

## **Washington Occupational Injury and Illness Surveillance Program**

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2. PFA: Washington Fatality Assessment and Control Evaluation (FACE) Program; Project Director: Todd Schoonover, PhD, Co-Investigators: Randy Clark, BA, Eric Jalonen, MPH, Christina Rappin, BS.
3. PFA: Using Workers Compensation Data to Identify High WMSD Risk Workplaces in Washington; Project Director: Ninica Howard, MSc, Co-Investigators: Stephen Bao, PhD, MSc, Daniel Hunter, MA, Alysa Haas, MA, Darrin Adams, BA, Jia-Hua (Jim) Lin, PhD, Barbara Silverstein, PhD, MPH, Naomi Anderson, MPH.
4. PFA: NORA Industry-based Surveillance Projects:
  - a. The Trucking Industry Reduction Emphasis through Surveillance (TIRES) Program; Project Director: Caroline Smith, MPH, Co-Investigators: Jena Williams, BA, Scott Edwards, CSP, Edmund Rauser, PE, Randy Clark, BA, Kyung Han Kim, PhD, Darrin Adams, BS, Huan Zhao, PhD, Stephen Bao, PhD, CPE, CSP
  - b. Injury Reduction Among Temporary Workers in Washington State through Surveillance; Project Director: Michael Foley, MA, Co-Investigators: Elyette Martin, BA, Christina Rappin, BS, Edmund Rauser, PE, Fabiola Gonzalez, BA.
5. PFA: Maintaining and Improving Pesticide-Illness Surveillance in Washington State; Project Director: Joanne Prado, MPH, Co-Investigators: Jennifer Sievert, Tito Rodriguez.

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## List of Terms & Abbreviations

<b>Terms</b>	
Compensable Claim	Accepted workers' compensation claims with more than 3 days of time loss or: being kept on salary, provisional or loss of earning potential.
Risk class	A term for a Washington Industrial Classification (WIC) system grouping that combines industry and occupation to group workplaces by similar risk of injury for insurance purposes (e.g., a painter and an electrician within the same construction company may have the same North American Industrial Classification (NAICS) code but will be assigned different risk classes). In all there are 316 "risk classes" in the WIC system.
State Fund (SF) or Self-Insured (SI)	Designation for how a Washington State employer obtains workers' compensation insurance: either they are covered by L&I through the State Fund (SF) (the majority of employers) or they qualify to Self-Insure (SI) (typically the largest companies or groups of companies).
Temporary Help Supply (THS)	Establishments in North American Industrial Classification (NAICS) Code: 561320 - Temporary Help Services; which supply workers to client's businesses for limited periods of time.
The Trucking Industry	Companies whose primary activity falls into one of the following North American Industrial Classification (NAICS) Codes: General Local Freight (484110), Long Distance Freight - Truckload (484121), Long Distance Freight - LTL (484122), Movers (484210), Specialized Local Freight (484220), Specialized Long Distance Freight (484230), Couriers (492110), Local Messengers & Local Delivery (492210), Solid Waste (562111), and Hazardous Waste (562112), Other Waste Collection (562119).

<b>Abbreviations</b>	
ACBS	Behavioral Risk Factor Surveillance System (BRFSS) Asthma Call-Back Survey
ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
APHA	American Public Health Association
APP	Accident Prevention Plan
BLS	Bureau of Labor Statistics
BRFSS	Behavioral Risk Factor Surveillance System
CDC	Centers for Disease Control
CDL	Commercial Driver's License
CFOI	Census of Fatal Occupational Injury
CHARS	Comprehensive Hospital Abstract Reporting System
CI (e.g. 95% CI)	Confidence Interval
CIR	Compensable Incidence Rate

CPT	Current Procedure Terminology
CSTE	Council of State and Territorial Epidemiologists
CTS	Carpal Tunnel Syndrome
CWCS	Center for Workers' Compensation Studies
DOH	Washington State Department of Health
DOSH	Washington State's Division of Occupational Health and Safety
EPA	Environmental Protection Agency
EU	European Union
FACE	Fatality Assessment and Control Evaluation
FMD	Frequent Mental Distress
FTE	Full Time Equivalent worker (defined here as 2000 hours worked per year is equal to 1 FTE).
HAL	Hand Activity Level
HF	Hydrofluoric Acid
I/O	Industry and Occupation
ICD (-9)	International Classification of Diseases (-9th Edition)
ILI	Influenza-like Illness
IR	Incidence Rate
IRB	Institutional Review Board
KOS	Kept On Salary
L&I	Washington State Department of Labor and Industries
LINIIS	Labor and Industries Industrial Insurance System - Washington State Department of Labor & Industry records system
LSI	Logger Safety Initiative
LTL	Less Than Truckload
MIPS	Medical Information Payment System - Washington State Department of Labor & Industry records system
MMH	Manual Material Handling
MSDs	Musculoskeletal Disorders
NAICS	North American Industrial Classification System
NEP	National Emphasis Program
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NIOSH	National Institute for Occupational Safety and Health
NORA	National Occupational Research Agenda
NT-MSDs	Non-traumatic neck, back, and upper extremity musculoskeletal disorders
OCP	Organizational Culture Profile
OHI	Occupational Health Indicators
OIICS	Occupational Injury and Illness Classification System
OR	Odds Ratio

ORION	Organized Information Online system - Washington State Department of Labor & Industry records system
OSHA	The Occupational Safety and Health Administration
PI	Prevention Index = $[\text{Frequency Rank} + \text{Rate Rank}]/2$
PNASH	Pacific Northwest Agriculture Safety and Health Center
PPE	Personal Protective Equipment
QEC	Quick Exposure Checklist
ROPS	Roll-over Protective Structures
SD	Standard Deviation
SF	WA workers' compensation State Fund
SHARP	Safety and Health Assessment and Research for Prevention
SI	Self-Insured
SI method	Strain Index method
SIC	Standard Industrial Classification System
SOC (-2K)	Standard Occupational Classification System (-year 2000 edition)
SOII	Survey of Occupational Injury and Illness
SPIDER	CDC-NIOSH software (database) program that allows states to enter data on each individual with pesticide-related illness and allows NIOSH to aggregate data across states.
SR	Severity Rate
THS	Temporary Help Supply
TIRES	Trucking Injury Reduction Emphasis through Surveillance
TL	Truckload
TLV	Threshold Limit Values
WA	Washington State
WC	Workers' compensation
WIC	Washington Industrial Classification system
WMSD	Work-related Musculoskeletal Disorders
WOIISP	Washington State Occupational Injury and Illness Surveillance and Prevention Program
WRA	Work-related Asthma
WSIRB	Washington State Institutional Review Board

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**Abstract:** In its most simple form public health surveillance is about collecting information for action. During the period from July 2010 – June 2015, the ‘Washington Occupational Injury and Illness Surveillance and Prevention Program’ consisted of five discrete programs dedicated to occupational public health surveillance. These programs are:

1. Washington Fundamental Occupational Safety and Health Surveillance Program. The program:
  - a) Publishes an annual set of occupational health indicators.
  - b) Identified differences in health behaviors of Washington’s workforce by industry and occupation.
  - c) Developed a method to allocate prevention resources by Washington’s OSHA program.
  - d) Identified clusters of occupational illness and injury; specifically hop dust and asthma, hydrofluoric acid burns in truck wash workers.
  
2. Washington Fatality Assessment and Control Evaluation (FACE) Program. The program:
  - a) Contributed to a reduction in occupational injury fatalities in Washington, with an average of 67 workers dying annually from 2010 – 2014 compared to 77 workers dying annually from 2005-2009.
  - b) Produced and effectively distributed over 150 fatality narratives, fatality investigations, or other resources for prevention and education to reduce fatalities in Washington State. Feedback surveys from employers deem them ‘very useful’ for prevention purposes.
  - c) Is the authoritative source for occupational fatality data in Washington.
  
3. Using Workers Compensation Data to Identify High Work-related Musculoskeletal Disorders (WMSD) Risk Workplaces in Washington. The program:
  - a) Identified positive correlations between high company WMSD claim rates and higher exposures to WMSD physical risk factors.

b) Created evidence based physical job-evaluation checklists for the manufacturing, wholesale/retail, and healthcare sectors.

c) Published a comprehensive report on the burden of WMSDs in Washington.

4. Two NORA Industry-based Surveillance Projects:

A. The Trucking Industry Reduction Emphasis through Surveillance (TIRES) Program; The program:

a) Identified the root cause of the most common work injuries in the trucking industry.

b) Developed 150 trucking injury prevention resources, including pioneering the use of online simulation training tools. These resources were developed in partnership with the TIRES steering committee composed of trucking industry labor and business leaders.

c) Continues to use social media and our collaborative web site, [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org), for publication and information dissemination.

B. Injury Reduction Among Temporary Workers in Washington State through Surveillance. The program demonstrated that temporary workers:

a) Have significantly higher claims rates than their permanently-employed counterparts.

b) Through a survey 423 injured temporary and age-, gender-, industry-, matched permanent workers, temporary workers showed a lack of pre-assignment job screening, inadequate safety training, and inability to refuse work assignments.

5. Maintaining and Improving Pesticide-Illness Surveillance in Washington State. This program, based at the Washington Department of Health, identified:

a) A high number of pesticide drift incidents impacting farmworker and other bystanders.

b) That acrolein and chlorpyrifos were pesticides of high concern.

c) That pesticide illness disproportionately impacts Latino farmworkers.

Further the program contributed to development of a biomonitoring study of pesticide applicators, case capture of antimicrobial case reports to the pesticide surveillance program and state-federal collaborations publishing surveillance findings.

## **Washington Fundamental Occupational Safety and Health Surveillance Program**

Washington Occupational Injury and Illness Surveillance and Prevention Program

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## Washington Fundamental Occupational Safety and Health Surveillance Program

Washington Occupational Injury and Illness Surveillance and Prevention Program  
Grant Number: 2 U60 OH008487

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**Abstract:** The prevention of work-related injuries and illnesses depends on accurate and reliable data. Occupational health surveillance plays a role by providing the necessary information for action through systematic data collection, analysis, and distribution of results. The goal of Washington State's fundamental occupational safety and health surveillance program is to enhance capacity to provide information for action to improve the occupational safety and health of Washington workers.

A core activity of the Washington State Occupational Injury and Illness Surveillance and Prevention Program (WOIISP) is collection of Occupational Health Indicator data. The Indicators are a set of measures that give an annual snapshot describing the occupational health status of the WA working population. The Indicators track numbers and rates of a variety of occupational injuries, illnesses, and related factors. WA publishes quarterly updates of twenty Indicators on the Department of Labor & Industries website.

Washington State pioneered using the Washington State Behavioral Risk Factor Surveillance System (BRFSS), an annual telephone survey, to collect Industry and Occupation (I/O) data. The survey collects data on a wide variety of health outcomes and behaviors, and with the addition of I/O questions, can be used to quantify the prevalence of certain outcomes by I/O and better characterize work-related injuries. WA has coded I/O for over 100,000 respondents, and identified groups with: underreporting of work-related injury, differences in access to health care, depression, obesity, influenza-like illness, and work-related asthma. These analyses laid the groundwork for other states to include these questions, and for the National Institute for Occupational Safety and Health (NIOSH) to begin funding I/O question addition.

Surveillance data can be used to identify high-risk populations and target prevention resources towards industry, occupation, or sector-specific hazards. The WOIISP uses the Prevention Index (PI) method to prioritize industries for occupational health and safety efforts, which uses count and rate of several common, high-cost occupational injuries to identify high-risk industries which could most benefit from prevention efforts. In WA, these include: construction contractors, general freight trucking, logging, and services to buildings and dwellings. This framework was adopted by WA's Division of Occupational Health and Safety and served as a model for a NIOSH-issued program announcement. WA surveillance work also identified and characterized work-related asthma caused by isocyanates and hop dust; and identified hydrofluoric acid as a hazard that causes chemical burns, toxicity, and fatality. Information from WA surveillance of work-related amputations was submitted to the Occupational Safety and Health Administration (OSHA) and informed the process for new recordkeeping rules; and WA submitted detailed surveillance data for isocyanate-induced asthma cases to inform the development of OSHA's National Emphasis Program on isocyanates.

WA communicates occupational health and safety information through a variety of methods to reach the widest audience of those who could benefit, including through traditional and social media coverage. During this grant cycle, the WOIISP has published 12 peer-review journal articles, 1 trade-journal article, 8 resources for prevention, 8 research findings, and 2 infographics. WA researchers regularly present our findings at annual professional conferences, webinars, and stakeholder meetings.

## Section 1

### Significant (Key) Findings

We report several key findings from our fundamental state-based surveillance program.

