

Occupational Falls in Non-Construction Industries

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A thesis

submitted in partial fulfillment of  
the requirements for the degree of

Master of Science

University of Washington

2017

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Program Authorized to Offer Degree:

Environmental and Occupational Health

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**Abstract**  
**Occupational Falls in Non-Construction Industries**  
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*Background:* Falls are the second leading cause of occupational injury and the second leading cause of occupational fatalities in the United States. An occupational fall can lead to a non-time loss injury, loss of work, disability, or in severe cases, death. These injuries can have dire effects on the lives of workers impacted, through loss of their livelihood or in some cases, their life. Indirect costs can also be felt by the affected worker's family and their workplace.

*Objectives:* This study aims to determine the rate at which occupational fall-related injuries occur in non-construction industries in Washington State, and to determine best steps forward considering how these injuries might be reduced or prevented.

*Methods:* Workers' compensation claims were identified in the Washington State Labor and Industries Industrial Insurance System for workers who have suffered a fall, as defined by Occupational Injury and Illness Classification System codes. The claims were then categorized based on the industry of their employer, as defined by the North American Industry Classification System codes to identify which industries had the highest rates of falls. The claims were described by occupation, industry, type of fall, source or cause of fall, injury types, and cost. Using these factors, trends in occupational falls and the associated injuries were investigated.

*Results:* Agriculture, Medical, and Service industry sectors were found to be industries where prevention efforts would be best focused regarding occupational falls.

Prevention efforts could also be focused using cost data, both total cost, and average cost. Prevention efforts may be best focused on injuries that result in severe injury to the worker requiring immediate hospitalization.

*Conclusions:* Further research is needed to determine the characteristics of specific industry group fall injuries in order to better guide prevention efforts. This data is best served as a guiding document for selection of industry groups most in need of prevention efforts, especially those outside the already identified construction industries.

## **Acknowledgements**

Thank you to everyone who helped and supported me through the development of this thesis. Specifically, I would like to thank Marty Cohen for taking on the responsibility of being my committee chair, complete with the constant questions and lurking outside his office. Thank you to Todd Schoonover for acting as our man on the front lines in acquiring and preparing this dataset. Thank you to Richard Gleason for his enthusiasm and guidance on this project. Thank you to Goodrich Aviation Technical Services for providing the gift to the department that funded this project. Thank you to my family and friends for supporting me through this whole process, I could not have done any of this without you.

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# Introduction

## Occupational Falls

According to the U.S. Bureau of Labor Statistics, falls are the second most common source of occupational injury. In 2014 alone, nationally, 818 workers were killed, and 203,480 injured from falls to the same or lower level <sup>1,2</sup>. Construction industries saw the highest frequency of fall-related fatalities, while non-fatal falls were most common in health services and retail. When compared to all other incidents, falls are the second most prevalent source of fatal injuries on the job, with only motor vehicle accidents causing a greater number of fatalities on the job.

In addition to the high percentage of occupational injuries and fatalities coming from occupational falls, the number of fatal occupational falls increased from 2013 to 2014 by 94 fatalities<sup>3</sup>. Fatal falls to a lower level also increased by 11% from 2013 to 2014, from 595 to 660<sup>3</sup> with a small decrease to 648 fatal falls in 2015<sup>4</sup>. While this is a decrease from the previous year, it still represents an overall increase from 2013 data, nationwide.

Currently, Washington State has regulatory requirements in the construction industry to protect workers when working on elevated surfaces regardless of height, at four feet or more, and at ten feet or more <sup>5</sup>. Protections for workers in general industry are also contained within the Washington Administrative Code (WAC), covering the same topics as federal OSHA guidelines on walking/working surfaces <sup>6,7</sup>.

In Washington State, non-fatal and fatal injuries from falls resulted in a total direct monetary cost of over \$121 million for fiscal year 2015 alone. Average costs of each fall

ranged from \$7,400 for a fall to the same level to \$12,000 for a fall to a lower level with other fall categories falling in between. These data only include injuries and fatalities that were administered by the Washington State Labor and Industries Industrial Insurance System (LIINIS), and do not include the largest employers in the state who are able to self-insure. With the total annual cost incurred in Washington state for occupational injuries at over \$566 million, this puts the burden of falls at 21.5% of the total cost incurred for occupational injuries and fatalities in 2015<sup>8</sup>.

Anderson et al identified falls as the second most common event/exposure for occupational injuries in Washington State, coming second to only Workplace Musculoskeletal Disorders (WMSD) between 2002 and 2010<sup>9</sup>. For injuries from falls to the same level, construction industries made up the top two industries, freight trucking in third, residential mental health and drug treatment facilities in fourth, and nursing care facilities in fifth. The top five industries with falls from elevation include construction industries as the top three, with fruit and tree nut farming and general freight trucking filling out the top five. This highlights a need for high quality studies of trends and descriptions of falls in non-construction industries, as they make up a significant portion of the fall injuries sustained in the workplace<sup>9</sup>.

Smith and Williams identified the risks involved to trucking industry workers in Washington State, and identified falls as the second leading cause of injury, only behind work-related musculoskeletal disorders (WMSD)<sup>10</sup>. Hofmann et al described the risks related to orchard workers in Washington State, finding that ladders contributed to 48% of compensable claims, making injuries involving ladders not only the most frequent but

the costliest as well<sup>11</sup>. Better characterization of falls could improve our understanding of how to prevent these injuries from ever happening.

Additionally, when considering fall protection, the common group seen at risk is the construction worker, whose job may cause him/her to be at high elevation and at greater risk of falls to a lower level. According to the Washington State Department of Labor and Industries (L&I), in the first half of 2016, in Washington State, there were 10 fatalities due to falls in the workplace. Three of these falls were in the construction industry, two were in Administrative and Support and Waste Management and Remediation Services, one was in utilities, one was in agriculture, one was in information technology, and one was in other services. The risk of falls applies to all workers.

Occupational falls may result in dire health consequences that have large monetary and social implications, along with presenting a risk for death to the worker. Our research will determine any trends in work-related falls in non-construction industries, compare them with the construction industries, and working with L&I, explore next steps to develop appropriate controls or interventions that could further reduce the number of occupational falls occurring in the state.

## **Exposure Controls and Regulations**

Both the federal government and state of Washington have specific regulations in place to protect workers from the hazards of falls. The hierarchy of controls states that we must focus on first trying to completely eliminate the hazard. In many cases, elimination and substitution are simply results of engineering controls. If something is

removed from the workplace, then it has, in effect, been engineered out. If a different object is used for a floor covering that reduces falls, then that substitution is an engineering control. Engineering options are well documented within the regulations regarding walking and working surfaces and the duty to provide fall protection included within both the state and federal standards<sup>5-7</sup>. Engineered controls are required in guardrails for any work done at height, ladders are required to be secured for use, or to have a cage installed around tall fixed ladders, guardrails are required on stairways, and materials used on stairs and floor surfaces may be specifically designed to prevent falls. Administrative controls can be used to prevent falls as well. For example, it could be the policy of a woodworking facility to sweep up all wood dust generated at least once an hour provided it is not captured by their ventilation system. Personal protective equipment is supposed to be the last line of defense against a hazard. In terms of fall protection, this can include harnesses, fall arrest systems, and fall prevention systems. Most of these systems are used in conjunction with both administrative and engineering controls in order to provide the maximum level of protection. With some work taking place at great height, having multiple layers of protection can improve a worker's outcome should a fall occur.

Prevention through design (PtD) is a NIOSH initiative with the goal of reducing injuries and fatalities in the workplace through the complete redesign of processes in order to engineer out any hazards that may be inherent to the industry in question. This could include designing a construction site so that work from height is done fully protected through the use of guardrails, safety nets, and personal fall protection. At a woodworking facility, this may mean using machinery that collects most, if not all, of the

dust produced during the processes in order to reduce slip hazards on the ground of the facility. In agricultural settings, it may mean altering the way plants are grown in order to allow harvest of produce without using a ladder, or without having to bend over. The idea is to use stakeholder input and associated research to develop methods by which to completely eliminate hazards in the work place through the design of the process<sup>12</sup>. Some steps have been made in the construction industry to design building processes to eliminate hazards before they are even created. Melzner, et al. explored how Building Information Management software could be used to plan for possible fall hazards before construction even began, allowing fall prevention efforts to be a part of the planned work, rather than something that had to be noticed<sup>13</sup>.

Under federal law, an employer is required to provide fall protection for any employees walking or working on a surface with an unprotected edge over 6 feet above a lower level in construction industries<sup>14</sup>. For general industry, any open sided walkway that is over 4 feet above a lower level must be guarded with a standard railing. Under the general industry requirements, walking and working surfaces must be kept clean of all debris, ice, and any other hazards that may contribute to a slip, trip, or fall<sup>15</sup>. These regulations are designed to keep workers safe in the workplace from the hazards of falling. Washington State rules are quite a bit more complicated. To the point where the state has released a twenty- page table that outlines the differences. Rules are different depending on the industry, with some rules applying to all industries, and specific rules for construction, agriculture, electrical work, woodworking, logging, longshoremen, paper mills, shipbuilding, ski facilities, telecommunications, textiles, and window washing. Trigger heights range between 4 feet and 10 feet depending on what

activities are being conducted and in what industry<sup>16</sup>. Currently, the state is beginning the process of unifying the rule at the behest of OSHA in order to both comply with OSHA standards and simplify implementation of fall protection standards<sup>17</sup>.

Enforcement of the walking/working surfaces standard varies greatly depending on the state. Several states, Washington being one, administer their own workplace safety program. The Division of Occupational Safety and Health (DOSH) within L&I administers the state workplace safety and health program, and is responsible for ensuring that the program is as effective, or more effective, as that administered by OSHA. Nelson et al found that employers in the construction industry in Washington State who were inspected and cited by L&I saw their workplace injury rates for falls decrease from 1.78 to 1.39 per 200,000 hours, from the year before the inspection to the year following. They concluded that increases in enforcement might be a prudent solution to the high prevalence of fall related injuries<sup>18</sup>. Kaskutas et al found that the use of fall protection and the guarding of openings and holes on residential construction sites was rare during an audit of worksites in St. Louis. Larger residential construction companies were more likely to have appropriate fall prevention plans in place, and workers at these larger companies were more likely to know the fall protection plan than those at smaller employers<sup>19</sup>. The lack of awareness of fall protection rules, coupled with the lack of enforcement, leads to workplaces where falls are not protected against, and where falls are more likely to happen.

