuries with the injury rate of 4.8 per 100 FTE for female workers in 2013. This shows that the number of knee injuries for females was 48% higher. The number of the head and lower trunk injuries had also similar patterns for both sexes. Female workers had more head injuries 26,100 (95% CI 21,200 – 31,000) and lower trunk injuries 25,500 (95% CI 19,900 – 31,100) compared to their male counterparts in 2014. Furthermore, it was found that injury rates for both male and female workers increased between 2012-2014, except for the reducing rate of knee injuries for female workers from

4.8% in 2013 to 4.7% in 2014. Injury rates for female workers have been calculated higher than male workers.

Table 7. Estimates of body parts injured of nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014 for female and male workers.

		2012				2013				2014			
Sex	Part(s) of body	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**
Male													
	Head	5.2	±5.2	0.80%	**3.0**	26.2	±4.4	0.90%	**3.4**	29.8	±3.8	1.10%	**3.8**
	Neck (inc. cervical vertebrae)	1.9	±0.9	0.10%	**0.3**	2.8	±1.2	0.10%	**0.4**	3.8	±1.8	0.10%	**0.5**
	Arm,lower (inc. elbow & wrist)	16.8	±1.8	0.70%	**2.2**	18.4	±1.9	0.70%	**2.2**	16	±1.9	0.60%	**2.0**
	Hand	7.9	±2.3	0.30%	**1.0**	8.8	±2.0	0.30%	**1.2**	7.1	±1.0	0.30%	**0.9**
	Trunk (inc.shoulders)	37.5	±3.7	1.30%	**5.0**	38.7	±3.4	1.40%	**5.1**	49.9	±4.4	1.80%	**6.4**
	Leg,upper	1.9	±0.9	0.10%	**0.3**	-	-	-	**-**	7.2	±2.2	0.30%	**0.9**
	Leg,lower (inc. knee or ankle)	24.7	±5.0	1.20%	**3.3**	39.3	±4.1	1.40%	**3.5**	43.6	±3.9	1.60%	**4.2**
Female													
	Head	28.5	±4.9	1.10%	**4.3**	30.1	±5.7	1.10%	**4.5**	32.2	±4.9	1.10%	**4.7**
	Neck (inc. cervical vertebrae)	4.1	±1.9	0.10%	**0.6**	3.8	±1.7	0.10%	**0.6**	5.1	±1.7	0.20%	**0.7**
	Arm,upper	2.2	±0.8	0.10%	**0.3**	2	±0.8	0.10%	**0.3**	-	-	-	**-**
	Arm,lower (inc. elbow & wrist)	18.8	±1.5	0.70%	**2.8**	18.8	±1.5	0.60%	**2.8**	22.7	±1.6	0.80%	**3.3**
	Trunk (inc.shoulders)	41.1	±3.3	1.50%	**6.1**	43.3	±2.7	1.50%	**6.4**	46.8	±2.6	1.70%	**6.8**
	Leg,lower (inc. knee or ankle)	42	±1.5	1.40%	**6.3**	46.5	±1.4	1.70%	**6.9**	46.8	±1.4	1.70%	**6.8**

Floors, walkways and ground surfaces were estimated as the primary sources of the fall on same level injuries, 260,000 (95% CI 211,300 – 308,700) with an injury rate of 0.19 per 100 FTE. Liquids, cords (power, electrical, extension), and nonstructural floor coverings were determined as the secondary sources of injuries that were involved most frequently. The floor materials and floor, walkway, and ground surfaces could be engineered to better resist the harsh conditions of the workplaces, such as heavy powered industrial truck movements, heavy loads such as unloading heavy materials, and products with cranes or harsh outside environmental conditions.

Rates per 100 FTE for nonfatal occupational fall on same level injuries treated in EDs by the industry as the workers' primary job showed that the mining industry had the highest rates for both male (43%) and female (59%) workers for three consecutive years (Table 8). Rates for male workers increased (11.2, 13.4, and 14.1) with years but fluctuated (118.6, 87.9, and 105.4) for female workers in the mining industry. Estimated injury rates for both male (24%) and female (20%) workers in the agriculture, forestry, and fishing industry category had the second highest numbers and increased from 2012 to 2014.

The construction industry was the third highest and injury rates stayed stable for three consecutive years. All other industry categories, such as transportation and manufacturing, with lower injury rates also presented increasing injury rates.

Table 8. The estimated rate of nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014 for female and male workers by the industrial group

		Rate per 100 FTE		
Industry Group	Sex	2012	2013	2014
Agriculture, forestry, fishing	Male	6.4	6.9	8.0
	Female	32.1	35.5	35.6
Mining	Male	11.2	13.4	14.1
	Female	59.0	44.0	52.0
Construction	Male	1.5	1.5	1.7
	Female	21.2	21.0	21.4
Manufacturing	Male	1.0	1.4	1.4
	Female	3.5	2.9	3.4
Trade	Male	1.1	1.1	1.3
	Female	2.0	2.1	2.2
Transportation/ warehouse/ utililities	Male	2.0	2.6	2.7
	Female	9.4	7.6	9.2
Services	Male	0.3	0.4	0.4
	Female	0.5	0.5	0.5
Health, social services	Male	2.7	3.6	3.8
	Female	1.1	0.9	1.1

Female workers were more at risk compared to their male counterparts for all industry categories except the industry of health and social services (Figure 5). Injury rates per 100 FTE were estimated roughly 5 to 15 times higher for female workers who worked in the construction industry, the agriculture, forestry, fishing industry, and the mining industry. Service industry had the lowest injury rate among all other industry groups.

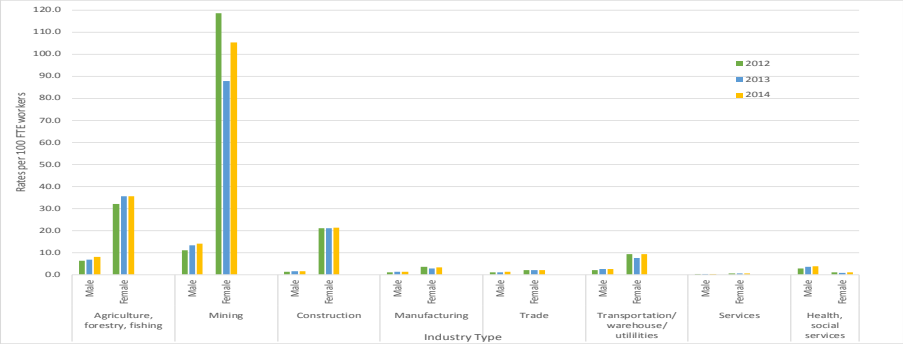


Figure 9. The estimated rate of nonfatal occupational fall on same level injuries treated in U.S. emergency departments, 2012 – 2014 for female and male workers by the industrial group.

4. DISCUSSIONS

The injury rates estimated through NEISS-Work showed that despite existing federal regulations and requirements, nonfatal occupational fall on same level injuries treated EDs increased during the study period. Our study showed that older female workers (over 45 years old) had the highest injury rates compared to their male counterparts (30-34 years old). It is not only the differences in the number of injuries that were significant; the study also showed female workers were at higher injury risk at work. It is suggested that these need to be taken into consideration when incident prevention plans, engineering controls, and training programs are being developed and implemented. Safety professionals usually rely on OSHA-required standard training programs to prevent occupational injuries at workplaces [23, 24]. Even though these training programs include general safety training such as fall protection, material handling, ergonomics, and walking and working surfaces[23], workplace training programs need to be customized for different demographics. The distribution of parts of body affected did not change significantly over the study period. However, the results clearly showed that fall on same level injuries mainly affected knees, heads, lower trunks, shoulders, and wrists. OSHA standard 29 CFR 1910.132 requires employers to assess their workplace to determine if hazards are

present, or are likely to be present, which requires the use of proper personal equipment (PPE). Therefore, it is recommended that engineering controls along with PPE be enforced after a comprehensive assessment by considering the parts of the body that have a higher risk to be injured along with the sex and the age of the employee. Although the mining industry and the agriculture, forestry and fishing industries have been found as the high-risk industries, more specific training and injury prevention plans need to be developed and implemented for female workers to reduce higher injury occurrences in all industry categories.

5. CONCLUSIONS

The outcome of this study provides more in-depth analysis of specific variables by analyzing the correlations and trends between demographics and injury types along with industry groups and will be highly effective tool for health and safety professionals while developing and implementing customized, employee and industry-specific, more effective safety training, hazard assessments, tool and workstation designs, safety engineering controls, and the use of personal protective equipment. Investments in improved safety for these workers will likely have long-term benefits towards providing a safer work environment, reduce injuries and hence reduce worker's compensation cost. Every industry, every workplace has their own unique work environment. Floors, walkways, and ground surfaces being the main sources of fall on same level injuries in this study, floor materials and floor and walkway designs could be engineered to resist better to the harsh conditions of the workplaces such as heavy powered industrial truck movements and heavy loads, such as unloading heavy materials and products with cranes or harsh outside environmental conditions.

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CHARACTERIZATION OF NONFATAL OCCUPATIONAL OVEREXERTION INJURIES INVOLVING OUTSIDE SOURCES, 2012-2014

by

LEVENT ONAT, SELVUM PILLAY

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ABSTRACT

Introduction: The purpose of this study is to examine occupational nonfatal overexertion injuries involving outside sources treated in emergency departments (EDs) in the United States. *Method*: Data has been queried from National Electronic Surveillance System-Occupational Supplement (NEISS-Work) from 2012 to 2014. *Results*: Overexertion injuries accounted for more than 29% of the nonfatal occupational injuries treated in EDs in the United States. More than 56% of them and more than 15% of all nonfatal occupational injuries were overexertion injuries involving outside sources. Male workers experienced more than 60% compared to their female counterparts. The neck, wrist, shoulder, and lower and upper trunk were the most injured body parts for both sexes. The majority of the sources were patients and boxes, crates, and cartons. Female workers (20-29 age-old) have been injured 4.5 times more. Boxes-, crates-, and cartons- related injuries were the second leading injuries where male workers had slightly more injuries (0.5%) compared to female counterparts. Female workers in manufacturing, construction, agriculture, mining, and transportation were more susceptible to overexertion injuries. *Conclusions*: The influence of worker demographics on worker injuries by identifying the risk groups have been documented. In addition to the traditional methods, injury prevention efforts such as safety management programs, safety training, and engineering designs need to focus more on worker demographics. *Practical Applications*: Focusing on the impact of worker demographics on occupational injuries by developing and implementing more specific safety programs that are supported by engineering ergonomic designs and controls will help reduce occupational injuries.