**1. The burden of occupational injury and illness in Washington State is high:** Using the Occupational Health Indicator data for 2013, for the 3,221,000 employed persons in Washington State, there were 91,000 occupational injuries (480 per 10,000 full-time equivalent worker (FTE)). Of these, 12,400 involved 10 or more days away from work. There were 4,258 work-related injuries that resulted in hospitalizations (132.2/10,000 FTE). These injuries included: 70 amputations, 12,020 musculoskeletal disorders (MSDs) that involved days away from work (630/10,000 FTE). Washington has accelerated the publication of these indicators, and publishes the most current indicator data for the twenty OHIs on the Washington State Department of Labor & Industries website (data is available for 2000-2013).

**2. Capturing Industry and Occupation on National Surveys:** Washington State pioneered the collection of Industry and Occupation data on the Washington State Behavioral Risk Factor Surveillance System beginning in 1997. The WA surveillance program has coded industry and occupation for 100,000 WA BRFSS respondents for the years 2003-2013. Washington State has been able to identify industry/occupation groups with: underreporting of work-related injury, differences in access to health care, mental health issues, obesity, influenza-like illness, and work-related asthma. These analyses helped influence the addition of I/O questions by other states starting in 2010, and NIOSH has funded the addition of the I/O questions for 2013-2016, increasing the number of states asking the I/O questions to over 20 at present.

**3. Prioritizing research and prevention activities using the Washington State Prevention Index (PI):** The PI method is based on count and rate of several common, high-cost occupational injuries, and can be used to identify industries which are at high-risk for these injuries. In Washington State, the top 5 industry groups for 'All Injury' types were in the Construction sector and General Freight Trucking; additional industries at high risk included Logging and Services to Buildings and Dwellings (e.g. janitors).

**4. Work-related asthma surveillance identified common causes of asthma in Washington State:** WA identified several common asthma source agents and the industries with highest number of asthma claims. Data from Washington State's work-related asthma surveillance system were used to identify and characterize specific causes of work-related asthma: diisocyanates and hop dust.

**5. Our hospitalized burns surveillance program identified hydrofluoric acid use** in car and truck wash products as a common and poorly reported cause of chemical burns, toxicity, and fatality.

### Translation of Findings

WA endeavors to spread surveillance outputs and information through a variety of different communication formats to reach the widest audience possible of people who could benefit from these data. This effort includes integrating with the Washington Department of Labor and Industries' social media coordinator to publish surveillance information and the exploration of new formats to engage with the public. To this end we created two new formats to distribute research data:

**1. Infographics**, which are visual, graphical representations of data. Washington has created 2 infographics since 2014. The first infographic compared the burden of manual vs. mechanized logging. Manual loggers had nearly 10 times the number and rate of compensable claims as compared to mechanized logging, and nearly 6 times the claims cost. A second infographic was created to demonstrate the burden of work-related injury to janitorial services workers.

**2. “Research Findings”:** WA has also created a new format called to summarize and translate peer-review journal content into brief, easy-to-read one-page documents for non-technical audiences. These findings summarize the key points of peer-review publications, and can be distributed at outreach events, given to workers or employers, or sent to interested parties and the media.

Other outputs during this grant cycle, the Washington State Occupational Injury and Illness Surveillance Program has published 12 peer reviews, 1 trade journal publication, 8 resources for prevention (e.g. technical reports, hazard alerts), 8 Research Findings and 2 Infographics. Additionally, Washington has presented surveillance findings at annual professional conferences including the APHA and CSTE 14 times during this grant cycle, with topics including: Influenza-like Illness, Isocyanates-induced Asthma, Prevention Index Methodology, and sharing explorations of WA BRFSS data by industry and occupation, among others. Two poster presentations were selected as finalists for “Outstanding Poster Presentation” by CSTE, with one win in the Environmental Health/Occupational Health/Injury section.

Where stakeholder interest exists, our surveillance data has been presented through multiple other avenues, for example: hops asthma prevention materials were shared at events for the Hop Growers Association (through a webinar); Occupational and Environmental Medicine Grand Rounds at the University of Washington; to health care providers in Yakima (the hop growing region); and at the annual Division of Occupational Safety and Health Symposium (occupational health and safety professionals from around the state).

There has also been media interest in select Washington State occupational injury and illness surveillance topics. Influenza-like illness (ILI) surveillance was picked up for radio spots which included discussion of findings with union members representing some of the workers identified as being at high-risk for ILI - janitors and cleaners. The insidious nature of hydrofluoric acid as an identified burn hazard also led to media coverage, with over 100 news outlets picking up the story.

### Outcomes/Impact

Washington’s successful use of the Prevention Index (PI) method to prioritize industries for prevention efforts has led to several intermediate outcomes. The PI framework has been adopted by WA’s Division of Occupational Health and Safety (DOSH) for education and outreach activities. NIOSH issued a program announcement for improving use of workers compensation data for public health surveillance (PAR-14-227) - which used our 2013 “Prioritizing Industries for Occupational Injury and Illness Prevention and Research, Washington State Workers’ Compensation Claims Data, 2002-2010” report as a model for grantee research content; and the PI industry ranking inclusion criteria were adopted by NIOSH’s Center for Workers’ Compensation Studies.

Surveillance data can inform new workplace safety & health standards. Washington State’s surveillance of work-related amputations influenced the new recordkeeping rules on employer reporting of these injuries. Likewise, the surveillance program submitted detailed industry, occupation, process, and task data for 27 cases of isocyanate-induced asthma to OSHA to inform the development of OSHA’s National Emphasis Program (NEP) on isocyanates.

Washington State’s surveillance program builds occupational health capacity by working with state and national partners to improve the health of workers. Washington’s inclusion of industry and occupation (I/O) questions on the state BRFSS laid the groundwork for other states adding I/O questions starting in 2010. Due to the demonstrated value of this information, NIOSH has funded the addition of the I/O questions for 2013-2016, increasing the number of states asking the I/O questions to over 20 at present.

## Section 2

### Scientific Report

#### *Background*

The goal of Washington State's fundamental occupational safety and health surveillance program is to enhance capacity to provide information for action to improve the occupational safety and health of Washington's 3.5 million workers working at any of the 155,000 employers within the state.

#### *Methods*

The Washington State occupational safety and health surveillance program primarily collects and analyzes data from the state's workers' compensation (WC) program. In Washington State, non-federal employers are required to obtain workers' compensation insurance through the Department of Labor and Industries' (L&I) industrial insurance system, unless they meet specific requirements to self-insure, or are covered by an alternative workers' compensation system. L&I administers the State Fund (SF), an industrial insurance program that provides coverage for approximately two-thirds of Washington workers. The SF generally does not cover self-employed workers and other excluded types of workers, though elective coverage is available. Outside of the SF, there are approximately 450 self-insured (SI) entities (individual companies or groups of companies) that are not included in the State Fund insurance pool. Data from both SF and SI programs are collected and entered in centralized databases at L&I. These systems include: administrative information necessary to adjudicate a claim; identification of the employer and injured worker; codes characterizing the injury or illness; other necessary medical information; costs associated with disability payments, wage replacement, and pensions; billing information for health care providers, procedures, and treatment; and physician diagnoses codes. Information on SI claims is often incomplete regarding cost and time loss, and therefore SI claims are generally excluded from analysis. In addition to WC data, for certain surveillance projects, some employer and employee information is obtained from hospital or health-care provider reporting. Workers identified by WC or health-care physician reporting may be selected for follow-up interviews, and these protocols are approved by the Washington State Institutional Review Board (WSIRB).

Additional data sources include: comprehensive hospital abstract reporting system (CHARS) which contains hospital discharge information; the Behavioral Risk Factor Surveillance System (BRFSS) an annual national telephone survey which collects data on a variety of health behaviors and conditions.

For data related to the CSTE/NIOSH occupational health indicators, the data are collected from publically available data sets including: Bureau of Labor Statistics (BLS) Current Population Survey, Survey of Occupational Injury and Illness, and Census of Fatal of Injury data; hospital discharge data; death certificate data; and National Academy of Social Insurance data. Several indicator datasets are provided by the federal or state government or other entities (e.g. Poison Control Centers; Washington State Cancer Registry).

For the prioritizing industries project, we analyzed high-cost, common occupational injury types using a prevention index (PI) to rank industries for prevention activities by seven different injury types and within their National Occupational Research Agenda (NORA) Sectors. The PI is generated from the WC data and is the average of the rank orders of the claim count and claim incidence rate:  $PI = (\text{Count Rank} + \text{Incidence Rank})/2$ . In case of a tie, rate rank was used as the tiebreaker.

## Results & Discussion by Specific Aims

1). First, we will continue Washington State Occupational Health surveillance activities in accordance with the CSTE and NIOSH guidelines for state-based public health activities in occupational safety and health. This includes:

- a. Maintaining general program capacity for occupational injury and illness surveillance at the Washington State Department of Labor and Industries:

NIOSH Fundamental program funding has allowed us to maintain the core team associated with occupational health indicator (OHI) data collection, continuation of our state based surveillance programs for amputations, hospitalized burns, and work-related asthma data collection, and some collaboration with state and federal partners for surveillance activities. Continuation of funding has minimized inefficiencies related to hiring, training and development of surveillance content knowledge.

- b. Conducting population-based surveillance activities using the CSTE/NIOSH Occupational Indicators:

The Occupational Health Indicator (OHI) data describes the occupational health status of the Washington State working population. Washington collaborates with other NIOSH funded states to publish the indicator data on the CSTE website (submitted every year in June). Typically, CSTE and NIOSH publishes indicator data with at least a three-year time delay which our stakeholders found less acceptable. Washington State has accelerated the publication of the twenty CSTE Occupational Health Indicators on the Washington State Department of Labor Website. We have published quarterly to semiannual web-based updates of the most current indicator data available for Washington State. Data is available for the years 2000 through 2013. The most recent update was March 2015. Updates are available on the SHARP website: [www.sharp.Lni.wa.gov](http://www.sharp.Lni.wa.gov).

- c. Maintaining the ability to respond to emerging hazards and data requests from employers, workers, and groups representing employer and employees:

Data from Washington's work-related asthma surveillance program are regularly collected and analyzed to identify emerging or persistent hazards. A technical report summarizing work-related asthma (WRA) surveillance efforts in Washington State from 2009-2013 was published in 2015 and made available on the web. The report describes Washington's WRA methods and processes, and characterizes WRA cases captured by the system (e.g. demographics, claim information, industry, asthma source agent, asthma classification). The most common asthma source agents in Washington were: Miscellaneous Chemicals & Materials (which include cleaning materials), Plant Material (including wood dusts and hops), Mineral & Inorganic Dusts, Pyrolysis Products, and Microorganisms (mold). The industry sectors with the highest number of claims for WRA were: Health Care & Social Assistance, Manufacturing, Public Administration, Educational Services, and Administrative and Support and Waste Management and Remediation Services.

This report built on previous work including: a peer reviewed publication of a descriptive analysis of Washington's work-related asthma surveillance program data from 2000-2008, and a state technical report with a descriptive analysis of the same time period. These analyses identified the role of plant materials as a common cause of work-related asthma in Washington State, primarily

Western Red Cedar (and other wood dusts), hop (*Humulus lupulus*) dust, and grain, hay, and paper dusts. Other US states conducting surveillance for work-related asthma have not reported such high levels of plant material asthma and therefore we feel these exposures are unique to Washington State and demonstrate the need for additional state-based work-related asthma surveillance programs.

Once hop dust was identified as a common source agent for work-related asthma, additional resources were devoted to producing prevention materials for workers exposed to hop dust. Washington State produces the majority of US hops. Hop dust can cause respiratory disease, including asthma. Based on review of claims and medical records, outreach documents regarding hop exposure and respiratory illness were produced and sent out during July-August 2013 (before hop harvest season). These included: a general “Hop Dust and Respiratory Disease” information document; a letter to healthcare providers regarding hop dust exposure and respiratory disease and asking for case reporting; and a letter to hops growers (employers) alerting them to the possibility of respiratory disease in workers from hop dust. All documents are freely available on the SHARP website. A peer-reviewed publication documenting and evaluating hops respiratory disease cases was published in the *Annals of Allergy, Asthma & Immunology*, which found rates for hop-induced respiratory disease was 30x greater in hop farmers than the incidence rate of respiratory disease for field vegetable crop farmers. Exposure to hop dust came from all phases of hop harvest and processing.

Another hazard identified through data from Washington State’s work-related asthma surveillance system, was isocyanate-induced asthma cases. Data were analyzed to characterize cases occurring from 1999 through 2010. A peer-review article was published that made several key observations regarding the development of work-related asthma - that these cases were in association with a) paint application on large objects difficult to ventilate, b) indirect exposure to isocyanates, c) exposure during secondary or clean-up processes, and d) reports of dermal exposure. If used these observations may lessen the risk of isocyanate asthma.