## **Specific Aims**

The goal of this study is to describe occupational falls within the state of Washington by analyzing claims made to the Washington State workers' compensation system for fall-related injuries and fatalities sustained while at work. According to the Bureau of Labor Statistics, falls are the second leading cause of non-fatal injuries in the workplace (after overexertion), and the second leading cause of death (after transportation incidents)<sup>3</sup>. Washington State allows for a unique opportunity because the L&I administers the worker's compensation system. Claim information is maintained in an administrative database called the Labor and Industries' Industrial Insurance System (LINIIS). Claims records are compiled by trained coders who extract information from the report of accident (ROA) form completed by the injured worker and health care provider at the time of the incident. Coders assign codes and descriptions using the Occupational Injury and Illness Classification System (OIICS)<sup>20</sup>, with companies classified by their industry using the 2007 North American Industry Classification System (NAICS)<sup>21</sup> codes. The US Census describes the system as: "... an industry classification system that groups establishments into industries based on the similarity of their production processes"<sup>22</sup>. Using these classification systems, it is possible to describe the incidents (falls) and health outcomes that arise from these incidents, giving a better picture of how falls impact the workers employed in different industries. Claims can then be stratified by industry sector, severity, risk class, and several other factors. With slips, trips, and falls accounting for the second-most workplace injuries, determining the extent of these injuries on an industry basis could illuminate injury prevention interventions that could be used to prevent these incidents, and in turn

reduce costs to employers, employees, and the state. In this study we used the aforementioned data source to accomplish the following specific aims:

1. To characterize all accepted workers' compensation claims for falls either on the same level or from height in all industries in Washington State from 2005-2014 using OIICS (v1.01) codes and 2007 NAICS codes.
2. Describe incidents by various factors and compare and contrast based on industry sector and severity of injury.
  - a. Null hypothesis: There is no difference between industry sectors in fall severity and frequency.
3. Determine appropriate next steps towards developing controls and interventions to prevent and reduce falls.

We will accomplish these aims using a thorough analysis of workers' compensation claims by NAICS and OIICS codes for falls to same level, falls to a lower level, jumps to a lower level, and falls, not elsewhere classified (n.e.c.). This study will describe non-construction industry falls and develop recommendations for prevention activities that can help to reduce the number of falls in these industry sectors with comparisons to construction industry rates and numbers.

## **Methods**

### **Washington State Workers' Compensation System**

Washington State employers are required by law to obtain workers' compensation insurance through the Washington State Department of Labor and Industries Industrial Insurance System. L&I's State Fund provides workers' compensation to approximately two-thirds of the work force in the state, while the remaining third is employed by the state's largest employers (who can afford to self-insure)<sup>9,23,24</sup>. Workers not insured by the State Fund include those working for the federal government or for employers able to self-insure under alternative workers' compensation programs.

### **Worker's Compensation Database**

This cross-sectional study was conducted using records from the LINIIS with date of injury occurring between January 1, 2005 and December 31, 2014. Claims records were extracted on 04/12/2017. The population studied was all workers in Washington State who are covered through the State Fund insurance system and suffered an occupational fall as identified by OIICS event/exposure codes (v1.01 event/exposure 1\*), and had their claim accepted by the State Fund. Individual claims were identified by their OIICS accident type code assigned to them, while the industry classification for each claim was assigned based on the NAICS code of the worker's company of employment at the time of their injury. Using these data, we described the falls that occurred over the study time frame. We only used data from the State Fund

claims, as detailed data regarding self-insured employer injuries is not contained within the State Fund database.

A fall is defined in the OIICS codes as, “events in which the injury was produced by impact between the injured person and the source of injury when the motion producing contact was generated by gravity”<sup>25</sup>. The data set used for this study uses the OIICS v1.01 coding system in order to identify claims where a fall has occurred. Falls are identified by OIICS Event/Exposure Codes starting with the number 1, and expanding to up to 4 digits to describe the type of fall. Falls to a lower level start with 11, jumps to a lower level start with 12, falls on the same level start with 13, falls that are unspecified start with 10, and falls that are not elsewhere classified start with 19. An unspecified fall would be a fall where the details of the outcome of the fall are not clearly recorded in the claim. A fall not elsewhere classified covers falls that cannot be classified using the established coding system. For a fall to a lower level, this includes falls from trees, chairs, or horses and any other fall not elsewhere classified. Falls from moving vehicles, parachuting accidents, falls from or on boats, and jumping up and down are not classified as falls under the OIICS event/exposure codes<sup>25</sup>.

OIICS codes also describe the incident in further detail based on the nature of the injury (i.e. 012 indicates a traumatic fracture of a bone), the part of the body affected (i.e. 312 indicates an injury to the elbow), and the source of the injury (i.e. 625 indicates that steps/stairs were the source of the injury). Each claim is assigned a code from each of the code trees if the information is available for the injury. Depending on the event/exposure that occurred to cause the injury, varying levels of information may be

available about the injury depending on what information was reported regarding the event<sup>25</sup>.

Each time a claim is accepted by the State Fund, the claim is given a unique claim identification number for reference. The date of injury is recorded, along with the date the claim was established. OIICS codes are also assigned for the source of the injury, nature of the injury, body part affected, and accident type. An actuarial incurred total cost is assigned to each claim as an estimate of the total cost of the worker's injury as projected, however this number may change over time depending on the money actually paid out. NAICS codes and descriptions are assigned based on the company where the injury occurred. Descriptors are also collected for each claimant including their age, job title and duties, length of employment, wages, sex, and foreign language preference. A claim status description is also assigned to the claim, which also can change over time depending on the ultimate outcome of the injury (e.g. a worker could be injured and become permanently disabled due to complications from recovery). At any given time, an entry within the database will only have one claim status description.

Claims statuses are classified using 6 different categories describing the benefits associated with the claim. Non-compensable claims are claims where the cost of the injury is for medical treatment only, with no time-loss paid. Compensable claims are any claim that is expected to result in payments from the State Fund for time-loss of greater than three days, disability, or death. Compensable injuries can be further classified depending on the severity of the injury. A kept on salary claim is an injury where a worker's salary continues during a period of disability, rehabilitation, or modified job assignment. A death benefit claim, or a fatal claim, is a claim where the injury or

disease results in the death of the worker. A total permanent disability claim involves an injury that permanently and completely incapacitates a worker, preventing the worker from ever performing any gainful employment. This cannot be established until after the worker's injuries have been treated and the worker deemed stable. A loss of earning power claim is an injury where the worker will be earning at least 5% less than their pre-injury wages while conducting either light duty or modified work.

Claims are sorted by industry using the North American Industry Classification System (NAICS). NAICS codes are between two and six digits and is a production-oriented industry classification system, grouping establishments into industries according to similarities in processes used to generate goods or services<sup>22</sup>. The number of digits in a NAICS codes offers increasing resolution as to the exact function of the industry. A two-digit code indicates the industry sector (e.g. 23 indicates Construction, 11 indicates Agriculture, Forestry, Fishing and Hunting), a three-digit code indicates the industry subsector (e.g. 111 indicates Crop Production, while 621 indicates Ambulatory Health Care Services). A four digit code indicates the industry group (e.g. 1111 indicates Oilseed and Grain Farming, while 1113 indicates Fruit and Tree Nut Farming). Up to six digits can be used to offer further resolution on the functions of the industry<sup>22</sup>. For this study, we are using two-digit and four-digit codes to describe trends by sector and by group, respectively. NAICS codes are updated on a 5 year time-table in order to keep pace with changes in industry across all sectors. Labor and Industries currently uses NAICS codes from 2007.

Claims are also described in the database based on risk classes. A risk class is a description of the claimant's occupation regardless of industry. Risk classes are

coded based on the Washington Industrial Classification System (WIC). These codes are used by the workers' compensation fund to determine the proportion of different work done by workers at any given company. For example, a construction company may employ electricians and framers, whose industry group would be the same, but their risk classes would be different<sup>26</sup>, 0601 and 0510, respectively. These can be used to identify falls that occur based on actual risk associated with the work at the time of injury, rather than overall production processes as described by NAICS codes.

Standard Occupation Classification (SOC) codes are also assigned for each claim and are used to classify workers into occupational categories for a variety of purposes<sup>27</sup>. This data is akin to a job title, and is seen as more descriptive than industry codes, especially when classifying activities conducted by individual workers. These codes are used by the federal government in order to facilitate data analysis across datasets as a unifying variable.

Cost data are documented within the database for all compensable and non-compensable injury claims. Cost of a claim depends on the money paid out of the State Fund to cover the cost associated with the claim. Costs include medical payments, wage replacement, death benefits, and coverage for loss of earning power, total permanent disability, and kept on salary. The majority of claims records indicate positive costs. The exception to this is claims where money was paid out, and then money had to be recouped by Labor and Industries due to either a change in claim status, or the worker seeking monetary damages from another source (e.g. suing a ladder manufacturer over a faulty ladder that caused a serious injury). These claims are

represented by a negative cost in the database. If the claim was rejected by the workers' compensation system, it does not appear in the extracted dataset.

Health care facility admission information is collected for each claim, indicating whether the worker was admitted at either an urgent care unit, a trauma center, an emergency department, had an elective admission, or were not admitted at all. Elective admissions are usually attributed to claims where workers were injured on the job, and required surgery at a later date. Data are also collected on the time from injury that it takes for the worker to be admitted to the hospital, as a measure of severity. Data in our set is subdivided into admissions at one day or less and all other admissions. Median costs were extracted for claims meeting both of these criteria by industry group only.

Worker demographic and limited employment data are also collected for each claim. This includes length of employment, gender, and age. Length of employment, or tenure, is collected at the time of the claim being accepted, indicating the time from hire to the injury. Gender and age are collected when the claim is filed. Tenure of employment data was delivered using summary statistics to describe the spread of the data, and not as information regarding individual industries. This included percentile values, which were used to determine the median tenure for employment at the time of the fall.

Summary tables were created by first querying the state fund database for all claims where the event/exposure was classified as a 1, indicating that the event was a fall, between the years of 2005 and 2014. Data extracted and tables were created by Todd Schoonover at the Safety and Health Assessment and Research for Prevention

(SHARP) program at Labor and Industries (L&I). Summary table contents were requested and guided by Samuel House (the researcher) at the University of Washington for the purposes of this thesis project. Summary tables were segregated by industry group description, and extracted frequencies for each industry group by the following measures: claim description, costs by claim type (compensable vs. non-compensable), gender and age, hospital admission type, and hours worked by company size.

## **Analysis**

All analysis was conducted using STATA 13 statistical analysis software. Data was extracted in Excel format and converted to comma delimited (csv) format and then imported into STATA. NAICS 2007 codes were attached to their corresponding description strings in order to allow for determination of industry sector classifications later on in the analysis. Falls with no industry group designation were dropped from the dataset, as they represented 0.0004% (61 out of 144,647) of the total falls over the time period of the study. Data sets were merged using the industry group string as a matching point. All data segregated by industry group was merged into one table, with the exception of the admission type data, as these data were extracted as totals for the entire 10 year period, instead of on a year by year basis.