Keywords: Occupational injury; overexertion; ergonomics; national electronic injury surveillance system occupational supplement (NEISS-Work); emergency department

1. INTRODUCTION

According to Liberty Mutuals' 2013 workplace safety index, overexertion involving outside sources, which include injuries related to lifting, pushing, pulling, holding, carrying, or throwing, was the leading disabling injury in the United States [1]. This injury category costs businesses $14.2 billion in direct costs and accounted for more than 25% of the overall national cost [1]. Overexertion involving outside sources was also the leading event or exposure with 408,760 cases reported by the Bureau of Labor Statistics' (BLS) News Release in 2012 [2]. Lifting carrying, pushing, pulling holding, or throwing by exceeding the capacity of the human joint system leads to overexertion injuries. Overexertion causes damage to muscles, tendons, ligaments, or cartilage, joint or peripheral nerve, sprains, strains or pain [3]. Overexertion injuries can result from a variety of different activities. However, more than half of them occurs when lifting objects. Some personal factors have been associated with overexertion injuries such as aging and loss of body flexibility and poor physical condition. [3, 4]. Gray S. et.al. reported that between the years 1999 and 2013, overexertion involving outside sources was ranked first as a leading cause of disabling injury at fitness facilities using Victorian Emergency Minimum Dataset (VEMD) through the Victorian Injury Surveillance Unit (VISU). Injuries due to overexertion were most common overall (36.2% of all cases) [5]. Libscomb et.al. has studied the union carpenters who worked in the state of Washington between 1989 and 2003. He also stated that overexertion injuries from manual materials handling activities are responsible for the largest burden of back injuries among these carpenters [6]. Using

the information obtained from NEISS, Brian R. Waterman et al. found that about 2 million people in the U.S. went to EDs for low back pain between 2004 and 2008, accounting for about 3% of all ED visits [7]. In another study, Reichard A. et.al. studied occupational injuries among emergency medical technicians by analyzing NEISS-work and concluded that nonfatal injuries were primarily associated with stress on some part of the body from motion or overexertion (33%) [8]. According to Marcin et al., overexertion injuries are the most common cause of workers' compensation claims [9]. In this study, data have been queried from NEISS-Work and were analyzed and interpreted in order to determine the role of worker demographics such as age, sex, and body parts that would influence the worker injury characteristics. At-risk groups have been identified to help understand the significance of worker demographics and also support future studies to reduce workplace injuries.

2. METHODS

Nonfatal occupational overexertion injuries involving outside sources treated in EDs that have been queried from NEISS-Work data from 2012 to 2014 have been examined and evaluated for the selected period for treatment year, age group, sex, part of the body affected, event, and industry group. The National Institute for Occupational Safety and Health (NIOSH) owns and manages this injury database, reviews all cases, and finalizes the data [10]. There are 67 hospital EDs around the United Stated recording the work-relatedness in ED charts [11]. When the patient visits a NEISS-Work sample ED, NEISS hospital coder abstracts and submits the case to Consumer Product Safety Commission (CPSC) for their review. NIOSH also developed Work-Related Injury Statistics Query System (Work-RISQS) by collaborating with CPSC to collect the data through

NEISS-Work. This query system was used in this research as the interactive data access system to the surveillance data to access demographic characteristics, nature of the injury, and incident circumstances for ED-treated nonfatal occupational overexertion injuries involving outside sources to obtain national estimates. The 95% confidence intervals were calculated by taking different random samples of all U.S. hospitals that were obtained an injury estimate that falls within the confidence interval range at least 95% of the time [12].

The BLS Occupational Injury and Illness Classification System (OIICS)'s injury classification codes have been adopted in the coding of this database by NIOSH [13]. OIICS v.1.01 is used for 1998-2011 data and OIICS v.2.01 is used for 2012 to present data. The treatment years 2012 through 2014 have been studied, therefore OIICS v.2.01 injury classification system was used in this study. The worker demographics of treatment year, age group, part(s) of the body affected, events, and sex have been queried through WORK-RISQS. The systems allowed only one year to be queried at a time and age groups were selected as 15 and over at pre-set 5-year age groups. In order to calculate estimates of national injury rates of injuries per full-time equivalent workers (FTE) for all industry groups, BLS's Current Population Survey (CPS) provided us the employed labor force (ELF) data [14]. Injury rates for Work-RISQS were estimated by dividing the Work-RISQS estimate by the selected worker population number. Results have been studied and analyzed by the injury category and the selected worker demographics.

3. RESULTS

NEISS-Work data from 2012 to 2014 showed that overexertion and bodily reaction injuries were among the top three nonfatal occupational injuries treated at EDs (Figure 1).

Overexertion and bodily reaction injuries with a slightly but consistently increasing percentage had the second highest number of injuries after contact with object injuries and followed by fall injuries for three consecutive years.

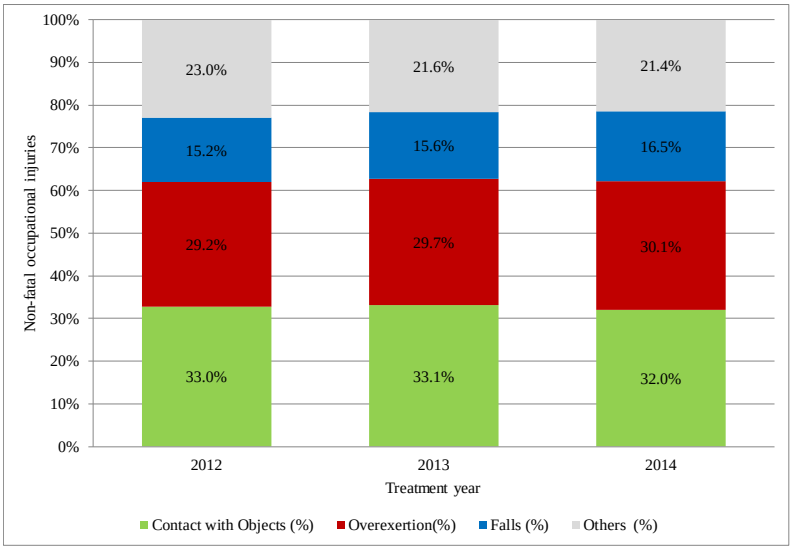


Figure 1. Distribution of NEISS-Work nonfatal occupational injury data from 2012 through 2014 (in percentages).

Table 1 shows the estimated numbers of overexertion and bodily reaction injuries. The numbers changed slightly but it can clearly be seen that the change is very minimal considering the 95% confidence interval (CI) for each year.

Table 1. Yearly estimated number of injuries of nonfatal occupational overexertion injuries treated in U.S. emergency departments, 2012 – 2014

Year	Number of injuries/illnesses	95% CI	Percent of total annual estimate
2012	811,500	1,038,500 - 584,500	29.20%
2013	811,200	1,027,700 - 594,700	29.70%
2014	827,600	984,700 - 670,500	30.10%

64.7%, 51.9%, and 56.1% of all overexertion and bodily reaction injuries were overexertion injuries involving outside sources in 2012, 2013, and 2014, respectively (Figure 2). Overexertion injuries involving outside sources remained the highest occurring injury category among other overexertion injuries. The subcategories of the main overexertion and bodily reaction injury category have been used as they have been classified in BLS OIICS.

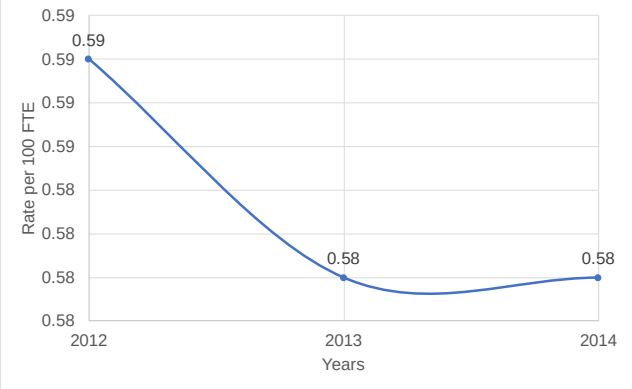


Figure 2. Yearly injury rate per 10 FTE for nonfatal occupational overexertion injuries treated in U.S. emergency departments, 2012 – 2014

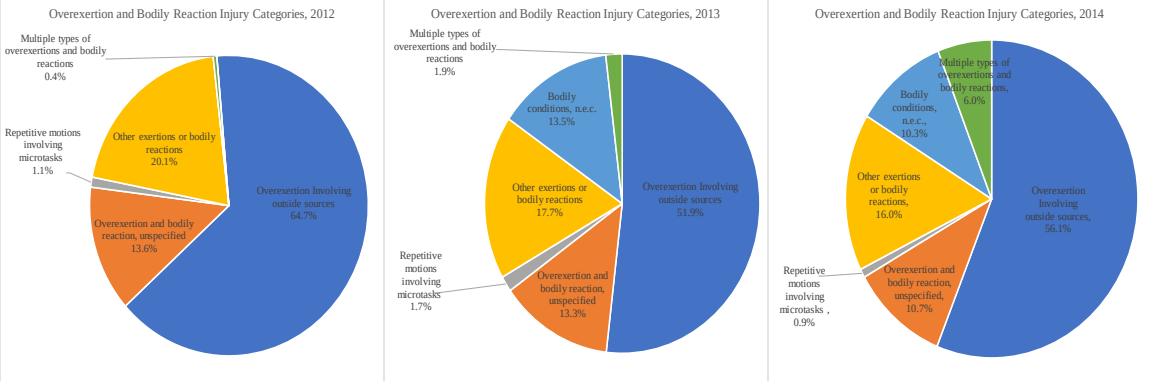


Figure 3. Percentage of nonfatal occupational overexertion injuries involving outside sources compared to other overexertion and bodily reaction injury subcategories in NEISS-Work from 2012 through 2014.