Maintaining the capacity to respond to these emerging hazards and data requests from stakeholders, we are able to respond to general requests for data from employers and workers in Washington State – over the grant period, we provided data regarding: hearing loss, injuries in orchards, injuries and illnesses in nursing homes, injuries in retail workers, injuries to janitors, and asbestos related pulmonary disorders, among others.

In response to injuries in the logging industry, and to requests from logging stakeholders, specifically to private industry and public sector landowners who control approximately 80% of timber production, there was an increased focus on logging injuries and better evaluation and characterization of the issues faced by workers in this industry. Currently, the injury rate and workers compensation premium rate (~\$18.50/hour) for those doing non-mechanized logging are unsustainable – the premium reflects a very high injury rate (e.g. the acute inpatient hospitalization rate is 4 per 100 FTE or 50x higher than the state fund average). The work with logging stakeholders could lead to possibly a significant impact from our surveillance programs. This work led to the creation of an infographic to better disseminate information regarding the burden of injury in non-mechanized logging.

- d. And finally, collaborating with other state and federal partners on state-based surveillance activities and initiatives:

Our collaboration with state and federal partners generally occur in two main areas, the Indicators, and work with the Behavioral Risk Factor Surveillance System (BRFSS) data.

For the production of the CSTE OHI we participate regularly in the CSTE OHI workgroup, and serve as the lead for 4 Indicators (#5,#8, #17, and #20). The PI is on the CSTE OH Leadership group, and both the PI and Epidemiologist are active in subcommittees and workgroups.

We engage with state and national partners in our BRFSS work, as Washington State pioneered the practice of adding questions to capture industry and occupation (I/O) on the BRFSS, and has worked to build occupational health capacity in this way. Currently, I/O data collection on national health and behavioral surveillance systems are not widely done (e.g. NHIS, NHANES, BRFSS). Very little data are available to describe health and health behaviors of the workforce at the state level by the workers' industry and occupation of employment. Both NIOSH and CSTE have advocated for such I/O data collection in the past and recently NIOSH has led efforts to collect I/O data on CDC's Behavioral Risk Factor Surveillance System (BRFSS). Washington State has collected I/O data from 1997 until present on the Washington State BRFSS with some analyses of this data in the past. We have coded over 100,000 records for the years 2003-2013, and this allows us to analyze a wide variety of conditions by I/O, and identify workers at risk.

These conditions include:

**Health coverage:** WA BRFSS analyses published in 2011 demonstrated the persistent gap in health-care coverage between low- and high- income workers. The proportions of uninsured were 38.2% for low-income workers and 6.3% for high-income workers. Besides income, workers were more likely to be uninsured if they were younger; male; Hispanic; less educated; not married; current smokers; self-employed; or employed in agriculture/forestry/fisheries, construction, and retail. Additional work is in progress which evaluates access to health care across states (Washington is collaborating in these efforts with Massachusetts and New Hampshire).

**Mental health:** Mental health problems affect many employees' ability to work and live. A growing body of evidence suggests that mental disorders impair work performance, reduce productivity, increase absenteeism, and increase risk of injury. Given the high costs of depression in the workplace, accurate information about the prevalence of depression and characteristics of workers with depression has direct relevance for employers in planning policies for prevention and treatment. A peer-reviewed publication using BRFSS data showed considerable variance in the prevalence of current depression and frequent mental distress (FMD) across occupational groups. There was an observed 10-fold difference across 20 occupational groups in the prevalence of current depression. The prevalence of FMD also varied among the occupational groups, with a 3-fold difference. Overall, workers in Sales, Administrative Support, Services, and Machine Operator occupations, and Truck Drivers appeared to be at higher risk of having current depression. Services workers and Truck Drivers had higher risk of FMD, while Education/ Training/ Library/ Arts/ Entertainment/ Legal Services occupations had lower risk of FMD.

**Obesity:** Obesity is a threat to public health. The prevalence of obesity has increased in the United States in recent decades, and is associated with sick leave, absenteeism, increased risk of cancers, musculoskeletal disorders, cardiovascular disease, and stress. Estimating the prevalence of obesity across occupational categories can help identify at-risk populations, and aid in the development of targeted prevention efforts. Using BRFSS data (odd numbered years 2003-2009), we estimated the prevalence of workers across occupational categories in WA. The overall prevalence of obesity for all workers was 24.6% (95% CI 24.0 – 25.1), ranging from 11.6% (95%

CI 8.0 – 15.2) for Health Diagnosing Occupations to 38.6% (95% CI 33.3 – 44.0) for Truck Drivers. There was significant disparity in obesity prevalence (as well as intake of fruits and vegetables, and levels of Leisure Time Physical Activity) across occupations in WA. Several occupations with significantly higher prevalence estimates of obesity compared to the reference group (Health Diagnosing Occupations) included Truck Drivers, Transportation and Material Moving, Protective Services, and Cleaning/Building Services.

**Influenza-like illness:** Influenza is an infectious respiratory illness that is costly and associated with missed work and decreased work productivity; pandemic influenza has potentially profound effects on the workforce. Community-based surveillance of self-reported ILI on BRFSS began in September 2009 to assess the impact of the H1N1 Influenza pandemic. Washington State was able to partner with NIOSH to examine self-reported influenza-like illness (ILI) among Washington State workers by Industry and Occupation from BRFSS data. We produced a descriptive report for NIOSH that concluded there was some variation in the prevalence of ILI across industry and occupation. Following those efforts, we produced a paper further describing and analyzing the distribution of self-reported ILI in Washington, and identifying occupations with increased risk of ILI, published by PLOS ONE in 2012 and widely viewed (over 2,868 views, 6 shares, and several citations). ‘Janitors and Cleaners’ (PR 2.5; 95% CI 1.3, 4.7) and ‘Secretaries’ (PR 2.4; 95% CI 1.1, 5.4) had an increased risk of ILI as compared to the overall prevalence and a reference group; while ‘Truck Drivers’ (PR 0.2; 95% CI 0.1, 0.7) and ‘Technicians, not elsewhere classified’ (PR 0.4; 95% CI 0.2, 0.9) had lower risk of ILI than other occupations that were analyzed.

**Work-related Asthma:** asthma is a common and costly respiratory disease, a significant proportion of which is caused or aggravated by exposures at work. A paper using the WA 2006-2009 data from the BRFSS and the BRFSS Asthma Call-Back Survey (ACBS) to examine asthma and work-related asthma by occupation was published in 2014. Questions on the ACBS that ask whether respondents believe that their asthma is caused or worsened by chemicals/dust/fumes from their work environment were analyzed and used as a proxy measure for work-related asthma (WRA). More than half of workers with asthma (55.1%) believe that their asthma symptoms were caused or worsened by any current or past job. However, very few (10.7%) had ever discussed their asthma being work-related with a health-care professional. The occupations identified as having a higher prevalence of WRA than the reference group included: Farming, Forestry, Fishing; Construction & Extraction; Mechanics & Repairers, Precision Production; Other Health Services; Machine Operators, Equipment Cleaners, Laborers; and Cleaning and Building, Personal Services occupations, among others.

Additionally, we compared the results of top 10 identified occupations by ACBS WRA questions to top 10 occupations identified by WA asthma surveillance interviews during the same time period (2006-2009). Eight (8) out of 10 top occupations were identified in common by the two sources, confirming that BRFSS results are representative of what is occurring in the state, and can be used to complement existing surveillance, or as a rough estimate of WRA where more in-depth surveillance is not feasible.

Furthermore, we have been active in sharing our work through presentations and participation in professional conferences, sharing both the results of analyses, as well as our practical expertise in coding and grouping industries and occupations for analysis, and distributing this information to interested state/national partners.

An additional avenue for collaboration has been the Washington State surveillance program’s work wherein we identify industries at high risk for occupational injury using WC claim and rate.

Prioritizing industries in this way (prevention index method) has drawn state and national attention, and the PI has engaged with NIOSH & CDC-NIOSH's Center for Workers' Compensation Studies (CWCS), who have recently adopted this method (described below) as the model for recently awarded grants that intend to improve the use of WC data in occupational health surveillance.

2) Second, we intend to produce and disseminate a biennial report that identifies industries at high risk for high cost, high frequency non-fatal occupational injuries.

The prioritizing industries project continues work initiated in 2003, that uses prevention index (PI) methodology and WC claim count and rate to rank industry groups to determine which industry groups are at high risk for seven common injury types. This allows WA to establish a data-driven basis for efficient targeting of prevention resources.

A technical report was published in 2013 that analyzed claims data from 2002-2010. During this period, there were 267,581 compensable Washington SF claims, which accounted for over 11 billion dollars in direct workers' compensation costs. The top 5 industry groups for 'All Injury Types' were: Foundation, Structure, and Building Exterior Contractors (NAICS 2381); Residential Building Construction (NAICS 2361); Building Finishing Contractors (NAICS 2383); General Freight Trucking (NAICS 4841); and Building Equipment Contractors (NAICS 2382). These 4 Construction industry groups are ranked highly for prevention in the PIs for almost all of the 7 identified injury types. Logging (NAICS 1133), Other Specialty Trade Contractors (NAICS 2389), and Services to Buildings and Dwellings (NAICS 5617) also appear in the Top 25 of all 7 identified common injury types. These findings are similar to our previous work in prioritizing industries, reflecting the continuing need for safety and prevention efforts in these key industry groups.

These methods can also be used to focus on particular groups of industries that are at high-risk of occupational injury. Particularly, 5 of the top 25 industry groups identified by the 2013 Prioritizing Industries report as being at high-risk were in the Services Sector (using the National Occupational Research Agenda industry grouping). This led to the publication of a paper using the PI rankings of industry groups within the NORA Services Sector. We analyzed the Services Sector by 7 high-cost, common occupational injury types and the Services Sector industry groups which demonstrated a higher burden of injury by PI rankings included: Executive, Legislative, and Other General Government Support (NAICS 9211), Services to Buildings and Dwellings (NAICS 5617), Employment Services (NAICS 5613), Waste Collection (NAICS 5621), and Automotive Repair and Maintenance (NAICS 8111).

3) Third, we will continue Washington's occupational health surveillance and prevention activities for work-related amputations and hospitalized burns and promote action by industry, labor, and government stakeholders. Through our proposal we intend to maintain the flexibility to assure the Washington State public of the presence of a program to identify and address the needs of occupational hazard, injury, and illness prevention.

Hospitalized work-related burns and work-related amputations reflect sentinel injuries to identify high risk workplaces for occupational injury. Recent publications of our surveillance data for these conditions have generated interest from other researchers regarding the adequacy of data capture for their prevention of workplace injuries as well as from interested parties in industry.

In response to a partial solicitation by the editor of an Electricians' trade publication, we published an article based on our previous peer-review of the psychiatric sequelae of hospitalized work-related burns. This work highlighted our results that showed that workers burned by electricity were 7 times more likely to have mental health problems compared to workers burned from fire, chemicals or radiation. Publication in trade journals allows us to translate our research into meaningful information given directly to the workers most at risk.

In response to a request, a report was produced that detailed work-related heat burns in restaurant/fast-food workers. The Primary sources of heat related burns in Restaurants were 'Fats and Oils' and 'Water'. Recipients reported sharing the data with their workers' compensation loss control personnel.

Exposure to hydrofluoric acid (HF) causes corrosive chemical burns and can be fatal. HF is widely used in cleaning products, rust removers and brighteners in the car and truck washing industry, as well as auto detailing and other industries. An analysis of the burden of injury and fatality in WA (48 occupational burns and 1 fatality) due to HF in the car and truck washing was published in MMWR. An accompanying hazard alert was produced to provide an easy-to-read version for employers and employees. There was wide media response to the story, with over 100 news outlets picking up the story.

### *Conclusions*

The Washington State Occupational Injury and Illness Surveillance Program strives to provide information for action to improve the occupational safety and health of Washington workers. To these ends, during the grant period described, WA has accomplished substantial work on all stated goals, including: the identification of emerging hazards, the identification of at-risk groups of workers, using data to prioritize industries for prevention efforts, collaborating with state and federal partners, and translating surveillance knowledge into actionable information for workers, employers, and other stakeholders.

### Publications

#### *Journal Articles*

Anderson NJ, Bonauto DK, Adams D: [2014] Prioritizing industries for occupational injury prevention and research in the Services Sector in Washington State, 2002-2010. *Journal of Occupational Medicine and Toxicology* 9:37.

Anderson NJ, Fan ZJ, Reeb-Whitaker CK, Bonauto, DK, Rauser E: [2014] Distribution of asthma by occupation: Washington State Behavioral Risk Factor Surveillance System Data, 2006-2009. *Journal of Asthma* 51(10):1035-1042.