Rate of falls was generated by first determining the number of full time employees in each industry, which was achieved by dividing the total number of hours worked by 2000 which gives the number of full-time equivalents (FTE) in each industry. This assumes 50 weeks spent at work in a given year. Hours spent on vacation are not

counted for total hours worked, as injuries on these hours would not be considered “on-the-job”. Total falls were then divided by this full-time equivalent number for each industry in order to give a rate of falls per FTE. Rates were generated on both a yearly basis, and as an average rate over the entire ten-year period. These were then multiplied by 1000 to convert the rate to falls per 1000 FTE for ease of use. This is reflected in the following equation:

$$\frac{\text{Falls}}{1000 \text{ FTE}} = \frac{\text{Total Falls By Industry}}{\left(\frac{\text{Industry Hours}}{2000}\right)} \times 1000$$

A prevention index was used to determine which industries were best suited for intervention<sup>23</sup>. A prevention index is obtained by first ranking the total number (frequency) of falls by industry over the time period of interest. Then the fall rate is ranked in the same manner. Taking the average of these two ranks generates a prevention index. This prevention index takes into account both the rate and the frequency of falls, balancing out the effects of industries with high rates but low frequencies, and industries with high frequencies but low rates. The prevention index was applied to both industry group classifications and industry sector classifications. Prevention indices are commonly used in SHARP reports to identify industries that should be prioritized for prevention interventions<sup>9,28</sup>. The prevention index is calculated using the following formula:

$$PI (\text{Prevention Index}) = \frac{(\text{Fall Count Rank} + \text{Fall Rate Rank})}{2}$$

Cost data were organized in a similar manner to the prevention index, using median cost and total cost for a Cost Index. This measure was used to prioritize industries both with severe outcomes (high median costs) and many falls (total costs), when compared to the other industries based on cost incurred. This measure is not used in Labor and Industries reports, but used in this report to better describe the costs of falls within each industry group and industry sector. This index was used to describe fall severity on an industry group and industry sector basis. Cost index was calculated using the following equation:

$$CI \text{ (Cost Index)} = \frac{(\textit{Total Cost Rank} + \textit{Median Cost Rank})}{2}$$

Health care facility (HCF) admission data was only received as totals for the entire 10 year period, so year by year analysis was not conducted with this data included. HCF admission data gives one picture of severity, with hospital admissions representing more severe falls than those where an admission was not present. Data for the time from injury to hospital admission was extracted on an industry group basis.

Frequency of falls by Washington Industrial Code (WIC) Risk Classes data was extracted on a year-by-year basis and summarized. Standard Occupational Classification (SOC) code frequencies were extracted for the entire 10 year period, not on a year by year basis. Both of these datasets were used independently to show where falls are occurring in risk classes and occupations as a comparison to the NAICS information that was extracted for the rest of the dataset.

## Results

All tables and figures referenced in the results are included at the end of this paper, prior to the bibliography. **Error! Reference source not found.** shows a summary of the data, demographics of the claimants, and the totals measured for the variables used to describe the falls over the course of the analysis. This data is only for claims that meet the case definition for this study. From this data, we can see that most of the claims accepted over the time period of the study were from males (59%), with males between the ages of 25-54 being the most likely to suffer a fall while at work (40% of all claims). Female workers had fewer falls than male workers, and females aged 45-54 were the most likely to suffer a fall. Tenure data is also included, showing the median tenure of 440 days for a worker to suffer a fall at work, with the 99<sup>th</sup> percentile being 30 years.

Fall claims can be characterized by their claim status, which shows how the claim was classified at the time of data extraction. Table 2 shows the distribution of falls by the claim status on a yearly basis. This gives a basic idea of what the distribution of claim types is year by year. The claim statuses are fixed at the time the data was extracted, though the claim status may have changed for individual claims since the data was extracted. This shows that claims are most likely to be non-compensable (64%), with compensable claims being the second most common claims status (30.2%).

**Error! Not a valid bookmark self-reference.** shows both the frequency of fall claims and the rate of claims on a yearly basis, indicating that over the timeframe of the study, there was a decrease in the total number of fall injury claims, and a corresponding drop in the rate by which fall claims were being made. Near the end of

the study period, there is a slight increase in the fall frequencies, but the rate continues to decrease slowly. The drop in fall claims corresponds with a similar drop in hours worked between 2008 and 2010.

Table 3 shows the top 10 industry groups when sorted by prevention index for all years included in the study. This information was used to prioritize industries for further analysis. Fruit and Tree Nut Farming jumps out as an industry where interventions might have great effect. Logging and Freight Trucking could also be areas where interventions might have positive effects. Included in this table are also the two service industry groups, as their rankings for total falls are in the top 10.

Table 4 shows the top 11 industry sectors by prevention index (11 industry sectors are listed due to a tie in prevention index). Notable features of these tables is that by prevention index over the study period, Fruit and Tree Nut Farming elevates to the top of the list, indicating as an industry group where there may be the most opportunity for intervention to prevent falls. Additional industries where total falls was ranked highly were also included in this table to highlight industries where many falls occur, but the rate is low. When organizing falls by industry sector, Construction rises to the top as the industry with the lowest prevention index, indicating that interventions would be needed in the industry. However, Agriculture, Forestry, Fishing and Hunting (Agriculture) are a very close second, indicating that interventions are just as needed in this sector as they are within the construction industries.

**Error! Reference source not found.** shows the falls per 1000 FTEs for the top 10 Prevention Index Industry Groups over the time frame of the study. Noticeably, there is a large drop in the fall rate for the logging industry, and many of the other industries appear to have relatively flat changes in their fall rates. Table 5 shows the coefficients of regression as they relate to the fall rate for each of the top 10 industries. For each unit of increase in the year, the coefficient value represents the corresponding increase in the number of falls per 1000 FTE within that industry. P-values are also included to indicate the statistical significance of the changes in each industry group. Even though the changes in fall rates are quite small, it is interesting to note that these changes are statistically significant for most of the industry groups listed, with only Fruit and Tree Nut Farming, Services to Buildings and Dwellings, and Other Crop Farming showing no significant change over the time frame of the study.

Figure 3 shows prevention index by NAICS industry sector over time. It is important to note that the lower the prevention index, the more need there is for intervention in a given industry. It's notable that Construction and Agriculture have consistently taken up the top two spots for Prevention index, while Accommodation and Food Services, and Administrative and Support and Waste Management and Remediation Services have improved over time, with Health Care and Social Assistance starting the timeframe as the lowest priority, moving to the middle, and then moving back into the lowest priority position.

The top five frequency industries for falls by gender were separated out in order to see what sorts of age and gender distribution differences might be present between the different industry sectors. Figure 4 and Figure 5 show the percentage of falls in each of the top 5 frequency industry sectors for females only and males only, respectively. These figures divide out the falls into age groupings for each of the industry sectors. Distributions may be due to populations contained within each industry sector described, but they also could indicate trends in who is falling at work. Notable trends include increased falls for older women in education and healthcare industries, and increased falls for men in construction industries. Agriculture showed fairly similar age demographics across both men and women.

Table 6 includes data for the number of falls in the top 10 prevention index industries by the time to hospital admission. A time to admission greater than one day is used to indicate a less severe fall. Admissions that occur on the same day as the fall are seen as more urgent and severe injuries, and this assumption is borne out by the median cost differences for these two types of admissions.

Cost index data is displayed in Table 7. When cost is used as the measure to determine where falls are having the greatest impact, construction industries (NAICS Codes starting with 23) begin to become more present in the top 10 industries. Fruit and Tree Nut Farming, the top industry when using a prevention index, disappears from the top 10, dropping all the way down to number 63 when measured by this index, with total costs of \$87.8 million and a median cost per claim of \$1160. Additional notable industries have been included at the bottom of this table to highlight industries where total costs are high, but median costs remain low.

Delving deeper into the OIICS coding for each of the top prevention index industries, gives some insight into where these falls are occurring, what parts of the body are being injured, and what the source of the injury is (for most falls it is going to be either the ground or a flat surface). The top 5 industry event/exposure codes are included in

**Table 8.** This shows the distribution of the falls within different industries, and highlight areas where interventions might be effective at reducing the number of falls on an industry by industry basis. For instance, focusing on falls from ladders in Fruit and Tree Nut Farming, and reasons that workers are falling to the same level working in Services to Buildings and Dwellings.

Table **9** furthers our comparison between the construction industry and other industries by separating out OIICS Event/Exposure descriptions by Industry Sector, showing the different types of falls that occur in the top 5 sectors by prevention index. This again shows what types of falls are occurring, and gives some clarity into what types of falls are most common in what sectors. Noticeably, Construction falls happen both from ladders and to the same level with relatively the same frequency. Most other industries, however, have falls predominantly from one type of event or exposure, with the greatest difference appearing in Health Care where almost all of the falls are occurring to the same level.

Next, we looked at source of injury by the event/exposure.

Table **10** shows the sources of injuries that were associated with different event/exposures classified as falls. The source of injury helps to describe what is happening to workers when they are injured at work. The sources of injuries based on the events seem to be what would be expected from a fall, being that people are falling onto the ground or floor, or in the cases of falling down stairs or off a ladder, the stairs and the ladder can be a contributing factor to their injury. Because this information isn't very specific, the next step is to look into the parts of the body most injured for the same event/exposure groups.

When separating out by body part injured during falls, there is a bit more resolution to the nature of falls contained within our dataset.

Table 11 shows what body parts are most commonly injured for the same events/exposures that are included in the previous tables. Multiple body parts is the most common classification in this table, but ankles, knees, shoulders, and lumbar injuries are present within many of the groups as well. Multiple body parts is defined in the OIICS manual as injuries where two or more divisions from the coding tree are included in the injury (i.e. a broken wrist and a sprained ankle)<sup>25</sup>. Wrists are a common injury for falls to the same level.

Another way we can describe where falls are happening is by classifying falls by both their Standard Occupation Classification (SOC) and their Washington Industrial Code (WIC) Risk Class. SOCs have quite a bit of missing information for this dataset, as the most common SOC for workers that fell in Washington State is “Unclassifiable”. Because WIC risk classes give us a combination of occupation and industry, this information gives a little more clarity into what the people who are being injured by falls are actually doing in the work place. Table 12 and

**Table 13** show the distribution of falls by risk class and occupation classification, respectively. Interestingly, Restaurants and Taverns come up as the top frequency risk class for falls. This is likely due to the fact that NAICS differentiates between Full-Service Restaurants, Limited Service Eating Places, and Drinking Places, meaning that the high frequency of falls within that risk class is spread to multiple industries for our NAICS codes. The presence of so many non-classifiable falls in the SOC system indicates that any meaningful comparison may be impossible to do given the data as it stands.