Overexertion injuries involving outside sources also has its subcategories as shown in Figure 3, 4, and 5. As can be interpreted from those figures, the type of injuries that had the highest percentage among others did not change throughout the years. Overexertion in lifting multiple episodes with an injury rate of 2.0 per 1000 FTE increased 4% in three years where overexertion in lifting single episode decreased 2%. On the other hand, the category of multiple types of overexertion injuries involving outside sources has increased by 6%.

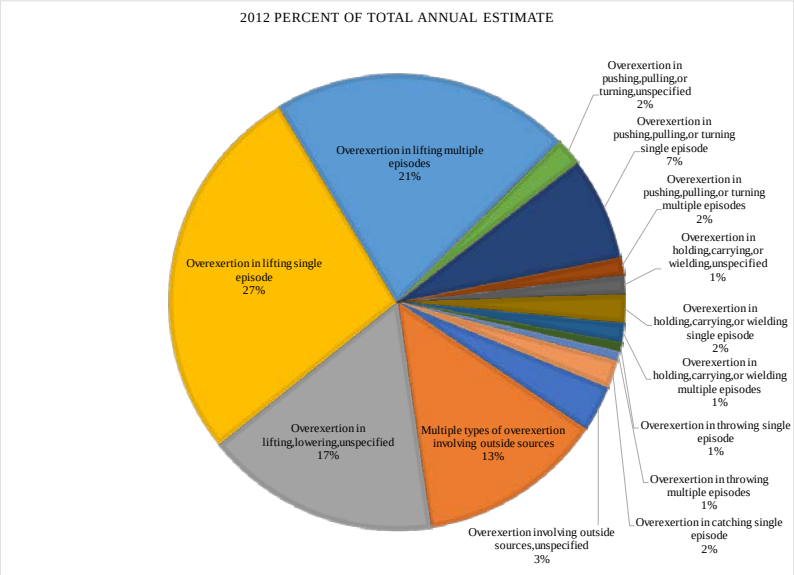


Figure 4. Distribution of the number of nonfatal occupational overexertion injuries involving outside sources subcategories in NEISS-Work in 2012.

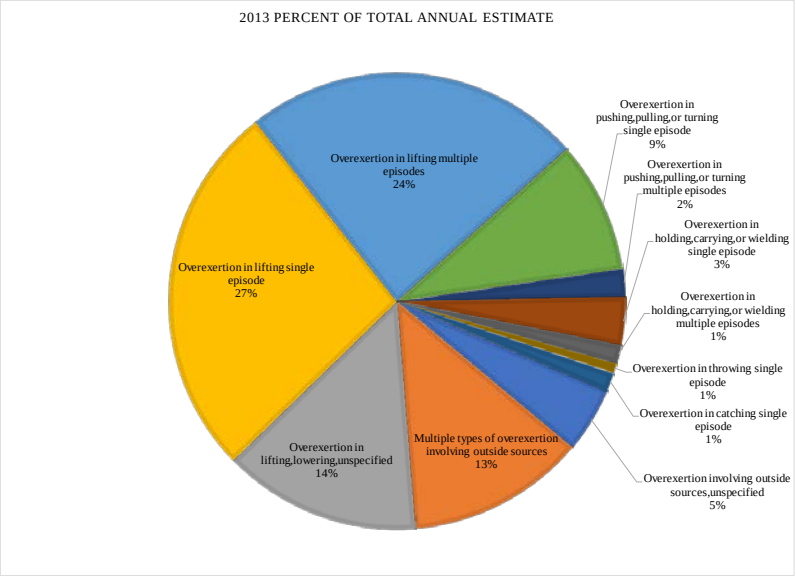


Figure 5. Distribution of the number of nonfatal occupational overexertion injuries involving outside sources subcategories in NEISS-Work in 2013.

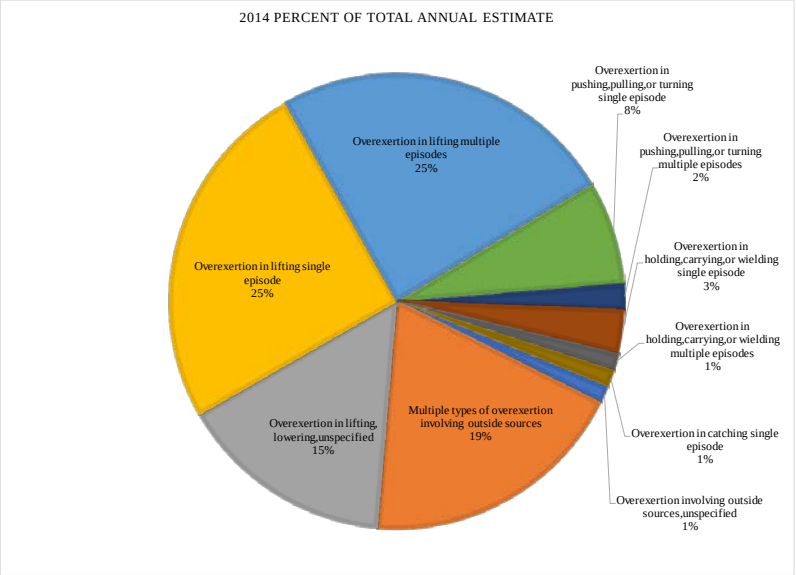


Figure 6. Distribution of the number of nonfatal occupational overexertion injuries involving outside sources subcategories in NEISS-Work in 2014.

15.2% of the all nonfatal occupational injuries treated in EDs in 2012 and 2013 and 16.7% in 2014 were overexertion injuries involving outside sources (Table 2). The injury rates have been estimated as 0.31, 0.30, and 0.32 per 100 FTE workers treated in EDs for the years 2012, 2013, and 2014, respectively (Figure 6).

Table 2. Yearly injury and rate estimate of nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014.

Year	Number of injuries/illnesses	95% CI	Percent of total annual estimate
2012	423,000	1,038,500 - 584,500	15.20%
2013	415,800	1,027,700 - 594,700	15.20%
2014	459,300	984,700 - 670,500	16.70%

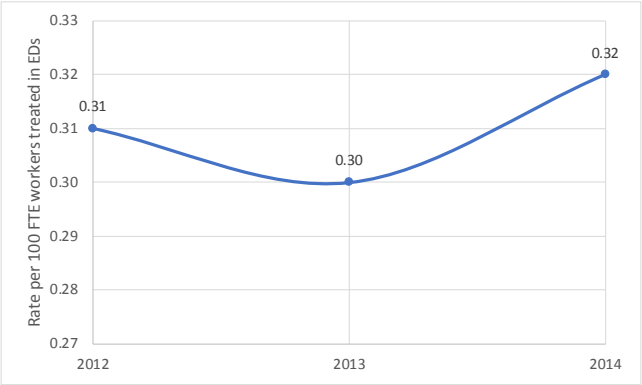


Figure 7. Non-fatal occupational overexertion involving outside sources injury rates per 100 FTE workers.

The big differences in total number of injuries and their percentage of the total annual estimate were observed between male and female workers (Table 3). Male workers had 61% - 62% more overexertion injuries involving outside sources. Both sexes have experienced fewer injuries in 2013 compared to 2012 and 2014. The injury rate per 100 FTE for male workers were estimated as 0.33, 0.33, and 0.35, while they were 0.27, 0.26, and 0.29 for female workers in 2012, 2013, and 2014, respectively.

Table 3. Estimates of the number of male and female workers injured from nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014.

	2012			2013			2014		
Sex	Number of injuries/illnesses	95% CI	Percent of total annual estimate	Number of injuries/illnesses	95% CI	Percent of total annual estimate	Number of injuries/illnesses	95% CI	Percent of total annual estimate
Male	260,300	210,700 - 309,900	10.30%	257,500	201,200 - 313,800	9.4%	283,300	222,900 - 343,700	10.30%
Female	162,600	128,400 - 196,800	6.4%	158,300	123,600 - 193,000	5.80%	176,000	138,000 - 214,000	6.4%