Anderson NJ, Bonuato DK, Fan ZJ, Spector J: [2012] Distribution of Influenza-like Illness (ILI) by Occupation in Washington State, September 2009-August 2010. *PLoS One* 7(11):e48806.

Anderson NJ, Reeb-Whitaker CK, Bonauto DK, Rauser E: [2011] Work-related asthma in Washington State. *Journal of Asthma* 48(8):773-782.

Anderson NJ, Bonauto DK, Adams D: [2011] Psychiatric diagnoses after hospitalization with work-related burn injuries in Washington State. *Journal of Burn Care & Research* 32(3):369-378.

Bonauto, DK, Lu, D, & Fan, J: [2014] Obesity prevalence by occupation in Washington State, Behavioral Risk Factor Surveillance System. *Preventing Chronic Disease* 11(130219).

Fan ZJ, Anderson NJ, Foley M, Rauser E, Silverstein BA: [2011] The persistent gap in health-care coverage between low- and high-income workers in Washington State: BRFSS, 2003-2007. *Public Health Reports* 126(5):690-699.

Fan ZJ, Bonauto DK, Foley M, Anderson NJ, Yragui NL, Silverstein BA: [2012] Occupation and the prevalence of current depression and frequent mental distress, WA BRFSS 2006 and 2008. *American Journal of Industrial Medicine* 55(10):893-903.

Reeb-Whitaker C, Anderson NJ, Bonauto DK: [2013] Prevention Guidance for Isocyanate-Induced Asthma Using Occupational Surveillance Data. *Journal of Occupational and Environmental Hygiene* 10:11;597-608.

Reeb-Whitaker CK, Eckert CM, Anderson NJ, Bonauto DK: [2015] Occupational Hydrofluoric Acid Injury from Car and Truck Washing - Washington, 2001-2013. *Morbidity and Mortality Weekly Report* 64(32);874-877.

Reeb-Whitaker, C and Bonauto DK: [2014] Respiratory disease associated with occupational inhalation to hop (*Humulus lupulus*) during harvest and processing. *Annals of Allergy, Asthma, & Immunology* 113(5):533-537.

### *Trade Publications*

Anderson NJ, Reeb-Whitaker CK: [2012] Electrical burns and your mental health: facts about the injuries that you don't see. *Electrical Source Magazine* May/June 8(3):30-33.

### *Technical Reports*

Anderson NJ, Reeb-Whitaker CK, Bonauto DK, Martin E: [2015] Work-related Asthma in Washington State, 2009-2013. SHARP Technical Report #75-12-2015.

Adams D, Anderson NJ: [2014] Heat related burn injuries in restaurant industry workers in Washington State, 2006-2012. SHARP Technical Report #86-9-2014.

Anderson NJ, Bonauto DK, Adams D: [2013] Prioritizing Industries for Occupational Injury and Illness Prevention and Research, Washington State Workers' Compensation Claims Data, 2002-2010. SHARP Technical Report #64-1-2013.

Anderson NJ, Reeb-Whitaker CK, Bonauto DK: [2010] Work-Related Asthma in Washington State: A summary of SHARP's asthma surveillance data 2001-2008. SHARP Technical Report #64-13-2010.

### *Infographics*

Smith CK, Anderson NJ, Adams D: [2015] Work-related injuries in Janitorial Services workers in Washington State, 2003-2012 - Infographic. SHARP Publication #15-1-2015.

Rappin C, Anderson NJ: [2014] Mechanized vs. Manual Logging Washington State 2004-2012. SHARP Publication #47-4-2014.

### *Hazard Alerts*

Martin E, Reeb-Whitaker CK: [2015] Safety Hazard Alert: Hydrofluoric acid causes burn, amputation and death. Attention! Car wash, truck wash, auto detailers and truck drivers. SHARP Publication #83-9-2015.

### *Other Prevention Materials*

Reeb-Whitaker CK, Bonauto DK: [2013] Letter to physicians- hop dust exposure and respiratory disease.

Reeb-Whitaker CK, Bonauto DK: [2013] Letter to hop industry employers - hop dust exposure and respiratory disease.

Reeb-Whitaker CK, Bonauto DK: [2013] Hop dust and respiratory disease fact sheet/alert.

### Data Sets

Research resources and data collected under the Washington State Occupational Injury and Illness Surveillance Program grant can be made available to qualified individuals within the scientific community after publication. In Washington State, data sharing is governed by our state public disclosure laws, and additional specific Washington State statutes and administrative regulations associated with the entity owning the data system from which occupational injury and illness data or workforces estimates are ascertained.

Data collected by L&I researchers are treated differently than data originating from non-L&I (external) data sources. When non-public use data are obtained from a non-L&I entity, data sharing agreements with contractual agreements describing how the data are stored, used, and released are created between L&I researchers and the data owners. Generally, the originators of the data controls public release of data containing personal or employer identifiers; whereas de-identified datasets are available for use through public disclosure.

Data with personal identifiers collected and maintained within L&I have specific statutory protections which prohibit public disclosure of specific data elements, namely employer and employee name.

For data related to the CSTE/NIOSH occupational health indicators, the data available in public use datasets (BLS Current Population Survey data, BLS Survey of Occupational Injury and Illness data, BLS Census of Fatal Occupational Injury data, hospital discharge data, death certificate data and the National Academy of Social Insurance data) are available concurrently with SHARP's use of the data, and there are no restrictions on its use. This applies to Indicators 1 – 4, 6, 7, 9, 10, 14-16, 19, 20, and the Employment Profile.

Several datasets for indicators are provided by the federal government, state government or other entities. Data provided for the pesticide cases reported to the Poison Control Centers (indicator 11), data from the Washington State Cancer Registry (Indicator 12) and data related the number of health

professionals (CSTE) (Indicator 17) are summary data sets and we do not have access to the primary data. Data obtained from the BRFSS Asthma Call Back Survey (Indicator 21) must have a data sharing agreement with the Washington State Department of Health – describing use of the data for research purposes only.

For indicators relying on workers compensation data, #5-Amputations and #8 Carpal Tunnel Syndrome, aggregated data sets without personal identifiers are available under public disclosure.

Washington State notifiable conditions data with personal identifiers, specifically pesticide data, hospitalized burns data, blood lead data and occupational asthma data, are restricted from disclosure under state law (Washington Administrative Code 246-101 see <http://www.doh.wa.gov/notify/other/legal.htm>). However, use of datasets is possible following establishment of a data sharing agreements with the Department of Health, and study approval from the Washington State IRB. Following approval of the protocols data may be provided with individual identifiers.

For the workers compensation data, in general, de-identified datasets are available under public disclosure laws (Washington Public Records Act – RCW 42.56 see <http://apps.leg.wa.gov/rcw/default.aspx?cite=42.56>). This applies to surveillance and research projects. Identifiers removed, include name, workers compensation claim number, social security number, claimants address, phone number, date of birth, and other names of witnesses to the injury. However, some of these data are categorized for analysis and are not necessarily restricted from disclosure (date of birth to age groups, address to county of residence). The SHARP program generates the data from the workers compensation data set. Once the data set is generated by SHARP, the dataset is immediately available for release under public disclosure. Datasets are provided with descriptive variable names and documentation associated with data file. Generally, our surveillance data includes descriptive analyses and data summary such that record level data may not be required.

Employer and employee information obtained from worksite visits, case investigations, demonstration projects, and employee surveys are protected from public disclosure with identifiers (see RCW 49.17.210). Data can be de-identified and released in aggregated form such that individual worksite visits are not decipherable. Datasets with individual identifiers for research purposes can be obtained with a data sharing agreement with the Department of Labor and Industries and study approval from the Washington State IRB. Enforcement visits by the Washington State Division of Occupational Safety and Health (DOSH) are available for public disclosure with employer identifiers. Consultation visits by Washington State DOSH are confidential under statute and not available for public disclosure.

#### Other Materials available for other investigators

Other research materials or protocols may be available under the conditions described above. Qualified individuals within the scientific community who are interested may contact the Washington State Occupational Injury and Illness Surveillance Program directly.

#### Inclusion of gender and minority study subjects

The surveillance program does not collect additional data or “enroll” subjects. The surveillance projects passively collect data, and captured race and ethnicity when available, typically collected when a case follow-up interview occurs. The BRFSS data have race and ethnicity. No subjects were excluded.

### Inclusion of children

Surveillance data were passively collected. Per the definition provided by NIH, children are less than 21 years of age. Data was collected for persons younger than 21. There were a small number of injured workers less than 21 years of age identified by the surveillance system, but follow-up interviews were not conducted with workers under 18. Care was taken to ensure guidelines for working with small numbers were followed for protection of confidentiality in data analysis and presentation. The number of injured workers and subsequent respondents for children under 18 were too small to make any meaningful conclusions about this population.

## Success Stories

### Adding Industry & Occupation to the Behavioral Risk Factor Surveillance System

Washington Occupational Injury and Illness Surveillance and Prevention Program  
Safety and Health Assessment and Research for Prevention (SHARP) Program

Grant Number U60 OH008487

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#### The Challenge

What people do for work contributes to their health - on average, American adults spend more than half their waking hours at work. Very little data are available to describe health and health behaviors of the workforce at the state or national level by the workers' industry and occupation.



#### The Response

Washington State pioneered the collection of Industry and Occupation (I/O) data on the Washington State Behavioral Risk Factor Surveillance System (BRFSS), starting in 1997. Collecting I/O data in this way leverages the strengths of the BRFSS, the largest continuously conducted health survey system in the world, which collects data on a wide variety of health outcomes & behaviors. With the addition of I/O questions, these results can be used to quantify the prevalence of these factors by industry and occupation and better characterize work-related injuries and reporting to workers' compensation (WC). No other state-level data source exists for this information. The questions added to the BRFSS are:

- "What kind of business or industry do you work in?" and,
- "What is your job title?" If no job title is given, the respondent is then asked "What kind of work do you do?"

Open-text verbatim responses are then coded by trained coders into specific census industry and occupation codes which can then be analyzed. Washington has coded industry and occupation for over 100,000 Washington State BRFSS respondents for the years 2003 – 2013. Use of BRFSS I/O data can identify high-risk populations of workers.

## **The Impact**

Washington State has been able to identify differences by occupation including those in: underreporting of work-related injury, only about half (51.5%) of those reporting work-related injury or illness filed for WC; access to health care; depression and frequent mental distress; obesity; influenza-like illness; and work-related asthma, where half (55%) of respondent workers with asthma indicated they believed exposure at work had caused or worsened their asthma, but <11% had discussed their asthma being work-related with a health-care professional. Identified groups of workers at risk can be prioritized for prevention efforts. Recently, national efforts to include I/O on the BRFSS have grown, with NIOSH funding the addition of the I/O questions for 2013-2016, which has led to over 20 states asking for I/O on their state BRFSS.

## Prioritizing Industries for Occupational Injury and Illness Prevention and Research

Washington Occupational Injury and Illness Surveillance and Prevention Program  
Safety and Health Assessment and Research for Prevention (SHARP) Program  
Grant Number U60 OH008487

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### The Challenge

Do you know which industry in your state is the most hazardous? Would you like to focus your prevention efforts, time, and resources where they will make the most impact? The prevention of work-related injuries and illnesses depends on accurate and reliable data. Occupational health surveillance can provide the necessary information for better decision-making and meaningful action.

### The Response

Washington State periodically produces a report prioritizing industries for prevention efforts based on count and rate of workers' compensation claims, for seven common, high-cost injury types. This method, called the Prevention Index (PI), can be used to identify which industries are at risk for particular injuries, and rank them to identify where the most benefit from research and prevention could be gained.

The PI takes into account both:

- the number of claims - "how common are the injuries?" and,
- the rate of claims per Full-Time-Equivalent workers (FTE) - "how high is individual worker risk in this industry?"

$$PI = \frac{\text{count rank} + \text{rate rank}}{2}$$

	High Count	Low Count
High Rate	Industry-wide approach with enforcement, consultation and education/outreach	Risk concentrated in small industry. Focused Inspection approach may be appropriate
Low Rate	Injuries spread across large industry with lots of people. Likely no single workplace has high risk: education campaign	Minimal resources needed unless complaints or unique injuries/hazards emerge over time

The PI results can then suggest methods for prevention strategies tailored to the the specific events and hazards faced by workers in identified industries. PI results also allow for the identification of high-risk groups, such as Construction Sector and Logging workers, who are ranked highly across multiple injury types. Reducing claims incidence in even a few key industry groups

could be substantially beneficial.

### **The Impact**

The PI method is a simple way to get actionable data. The PI framework has been adopted by WA's Division of Occupational Health and Safety (DOSH) which has begun to use the PI framework and produce material using this methodology for education and outreach activities; NIOSH issued a program announcement for improving use of workers compensation data for public health surveillance which was modelled on our Prioritizing Industries report and PI framework; and PI industry ranking inclusion criteria were adopted by CDC-NIOSH's Center for Workers' Compensation Studies (CWCS).