## **Discussion**

In exploring the dataset, we were able to discover a number of trends that indicated areas where interventions regarding falls would likely serve to better protect workers. Because the data was limited in scope, and resolution was limited by the number of summary tables that could be extracted, these findings may indicate correlation, but they do not establish causation for many of the trends discovered.

Overall, the data from this study shows that some insight into underreporting may be necessary to understand why fall rates and frequencies dropped sharply in 2009. This could be due to effects from the economic downturn, however in that case, we would expect to see a drop in frequency, but not necessarily the corresponding drop in rate. Wuellner et al. found that underreporting for the BLS' Survey of Occupational Injuries and Illnesses (SOII) was mainly due to noncompliance with recordkeeping rules, noncompliance with reporting instructions, and employer misclassification of injury as non-work-related, data entry errors, and injury progression taking place post-employment<sup>29</sup>. The most common industry sectors identified for underreporting were

large construction companies, and small educational services companies, however, overall, as a company's size decreased, their likelihood of underreporting increased<sup>29</sup>. In Washington State, Fan et al determined that about 48% of workers who suffered an on-the-job injury did not file a workers' compensation claim. Reasons included the employer paying for medical treatment directly, unions paying costs, military paying the cost, and even private insurance. Also included was fear of retaliation for filing a claim, and the worker not knowing that a claim could be filed for their injury<sup>30</sup>.

Age data as it was included in the dataset had over 1800 instances where age was not reported. This, coupled with the falls where NAICS industry information doesn't exist, represents some misclassification in our dataset. Because of how the data is presented, it cannot be determined if this misclassification is consistent across all population groups. Misclassification on age data was attributed to the inability to read hand written ages on forms submitted for entry into the database. Further research would need to be conducted to determine if there is any pattern to the misclassification of age data across the study population, and to determine how this bias might be affecting the data itself. Patterns in demographic data or industry groups would be interesting to determine if there is some factor that leads to ages being classified as a zero.

The results of this analysis could help to further inform research into occupational falls, their causes, and possible areas to explore for interventions. Using prevention indices, we were able to find an industry that has potential for intervention, in Fruit and Tree Nut Farmers. The data clearly shows that this industry not only has a high prevention index, but most of the falls are coming from ladders, giving an area to focus

on for intervention. Either eliminating ladders from usage in the industry, or switching to ladders which offer better safety from falls in alternative to the traditionally used three-legged orchard ladders. Convincing employers that preventing these falls would save them money in worker's compensation insurance premiums might help drive the industry towards safer work practices. Overall costs for fall injuries are \$87.8 million, putting the cost at the 6<sup>th</sup> highest total for all industry groups in Washington State. However, this industry does not show up in our cost index analysis, because the median fall cost is only \$1,160. The high cost is reflective of the sheer number of falls occurring in the industry, while the low median reflects the lack of severe falls. Falls that required immediate hospitalization also saw lower median costs, indicating that even severe falls were less costly than other industries. Low cost on average could just be indicating that the falls occurring in this industry are simply less severe than those occurring in other industries, requiring less medical care, less time away from work, or less long term payments from the State Fund.

Ladders have driven the injury burden for Fruit and Tree Nut Farmers for a long time. Hofmann et al. and Salazar et al. identified ladders as a major contributor to injuries within an orchard setting<sup>11,31</sup>. In our data set, ladders accounted for 4962 falls, which amounts to 68.6% of the total falls within the industry group. Interventions currently in place include the use of platforms<sup>32</sup> to transport the workers around the field. These vehicles travel extremely slowly while the workers remain on a guarded platform picking the fruit as they pass. Growing of shorter fruit trees has become a popular method by which to reduce labor costs, while still maintaining the yield of fruit trees<sup>33</sup>. This has the additional consequence of having workers on ladders less of the

time. Further technologies involve using vacuum tubes to collect the fruit, and decelerators being used to drop the fruit relatively gently into a collection bin. These technologies have some problems involving damage to the fruit<sup>32</sup> which makes it unsellable in its whole form (cider apples, for example, do not need to be in good condition after harvesting).

The logging industry also has one of the highest fall rates of our industry groups studied, however, they have also shown marked improvement over the years which shows to be statistically significant. Exploration into the steps that have been taken to reduce the rate and number of falls in the logging industry would be helpful in exploring where interventions may be effective in other industry groups. Reductions in falls in the logging industry could also be attributed to changes in work practices, moving more workers inside machinery and reducing the number of workers on foot. It's important to note that the logging industry covered by the State Fund does not employ a large number of workers (2,813 FTE per year) especially when compared to other high prevention index industries (26,284 FTE per year for Fruit and Tree Nut Farming). These lower employment levels can lend themselves to higher volatility in rates over time, as a small count of falls can have a large impact on the rate. But because of this, any intervention that reduces the number of falls in the industry would greatly reduce the rate of falls within that workplace. With loggers commanding high industrial insurance costs in the state (\$18.18 per hour worked, with \$2.75 owed by the employee per hour)<sup>34</sup>, reduction in workplace accidents should have a strong financial incentive. Reductions in falls might be difficult to achieve in the logging industry due to the outdoor

nature of the work, and the mobile nature of the workplace as operations are not completely stationary over time.

A theme amongst all the industries that make appearances in the top 10 prevention index and cost index is the variable environment of the top industries. Industry sectors such as Manufacturing, Wholesale Trade, and Retail Trade, where the work environment can be consistently engineered see high numbers of falls, but also lower than average rates (7.66, 7.77, and 7.78 falls/1000 FTE, respectively). Conversely, industry sectors like Agriculture, Forestry, Fishing and Hunting (Agriculture) and Construction see both high numbers of falls and high rates. In Agriculture, this can be attributed to the variable nature of the outdoor environment. Logging, due to the outdoor environment of the workplace, and the changing nature of the location of a given workplace over time, mean that engineering out fall hazards that are natural can be difficult if not impossible. The use of automation in the logging industry<sup>35</sup> and elimination of ladders in the tree fruit industry<sup>36</sup> do hold promise for a reduction in falls within Agriculture. Construction industries have found success in reducing injuries through “Ladders-last” policies, which aim to complete all tasks at a site without the use of a ladder, except as a last resort. Turner Construction, a large national firm, has employed this strategy to great success, generating reductions in injury costs of up to 99%<sup>37</sup>.

Restaurant and Tavern workers showed up as the top risk class in the state for frequency of occupational falls. In our data, they were not present in the top 10 prevention index industries, likely due to the workers being split among at least three industry groups (Full-Service Restaurants, Limited-Service Eating Places, and Bars and

Drinking Places). In future research, these industries may show up in the top 10 if using an updated NAICS code (2012 or 2017), which combines Limited-Service Eating Places and Full-Service Restaurants under one code, Restaurants and Other Eating Places (7225)<sup>38</sup>. Both Full-Service Restaurants and Limited-Service Eating Places showed up in the top ten for fall counts, being third ranked and fifth ranked, respectively. Their presence on the prevention index top 10 was only prevented due to their above average, but relatively low rates (Other Crop Farming had 17.64 Falls/1000 FTE, while Full-Service Restaurants had 9.18 Falls/1000 FTE). This also translated to a relatively high overall cost, with Full-Service Restaurants representing \$57.2 million in claims from 2005-2014. The low rates and high numbers of falls are due to the high number of employees who work in this industry statewide. Accommodation and Food Services sector employees had falls that were predominantly on the same level, with falls down stairs or steps and falls onto or against objects representing 1341 falls and 1320 falls, respectively. Interventions would likely require additional research, as knowing which workers in these establishments are getting injured by falls the most would be enlightening to any intervention. Jeong et. al. found that injuries from falls within restaurants can be caused by water and oil on the walking surface, and that slips and falls represented the largest proportion of occupational injuries in their studied population<sup>39</sup>. Digging down into the workers' compensation data by describing falls by risk classes could also provide insights into further steps towards fall preventions in the Accommodation and Food Service sector.

Considering costs of falls can provide an avenue in which to pursue prevention efforts, to get the greatest benefit for each intervention. Industries where falls are

occurring that result in a high number of admissions to hospitals within 24 hours of the injury, and also have high median costs could be a good starting point for interventions. Cost indexes could be combined with prevention indexes to determine industries where both measures have determined that interventions would be best served.

Indirect costs are also an important consideration to make. When a worker is injured, the costs go beyond what is paid in workers' compensation premiums, medical costs, and wage replacement. OSHA considers indirect costs to include: wages paid to injured workers for absences not covered by workers' compensation, wage costs related to time lost through work stoppage, overtime costs necessitated by the injury, administrative time spent by staff after an injury, training costs for a replacement worker, lost productivity related to the injury, and repair to damaged property<sup>40</sup>. Common estimates put indirect costs to direct costs ratios at 4:1 but based on what is included as an indirect cost, however, Fred A Manuele updated these estimates, and puts the ratio at 0.8:1 meaning that a working ratio of 1:1 should provide useful estimates in real world settings<sup>41</sup>. This puts the costs of falls much higher than seen in the data collected for this project. Considering our overall costs for falls are at \$2.747 billion, this means that occupational falls represented in this dataset could have a real cost that is closer to \$6 billion.

When looking at data by either industry group and industry sector, there are noticeable differences in the types of falls that are occurring. While construction industries seem to have an even split between falls to the same level and falls from ladders, other sectors have a much more marked difference between the number of falls by event/exposure. Agriculture falls are mostly happening from ladders,

Accommodation and Food Services falls are mostly happening at the same level, Health Care is mostly happening at the same level, and the Administrative and Support and Waste Management and Remediation Services sector is happening from the same level as well. Since the OIICS sources listed in our dataset only give us the primary source of the injury, the most likely thing to be listed is either the ground or the floor, as that impact is what caused the injury for which the worker made their claim. Injured body parts do not offer much more clarity as to what is getting injured based on the type of fall.

Cost data involving admission to the hospital brings up further questions. When we separate out the cost of a claim based on whether the worker was admitted to the hospital within 24 hours, there is a marked difference in both frequency and cost for the claim. These claims indicate that the injury was severe enough to warrant admission to the hospital within 24 hours, yet when comparing industry groups, the median cost of these injuries varies greatly. Agriculture injuries being the lowest cost for an immediate admission, and Construction injuries having the highest cost for immediate admission. Further investigation into the characteristics of these falls would be illuminating as to what is driving the increase in cost between industries. These differences likely indicate a contrast in severity between the industries for falls that do warrant immediate hospital admission.

When deciding where to begin for fall interventions in the top prevention index work places, it seems that preventing the costliest falls would be a good place to start for any industry. A further study could be conducted on the characteristics of only falls where the admission day was less than or equal to one day after the fall had occurred.