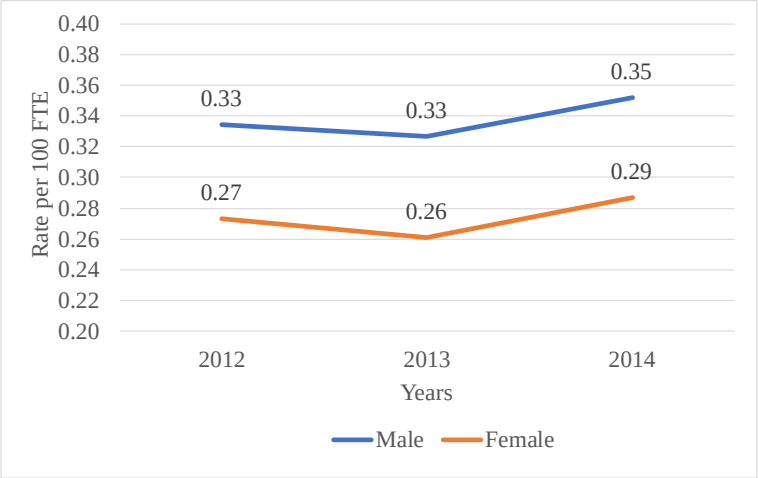


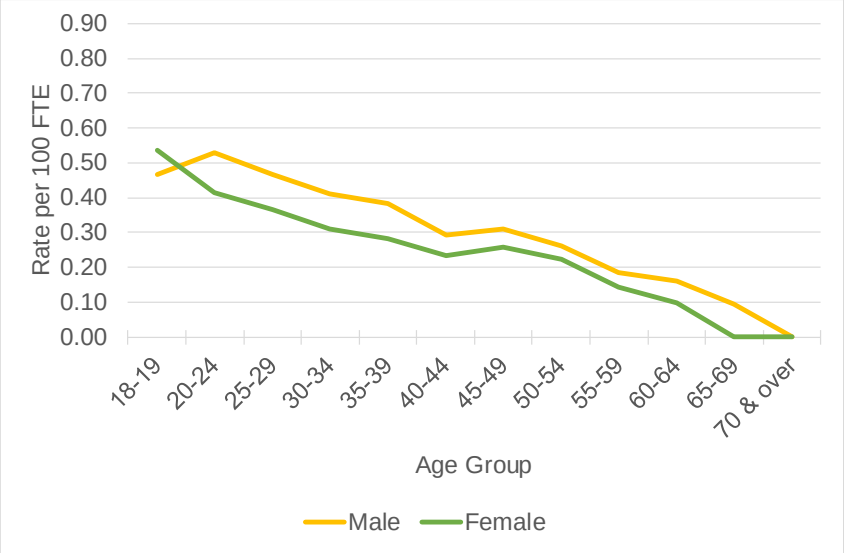
Figure 8. Injury rate per 100 FTE for male and female workers injured from nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014

In 2012, the highest number of injuries, 59,600 (95% CI 47,200 – 72,000) with 0.39 per 100 FTE injury rate, has been found for all workers at 20 - 34 years of age (Table 4). Workers younger than 20 years old and older than 55 years old had fewer injuries but the injury rate has declined with increasing age workers from 0.70 per 100 FTE to 0.08 per 100 FTE for 69 years old and over. Workers with increasing age were at lower risk of having occupational overexertion injuries. The same age groups of male and female workers had the most number of overexertion injuries at work in 2013 among the same sex where male workers were 50% more at risk compared to female workers. Female workers at the age of 20-24 had the highest number of overexertion injuries, 25,200 (95% CI 19,900 – 30,500), followed by the workers who were between 25-34 years old. Even though male workers who were between 25-34 simply had highest numbers of overexertion injuries involving outside sources, they had a high number of injuries for all age groups between 20 and 54 years.

Table 4. Non-Fatal occupational overexertion injuries involving outside sources treated in emergency departments in 2012 by age and sex

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
18-19	6.6	±2.4	7.1	±2.1	13.7	±2.9	0.4%
20-24	34	±6.7	25.2	±5.3	59.2	±12.5	2.0%
25-29	38.7	±9.0	20.4	±5.1	59.1	±14.0	2.4%
30-34	39	±8.0	20.6	±5.2	59.6	±12.4	2.1%
35-39	29.8	±6.7	17.8	±4.6	47.6	±12.1	1.9%
40-44	31.9	±6.8	18.8	±4.1	50.7	±10.5	1.6%
45-49	29.1	±6.9	18.5	±5.0	47.6	±10.5	1.7%
50-54	24.3	±6.0	16.6	±5.9	40.9	±12.1	1.5%
55-59	14.2	±3.1	9.1	±2.7	23.3	±6.0	0.9%
60-64	7.4	±2.6	7.4	±2.6	14.8	±4.6	0.4%
65-69	2.9	±1.3	0	0	2.9	±2.0	0.2%
70 & over	0	0	0	0	0	0	0.0%

Figure 9. Non-Fatal occupational overexertion injuries involving outside sources treated in emergency departments in 2012 by age and sex



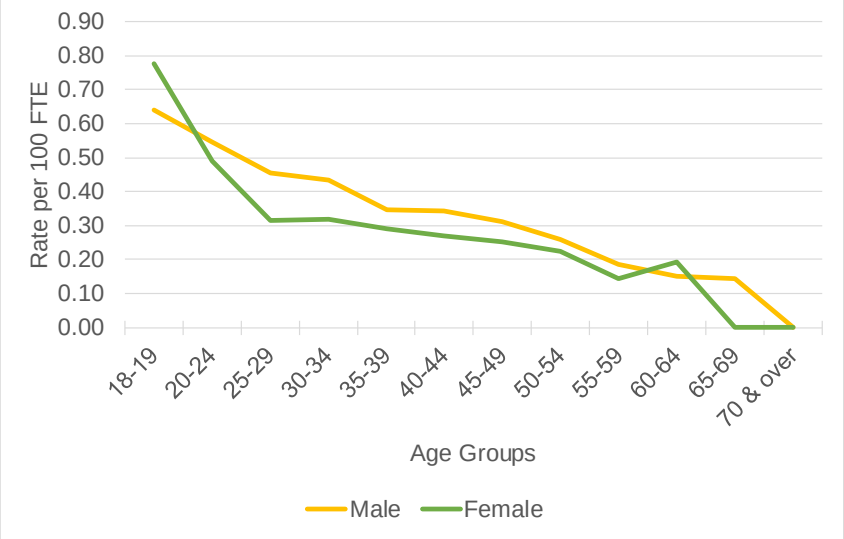
The highest number of overexertion injuries involving outside sources, 64,400 (95% CI 50,400 – 78,400), occurred for all workers within 25-29 years of age which correspond to 2.4% of the total number of nonfatal occupational injuries (Table 5). The injury rate for this age group was 0.42. Female workers had a lower number of injuries and lower injury rates compared to male workers in all age groups except the workers at ages

of 18 -19 years old (0.54 per 100 FTE). For male employees, the highest number of injuries, 40,200 (95% CI 31,500 – 48,900), occurred for the workers who were between the ages of 25-29 years, when it was estimated as 24,200 (95% CI 17,600 – 30,800) for female workers for the same age group. Injury rates for the same age groups were very similar between both sexes.

Table 5. Non-Fatal occupational overexertion injuries involving outside sources treated in emergency departments in 2013 by age and sex.

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
18-19	4.9	±1.6	5	±1.8	9.9	±2.9	0.40%
20-24	33.7	±8.2	22.1	±5.5	55.8	±12.5	2.00%
25-29	40.2	±8.7	24.2	±6.6	64.4	±14.0	2.40%
30-34	38.1	±8.9	20.5	±4.2	58.6	±12.4	2.10%
35-39	33.1	±8.0	17.7	±4.6	50.8	±12.1	1.90%
40-44	27.4	±7.6	16.1	±3.7	43.5	±10.5	1.60%
45-49	28.5	±7.1	18.4	±4.7	46.9	±10.5	1.70%
50-54	24.6	±6.9	16.7	±6.0	41.3	±12.1	1.50%
55-59	14.9	±4.3	9.3	±2.6	24.2	±6.0	0.90%
60-64	8	±3.2	3.8	±1.8	11.8	±4.6	0.40%
65-69	2	±1.2	0	0	4.2	±2.0	0.20%
70 & over	0	0	0	0	0	0	0.00%

Figure 10. Non-Fatal occupational overexertion injuries involving outside sources treated in emergency departments in 2013 by age and sex

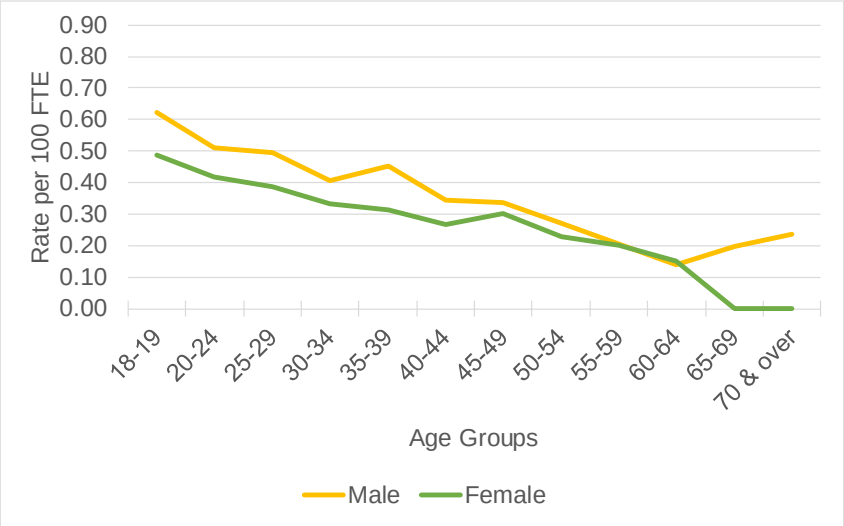


Similar to the years in 2012 and 2013, Table 6 also shows that the highest number of injuries occurred for all workers within 25-29 years of age, 70,100 (95% CI 53,500 – 86,700) in 2014, and workers younger than 20 years old and older than 55 remained as the age groups who had the lowest overexertion injuries among other age groups. On the other hand, around a 10% increase has been recorded compared to previous years' data. There was a slight increase (~7.5%) in the estimated the highest number of injuries for male employees compared to the previous year. Overexertion injuries showed a steady increase for three consecutive years. Unlike male workers, female workers did not have the increase in the number of injuries like the year in 2013.

Table 6. Non-Fatal occupational overexertion injuries involving outside sources treated in emergency departments in 2014 by age and sex.