**PFA: Washington Fatality Assessment and Control Evaluation (FACE) Program**

Washington Occupational Injury and Illness Surveillance Program

Grant Number: 2 U60 OH008487

Project Period: July 1, 2010 – June 30, 2015

Final Report Completed: September 23, 2015

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## **PFA: Washington Fatality Assessment and Control Evaluation (FACE) Program**

Washington Occupational Injury and Illness Surveillance Program  
Grant Number: 2 U60 OH008487

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**Abstract:** On average, sixty-seven workers died each year between 2010-2014 in preventable work-related incidents in Washington State according to The Washington State Fatality Assessment and Control Evaluation (WA FACE) surveillance program. This is a decrease from the average of 77 fatalities per year during the previous 2005-2009 surveillance period.

Between 2010-2014, the majority of work-related fatalities in Washington State occurred in the agriculture, forestry, fishing, and hunting industries. Regardless of industry, every work-related fatality provokes a significant financial and emotional burden on the employers, employees, and families involved. WA FACE considers every work-related fatality to be preventable and is dedicated to the goal of eliminating occupational fatalities.

To realize this goal, WA FACE collects and organizes high quality data on every work-related fatality. WA FACE uses over a dozen data sources. The high volume and quality of data collected provides WA FACE with several approaches to prevention. These range from the development of detailed profiles of individual cases that include incident specific practical preventive measures to multi-year perspectives of cases that communicate methods to identify and avoid frequent hazards.

WA FACE continues to develop and refine Fatality Narratives. Construction narratives have continued while the frequency of agriculture narratives has increased during this five year cycle.. The mailing distribution list for FACE construction Fatality Narratives contains almost 1000 valid email addresses and continues to expand after several years, while the relatively new agriculture Fatality Narratives mailing list now contains almost 400 subscribers.

WA FACE also conducts in-depth case investigations and prepares longer investigation reports. These reports are also distributed using a growing email distribution list of over 650 subscribers. Fatal Facts reports and short Hazard Alerts are used to characterize hazards in a particular industry, associated with a specific job, or of a common incident type among several industries.

In addition to various reports and their respective distribution lists, WA FACE is capable of targeted mailing of prevention materials using the unique WA State Workers' Compensation (WC) database to generate lists of at risk employers. All narratives and reports are mailed to employers at risk who will benefit most from FACE publications.

WA FACE sends feedback surveys along with all mailed investigation reports and other select resources to evaluate the reach, impact, and quality of their prevention efforts. The majority of responses from these surveys ranked WA FACE reports and resources as 'very good' and "very useful".

WA FACE has become a resource for all of Washington State by maintaining a responsive expert staff, detailed and nimble database, and an expanding web catalog of materials. WA FACE fulfilled over fifty requests from internal parties and over fifty requests from external parties for data and consultation in this cycle. In return, WA FACE benefits from extensive support from the health and safety, employer, and worker communities.

## Section 1

### Highlights/Significant Findings

For the five year grant cycle, WA FACE documented a decrease in the number of work injury fatalities from 89 in 2010 to 73 for 2014. Also of note, two of the five years in this cycle were the lowest state fatality counts on record. To provide better perspective, the Washington State fatal work injury rates generated by the Census of Fatal Occupational Injuries (CFOI) were compared with US fatal work injury rates. The fatal work injury rate in Washington State declined from 3.4 per 100,000 full-time equivalents (FTEs) in 2010 to 1.7 in 2013 while the rates for the US declined from 3.6 in 2010 to 3.3 in 2013.

WA FACE data shows that the top three industry sectors with the highest numbers of work injury fatalities in Washington State were: agriculture, forestry, fishing, and hunting; transportation and warehousing; and construction. Unlike previous five year cycles, construction industry fatalities were lowest among these three industries for all years while the agriculture, forestry, fishing, and hunting industry sector was highest for three years. To address this shift, the WA FACE program has focused more resources on these industries.

Within each of these top three industries, WA FACE is able to use data to focus on and characterize persistent hazards. In crop production, high numbers of workers continue to be at risk of tractor and machinery related hazards. Manual logging continues to be a risky industry with relatively few employers and employees but a high fatality rate. Transportation industry truck drivers as well as drivers in other industries continue to die in motor vehicle crashes.

In terms of incident type, motor vehicle incidents were responsible for the highest number of work-related fatalities each of the five years and overall. Overall, the industries subsector with the highest number of fatalities was truck transportation. Machinery accounts for the second highest number of incidents. Most of machinery incidents occur in logging and crop production.

### Translation of Findings

To address significant findings, WA FACE focused more resources for prevention in the following industries: agriculture, forestry, fishing, and hunting; construction; and transportation and warehousing. Prevention resources in the form of construction and agriculture specific Fatality Narratives and target incident investigation reports were frequently published, widely distributed, and positively evaluated. WA FACE aggressively pursued opportunities to investigate motor vehicle related cases and develop prevention resources for the transportation industry.

To address persistent fatalities among loggers, WA FACE partnered with the L&I Logger Safety Initiative (LSI) and the logging industry. WA FACE now uses surveillance data to develop a series of Logging Injury Alerts similar to traditional Fatality Narratives. Logging Injury Alerts are carefully written and reviewed to reflect the terminology and language familiar to loggers and better ensure understandability and approval. Each alert also contains a sign-in sheet that employers and safety trainers can use to document topic-specific training.

In response to a series of fatal tractor roll-over incidents in the agriculture industry, WA FACE developed a hazard alert for the crop producing sector of the agriculture industry. The hazard alert profiled a series of roll-over deaths and provided a list of incident specific recommendations for preventing tractor roll-overs. WA FACE also expanded the series of agriculture Fatality Narratives by adding slideshow and

Spanish translation versions. Three lengthy in-depth investigation reports of workers killed in orchards have also been produced, communicated, and evaluated in this cycle.

To address falls in construction, WA FACE developed a fall hazard and ladder training with the NIOSH Ladder Safety app as the centerpiece. WA FACE partnered with several construction apprentice programs to deliver the training to apprentices. Following each training, apprentices completed a short survey to provide information about changes in their level of ladder safety knowledge, attitudes, and behaviors.

Another effort to address the problem of falls in construction was the development of a digital story based on the investigation of a carpet installer who fell to his death. WA FACE worked closely with the Northwest Floor Covering Association to ensure the digital story accurately represented and would be well-received by the association's member contractors.

Also notable is WA FACE's consistent and growing involvement and efforts to promote and support the annual Stop Construction Falls Campaign Safety Stand-down. Promotions consisted of postcards mailed to employers, an agency website, and advertising on regional buses. Support efforts included mailing multiple prevention resources in English and Spanish and daily email blasts during the campaign. The 2015 campaign culminated with an evaluation survey available to employers by mail and online, a recognition page, and certificates of participation.

### Outcomes/Relevance/Impact

#### *Potential Outcomes*

WA FACE collects fatality case data and conducts in-depth investigations of select fatal incidents as defined in the NIOSH priority areas as well as Washington State priority areas. Using these data and information, WA FACE develops prevention resources that contain specific and detailed recommendations for employers that will aid in the prevention of future incidents. Prevention resources with recommendations are communicated using the growing email list, target employer mailings, and through reciprocal relationships with other networks such as Washington State OSHA (DOSH), and several business associations and labor groups, and meetings. WA FACE now develops and communicates both construction and agricultural fatalities at a regular frequency. Narratives have been enhanced with a new easily identifiable look, a hyper-linked section of relevant WA standards, and a section of relevant, specific, and practical recommendations. Currently, all Fatality Narratives are also developed into slideshow versions and approximately half are translated into Spanish.

#### *Intermediate Outcomes*

Multiple examples within the Results by Specific Aims section illustrate how WA FACE prevention resources are being adopted, shared, and used. Notable intermediate outcomes include the use of WA FACE reports in academic training and multiple requests for data from internal and external parties for use in press releases and new stories, training activities, and making informed decisions.

#### *End Outcomes*

WA FACE data, documents, and staff expertise have informed L&I agency goals for reducing work-related fatalities and policies on targeting high risk industries and occupations. Specifically, WA FACE provided L&I and DOSH directors with historic data and models that were used to set targets for reductions in work-related fatalities. In addition, WA FACE provided detailed data and consultation to DOSH at a series of meetings to identify high hazard and high fatality industries and occupations in need of intervention.

## Section 2

### Scientific Report

#### *Background for the Project*

WA FACE has been conducting fatality surveillance and prevention activities in Washington State since 1997. WA FACE enjoys extensive and near universal support from the employer and worker communities. The program continues to develop, maintain, and enhance its goal of preventing work-related traumatic injuries and deaths. The program has four components: 1) surveillance, 2) investigation, 3) prevention activities/information dissemination, and 4) evaluation. Detailed surveillance data is collected on all work-related fatalities in Washington State. The data is used to help focus incident investigations as well as describe the incidents and associated risk factors. The data is also used to develop and communicate information on preventive actions.

#### *Results by Specific Aims*

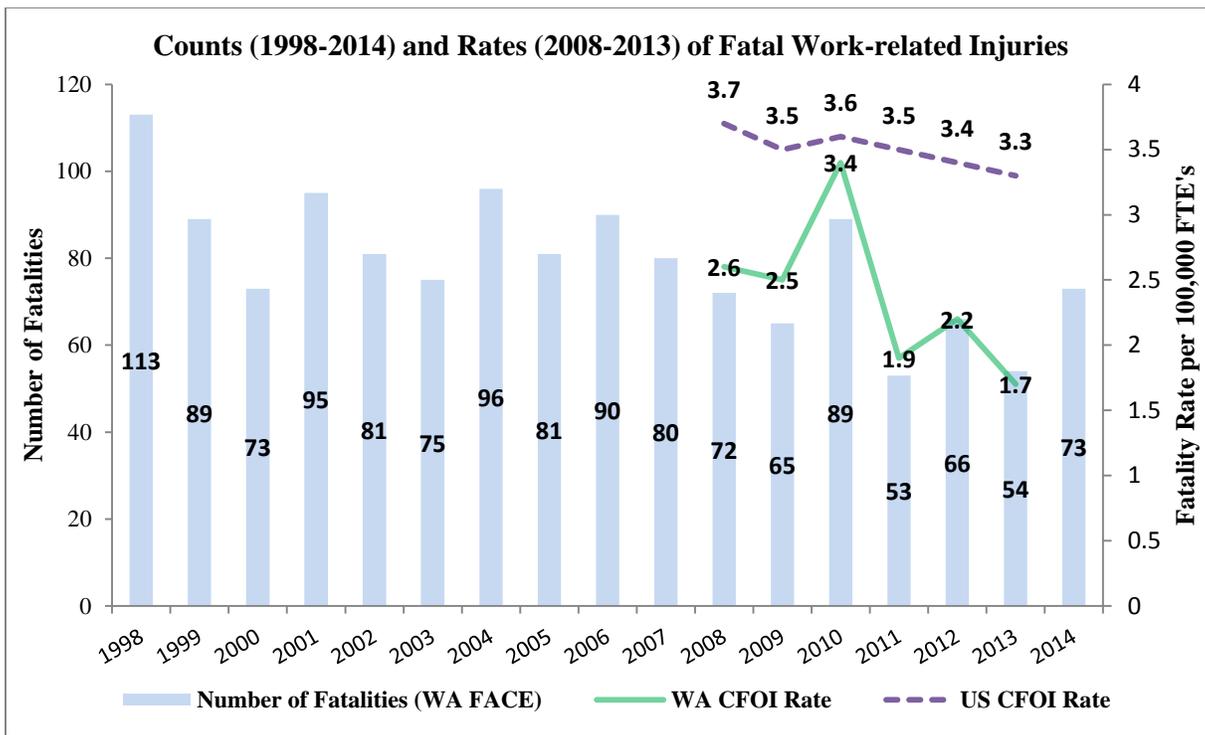
The nine specific aims of the WA FACE program along with five year updates are:

1) Maintain and enhance the current program's timely multi-source traumatic occupational fatality surveillance system.

The WA FACE surveillance system manager has over sixteen years' experience maintaining the system. In addition, the recently hired WA FACE research investigator is trained as an OSHA inspector and has expertise in occupational coding systems and database usage. Having two FACE personnel with expertise has enhanced the timeliness and overall ability to fulfill the numerous specific data requests from internal and external parties.

Additions to the system include a logging injury and fatality database. The new database is designed and maintained to manage and share up-to-date detailed case information to members of the LSI, logging health and safety professionals, and the logging industry.

A new source of early reports of work-related traumatic injury cases was added. WA FACE receives weekly reports of traumatic injury cases reported to L&I. Reports are scanned for cases considered novel or highlighting hazards worthy of developing alerts or other prevention resources.