In reducing these falls, the benefit to industry would be seen both in a reduction in direct costs through premium payments, and a reduction in indirect costs as well. Ideally an in-depth study into intervention strategies would consider that while reducing the number of falls is a goal, in reducing or eliminating the most expensive falls, the most benefit can be provided.

## **Limitations**

This study was done only using accepted State Fund covered workers' compensation claims. This means that while there is a large amount of data, it does not include data from approximately 400 of the largest employers in the state, which includes large aerospace manufacturing companies, government agencies, and technology companies. This data is only representative of the employees at companies who are covered under the State Fund, so while it does give a portion of the picture regarding falls in the state, it's only a portion. The number of employers represented in this data set gives it at the very least a relationship to the state as a whole. The important distinction that needs to be made is that the self-insured companies are the largest employers in the state, and larger companies were shown to have better performance rates in safety in most industry sectors<sup>29,30</sup>.

Data was extracted primarily based on NAICS industry groups, meaning that actual occupation information is not included in much of the data. WIC and SOC data was delivered, but only involved frequencies, and not information regarding hours or rates of falls within each of the codes. Additionally, the SOC codes had some non-classifiable occupations (10%). This means at the worst there was no certainty in what

actual jobs people were conducting when they suffered a fall, and at the best, the occupation of individuals suffering falls was unclear.

Data is also only present for injuries where a claim was made. If a worker never makes a claim when they are injured at work, then this injury never shows up in the workers' compensation database. As mentioned earlier, one study put the number of workers who did not report a WMSD injury at 48% of the population<sup>30</sup>. Workers may not report injuries for fear of retribution, loss of bonuses for an accident-free workplace, not knowing that they could report the injury, having the injury covered by their employer directly, or simply not reporting the injury as work-related. Because this data set only includes records of claims, underreporting will have to be considered for all research involving this data set.

This analysis was also limited by time. Due to the date of the reception of data, and the quick turnaround required to successfully complete the thesis project within the quarter, many types of analysis were not possible. Due to database administrator policies, summary tables were the only format available, meaning that all analysis had to be done before summary tables could be delivered. Given unlimited time, different types of analysis could have been explored in this data set in order to gather some clarity on the trends that were discovered over the course of the study. Additional research could focus on getting better descriptions of only severe falls within an industry, offering the best reduction of costs and improved safety for workers.

## **Future Research and Conclusions**

This study has helped to illuminate areas where intervention may be prudent within the many industries of Washington State. This research could be used as a

guide to single out industries where intervention efforts and research should be conducted in earnest. Using the prevention and cost index methods combined with admissions data, could help inform industries where intervention could be provided the most benefit for the efforts put forth. It is important to note that the state of Washington is currently in the process of developing a unified fall protection rule, which may effectively tighten regulations regarding fall protection in the state. It would be prudent to consider how these changes might affect the numbers we are seeing within this study, and where further intervention may address any gaps either created by or eliminated by the unified fall protection rule.

Further research into the characteristics of falls by risk class could also be illuminating for areas where interventions might be needed within industry in order to prevent falls. Risk classes also have their own hours of work assigned, meaning that rates by risk classes could be created. This would offer the opportunity to compare risk class prevention indices with the prevention indices developed in this study. This would allow for more specific areas within industry to be targeted for intervention, and hopefully narrow down the field even further to find areas where efforts would best focused to have the maximum impact on worker safety and health.

This study offers a good starting point for identifying places to begin addressing safety and health as they relate to falls. This data, coupled with past research, could provide a guide for industries that are in need of interventions, help solidify trends in longer timeframes, or inform industries in general terms where improvements might be best served.

## Tables

**Table 1: Summary of All Accepted Claims 2005-2014**

		%
<b>Total Falls</b>	144,586	
<b>Yearly Average</b>	14,459	
<b>Total Hours (Billions)</b>	32.218	
<b>Total FTE (Millions)</b>	16.11	
<b>Fall/1000 FTE</b>	8.98	
<b>Total Costs (Billions)</b>	\$2.747	
<b>Sex/Age</b>		
<b>Male</b>	85,060	59
<18	412	0
18-24	10,939	8
25-34	19,924	14
35-44	19,447	13
45-54	18,882	13
55-64	11,917	8
>65	2,530	2
NR*	1,009	1
<b>Female</b>	59,521	41
<18	506	0
18-24	6,672	5
25-34	10,724	7
35-44	11,636	8
45-54	15,021	10
55-64	11,691	8
>65	2,452	2
NR*	819	1
<b>No Gender</b>	3	0
<b>No Gender/Age</b>	2	0
<b>Median Tenure (days)</b>	455	
<b>99<sup>th</sup> %ile Tenure</b>	10,950	

\* Not Recorded

**Table 2: Falls by Year by Claim Status for All Industries in the State Fund Database (LINIIS)**

Year	Non-Compensable	Compensable	Kept on Salary	Total Permanent Disability	Loss of Earning Power	Fatal	Total Falls
2005	10,620	4,939	485	251	25	9	16,329
2006	10,836	5,237	660	280	35	13	17,061
2007	11,069	5,326	664	277	23	7	17,366
2008	9,959	4,930	631	243	28	5	15,796
2009	8,036	3,935	492	152	32	6	12,653
2010	7,942	3,942	557	124	27	2	12,594
2011	8,164	3,813	562	94	32	6	12,671
2012	8,362	3,824	606	83	37	8	12,920
2013	8,638	3,838	789	48	89	4	13,406
2014	8,847	3,869	955	21	89	9	13,790
<b>Total</b>	<b>92,473</b>	<b>43,653</b>	<b>6,401</b>	<b>1,573</b>	<b>417</b>	<b>69</b>	<b>144,586</b>

**Table 3: Top 10 Industry Groups by Prevention Index for All Years with Other Notable Industries**

NAICS	Industry Group	Total Falls	Rank	Falls per 1000 FTE	Rank	Prevention Index
1113	Fruit and Tree Nut Farming	7,233	1	27.52	11	6.0
2381	Foundation, Structure, and Building Exterior Contractors	5,796	2	26.68	12	7.0
2383	Building Finishing Contractors	3,620	8	24.23	14	11.0
2361	Residential Building Construction	3,778	7	22.73	18	12.5
5617	Services to Buildings and Dwellings	4,359	4	19.43	27	15.5
1151	Support Activities for Crop Production	2,635	9	20.82	23	16.0
4841	General Freight Trucking	2,223	17	22.64	20	18.5
4842	Specialized Freight Trucking	1,394	28	24.70	13	20.5
1133	Logging	984	36	34.98	9	22.5
1119	Other Crop Farming	1,018	34	17.64	34	34.0
7221	Full-Service Restaurants	5,366	3	9.18	148	75.5
7222	Limited-Service Eating Places	4,273	5	9.86	134	69.5

**Table 4: Top 11 Industry Sectors by Prevention Index for All Years**

NAICS	Industry Sector	Total Falls	Rank	Falls per 1000 FTE		Prevention Index
				FTE	Rank	
23	Construction	22,353	1	17.61	2	1.5
11	Agriculture, Forestry, Fishing and Hunting	14,527	3	22.07	1	2.0
72	Accommodation and Food Services	13,674	4	10.18	4	4.0
62	Health Care and Social Assistance	15,257	2	8.27	10	6.0
56	Administrative and Support and Waste Management and Remediation Services	9,804	6	10.05	7	6.5
48-49	Transportation and Warehousing	6,843	10	15.24	3	6.5
45	Retail Trade	13,009	8	7.77	9	8.5
92	Public Administration	7,643	5	9.77	12	8.5
42	Wholesale Trade	7,404	7	7.78	13	10.0
71	Arts, Entertainment, and Recreation	2,272	9	10.13	11	10.0
31-33	Manufacturing	9,426	15	7.66	5	10.0

**Table 5: Top 10 Industry Groups Coefficients for Regression over Time**

NAICS	Industry Group	$\beta_1$	p-value
1113	Fruit and Tree Nut Farming	0.39	0.082
1133	Logging	-1.86	<b>0.001</b>
2383	Building Finishing Contractors	-1.02	<b>0.012</b>
5617	Services to Buildings and Dwellings	-0.28	0.139
4841	General Freight Trucking	-0.65	<b>0.031</b>
2381	Foundation, Structure, and Building Exterior Contractors	-0.94	<b>0.019</b>
2361	Residential Building Construction	-0.87	<b>0.015</b>
1151	Support Activities for Crop Production	0.41	<b>0.016</b>
4842	Specialized Freight Trucking	-0.87	<b>0.026</b>
1119	Other Crop Farming	-0.22	0.218

**Table 6:** Top 10 Prevention Index Industries by Cost and Time Between Injury and Hospital Admission.

NAICS	Industry Group	<u>Admit &gt; One</u>		<u>Admit within 24</u>		Total Falls
		N	Median Cost	N	Median Cost	
1113	Fruit and Tree Nut Farming	7,101	\$1,120	132	\$50,219	7,233
2381	Foundation, Structure, and Building Exterior Contractors	5,381	\$1,862	415	\$88,366	5,796
2383	Building Finishing Contractors	3,445	\$1,882	175	\$118,541	3,620
2361	Residential Building Construction	3,527	\$1,727	251	\$78,017	3,778
5617	Services to Buildings and Dwellings	4,223	\$1,690	136	\$86,511	4,359
1151	Support Activities for Crop Production	2,596	\$1,088	39	\$51,651	2,635
4841	General Freight Trucking	2,161	\$1,740	62	\$45,857	2,223
4842	Specialized Freight Trucking	1,360	\$1,692	34	\$56,359	1,394
1133	Logging	960	\$1,214	24	\$76,562	984
1119	Other Crop Farming	995	\$1,281	23	\$72,412	1,018

**Table 7: Top 10 Industry Groups by Cost Index for All Years and Other Notable Industries**

<b>NAICS</b>	<b>Industry Group</b>	<b>Total Cost (Millions)</b>	<b>Rank</b>	<b>Median Cost</b>	<b>Rank</b>	<b>Cost Index</b>
<b>2381</b>	Foundation, Structure, and Building Exterior Contractors	\$255.2	1	\$2,286	27	14.0
<b>2383</b>	Building Finishing Contractors	\$149.1	3	\$2,138	32	17.5
<b>2361</b>	Residential Building Construction	\$165.4	2	\$2,109	34	18.0
<b>4841</b>	General Freight Trucking	\$65.5	7	\$1,952	40	23.5
<b>5617</b>	Services to Buildings and Dwellings	\$103.0	5	\$1,805	46	25.5
<b>4842</b>	Specialized Freight Trucking	\$43.7	11	\$1,838	45	28.0
<b>2362</b>	Nonresidential Building Construction	\$56.7	9	\$1,787	49	29.0
<b>2389</b>	Other Specialty Trade Contractors	\$55.2	10	\$1,777	50	30.0
<b>5312</b>	Offices of Real Estate Agents and Brokers	\$15.8	38	\$2,168	31	34.5
<b>9261</b>	Administration of Economic Program	\$16.3	37	\$1,966	38	37.5
<b>1113</b>	Fruit and Tree Nut Farming	\$87.8	<b>6</b>	\$1,160	190	98.0
<b>7221</b>	Full-Service Restaurants	\$57.2	<b>8</b>	\$929	270	139.0