Age Group (Years)	Male		Female		Total		
	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Number of Injuries (in 1000s)	95% CI (in 1000s)	Percent of total annual estimate
18-19	6.7	±1.8	4.5	±1.8	11.2	±3.3	0.40%
20-24	33.4	±8.1	22.6	±5.5	56	±12.9	2.00%
25-29	43.6	±10.3	26.5	±7.0	70.1	±16.6	2.50%
30-34	38.6	±9.5	22.5	±6.1	61	±14.6	2.20%
35-39	40.5	±10.2	20.1	±5.4	60.6	±14.6	2.20%
40-44	32	±7.2	18.4	±4.7	50.4	±11.4	1.80%
45-49	31	±8.5	21.3	±5.3	52.2	±13.2	1.90%
50-54	25.7	±5.0	17.3	±4.7	43	±8.6	1.60%
55-59	16.4	±3.8	13.1	±3.3	29.6	±6.1	1.10%
60-64	7.5	±2.2	6.1	±1.9	13.7	±3.6	0.50%
65-69	4.4	±1.9	0	0	6.2	±3.5	0.20%
70 & over	2.1	±1.1	0	0	3.4	±1.4	0.10%

Figure 11. Non-Fatal occupational overexertion injuries involving outside sources treated in emergency departments in 2014 by age and sex



As shown in Table 7, trunk, neck, and lower arm were the most at-risk body parts for both sexes during the years studied. Overexertion injuries involving outside sources that caused trunk injuries have been estimated as the most frequently occurring injuries for three consecutive years, with 2014 having the highest number of injuries, 191,900 (95% CI 147,100 – 236,700). It also had the highest percentage (7%) compared to other body part injuries within the total annual estimate.

Table 7. Estimates of body parts injured of nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014.

Part(s) of body	2012				2013				2014			
	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate per 100 FTE**
Neck (inc. cervical vertebrae)	21.3	±7.1	0.80%	**1.55**	17.7	±6.2	0.60%	**1.27**	22.8	±6.0	0.80%	**1.61**
Arm,upper	3.6	±1.2	0.10%	**0.26**	4.1	±1.4	0.20%	**0.29**	5.1	±1.9	0.20%	**0.36**
Arm,lower (inc. elbow & wrist)	36.1	±2.6	1.20%	**2.63**	36.7	±2.0	1.40%	**2.63**	38.7	±2.2	1.40%	**2.73**
Hand	10.7	±2.4	0.30%	**0.78**	12	±2.8	0.50%	**0.86**	12.9	±1.7	0.50%	**0.91**
Trunk (inc.shoulders)	330.1	±31.8	11.90%	**24.04**	322.8	±37.2	11.90%	**23.15**	355.4	±44.8	12.90%	**25.06**
Leg,upper	2.1	±1.1	0.10%	**0.15**	1.9	±1.0	0.10%	**0.14**	1.7	±0.9	0.10%	**0.12**
Leg,lower (inc. knee or ankle)	14.3	±0.8	0.50%	**1.04**	15.2	±1.2	0.60%	**1.09**	16.5	±0.8	0.60%	**1.16**
All parts of the body (> 50% of body)	2.2	±1.2	0.10%	**0.16**	-	-	-	**-**	1.5	±0.9	0.10%	**0.11**

Neck and trunk were the most commonly injured body parts for both female and male workers. The number of people who injured their trunks (including shoulders) due to overexertion injuries involving outside sources showed an increasing trend for three

consecutive years (Table 8). Rate per 100 FTE increased 1.0% for male workers who injured their trunk in 2014. The rate increased for female workers from 2012 to 2014, as well. In other words, while both sexes were experiencing more overexertion injuries effecting mostly their trunks, shoulders, necks, and lower arms every year, in the meantime not only the less number of female workers were getting injured, but the injury rate per 100 FTE was decreasing with years.

Table 8. Estimates of body parts injured of nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014 for female and male workers.

		2012				2013				2014			
Sex	Part(s) of body	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**	Number of injuries/illnesses (in 1,000's)	95% Confidence interval (in 1,000's)	Percent of total annual estimate	**Rate Per 100 FTE**
Male													
	Neck (inc. cervical vertebrae)	11.3	±3.4	0.40%	**1.5**	9	±3.5	0.30%	**1.1**	11.6	±3.5	0.40%	**1.4**
	Arm,upper	3.2	±1.2	0.10%	**0.4**	2.7	±0.9	0.10%	**0.3**	3.8	±1.8	0.10%	**0.5**
	Arm,lower (inc. elbow & wrist)	21.5	±1.9	0.80%	**2.8**	21.2	±1.5	0.80%	**2.7**	23.9	±1.7	0.90%	**3.0**
	Hand (inc. finger)	6.1	±1.5	0.20%	**0.8**	7.4	±1.5	0.20%	**0.9**	7.5	±1.0	0.20%	**0.9**
	Trunk (inc.shoulders)	205	±21.6	7.40%	**26.4**	202.4	±24.8	7.50%	**25.7**	221.5	±26.7	8.10%	**27.5**
	Leg,lower (inc. knee or ankle)	8.1	±0.8	0.30%	**1.0**	8.5	±0.7	0.30%	**1.1**	8.1	±0.7	0.30%	**1.0**
Female													
	Neck (inc. cervical vertebrae)	10	±4.0	0.40%	**1.7**	8.7	±3.1	0.30%	**1.4**	11.2	±3.3	0.40%	**0.9**
	Arm,lower (inc. elbow & wrist)	14.7	±1.0	0.60%	**2.5**	15.7	±1.1	0.60%	**2.6**	14.8	±1.1	0.60%	**1.8**
	Hand (inc. finger)	4.5	±1.3	0.42%	**0.8**	3.3	±1.5	0.10%	**0.5**	5.4	±1.2	0.20%	**0.8**
	Trunk (inc.shoulders)	125	±12.5	4.50%	**21.0**	120.5	±14.5	4.40%	**19.9**	133.9	±18.9	4.80%	**21.8**
	Knee	3.8	±1.8	0.10%	**0.6**	3.1	±1.5	0.10%	**0.5**	5	±2.3	0.20%	**2.4**

Figure 7 shows the distribution of sources that have caused the workers to get injured at work and report to EDs between 2012 and 2014. In NEISS-Work data, the very large number of injury sources, 128,200 (95% CI 100,400 – 156,000), have not been reported or recorded. These were shown as “nonclassifiable” in the figure. Even though there were many sources that have contributed to the overexertion injuries, the main contributing sources were patients with 62,600 (95% CI 48,700 – 76,500) injuries and boxes/crates/cartons with 61,200 (95% CI 47,600 – 74,800) injuries. Patient (code: 574) has been listed under persons, plants, animals, and minerals (code: 5) and person-other than injured or ill worker (code: 57). Boxes/crates/cartons (code: 2114) were listed under containers, furniture, and fixtures (code: 2), containers (code:21), and containers-non-pressurized (code: 211) in the database. While the sources patient had 2.30% of the total

annual estimate, boxes/crates/cartons were at 2.20%. When compared to other sources that have caused the overexertion injuries involving outside sources, these two sources caused injuries more than five times that of other sources. More specifically, the closest injury source was bags/sacks with 12,200 (95% CI 8,200 – 16,200) injuries which were the 0.40% of the total annual estimate.

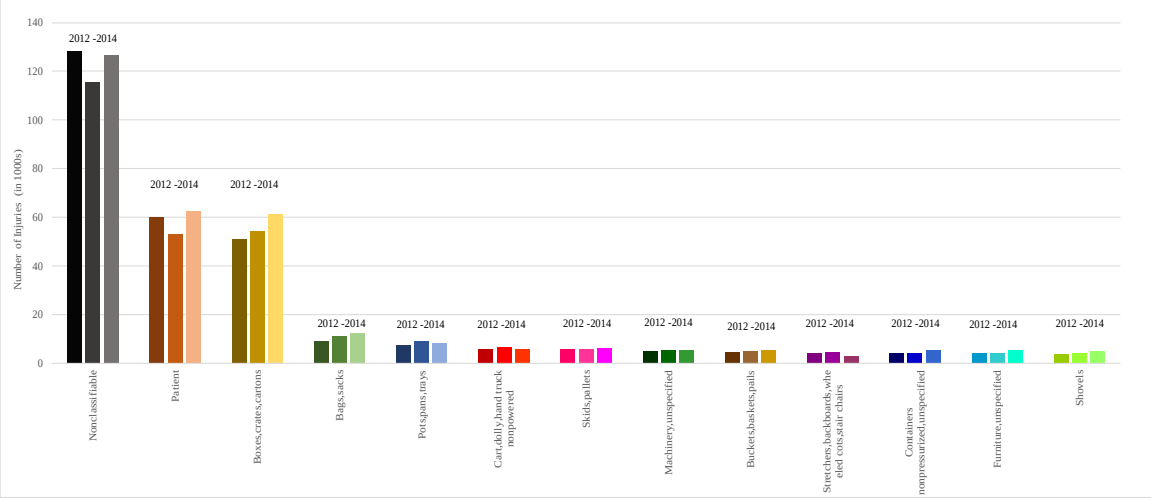


Figure 12. The Source distribution of the nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014.

One of the main sources that were involved with the overexertion injuries of workers were patients which were classified as one of the sources under the persons other than injured workers. It has been estimated that most of the workers injured due to an act of a patient were mainly female workers (Figure 8a). More specifically, while male workers had 11,500 (95% CI 8,400 -14,600) injuries, the number of female worker overexertion injuries involving a patient was 51,100 (95% CI 38,600 – 63,300) in 2014. There was also a 24% increase in the number of injuries for male workers compared to 2012 (9,300 (95% CI 6,400 – 12,200)). For the same year period, female workers showed a

0.7% increase in the estimated number of injuries, 50,700 (95% CI 39,700 – 61,700), involving a patient as the injury source. Even though boxes, crates, and cartons related injuries were the second leading injuries for both sexes, they followed a different pattern (Figure 8b). Male workers experienced more injuries compared to their counterparts with the injuries involving boxes, crates, and cartons. With respect to that, the estimated number of injured male workers increased from 29,100 (95% CI 20,700 – 37,800) to 36,600 (95% CI 25,900 – 47,300), and, for the same period of time, the estimated number of female worker overexertion injuries slightly increased from 21,600 (95% CI 15,400 – 27,800) to 24,700 (95% CI 19,200 – 30,200).