2) Identify situations and factors using epidemiological, safety engineering, and human factors/ergonomics methods to focus prevention strategies.

The WA FACE staff consists of an industrial hygienist, health and safety specialist, and research investigator with several years of education, training, and experience. FACE staff continues to utilize fundamental epidemiologic tools to identify frequent and new hazards and promote practical preventive safety measures.

WA FACE staff addresses every narrative and investigation case with a wide variety of expertise, resources, and research. Examples include reviewing literature for related fatality or injury cases, consulting with veteran ergonomists and topic-specific technical experts, and finding the most applicable standards and resource materials.

3) Investigate select fatal incidents as defined in the NIOSH priority areas as well as Washington State priority areas.

WA FACE has investigated priority area fatalities and communicated relevant hazard identification and prevention resources to targeted audiences. WA FACE also investigated cases that were novel or reflected the changes in the distribution of case types occurring in the state. All investigation reports contained several detailed recommendations for preventing future incidents.

## WA FACE Fatality Investigations and Reports by Year

Year	Recruitment Letters Sent	Investigations Conducted	Investigation Reports Published
2010	3	1	1
2011	52	8	2
2012	44	9	4
2013	22	9	3
2014	0	0	2
2015	21	1	3
<b>Total</b>	<b>142</b>	<b>28</b>	<b>15</b>

4) Develop and disseminate prevention materials that can be used to reduce the risk of fatal occupational injuries.

WA FACE strives to develop prevention resources with several practical recommendations for hazard identification and prevention that can be used by employers of various sizes and levels of resources.

WA FACE prevention resources are used in academic training of future safety and health professionals.

From: Steven E. Lacey, PhD, CIH, CSP  
Associate Professor & Chair  
Department of Environmental Health Science  
IU Fairbanks School of Public Health

“WA FACE reports have been thoroughly integrated into my occupational safety teaching toolkit. I used several WA FACE reports this past month at the regional Indiana Safety & Health Conference (hosted annually by the ASSE Indiana Chapter and the Indiana Chamber of Commerce) to help explain workplace injuries and fatalities in the green jobs industry. This fall, I will be offering an undergraduate/graduate course titled A433/A633 Occupational Health & Safety and the WA FACE reports will be adapted to serve as the centerpiece of classroom small group exercises -- in my experience, they prove extremely useful in keeping students *engaged*.”

During the 2015 Stop Construction Falls Campaign Safety Stand-down, WA FACE sent prevention resources along with evaluation postcards to approximately 2000 construction employers. Evaluations were received from 83 construction industry employers. Employers reported that 3399 workers took part in their Safety Stand-Down events. Approximately 90% of employers said the resources they used were good to excellent in the categories of readability and usefulness. Nearly half of the employers who responded said they planned to change the way they train workers and identify hazards following their Safety Stand-Down. Employers also reported planned changes in their use of safety gear, setting up jobsites, and planning jobs, among others.

WA FACE brought together and leveraged the resources of several partners to create a successful 2015 Stand-Down campaign.

Partners included:

- WA State Dept. of Labor and Industries (L&I)
  - Division of Occupational Safety and Health (DOSH)

- Public Affairs
- Communications
- Education and Outreach
- Construction contractors
- Construction industry associations
- Construction health and safety associations
- OSHA Region 10
- Lamar Advertising

WA FACE and the partners listed above:

- Identified five recent WA FACE Fatality Narratives describing diverse construction fall incidents and had them translated into Spanish, and fall safety resource packets including English and Spanish versions of the narratives, and information about the 2015 Stand-Down were mailed to over 2000 WA employers in NAICS sector 23.
- Worked to design and execute WA State 2015 Safety Stand-Down webpages that include information about the campaign, Stand-Down ideas, fall safety resources, and recognition opportunities for participating employers.  
<http://www.lni.wa.gov/StopFalls>
- Coordinated an on-site photo shoot with a local construction company for campaign promotional material. Photos were used for webpages, postcards, emails, and bus advertisements.
- Developed a postcard that was sent to WA construction employers preceding the Stand-Down that encouraged participation in the Stand-Down. The Associated General Contractors of Washington allowed us to use their logo on the mailing, showing their support for the Stand-Down.
- Worked with Lamar Advertising to take advantage of their special pricing to have campaign billboards installed on 30 transit busses in four major transit districts in Washington State.
- With L&I's Public Affairs department, drafted a press release about the Stand-Down that included quotes from the DOSH Assistant Director and the owner of a local construction company.  
<http://lni.wa.gov/News/2015/pr150511a.asp>
- Promoted the Stand-Down on the L&I website, blog, Twitter, and Facebook page leading up to, during, and after the event. <https://www.facebook.com/laborandindustries>  
<https://twitter.com/lniwa>  
<http://deptoflaborandindustries.tumblr.com/>
- Promoted the Stand-Down at meetings of the Puget Sound Area Safety Summit, which was attended by construction company safety professionals, and at Washington's 8<sup>th</sup> Annual Construction Safety Day.
- Printed Stand-Down hard hat stickers with the "Safety Pays. Falls Cost." Logo in both English and Spanish, and distributed them at safety events.
- Sent out daily emails for a week during the campaign to 857 construction contractors on the Washington Department of Labor and Industries contractor listserv. Emails encouraged participation in the Safety Stand-Down and promoted fall prevention resources.
- Developed online and print versions of a Stand-Down evaluation survey to be sent to employers who received FACE fall safety resource packets by mail and listserv.

5) Develop a series of case narratives that highlight fatal incidents, detailing risk factors for the incidents and recommendations for the prevention of future incidents. Use these and other materials to focus discussion at construction companies' tailgate safety meetings. Expand the case narratives to include selected agriculture-related fatalities and translate narratives into Spanish.

WA FACE produced a total of 42 Fatality Narratives for the agriculture and construction industries. Slideshow versions were produced for 30 of the narratives. Similar prevention resources developed in the form of 16 logging injury alerts and 17 young worker injury alerts. Forty-five Fatality Narratives and slideshows and 8 Young Worker Hazard Alerts were translated into Spanish. Together, the number of these resources emailed was nearly 70,000 and the total number mailed was close to 60,000.

WA FACE also produced 8 hazard alerts to inform employers of the hazards associated with chemical and physical hazards and how to identify and prevent them. These were mailed to 2646 at risk employers. Fifteen investigation reports were published during this period. Investigation reports were emailed to 9450 email subscribers and mailed to 4158 employers likely at risk of these hazards.

These resources were also used in numerous stakeholder meetings and presentations to business, labor, and government by FACE staff.

### **Outreach to Targeted Employers**

<b>Prevention resources</b>	<b>Number produced</b>	<b>Number mailed</b>	<b>Number emailed</b>
Construction Fatality Narrative	28	40862	32442
Agriculture Fatality Narrative	14	2216	6160
Logging Injury Narrative	16	2104	4304
Construction Fatality Slideshow	22	NA	20020
Agriculture Fatality Slideshow	8	NA	3080
Investigation Report	15	4158	9450
Hazard Alert	8	2646	NA
Resources in Spanish	45	12000	5142
Young Worker Injury Alert	17	NA	NA
<b>Total</b>	<b>177</b>	<b>63986</b>	<b>80598</b>

6) Utilize Washington State non-fatal injury data for potential incorporation into industry and hazard specific prevention materials.

WA FACE has incorporated injury statistics into several draft publications including recent Hazard Alerts. Non-fatal injury data was used to investigate injury hazards in the dairy, brewing, and winery industries. WA FACE used injury data to generate several summary tables characterizing injuries by incident and injury types. These tables were shared with staff at the University of Washington and used in projects and publications.

7) Identify and utilize public and organizational media outlets (like Twitter, blogs, organization newsletters and trade publications) to increase dissemination of targeted prevention materials.

Beginning in 2015, WA FACE partnered with L&I Public Affairs and other managers of established social media accounts to communicate all new and other relevant prevention resources via social media. Resources have already been communicated to nearly 14,000 Facebook and Twitter followers.

## Prevention Resources Communicated Through Social Media

<b>Publication Title</b>	<b>Type</b>	<b>Posted to</b>	<b>Account Manager</b>	<b>Followers</b>
Hop Yard Laborer Struck by Hop Pole	Fatality Narrative	Twitter	WA Dept. of L&I	4275
Log Truck Driver Dies When Struck by Logs Being Loaded Onto Trailer	Investigation Report	Twitter	Keep Trucking Safe	1268
Preventing Injuries to Retail Workers	Hazard Alert	Facebook	WA Dept. of L&I	1205
Orchard Laborer Dies after Being Struck and Run Over by Dump Trailer	Investigation Report	Twitter	WA Dept. of L&I	4275
		Facebook	WA Dept. of L&I	1205
		Twitter	WA State Dept. of Agriculture	1083
		Twitter	Good Fruit (Trade Journal)	624
<b>Total</b>				<b>13935</b>

Several WA FACE reports have been submitted to trade journals. Seven have been published as full articles and others have been mentioned.

## Association Publications and Trade Journal Articles

<b>Date Published</b>	<b>Article Title</b>	<b>Trade Journal Name</b>
January 2011	WA Face Issues New Recommendations For Safe Glass Handling	Glass Magazine
January 2011	Recommendations From WA Face To Prevent Fatal Incidents In Auto Wrecking Yards	Automotive Recycling Magazine
July 2011	Commercial Carpet Cleaning: Safety First	Cleanfax Online
May 2012	Following A Fatal Workplace Incident, Washington State Face Program Issues New Recommendation	Cranes Today
December 2012	Machinist Dies After Being Struck By Rotating Steel Bar Stock In Lathe In WA State	American Machinist
February 2014	Timber Cutter Killed After Walking Under A Standing Cut Up Tree	Springboard (WA Contract Loggers Assn)
February 2015	Truck Driver Run Over By Propane Transport Rolling Backward at Bulk Plant	National Truckers Association (Online)

8) Evaluate the materials that are developed and disseminated using electronic surveys, website activity tracking, and feedback from trainings.

The WA FACE electronic survey was functional from 2011-2014. Evaluations consistently showed that approximately 90% of the respondents believed WA FACE resources were good to excellent in terms of readability and usefulness. Major drawbacks were that the identity of reviewers and the specific resources being reviewed were unknown.

Starting in 2012, all investigation reports mailed to employers contained a self-addressed stamped evaluation postcard. The postcards allow for tracking feedback by the specific industry and resource being evaluated. The average response rate was 15% rates varied by industry. Feedback across industries indicate that employers rate WA FACE investigation reports high in terms of readability and usefulness.

Construction apprentices evaluated the ladder safety trainings administered by WA FACE. Feedback indicated that apprentices liked the training materials and content in addition to the increases in knowledge and confidence when working with ladders.

9) Evaluate the impact of WA FACE prevention activities by focusing on outcomes for selected incident types in high-risk industries.

WA FACE utilized the NIOSH Ladder Safety app to develop a training module targeting construction apprentices. The training also incorporates resources from the Stop Construction Falls Campaign, WA FACE, and WA State and US construction industry data. A Pilot of the training was conducted in September 2013 where two classes of 25 construction pre-apprentices participated. Evaluations of the Ladder Safety app during pilot training consistently evaluated the app as “very easy” to use and the ladder safety information as “very useful”. Based on feedback, the training and evaluation was modified. The revised evaluation attempts to measure: (1) the effect of training on trainees’ knowledge of ladder safety; (2) the effect of training on trainees’ confidence to use ladders safely; (3) trainees’ likelihood of using safety practices from the training or specific information from the app; and (4) trainees’ perception of what will help or keep them from working safely with ladders on the job. Following the pilot, 75 individuals in six programs have received the Ladder Safety app training and provided feedback.