**Table 8: Falls by OIICS Event/Exposure by Top 5 Prevention Index Industries**

<b>NAICS Description</b>	<b>OIICS Event/Exposure</b>	<b>N</b>
<b>Fruit and Tree Nut Farming</b>	Fall from ladder	4,962
	Fall to floor, walkway, or other surface	1,234
	Fall onto or against objects	341
	Fall from nonmoving vehicle	156
	Fall to lower level, n.e.c.	150
<b>Foundation, Structure, and Building Exterior Contractors</b>	Fall to floor, walkway, or other surface	1,391
	Fall from ladder	1,187
	Fall onto or against objects	553
	Fall to lower level, n.e.c.	443
	Fall from roof, unspecified	375
<b>Building Finishing Contractors</b>	Fall from ladder	1,107
	Fall to floor, walkway, or other surface	680
	Fall to lower level, n.e.c.	359
	Fall from scaffold, staging	318
	Fall onto or against objects	267
<b>Residential Building Construction</b>	Fall from ladder	1,000
	Fall to floor, walkway, or other surface	809
	Fall onto or against objects	345
	Fall to lower level, n.e.c.	344
	Fall down stairs or steps	226
<b>Services to Buildings and Dwellings</b>	Fall to floor, walkway, or other surface	1,737
	Fall from ladder	603
	Fall down stairs or steps	478
	Fall onto or against objects	450
	Fall to lower level, n.e.c.	292

**Table 9: Falls by Event/Exposure by Industry Sector**

<b>NAICS Industry Sector</b>	<b>OIICS Event/Exposure Description</b>	<b>N</b>
<b>Construction</b>	Fall to floor, walkway, or other surface	5,594
<b>Construction</b>	Fall from ladder	5,062
<b>Construction</b>	Fall onto or against objects	2,147
<b>Construction</b>	Fall to lower level, n.e.c.	1,902
<b>Construction</b>	Fall down stairs or steps	1,172
<b>Agriculture, Forestry, Fishing and Hunting</b>	Fall from ladder	6,742
<b>Agriculture, Forestry, Fishing and Hunting</b>	Fall to floor, walkway, or other surface	3,717
<b>Agriculture, Forestry, Fishing and Hunting</b>	Fall onto or against objects	1,176
<b>Agriculture, Forestry, Fishing and Hunting</b>	Fall from nonmoving vehicle	750
<b>Agriculture, Forestry, Fishing and Hunting</b>	Fall to lower level, n.e.c.	646
<b>Accommodation and Food Services</b>	Fall to floor, walkway, or other surface	8,894
<b>Accommodation and Food Services</b>	Fall down stairs or steps	1,341
<b>Accommodation and Food Services</b>	Fall onto or against objects	1,320
<b>Accommodation and Food Services</b>	Fall from ladder	451
<b>Accommodation and Food Services</b>	Fall, n.e.c.	396
<b>Health Care and Social Assistance</b>	Fall to floor, walkway, or other surface	10,282
<b>Health Care and Social Assistance</b>	Fall down stairs or steps	1,652
<b>Health Care and Social Assistance</b>	Fall onto or against objects	1,298
<b>Health Care and Social Assistance</b>	Fall to lower level, n.e.c.	455
<b>Health Care and Social Assistance</b>	Fall, n.e.c.	406
<b>Administrative and Support and Waste Management and Remediation Services</b>	Fall to floor, walkway, or other surface	4,270
<b>Administrative and Support and Waste Management and Remediation Services</b>	Fall down stairs or steps	1,015
<b>Administrative and Support and Waste Management and Remediation Services</b>	Fall onto or against objects	1,003
<b>Administrative and Support and Waste Management and Remediation Services</b>	Fall from ladder	958
<b>Administrative and Support and Waste Management and Remediation Services</b>	Fall from nonmoving vehicle	594

**Table 10: OIICS Injury Source by OIICS Event/Exposure**

<b>OIICS Event/Exposure</b>	<b>OIICS Source</b>	<b>N</b>
<b>Fall to floor, walkway, or other surface</b>	Floors, walkways, ground surfaces, unspecified	25,378
	Floor of building	23,057
	Ground	9,246
	Sidewalks, paths, outdoor walkways	2,058
	Parking lots	1,672
<b>Fall from ladder</b>	Floors, walkways, ground surfaces, unspecified	7,717
	Ground	6,751
	Floor of building	1,175
	Movable ladders, unspecified	472
	Other floors, walkways, ground surfaces, unspecified	257
<b>Fall onto or against objects</b>	Walls	700
	Tables, worktables	457
	Truck, unspecified	363
	Boxes, crates, cartons	359
	Doors	355
<b>Fall to lower level, n.e.c.</b>	Floors, walkways, ground surfaces, unspecified	3,108
	Ground	1,383
	Floor of building	1,031
	Surfaces below ground level, n.e.c.	408
	Floor, unspecified	125
<b>Fall down stairs or steps</b>	Stairs, steps, unspecified	9,553
	Stairs, steps--indoors	771
	Stairs, steps--outdoors	677
	Floors, walkways, ground surfaces, unspecified	503
	Floor of building	190

**Table 11: OIICS Body Part by Event/Exposure**

<b>OIICS Event/Exposure</b>	<b>OIICS Body Part</b>	<b>N</b>
<b>Fall to floor, walkway, or other surface</b>	Multiple body parts	16,599
	Knee(s)	9,481
	Lumbar region	4,314
	Shoulder, including clavicle, scapula	4,250
	Wrist(s)	3,959
<b>Fall from ladder</b>	Multiple body parts	5,214
	Ankle(s)	1,298
	Lumbar region	1,228
	Knee(s)	1,199
	Shoulder, including clavicle, scapula	1,005
<b>Fall onto or against objects</b>	Multiple body parts	2,272
	Chest, except internal location of diseases or disorders	1,516
	Knee(s)	1,171
	Shoulder, including clavicle, scapula	727
	Lumbar region	646
<b>Fall to lower level, n.e.c.</b>	Multiple body parts	1,824
	Knee(s)	757
	Ankle(s)	556
	Lumbar region	492
	Shoulder, including clavicle, scapula	396
<b>Fall down stairs or steps</b>	Multiple body parts	3,119
	Ankle(s)	1,667
	Knee(s)	1,343
	Lumbar region	757
	Shoulder, including clavicle, scapula	522

**Table 12: Falls by WIC Risk Class, All Years**

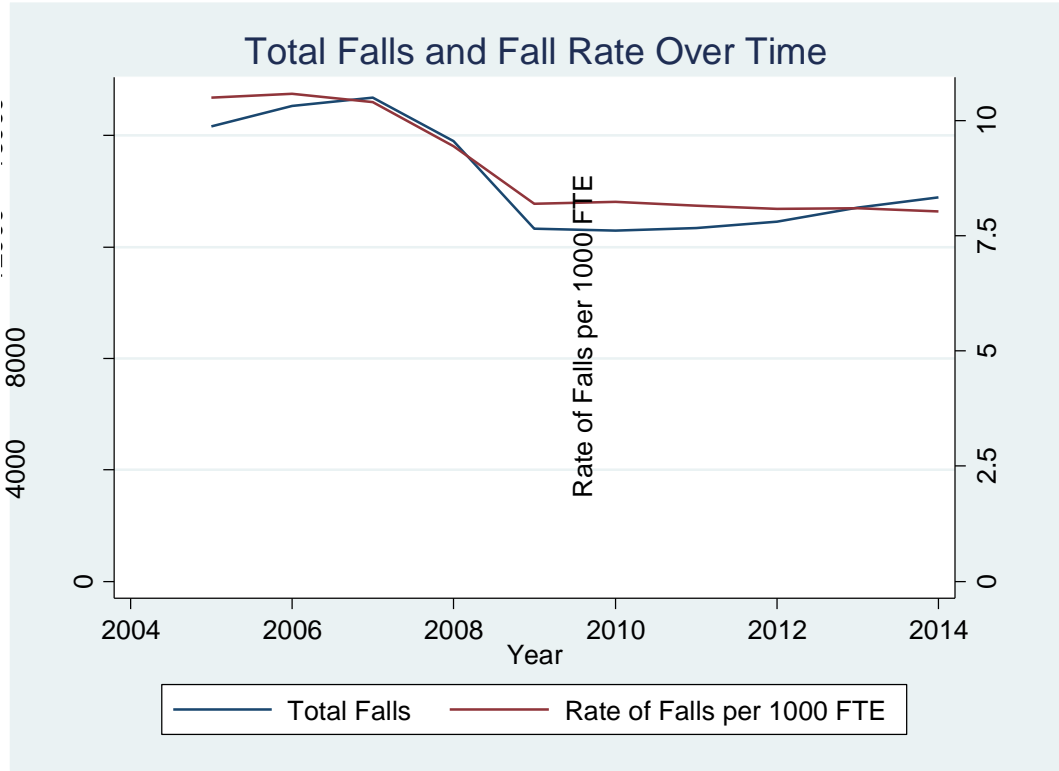
<b>Washington Industrial Codes Risk Class</b>	<b>N</b>
Restaurants and Taverns	10,886
Orchards	8,822
Schools, Churches and Day Care - Prof./Clerical Staff	3,748
Wood Frame Building Construction	3,695
Clerical Office, N.O.C.	3,390
Colleges & Universities	3,220
Boarding Homes and Retirement Centers	3,068
Nursing Homes	2,802
Trucking, N.O.C.	2,708
Physicians & Medical Clinics	2,607

**Table 13: Falls by SOC, All Years**

Standard Occupation Classification	N
Non-Classifiable	10,538
First-Line Supervisors/Managers	9,836
Farmworkers and Laborers, Crop	8,781
Truck Drivers, Heavy and Tractor Trailer	5,472
Laborers and Freight, Stock & Material Movers, Hand	4,264
Carpenters	4,175
Production Workers, All Other	3,737
Construction Craft Laborer	3,634
Janitors and Cleaners, Except Maids and Housekeeping	2,714
Retail Salespersons	2,464