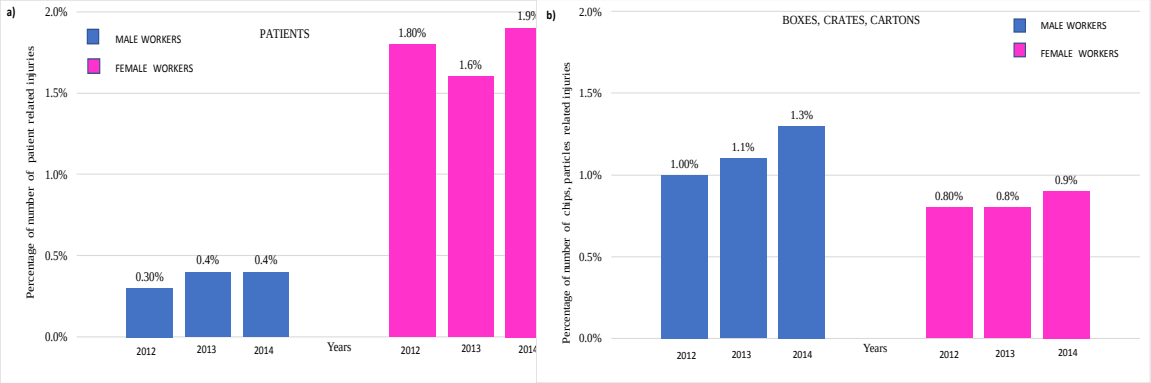


Figure 13. Percent of total annual estimate for the sources that have caused the highest number of nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments for male and female workers, 2012 – 2014. a) Injuries caused by a patient as the source b) Injuries caused by boxes, crates or cartons as the source.

NEISS-work data showed significant differences in terms of age distribution for the patient as the injury source (Figure 9). No injuries reported for any of the male worker age groups in 2012 which could be due to missing age information in the database. In addition to that, only the workers who were between 25 and 44 years of age have been reported as injured male workers due to an act of a patient in 2013 and 2014. Unlike

male workers, overexertion injuries involving a patient as the source have been estimated for all age groups for female workers other than the ones who were younger than 20 years old. The number of injured workers between 20 and 29 years of ages was 30% of the total annual estimate while the rest of the age groups were 20% and under.

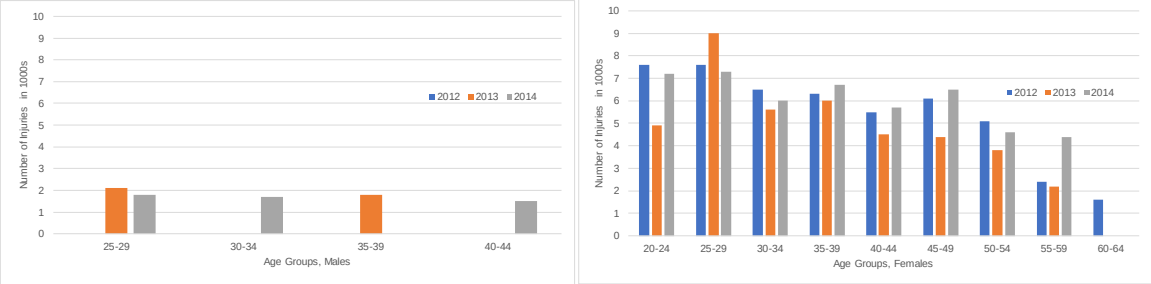


Figure 14. Workers' age distribution of nonfatal occupational overexertion injuries involving outside sources that involved patients as the source of injury for male workers and female workers, 2012 – 2014.

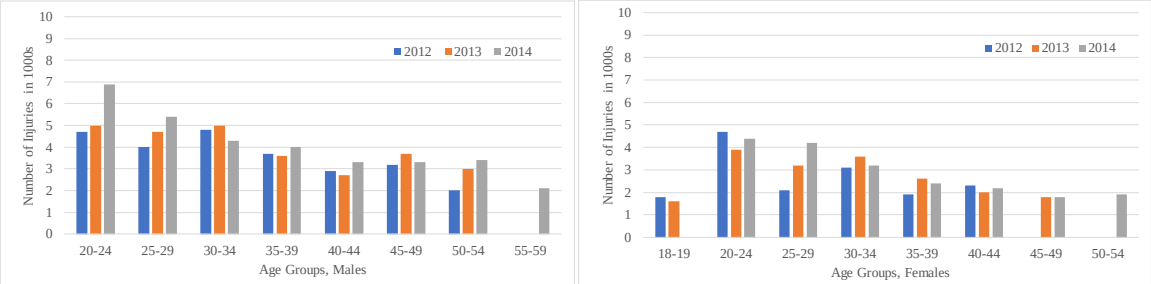


Figure 15. Workers' age distribution of nonfatal occupational overexertion injuries involving outside sources that involved boxes, crates or cartons as the source of injury for male workers and female workers, 2012 – 2014.

Table 9 shows how the injury rates per 100 FTE for nonfatal occupational overexertion injuries involving outside sources that are treated in EDs changed by the industry between 2012 and 2014. While mining industry and agriculture were the leading industries for this injury category with the highest injury rate per 100 FTE among both sexes, female workers experienced a higher rate of injuries in the construction industry

while male workers had more accidents in health and social services resulting in over-exertion injuries involving outside sources. Female workers who worked at manufacturing, construction, agriculture, forestry, fishing, mining, transportation, warehouse, and utilities were more susceptible to overexertion injuries involving outside sources.

Table 9. The estimated rate of nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014 for female and male workers by the industrial group.

		Rate per 100 FTE		
Industry Group	Sex	2012	2013	2014
Agriculture, forestry, fishing	Male	14.1	14.2	14.9
	Female	34.8	35.8	37.3
Mining	Male	24.5	22.1	23.8
	Female	64.0	55.0	61.0
Construction	Male	3.2	3.0	3.1
	Female	23.0	21.2	22.4
Manufacturing	Male	2.3	2.2	2.4
	Female	3.8	3.7	4.0
Trade	Male	2.3	2.3	2.5
	Female	2.2	2.1	2.3
Transportation/ warehouse/ utililities	Male	4.4	4.3	4.5
	Female	16.3	9.5	10.7
Services	Male	0.8	0.8	0.8
	Female	0.8	0.5	0.6
Health, social services	Male	6.0	5.9	6.5
	Female	1.2	1.1	1.2

More specifically, in the construction industry, female workers were seven times more at risk, five times more at risk in the mining industry, four times more at risk in the transportation, warehouse, and utility industries, and twice as at risk in the manufacturing, mining, and agriculture industries. Trade and services industries did not

show a significant difference between sexes and years but health and social services were the only industry category where male workers had a significantly higher number of overexertion injuries over female workers (Figure 11).

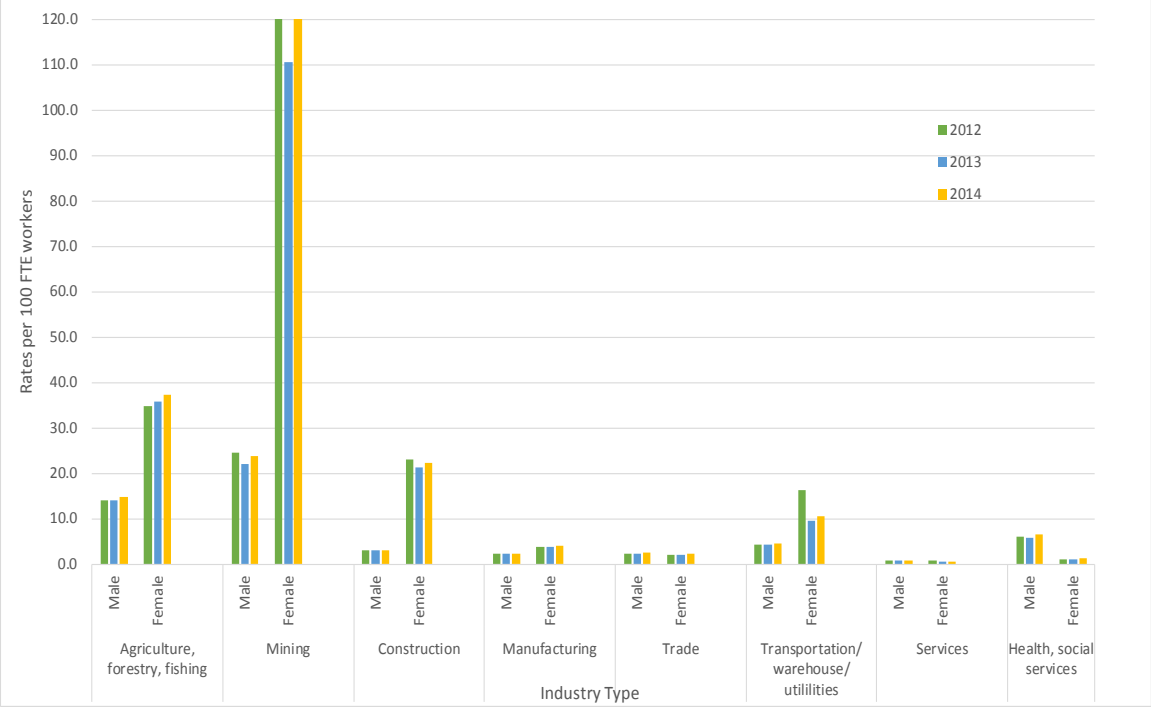


Figure 16. The estimated rate of nonfatal occupational overexertion injuries involving outside sources treated in U.S. emergency departments, 2012 – 2014 for female and male workers by the industrial group.