Responses following the Ladder Safety app training-75 (100%):

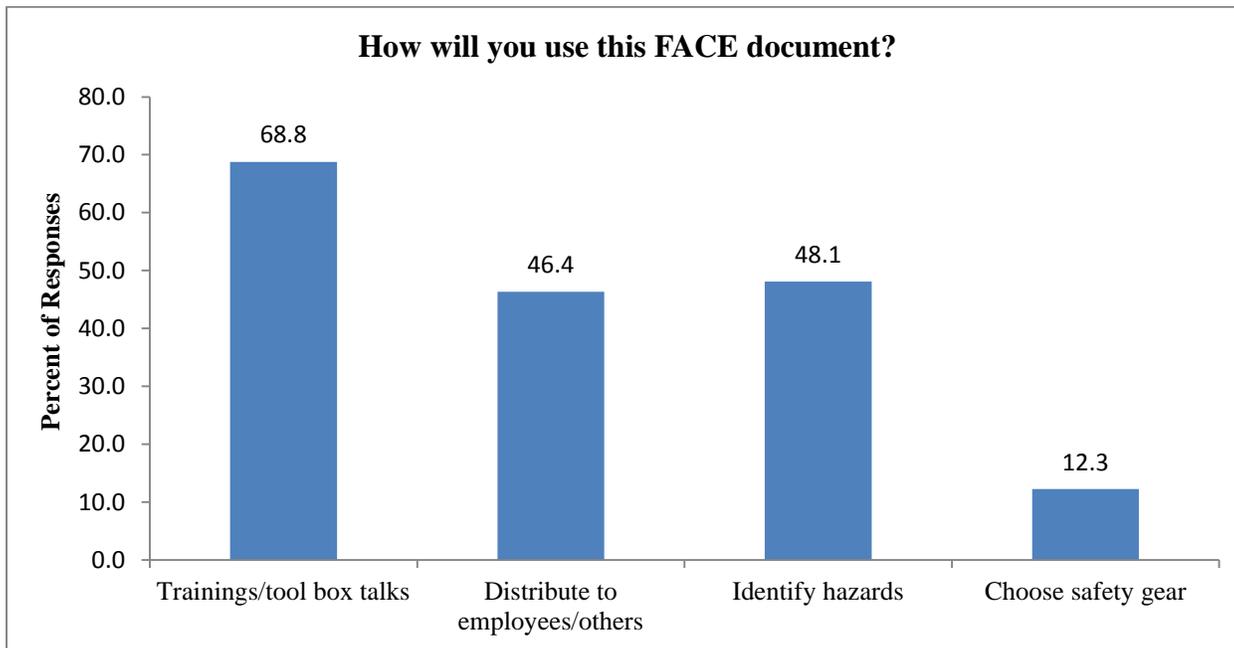
- 98% reported increased knowledge of ladder safety.
- 96% reported feeling more confident working safely with ladders.
- 100% reported they will use ladder safety practices discussed in this training.
- Among several options, trainees most strongly agreed that:
  - “proper tools” and “sufficient training” would be the most helpful in working safely with ladders.
  - “improper tools” and “not enough time for the job” would keep them from working safely with ladders.

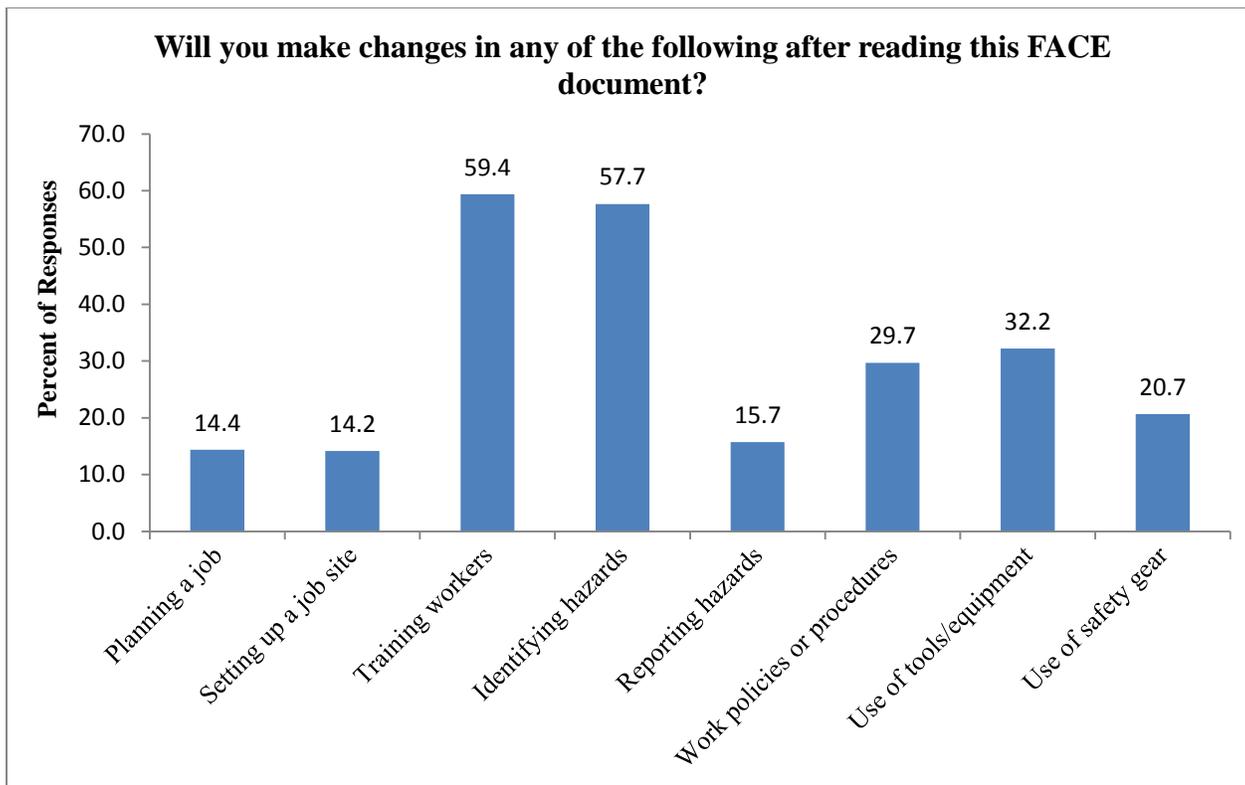
From 2011-2014, the WA FACE electronic survey yielded approximately 80 responses per year and is currently being redesigned. Evaluations consistently showed that approximately 90% of the respondents believed WA FACE resources rate from good to excellent for readability and usefulness. More importantly, high percentages of respondents reported they planned on making changes in hazard

identification, changes in job set-up, safety procedures, tool or safety gear use after reading WA FACE resources.

WA FACE continues to assess the impacts that prevention resources and activities have on employers. Evaluation surveys were mailed to target employers with all FACE Investigation Reports between 2012 and 2015. Employers were asked how they would use the FACE prevention resources and recommendations and what workplace safety changes they would make after reading it. Nearly 70% of employers said they would use reports to train workers and nearly 60% reported that they would make changes in the way they identify hazards.

The graphs below show the all industry aggregate results of the all surveys.





## Publications

### WA FACE Publications by Year

Year	Publication Title	Publication #
<b>2010</b>	Assembler / Fabricator Dies When Struck by "L" Rack Loaded with Glass Mirrors in Washington State	52-20-2010
	Laborer Struck by Boom of Excavator When it Tips Over	71-96-2010
	Orchard Laborer Caught in Tractor-Mounted Post Hole Digger	71-97-2010
	Crane Rigger Killed When Struck by Falling Crane Load	71-98-2010
	<b>2011</b>	Hazards to Truck Drivers and other Workers while Loading and Unloading Trucks and Trailers
	A Commercial Cleaning Company Worker Dies of Carbon Monoxide (CO) Poisoning at a Warehouse in Washington State	52-21-2011
	Crane Operator Dies after Falling From Crane Turntable Deck in Washington State	52-22-2011
	Ironworker Killed When Rebar Cage Collapses	71-100-2011
	Nursery Laborer Electrocuted When Irrigation Pipe Contacts Overhead Power Line	71-101-2011
	Laborer Crushed Under House	71-102-2011
	Contractor Killed When Boom Truck Crashes	71-103-2011
	Ranch Worker Dies When ATV Rolls Over	71-104-2011
	Trabajador de una hacienda muere al volcar un vehículo todoterreno (Spanish version)	71-104-2011
	Framer Falls When Floor Section Collapses	71-105-2011

	Floor Installer Killed in Motor Vehicle Crash. Incident date: November 17, 2008.	71-99-2011
	Temporary Worker Seriously Injures Hand Unclogging Dust Collection Machine	91-01-2011
	Hay Buyer Fractures Skull, Breaks Shoulder Falling Off Feed Table	91-02-2011
	Animal Caretaker Breaks Arm and Wrist After Ladder Fall	91-03-2011
	Commercial Roofer Falls, Breaks Leg When Ladder Slips	91-04-2011
	Worker's Foot Amputated, Lung Collapsed by 3.5 Ton Steel Container	91-05-2011
	Falling Log Causes Internal Injuries and Fractures Hip of Worker	91-06-2011
	Worker's Partially Amputated Fingers spur Change in Well-drilling Procedures	91-07-2011
	Employer Sees a Change in Attitude Regarding Safety After Employee Injury	91-08-2011
	Food Service Worker has Eye Surgery after Bottle Shatters in her Face	91-09-2011
<b>2012</b>	Hazards to Orchard Tractor and Machinery Operators	47-21-2012
	Peligros para los operadores de tractores y otra maquinaria en las huertas (Spanish version)	47-21-2012
	Carpet Installer Dies after Falling 32 Feet at a Commercial Jobsite	52-23-2012
	Deck Engineer on Barge Dies When Struck by Crane Counterweight in Washington State	52-24-2012
	Machinist Dies After Being Struck by Rotating Steel Bar Stock in Lathe in Washington State	52-25-2012
	Operator Dies after Being Caught between Bulldozer's Track and Fender	52-26-2012
	Herrero muerto por el derrumbe de un encofrado de varillas (Spanish version)	71-100-2011
	Trabajador de un vivero electrocutado al tocar un cable aéreo de alta tensión con una tubería de riego (Spanish version)	71-101-2011
	Obrero aplastado bajo casa (Spanish version)	71-102-2011
	Contratista muerto debido al choque de un camión pluma (Spanish version)	71-103-2011
	Carpintero de obra cae al desplomarse una sección del piso (Spanish version)	71-105-2011
	Skid-Steer Loader Operator Crushed Between Backhoe Attachment and Cab	71-106-2011
	Operador de un cargador de dirección deslizante aplastado entre el accesorio retroexcavador y la cabina (Spanish version)	71-106-2011
	Electrician Falls from Ladder or Awning	71-107-2011
	Electricista cae de una escalera o un toldo (Spanish version)	71-107-2011
	Orchard Tractor Operator Dies When Tractor Rolls Over	71-108-2012
	Trabajador hortícola muere al volcar el tractor que operaba (Spanish version)	71-108-2012
	Laborer Run Over by Reversing Dump Truck in Highway Work Zone	71-109-2012
	Painter Falls from Stepladder	71-110-2012
	Dairy Worker Struck by Bull	71-111-2012
	Carpet Installer Dies After Falling from Window Opening	71-112-2012
	Crane Operator Dies after Falling from Crane Turntable Deck	71-113-2012
	Farm Laborer Killed by Falling 1,500 lb Hay Bale	71-114-2012

	Skid Steer Loader Operator Impaled by Rebar	71-115-2012
	Roofer Dies After Falling from Ladder or Roof	71-116-2012
	Obrero golpeado por brazo de excavadora al volcar (Spanish version)	71-96-2010
	Trabajador hortícola atrapado en una barrenadora para postes montada en un tractor (Spanish version)	71-97-2010
	Aparejador de grúa muere al ser golpeado por la carga de la grúa cuando cae (Spanish version)	71-98-2010
	Instalador de pisos muerto en un accidente automovilístico (Spanish version)	71-99-2011
	Bathtub Refinishers: Deaths from Methylene Chloride. from Methylene Chloride (MC)	81-8a-2012
	Successful Bathtub Stripping with Benzyl Alcohol as an Alternative to Methylene Chloride (MC)	81-8b-2012
	Parking Lot Attendant Falls Three Stories Off Manlift	91-10-2012
	Unguarded Conveyor Tears Ligament in Teen's Thumb	91-11-2012
	Un transportador no protegido desgarró los ligamentos en el dedo pulgar de un adolescente (Spanish version)	91-11-2012
	Landscaper Nearly Loses Finger Checking Underneath Mower Deck	91-12-2012
	Bicycle Delivery Driver Dies after Colliding with Car	91-13-2012
	Falling 700-lb Joist Breaks Laborer's Leg	91-14-2012
	Vocational woodshop laborer suffer partial thumb amputation while cutting board	91-15-2012
	Timber Cutter Suffers Broken Leg When Struck by Cut Tree Sliding Downhill	92-01-2012
	Hooktender Suffers Internal Injuries and a Broken Arm after Choker Breaks	92-02-2012
<b>2013</b>	Orchard Laborer Dies When Crushed Between a Motor Grader and Semi-Truck in Washington State	52-27-2013
	Truck Driver Dies after being Run Over by Propane Transport Rolling Backward at Bulk Plant	52-28-2013
	Orchard Tractor Operator Dies when Run Over by Trailer-Mounted Water Tank Towed by Tractor	52-29-2013
	Laborer Falls through Roof Opening	71-117-2013
	Deck Engineer on Barge Struck by Crane Counterweight	71-118-2013
	Orchard Laborer Crushed Between Grader and Semi-Truck	71-119-2013
	Bulldozer Operator Caught Between Track and Fender	71-120-2013
	Carpenter Falls from Beam while Setting Rim Joist	71-121-2013
	Carpintero cae de una viga mientras instalaba una vigueta de borde (Spanish version)	71-121-2013
	Carpintero cae de una viga mientras instalaba una vigueta de borde (Spanish version - slideshow)	71-121-2013
	Carpenter Falls from Beam while Setting Rim Joist (Slideshow)	71-121-2013
	Orchard Supervisor Run Over by Tractor and Attached Tank Sprayer	71-122-2013
	Orchard Supervisor Run Over by Tractor and Attached Tank Sprayer (Slideshow)	71-122-2013
	Framer Electrocuted when Crane Hoist Line Contacts Power Line	71-123-2013
	Framer Electrocuted when Crane Hoist Line Contacts Power Line	71-123-2013