**Figures**

**Figure 1: Total Falls and Fall Rate over Time for All Industries**



**Figure 2: Fall Rate over Time for Top 10 Prevention Index Industries**

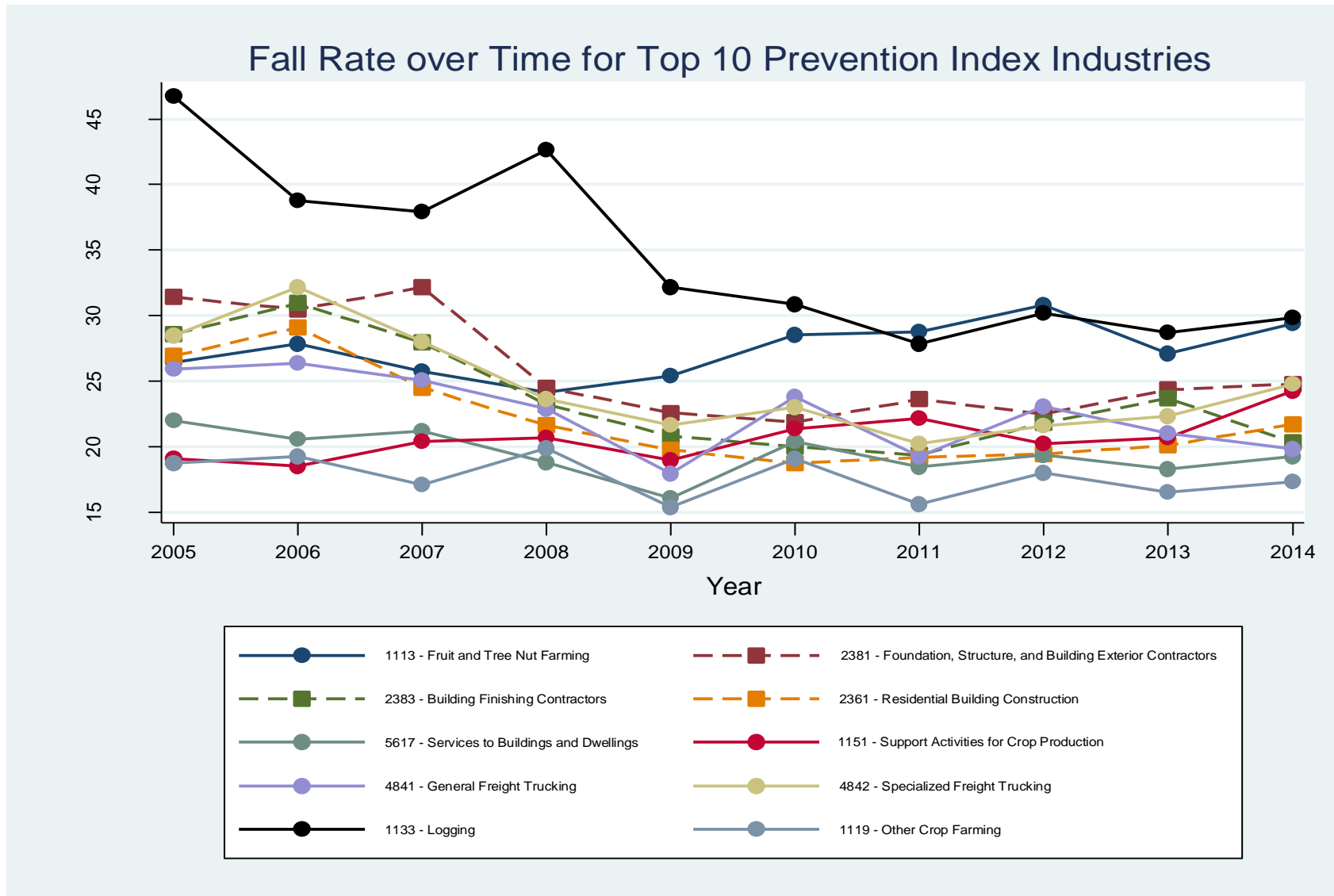
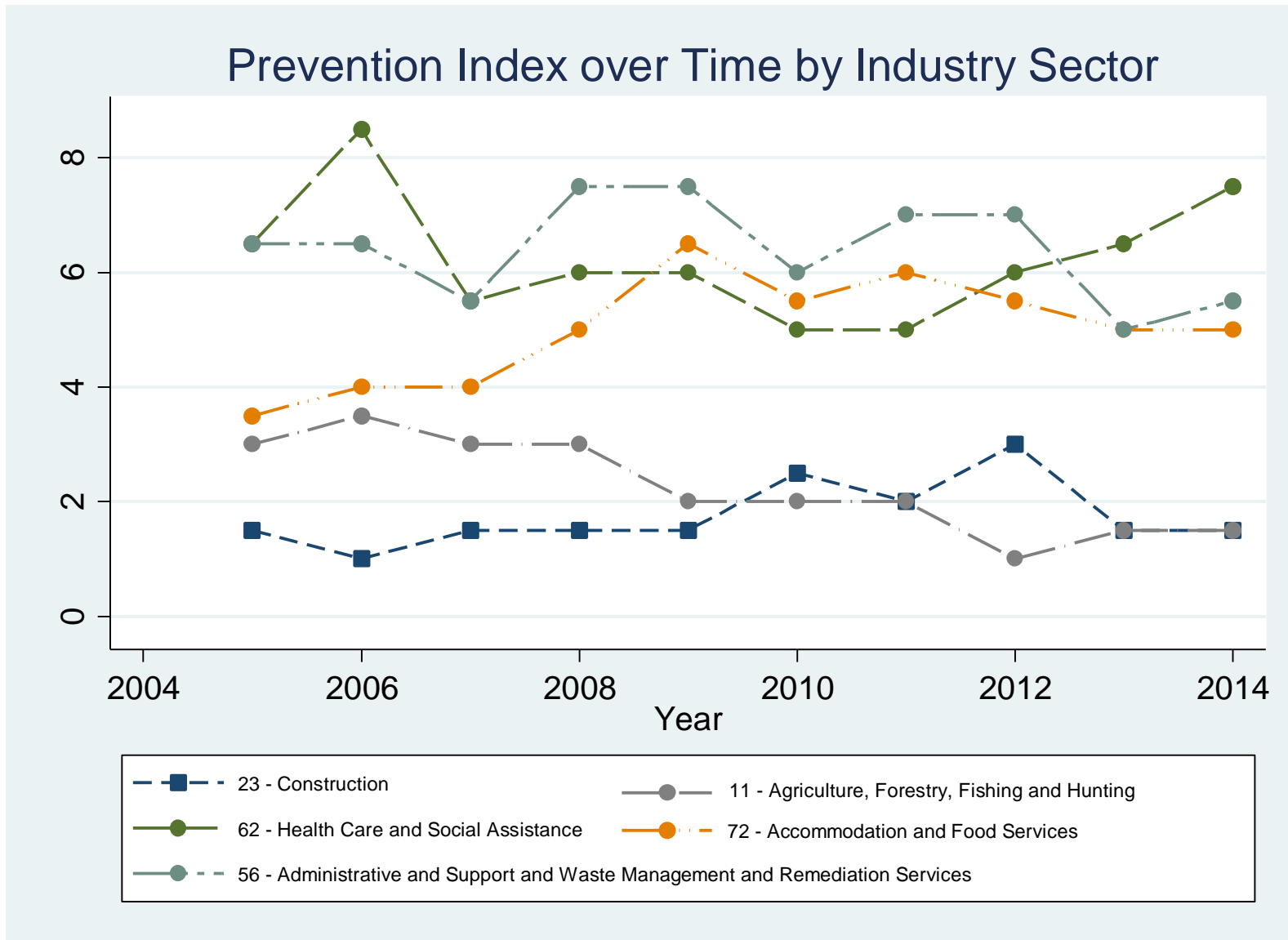
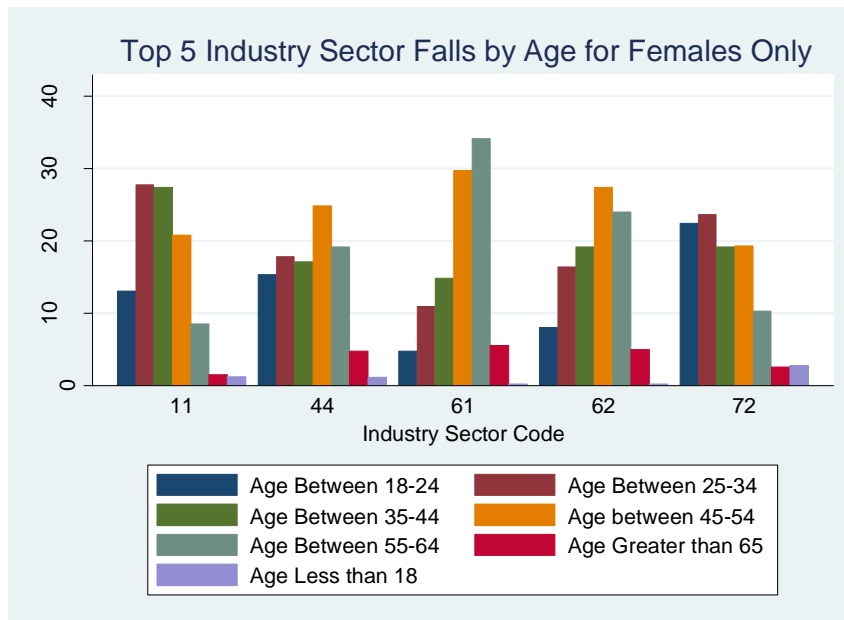


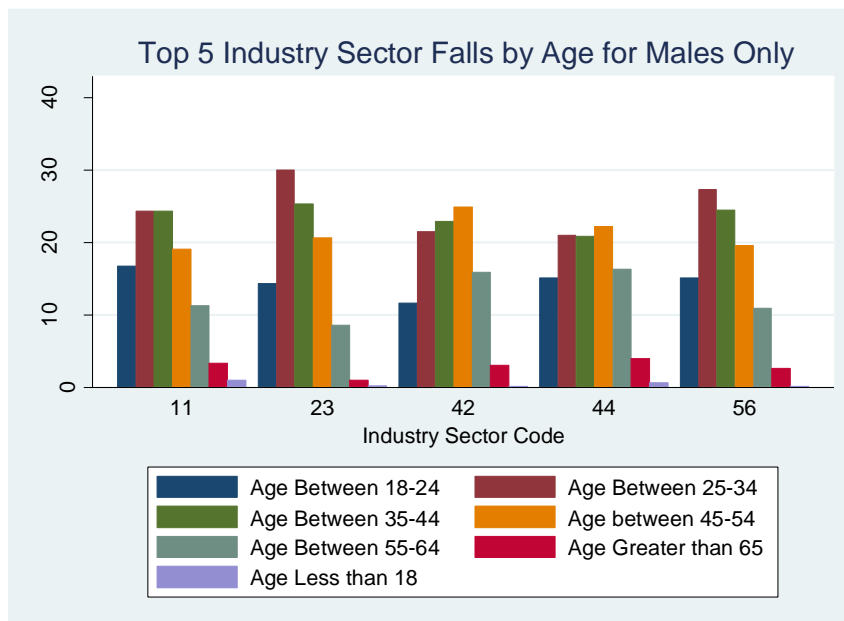
Figure 3: Prevention Index over Time by Industry Sector