4. DISCUSSION

Non-fatal occupational overexertion and bodily reaction injuries that have been treated in EDs in the U.S. have remained the second leading injury category (between 20% - 30% of the total annual estimate) for three consecutive years. More than half of these type of injuries were injuries that involved outside sources. In other words, current federal and state regulations, as well as employer and employees' efforts to reduce the number of injuries, did not have a positive impact. Workers continued to get injured with

increasing numbers and continued to visit emergency rooms due to work-related overexertion injuries involving outside sources. Even though the rate per 100 FTE increased only from 0.31 to 0.32, nondecreasing injury rate also supported the fact that the sources that caused the highest number of injuries need to be studied in detail to reduce the worker injuries. Demographic differences played an important role as well where males had over 60% more injuries and workers who were between the ages of 20 and 39 experienced the highest number of injuries. Impact of worker demographics on worker safety should be studied more in-depth to understand the root cause of those discrepancies and safety measures need to be developed and implemented by considering these variables. Unsurprisingly, the shoulders, neck, wrist, and trunk of the workers were the most at-risk body parts of the injured workers. As one of the limitations of the NEISS-Work database, either due to not been reported or recorded, a large number of data for the sources of the injuries have been listed as non-classified. Patients and boxes/crates/cartons were the most reported sources in the data that caused the overexertion injuries. Since the estimated number of injuries due to sources that couldn't be classified were more than twice the number of these sources, it would be difficult to estimate the impact of them if they were known. This was a limitation of the data in order to determine if the more representative number of the sources caused the injuries. Even with a large number of injuries with unknown sources, results showing the patient as the leading source that caused the injuries was surprising. The source patient has been classified under the persons other than the injured or ill worker in the BLS OIICS [15] and it includes patients in healthcare facilities such as hospitals, nursing homes, mental health facilities, and doctors' and dentists' offices. On average, it has been recorded that 6.4 work-related injuries and illnesses

for every 100 full-time employees occurred at U.S. hospitals in 2013. This number was 3.3 per 100 full-time employees for all U.S. industries combined, showing that hospitals have high rates of nonfatal occupational injuries and illnesses [16]. In 2013, 34 percent of recorded hospital worker injuries nationwide that resulted in days away from work were associated with patient interactions [16]. Even though the Occupational Safety and Health Administration (OSHA) developed resources to help hospitals assess workplace safety needs, implement safety and health management systems, and enhance their safe patient handling programs [17], the number of overexertion injuries involving a patient as the source did not go down over the years. This also shows the importance of considering worker demographics to better understand how to eliminate these injuries.

Our findings are consistent with earlier studies with regards to boxes, crates, and cartons being one of the main sources that caused an overexertion injury, due to the act of lifting, pushing, pulling, carrying, and holding them while working [7]. In another study for the injuries in the grocery stores, it has been reported that in the grocery stores 27% of the injuries were containers (boxes, crates, and cartons) related [18]. It has been reported in the literature that the cost and the number of occupational injuries continued to increase even though there have been many improvements in ergonomics interventions and job designs that could prevent the injuries by two-thirds [19]. NEISS-Work data do not include the details of the source which is a major limitation. Using the boxes, crates, and cartons that are ergonomically well-designed and using properly-designed and stationed lift-assist devices will help reduce worker injuries.

5. CONCLUSIONS

In conclusion, our study documented the importance of workers demographics and how they play a role in influencing the injury characteristics. Determining the focus of ergonomic interventions is the key to reducing overexertion injuries. This study identified at-risk groups regarding one of the top three most occurring injury category's (overexertion and bodily reaction) highest occurring subcategory (overexertion involving outside sources). Since the direct relationship between the studied worker demographics and the number of work-related injuries has been identified, these risk groups need to be further studied to identify the root cause of these injuries. The potential injury due to lifting, pushing, or pulling containers could be eliminated by ergonomically engineered, easier to handle, composite/lightweight containers and by engineering more effective and practical lift assist devices in addition to more specific safety training considering worker demographics. Ergonomics researchers and safety professionals collaborating with other disciplines need to study focusing on these findings and also to explain the underlying reasons which will help reduce the number of occupational overexertion injuries at workplaces.

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SUMMARY AND CONCLUSION

Overall, this study shows that the three nonfatal occupational injuries, contact with object or equipment, fall on same level, and overexertion injuries involving outside sources are the top three worker injury categories that had the highest estimated injury rates in the United States. Despite all the established and implemented regulations that are being developed and enforced by the federal government, the state and the local authorities, company policies and procedures, and other related supporting institutions and organizations such as NIOSH, worker injury rates increased for the years studied (2012-2014). In other words, the United States workforce continued to experience work-related injuries with increasing numbers over the years in relation to worker demographics.

The NEISS-Work injury data suggested that age and sex play a very important role in the number of all three most occurring injury categories. It was not only the workers in different age groups that influenced the injury rates. Male and female workers have experienced a significantly different number of injuries depending on their ages, the sources that directly caused the injuries varied by changing worker demographics and the injury categories, as well.

This study showed that contact with object and equipment injuries remained as the highest occurring nonfatal occupational injuries treated in EDs among other injury categories during the study period for three years and existing efforts to reduce the number of injuries did not make a significant impact. Male workers continued to have more injuries with increasing numbers compared to female workers. Overall, it has been found that

younger workers who were between 20 and 24 years old were the highest risk group and 25-29 workers placed second. 19-years-old and younger workers experienced 1/3 fewer injuries than the workers between 20 and 25 years old. But the injury rate per 100 FTE was higher for the workers in this age group due to the number of workers in this age group in the workforce. This is an important finding since it has been consistently reported in the literature that workers who were younger than 25 years old had the highest injury rate. Therefore, the reason for the high injury rates among the certain age group of young workers may not only be occurring most frequently because of their youth and inexperience. It has also been found that both sexes have injured their fingers the most (males injury rate 31 per 100 FTE and females 13 per 100 FTE) followed by hand and eye injuries for males and head and foot injuries for females. But while males were injuring their hands at very high rates (12 per 100 FTE), females experienced zero hand injuries. On the other hand, males experienced zero foot injuries where females injured their foot at 2.3% rate. This leads to a conclusion that differences between males and females in terms of the injury estimates should be taken into consideration very carefully in order to achieve an effective reduction at injury rates. On another note, knives/cutters being the number one cause of the contact with object injuries for both sexes, females tend to have 4 times more injuries involving doors, except garage and vehicle compared to males where males got injured 4 times more due to contact with metal chips/particles. This study also showed that even with a different injury rates (0.52 per 100 FTE for 19 and younger and 0.05 per 100 FTE for 50 and older), regardless of their sex, the youngest workers (19 and younger with 5,300 (95% CI 3,400 – 7,200)) and the older workers (50

and older 4,500 95% CI 2,900 – 7,100)) had the lowest number of injuries that were caused by cutters/knives.

The results showed the distinctive relation between the injury rate per 100 FTE workers' sex and the type of the industries, which may be due to the type of work or assigned tasks, the work environment, type of tools being used, and, more importantly, the training provided. Female workers who worked in agriculture, mining, construction, and transportation/warehouse industries were more at risk. Manufacturing, trade, services, and health industries were where male workers were getting injured more frequently compared to females.

The analysis of contact with object or equipment injuries showed that cutters/knives were the main sources of worker injuries. Even though the data do not provide information on how the injury occurred, injuries involving knives at work were most likely due to not using the tool correctly, not using a properly designed cutter/knife for the task, or not using the proper personal protective equipment (PPE), such as cut resistant gloves. There are a variety of industrial knives designed ergonomically and cut-resistant industrial gloves engineered using different materials in the market. This study also suggests that materials engineers and safety engineers need to be closely studying the injury sources and their close relationship with injury characteristics and worker demographics. An improved design of an industrial knife and a cut resistant glove which was engineered by using more appropriate material and design can help reduce or even eliminate future workplace injuries.

Fall on same level injuries have been calculated as the most frequently occurring injury category among all other fall injury categories for three consecutive years. They oc-

curred 40% more than other fall-related injury categories. Using the records from NEISS-Work, nonfatal occupational fall on same level injuries were estimated at a 19% increase in the number of injuries from 2012 to 2014. The highest estimated number of fall on same level injuries, 319,600 (95% CI 272 600 – 366,600), occurred in 2014. The injury rates have been estimated at 0.19, 0.20, and 0.22 per 100 workers treated in EDs for the years 2012, 2013, and 2014, respectively. Estimates of workers injured due to nonfatal occupational fall on same level injuries treated in EDs showed a similar increasing trend for both sexes.

However, female workers experienced more injuries compared to male workers each year. While the difference in the estimated number of injured female vs male in 2012 and in 2013 was 31,000, this number dropped 48% in 2014. Male workers had 5.72% more injuries in 2013 and 17.07% more injuries in 2014 compared to previous years where the change in female worker injuries did not change at the same rate as male workers (4.40% in 2013, 6.67% in 2014). In short, the significant increase in male worker injuries in 2014 caused the reduction of the difference in the female and male worker injuries. In 2012, the highest number of injuries occurred for all workers between 50-54 years of age, 33,600 (95% CI 26,400 – 40,800). Female workers had a lower number of injuries compared to male workers between 25-44-year-old, whereas female workers had more injuries at other age groups. For male employees, the highest number of injuries, 15,600 (95% CI 12,400 – 18,800), occurred for the workers who were between the ages of 30-34 years, when it was estimated as 20,200 (95% CI 15,400 – 25,000) for female workers for the age group of 50 – 54 years old.

Unlike the results in 2012, in 2013 female workers had only fewer injuries than male workers for the age group of 25-29. The number of male worker injuries has been estimated as 14,900 (95% CI 10,800- 19,000) and female workers as 12,100 (95% CI 9,000 – 15,200). The highest number of injuries occurred for all workers between 50-54 years of age, 37,900 (95% CI 30,400 – 45,400), in 2014. For male employees, the highest estimated number of injuries, 17,800 (95% CI 13,400 – 22,200), occurred for the workers who were between the ages of 30-34 years. Number of injuries for female workers were very similar for the age groups 50-54 [21,600 (95% CI 17,100 – 26,100)] and 55-59 [21,000 (95% CI 17,100 – 24,900)]. As in 2012, the age group that female workers had less number of injuries compared to the male workers were between 25 and 44 years in 2014.