**Figure 4: Top 5 Industry Sector falls by Age for Females Only<sup>1</sup>**



**Figure 5: Top 5 Industry Sector Falls by Age for Males Only**



<sup>1</sup> \*- 11 = Agriculture, Forestry, Fishing and Hunting; 23 = Construction; 42 = Wholesale Trade; 44 = Retail Trade; 56 = Administrative and Support and Waste Management and Remediation Services; 61 = Educational Services; 62 = Health Care and Social Assistance; 72 = Accommodation and Food Services

## Bibliography

1. Statistics B of L. *2014 Nonfatal Occupational Injuries and Illnesses: Cases with Days Away from Work.*; 2015. [papers3://publication/uuid/BF0C86E1-517E-45A8-86C2-E974A2B63624](https://papers3://publication/uuid/BF0C86E1-517E-45A8-86C2-E974A2B63624).
2. Bureau of Labor Statistics [BLS]. *Fatal Occupational Injuries by Industries and Event or Exposures - All United States.*; 2014.
3. Bureau of Labor Statistics [BLS]. *Fatal Injury Report 1992-2014.*; 2014.
4. Bureau of Labor Statistics U. *Fatal Occupational Injuries in 2015 (Charts).*; 2015. <https://www.bls.gov/iif/oshwc/foi/cfch0014.pdf>. Accessed May 8, 2017.
5. Washington State Administrative Code. Chapter 296-155 WAC: SAFETY STANDARDS FOR CONSTRUCTION WORK. <http://apps.leg.wa.gov/WAC/default.aspx?cite=296-155>. Accessed April 28, 2017.
6. Washington State Administrative Code. WAC 296-24-73505: Aisles and passageways. <http://apps.leg.wa.gov/wac/default.aspx?cite=296-24-73505>. Accessed April 28, 2017.
7. Occupational Safety and Health Administration. 29 CFR 1910.21 Walking Working Surfaces. [https://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=9713](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9713). Accessed April 28, 2017.
8. Washington State Department of Labor and Industries. Injury Data. <http://www.lni.wa.gov/ClaimsIns/Insurance/DataStatistics/WorkersCompData/default.asp>. Accessed April 28, 2017.
9. Anderson NJ, Bonauto DK, Adams D. Prioritizing industries for occupational injury prevention and research in the Services Sector in Washington State, 2002-2010. *Accid Anal Prev.* 2013;64(1):2002-2010. doi:10.1186/s12995-014-0037-2.
10. Smith CK, Williams J. Work related injuries in Washington State's Trucking Industry, by industry sector and occupation. *Accid Anal Prev.* 2014;65:63-71. doi:10.1016/j.aap.2013.12.012.
11. Hofmann J, Snyder K, Keifer M. A descriptive study of workers' compensation claims in Washington State orchards. *Occup Med.* 2006;56(4):251-257. doi:10.1093/occmed/kql018.
12. Centers for Disease Control and Prevention. CDC - Prevention through Design - NIOSH Workplace Safety and Health Topic. <https://www.cdc.gov/niosh/topics/ptd/>. Accessed May 18, 2017.
13. Melzner J, Zhang S, Teizer J, Bargstädt H-J. A case study on automated safety compliance checking to assist fall protection design and planning in building information models. *Constr Manag Econ.* 2013;31(6):661-674. doi:10.1080/01446193.2013.780662.
14. Occupational Safety and Health Administration. 29 CFR 1926.501 Duty to Have Fall Protection. [https://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=standards&p\\_id=10757](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10757). Accessed April 28, 2017.

15. Occupational Safety and Health Administration. Duty to have fall protection and falling object protection. - 1910.28 | Occupational Safety and Health Administration. 1910.28. [https://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=9720](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9720). Accessed May 2, 2017.
16. Washington State Department of Labor and Industries Division of Occupational Safety and Health. Fall Protection in Washington State All Industries. <http://wisha-training.lni.wa.gov/training/presentations/CompChartFallProtReqs.pdf>. Accessed May 18, 2017.
17. Washington State Department of Labor and Industries. Unified Fall Protection Rules for General Industry. <http://www.lni.wa.gov/Safety/Rules/WhatsNew/FallProtection2016/unified.asp>. Accessed May 18, 2017.
18. Nelson NA, Kaufman J, Kalat J, Silverstein B. Falls in construction: Injury rates for OSHA-inspected employers before and after citation for violating the Washington state fall protection standard. *Am J Ind Med.* 1997;31(3):296-302. doi:10.1002/(SICI)1097-0274(199703)31:3<296::AID-AJIM5>3.0.CO;2-W.
19. Kaskutas V, Dale AM, Nolan J, Patterson D, Lipscomb HJ, Evanoff B. Fall hazard control observed on residential construction sites. *Am J Ind Med.* 2009;52(6):491-499. doi:10.1002/ajim.20698.
20. Centers for Disease Control and Prevention. OIICS Code Trees. <https://wwwn.cdc.gov/wisards/oiics/Trees/MultiTree.aspx?Year=2007>. Published 2007. Accessed April 28, 2017.
21. US Census Bureau. 2007 NAICS Codes 2-6 Digit. [https://www.census.gov/eos/www/naics/reference\\_files\\_tools/2007/naics07.txt](https://www.census.gov/eos/www/naics/reference_files_tools/2007/naics07.txt). Published 2007. Accessed April 28, 2017.
22. US Census Bureau. *North American Industry Classification System.*; 2017. [https://www.census.gov/eos/www/naics/2017NAICS/2017\\_NAICS\\_Manual.pdf](https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf). Accessed May 2, 2017.
23. Silverstein B, Viikari-Juntura E, Kalat J. Use of a prevention index to identify industries at high risk for work-related musculoskeletal disorders of the neck, back, and upper extremity in Washington State, 1990-1998. *Am J Ind Med.* 2002;41(3):149-169. doi:10.1002/ajim.10054.
24. Bonauto D, Silverstein B, Adams D, Foley M. Prioritizing industries for occupational injury and illness prevention and research, Washington State Workers' compensation claims, 1999-2003. *J Occup Environ Med.* 2006;48(8):840-851. doi:10.1097/01.jom.0000225062.88285.b3.
25. Bureau of Labor Statistics. *Occupational Injury and Illness Classification Manual.*; 2007. [https://www.bls.gov/iif/oiics\\_manual\\_2007.pdf](https://www.bls.gov/iif/oiics_manual_2007.pdf). Accessed May 2, 2017.
26. Industries WSL and. *Workers' Compensation Insurance Manual.*; 2013.
27. Bureau of Labor Statistics. Standard Occupational Classification (SOC) System. <https://www.bls.gov/soc/>. Accessed May 12, 2017.
28. Marcum J, Adams D. Work-related musculoskeletal disorder surveillance using the Washington state workers' compensation system: Recent declines and patterns by

- industry, 1999-2013. *Am J Ind Med.* 2017;(February):457-471. doi:10.1002/ajim.22708.
29. Wuellner SE, Adams DA, Bonauto DK. Unreported workers' compensation claims to the BLS Survey of Occupational Injuries and Illnesses: Establishment factors. *Am J Ind Med.* 2016;59(4):274-289. doi:10.1002/ajim.22563.
  30. Fan ZJ, Bonauto DK, Foley MP, Silverstein B a. Underreporting of work-related injury or illness to workers' compensation: individual and industry factors. *J Occup Environ Med.* 2006;48:914-922. doi:10.1097/01.jom.0000226253.54138.1e.
  31. Salazar MK, Keifer M, Negrete M, Estrada F, Synder K. Occupational risk among orchard workers: a descriptive study. *Fam Community Health.* 2005;28(3):239-252. doi:10.1097/00003727-200507000-00005.
  32. Lewis KM, Hanrahan I. *Field Testing of Two Harvest Aids in Washington Apple Orchards WA State Tree Fruit Orchards.*; 2011.
  33. Hansen M. Training trees to be short | Good Fruit Grower. <http://www.goodfruit.com/training-trees-to-be-short/>. Accessed May 30, 2017.
  34. Washington State Department of Labor and Industries. Labor and Industries Risk Class Lookup. <http://www.lni.wa.gov/apps/riskclasslookup/details.asp?id=169>. Published 2017. Accessed May 19, 2017.
  35. Ringdahl O. *Automation in Forestry : Development of Unmanned Forwarders.*; 2011. <http://umu.diva-portal.org/smash/record.jsf?pid=diva2:412664>.
  36. Tomlinson RW, Cottrell FB. Investigation by laboratory simulation of some factors influencing the picking of fruit from mobile platforms. *J Agric Eng Res.* 1970;15(1):39-51. doi:10.1016/0021-8634(70)90109-5.
  37. News | Turner Construction Company Stands Down to Stand Up for Safety. | Turner Construction Company. <https://www.turnerconstruction.com/news/item/658b/Turner-Construction-Company-Stands-Down-to-Stand-Up-for-Safety>. Published 2014. Accessed May 30, 2017.
  38. Centers for Disease Control (CDC). *NAICS 2017 Code Definitions.*; 2017. [https://www.census.gov/eos/www/naics/2017NAICS/2017\\_Definition\\_File.pdf](https://www.census.gov/eos/www/naics/2017NAICS/2017_Definition_File.pdf). Accessed May 30, 2017.
  39. Jeong BY, Shin DS. Characteristics of Occupational Accidents in Korean, Chinese, Japanese and Western Cuisine Restaurants. *Hum Factors Ergon Manuf Serv Ind.* 2006;26(3):316-322. doi:10.1002/hfm.
  40. Occupational Safety and Health Administration. OSHA Small Business | Safety Pays Program - Background | Occupational Safety and Health Administration. <https://www.osha.gov/dcsp/smallbusiness/safetypays/background.html>. Accessed May 18, 2017.
  41. Manuele FA. Accident Costs: Rethinking ratios of indirect to direct costs. [http://aeasseincludes.asse.org/professionalsafety/pastissues/056/01/039\\_047\\_F2Manuele\\_0111Z.pdf](http://aeasseincludes.asse.org/professionalsafety/pastissues/056/01/039_047_F2Manuele_0111Z.pdf). Accessed May 30, 2017.