The distribution of parts of the body affected for all employees treated in EDs did not change significantly over the study period. Injuries most often involved knee, head, and lower trunk injuries for all three years with increasing numbers from 2012 to 2014. Upper arm and leg injuries have been recorded as the lowest number of injuries for 2012 and 2013. In addition to the upper arm and leg injuries, mouth (including lips, tongue, and teeth) and all parts of the body (more than 50% of the body) have also occurred as the lowest number of estimates for the year of 2014. The body parts most affected for male and female workers were knee injuries, head injuries, and lower trunk injuries, the most common injuries for both male and female workers for the study period. The year 2014 had the highest estimated number of injuries for these three body parts compared to the previous years, except the knee injuries for female workers in 2013.

Furthermore, it was found that injury rates for both male and female workers increased between 2012-2014, except for the reducing rate of knee injuries for female workers from 4.8% in 2013 to 4.7% in 2014. Injury rates for female workers have been calculated higher than male workers. Rates per 100 FTE for nonfatal occupational fall on same level injuries treated in EDs by the industry as the workers' primary job showed that the mining industry had the highest rates for both male (43%) and female (59%) workers for three consecutive years. Rates for male workers increased (11.2, 13.4, and 14.1) with years but fluctuated (118.6, 87.9, and 105.4) for female workers in the mining industry. Estimated injury rates for both male (24%) and female (20%) workers in the agriculture, forestry and fishing industry category had the second highest numbers and increased from 2012 to 2014. The construction industry was the third highest and injury rates stayed stable for three consecutive years. All other industry categories such as transportation and manufacturing with lower injury rates also presented increasing injury rates. Female workers were more at risk compared to their male counterparts for all industry categories except the industry of health and social services. Injury rates per 100 FTE were estimated roughly 5 to 15 times higher for female workers who worked in the construction industry, the agriculture, forestry, fishing industry, and the mining industry. Service industry had the lowest injury rate among all other industry groups.

The outcome of this study provides more in-depth analysis of specific variables by analyzing the correlations and trends between demographics and injury types along with industry groups and will be a highly useful tool for health and safety professionals while developing and implementing customized and more specific employee and industry-specific safety training, hazard assessments, tool and workstation designs, safety

engineering controls, and personal protective equipment. Investments in improved safety for these workers will likely have long-term benefits towards providing a safer work environment, reducing injuries, and thusly reducing workers' compensation costs. Every industry, every workplace has their own unique work environment. Floors, walkways, and ground surfaces being the main sources of fall on same level injuries in this study. Floor materials and floor and walkway designs could be engineered to resist better to the harsh conditions of the workplaces, such as heavy powered industrial truck movements and heavy loads like unloading heavy materials and products with cranes or harsh outside environmental conditions.

Nonfatal occupational overexertion and bodily reaction injuries that have been treated in EDs in the U.S. have remained the second leading injury category (between 20% - 30% of the total annual estimate) for three consecutive years. More than half of these types of injuries were injuries that involved outside sources. Workers continued to get injured with increasing numbers and continued to visit emergency rooms due to work-related overexertion injuries involving outside sources. Even though the rate per 100 FTE increased only from 0.31 to 0.32, the nondecreasing injury rate also supported the fact that the sources that caused the highest number of injuries need to be studied in detail to reduce the worker injuries. Demographic differences played an important role as well where males had over 60% more injuries and workers who were between the ages of 20 and 39 experienced the highest number of injuries. Impact of worker demographics on worker safety should be studied more in-depth to understand the root causes of these issues, and safety measures need to be developed and implemented by considering these variables. Unsurprisingly, the shoulders, neck, wrist, and trunk of the workers were the

most at-risk body parts of the injured workers. As one of the limitations of the NEISS-Work database, either due to not been reported or recorded, a large number of data for the sources of the injuries have been listed as non-classified. Patients and boxes/crates/cartons were the most reported sources in the data that caused the overexertion injuries. Since the estimated number of injuries due to sources that couldn't be classified were more than twice the number of these sources, it would be difficult to estimate the impact of them if they were known. This was a limitation of the data in order to determine the more representative number of the sources causing the injuries. Even with the large number of injuries with unknown sources of injuries, results showing the patient in healthcare facilities such as hospitals, nursing homes, mental health facilities, and doctors' and dentists' office were determined the leading source that have caused the injuries, which was surprising. While mining and agriculture were the leading industries for this injury category with the highest injury rate per 100 FTE among both sexes, female workers experienced higher rate of injuries in the construction industry when male workers had more accidents in health and social services resulting in overexertion injuries involving outside sources. Female workers who worked at manufacturing, construction, agriculture, forestry, fishing, mining, transportation, warehouse, and utilities were more susceptible to overexertion injuries involving outside sources.

The potential injury due to lifting, pushing, or pulling containers could be eliminated by ergonomically engineered, easier to handle, composite/lightweight containers and by engineering more effective and practical lift assist devices in addition to more specific safety training considering worker demographics. Ergonomics researchers and safety professionals collaborating with other disciplines need to study focusing on these find-

ings and also work to explain the underlying reasons which will help reduce the number of occupational overexertion injuries at workplaces.

Safety engineers/professionals rely on OSHA-required standard training programs to prevent occupational injuries at workplaces. Our study suggests that these research findings need to be further investigated by analyzing other databases and taken into consideration when incident prevention plans, engineering controls, and safety training programs are being developed and implemented at workplaces. We also suggest that the impact of worker demographics on the number of worker injuries need to be considered at the engineering design phase of the workplaces, such as in workstations, equipment, walking-working surfaces, and work tools to reduce or eliminate workplace injuries. To achieve that, worker demographics at workplaces need to be determined by safety engineers/ professionals and workplace risk assessments (RA), job safety analysis (JSA) and job hazard analysis (JHA), and safety training need to be revised by considering the impact of worker demographics and the industry to help prevent or eliminate any future occupational injuries for at-risk groups. Instead of implementing the same methods for all workers regardless of their age, sex and the industry, developing and implementing more specific safety engineering and safety management programs will help reduce the injury rate and improve the quality of people's lives, ultimately leading to an injury-free work environment.

The recent data between 2012 and 2014 have been analyzed to eliminate the limitation of the interpreting and reporting results for the data before 2011 with OIICS v.1.01 for event and source codes and between 2012 and 2014 with OIICS v.2.01, comparisons between event and source should not be made between years that cross this break. There-

fore, scope of this study was limited to the three-year period. Because of the categorical differences, we wouldn't be able to recategorize a wide range of years of data within the scope of this study. The goal of this study was to get a high-level information that the data would reflect in order to see the trend for the most recent years available without crossing the break between the classification codes.

Safety engineering and safety management recommendations: All three objectives conclude that age and sex play a very important role in worker injuries and injury characteristics for the top three nonfatal occupational injury categories. Males and females experience injuries at different injury rates for different injury categories. Younger workers had higher injury rate compared to older workers. Identified injury sources that directly caused the most frequently occurring incidents are specific to the three injury categories that have been studied. According to the outcome of this study, following safety engineering and safety management solutions are recommended to the companies and organizations in order to help reduce occupational injuries.

Management Practices:

- Examine injury and illness statistics for contact with object or equipment, fall on same level, and overexertion involving outside sources, including worker demographics at workplace, to determine at-risk groups at the facility and variables contributing to worker injuries.
- Identify sex and age groups of the employees by each department
- Conduct incident reviews and root cause analysis including worker demographics for each incident

- Develop and conduct employee surveys with different age groups and sexes on work-related injuries at your workplace
- Develop and implement sex and age sensitive:
  - Safety Audits
  - Ergonomic risk assessments (ERA)
  - Job Safety Analysis (JSA)
  - Job Hazard Analysis (JHA)
- Develop and implement sex and age sensitive workplace safety and health policy and procedures

Employee Awareness and Engagement:

- Females as well as males should be involved in health and safety management in the workplace.
- There should be an appropriate, balanced representations of the sexes on the health and safety committee and ergonomics committee
- All sections of the workforce should be represented on the employee safety committees to harvest their ideas.
- Conduct specific safety and health training to those worker groups who are more at-risk on contact with object or equipment hazards, fall on same level and hazards on overexertion injuries involving outside sources

Engineering Design:

- Conduct detailed risk assessments of all workstations

- Consult with safety engineers and safety management at the design stage of workstations, work tools and workplace designs in order to consider and pay special focus on these findings.
- Consider conducting trials on different lift assist devices, variety of personal protective equipment with different age-groups and sexes before purchasing and implementing them on the floor in order make a worker demographic sensitive decision
- Engineer out solutions of risk assessment results according to injury characteristics and worker demographics, such as work station height adjustments to prevent overexertion due to lifting and designing the walkways with the best possible layout to prevent fall on same level injuries
- Provide selection of work tools such as cutters, cut resistant gloves, and slip resistant shoes to give the option to different age groups and sexes to choose the one that fits best to prevent contact with object or equipment and fall on same level injuries

Administrative Controls:

- Considering the at-risk groups and contributing sources along with worker demographics, administer an age and sex sensitive work rotation schedule to minimize overexertion injuries

FUTURE WORK

There are so many options to enhance this research. Some of the future research alternatives are listed below:

- Analyzing different worker injury databases
- Exploring the relationship between worker demographics and injury characteristics at various industrial plants, such as foundries, automotive manufacturing facilities, and chemical plants, etc., and implement safety engineering and safety management programs and safety training programs related to the root causes of these injuries. Documenting the results of those studies will help reduce the workplace injuries at similar industrial workplaces.
- Investigation of possible psychological and physical reasons of the impact of worker demographics on worker injuries.
- Further studies such as researching the specifics of the source of the injuries and explore the engineering solutions, such as investigating the materials to make better cut resistant gloves or better ergonomically engineered industrial knives and more effective and easier to use lift assist devices to eliminate those sources to directly injure workers at higher rates.

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