	(Slideshow)	
	HVAC Technician Falls Through Skylight	71-124-2013
	Técnico de climatización o HVAC (por sus siglas en inglés) cae por un tragaluz (Spanish version)	71-124-2013
	HVAC Technician Falls Through Skylight (Slideshow)	71-124-2013
	Técnico de climatización o HVAC (por sus siglas en inglés) cae por un tragaluz (Spanish version - slideshow)	71-124-2013
	Shepherd Dies When ATV Struck by Motor Vehicle	71-125-2013
	Shepherd Dies When ATV Struck by Motor Vehicle (Slideshow)	71-125-2013
	Roofer Crushed Between Beam and Boom-Supported Elevating Work Platform	71-126-2013
	Roofer Crushed Between Beam and Boom-Supported Elevating Work Platform (Slideshow)	71-126-2013
	Successful bathtub stripping using sanding as an alternative to methylene chloride	81-8c-2013
	Un trabajador temporal lesiona gravemente su mano desatascando una máquina de recolección de polvo (Spanish version)	91-01-2011
	Un comprador de heno se fractura el cráneo, se quiebra el hombro al caerse de una mesa de procesamiento (Spanish version)	91-02-2011
	Un techador comercial se cae, se quiebra la pierna cuando la escalera se resbala (Spanish version)	91-04-2011
	La caída de un tronco causa lesiones internas y fractura la cadera de un trabajador (Spanish version)	91-06-2011
	Un jardinero casi pierde un dedo al inspeccionar la parte de abajo de la plataforma de corte de una cortacésped (Spanish version)	91-12-2012
	Young Worker Drowns After Kayak Overturms in River Rapids	91-16-2013
	Young woodworker's fingertips amputated by saw - "It took my hand with it"	91-17-2013
	Las yemas de los dedos de un trabajador joven fueron amputadas por una sierra (Spanish version)	91-17-2013
	Motorized Carriages Involved in a Fatality and a Serious Hand Injury	92-03-2013
	Timber Cutter Killed after Walking Under a Standing Cut Up Tree	92-04-2013
	Choker Setter Dies After Being Struck by Haywire	92-05-2013
	Choker Setter Struck by Log When Hung up Turn Comes Free	92-06-2013
<b>2014</b>	Timber Harvester Operator Killed Following a Chain Shot Incident	52-30-2014
	Operator Dies after Excavator Tips Over the Side of a Bridge into River	52-31-2014
	Painter/Rigger Falls 200 Feet from Bridge into River	71-127-2014
	Painter/Rigger Falls 200 Feet from Bridge into River (Slideshow)	71-127-2014
	Orchard Tractor Operator Run Over by Trailer-Mounted Water Tank	71-128-2014
	Orchard Tractor Operator Run Over by Trailer-Mounted Water Tank (Slideshow)	71-128-2014
	Contratista de techos cae de un techo desde 35 pies de altura (Spanish version)	71-129-2014
	Roofing Contractor Falls 35 Feet from Roof	71-129-2014
	Roofing Contractor Falls 35 Feet from Roof (Slideshow)	71-129-2014
	Contratista de techos cae de un techo desde 35 pies de altura (Spanish version)	71-129-2014

	Contratista de techos cae de un techo desde 35 pies de altura (Spanish version - slideshow)	71-129-2014
	Orchard Tractor Operator Run Over by Mower Attachment	71-130-2014
	Orchard Tractor Operator Run Over by Mower Attachment (Slideshow)	71-130-2014
	Pesticide Handler Run Over by Tractor	71-131-2014
	Pesticide Handler Run Over by Tractor (Slideshow)	71-131-2014
	Ironworker Falls 72 Feet from Mast Scaffold	71-132-2014
	Ironworker Falls 72 feet from Mast Scaffold (Slideshow)	71-132-2014
	Herrero cae de un andamio sobre mástil desde 72 pies (Spanish version)	71-132-2014
	Herrero cae de un andamio sobre mástil desde 72 pies (Spanish version - slideshow)	71-132-2014
	Backhoe Operator Crushed by Boom	71-133-2014
	Backhoe Operator Crushed by Boom (Slideshow)	71-133-2014
	Part-Time Fast Food Employee Suffers a Chemical Burn	91-18-2014
	Una trabajadora de tiempo parcial en la industria de comida rápida sufre una quemadura (Spanish version)	91-18-2014
	Chaser Dies When Crushed between Yarder and Stump	92-07-2014
	Choker Setter Falls 50 Feet from a Cliff	92-08-2014
	Timber Cutter Dies When Struck by Snag	92-09-2014
	Chaser Caught in Choker Bight	92-10-2014
	Timber Cutter Severely Injured when Struck by Snag	92-11-2014
	Choker Setter Injured When Struck by Log	92-12-2014
<b>2015</b>	Preventing Injuries to Retail Workers: How to Protect Retail Workers from being Struck by Motor Vehicles	47-23-2015
	Two Propane Gas Supplier Workers Electrocuted when Boom Truck Crane's Boom Contacts 7,200 Volt Overhead Power Line	52-32-2015
	Log Truck Driver Dies When Struck by Logs Being Loaded Onto Trailer	52-33-2015
	Orchard Laborer Dies after Being Struck and Run Over by Dump Trailer	52-34-2015
	Carpenter Falls from Ladder	71-134-2015
	Carpintero cae de la escalera (Spanish version - slideshow)	71-134-2015
	Carpenter Falls from Ladder (Slideshow)	71-134-2015
	Carpintero cae de la escalera (Spanish version)	71-134-2015
	Tractor Operator Crushed by Trailer	71-135-2015
	Tractor Operator Crushed by Trailer (Slideshow)	71-135-2015
	Laborer Electrocuted When Jackhammer Strikes Underground Power Line	71-136-2015
	Laborer Electrocuted When Jackhammer Strikes Underground Power Line (Slideshow)	71-136-2015
	Construction Worker Falls 14 Feet from a Beam onto Concrete and Suffers Serious Brain Injury	71-137-2015
	Construction Worker Falls 14 Feet from a Beam onto Concrete and Suffers Serious Brain Injury (Slideshow)	71-137-2015
	Hop Yard Laborer Struck by Hop Pole	71-138-2015
	Hop Yard Laborer Struck by Hop Pole (Slideshow)	71-138-2015
	Trabajador de finca de lupulos golpeado por un poste de lupulos (Spanish version)	71-138-2015
	Trabajador de finca de lupulos golpeado por un poste de lupulos (Spanish	71-138-2015

version - slideshow)	
Timber Cutter Injured When Struck by a Hung-up Tree	92-13-2015
Chaser Run Over by Loader	92-14-2015
Choker Setter Dies When Struck by Log	92-15-2015
Two Rigging Crew Members Injured When Log Slides Off Landing	92-16-2015

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### Data Sets

Research resources and data collected under the Washington State Occupational Injury and Illness Surveillance Program grant can be made available to qualified individuals within the scientific community after publication. In Washington State, data sharing is governed by our state public disclosure laws, and additional specific Washington State statutes and administrative regulations associated with the entity owning the data system from which occupational injury and illness data or workforces estimates are ascertained.

### Other Materials available for other investigators

Other research materials or protocols may be available under the conditions described above. Qualified individuals within the scientific community who are interested may contact the Washington State Occupational Injury and Illness Surveillance Program directly.

### Inclusion of gender and minority study subjects

No subjects were excluded based on gender or race/ethnicity. A completed cumulative inclusion enrollment report is attached.

### Inclusion of Children

Surveillance data were passively collected. Per the definition provided by NIH, children are less than 21 years of age. Data was collected for persons younger than 21. There were a small number of injured workers less than 21 years of age identified by the surveillance system. Care was taken to ensure guidelines for working with small numbers were followed for protection of confidentiality in data analysis and presentation. The number of injured workers and subsequent respondents for children under 18 were too small to make any meaningful conclusions about this population.

**Cumulative Inclusion Enrollment Report**  
**Washington Fatality Assessment and Control Evaluation (FACE) Program**

Program Director: Todd M. Schoonover, PhD, CIH, CSP

Grant Number: 2 U60 OH008487

Racial Categories	Ethnic Categories									Total
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	0	4	1	0	1	0	0	1	0	7
Asian	3	12	1	0	0	0	0	0	0	16
Native Hawaiian or Other Pacific Islander	0	0	0	0	0	0	0	0	0	0
Black or African American	0	3	0	0	0	0	0	0	0	3
White	18	212	0	3	39	0	0	1	0	273
More Than One Race	0	0	0	0	0	0	0	0	0	0
Unknown or Not Reported	0	0	0	0	0	0	0	13	0	13
<b>Total</b>	<b>21</b>	<b>231</b>	<b>2</b>	<b>3</b>	<b>40</b>	<b>0</b>	<b>0</b>	<b>15</b>	<b>0</b>	<b>312</b>

**PFA: Using Workers' Compensation Data to Identify High Risk Workplaces for Work-related Musculoskeletal Disorders (WMSDs)**

Washington Occupational Injury and Illness Surveillance Program:

CDC/NIOSH Cooperative Agreement: 5 U60 OH 008487

Project Period: July 1, 2010 – June 30, 2015

Final Report Completed: September 25, 2015

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## **PFA: Using Workers' Compensation Data to Identify High Risk Workplaces for Work-related Musculoskeletal Disorders (WMSDs)**

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**Abstract:** Work-related musculoskeletal disorders (WMSDs) are soft-tissue disorders of non-traumatic origin that are caused or exacerbated by the interaction with certain risk factors in the work environment. Across 6 industry sectors, the present study aimed to characterize WMSD of the back, shoulder, hand/wrist and knee using workers' compensation claims, WMSD injured worker interviews, comparisons of the WMSD exposure and organizational climate between low and high WMSD claims. From these activities a WMSD hazard surveillance tool was developed.

An examination of data from WMSD surveillance system found WMSDs accounted for approximately 40% of costs between 2002-2010. Costs were higher for WMSDs (\$44,687). The Healthcare sector was first on the Prevention Index with a compensable incidence rate (CIR) of 108.4 claims/10,000 FTEs and a severity rate (SR) of 12,085 lost workdays/10,000 FTE.

The a prior risk factors most frequently reported from injured worker interviews in the manufacturing, wholesale/retail and healthcare sectors were lifting, work pace, and repetitive hand/wrist motions. In a comparison of physical job characteristics between low and high WMSD claim companies, several differences emerged. More workers in high back WMSD claim healthcare companies performed heavier lifting (object weights were 3 times heavier than the ACGIH Lifting TLV) compared to low back WMSD claim companies (OR = 2.580, 95%CI: 1.359 – 4.899 for the lifting). No risk factors were statistically different between the high and low knee WMSD claim healthcare companies. In manufacturing, high repetition, high pinch force and high hand activity risk levels were associated with high hand/wrist WMSD claim companies compared to low WMSD claim companies, OR = 1.951 (95%CI: 1.216 – 3.130), 2.666 (1.365 – 5.205) and 2.238 (1.225 – 4.086) respectively. In wholesale/retail, based on the Quick Exposure Check wrist/hand score, more jobs among the high WMSD claim companies were in the very high risk category (20%) compared to that (5%) in the low WMSD claim companies (OR = 9.778, 95%CI: 1.876 – 50.965). No risk factors were statistically different between the high and low knee WMSD rate companies in the wholesale industry.

Using the results of assessment tools, evidence based physical job evaluation checklists have been created for the manufacturing, wholesale/retail, and healthcare sectors. These checklists provide companies with a tool to evaluate the risk of injury from physical risk factors common to an industry and to aid in prioritizing injury prevention efforts. Industry-specific reports have been created summarizing the results of the study for the manufacturing, wholesale/retail and healthcare sectors. Additionally, workshops for each industry were held for study participants to aid in the synthesis of the results and provide training on the physical job evaluation checklists. Using historical workers' compensation data as an outcome for risk of injury from WMSD risk factors was problematic in that the outcome is not directly

related to the exposure assessment. Additionally, not all potential risk factors for WMSD were captured by the exposure assessment tools.

## Section 1

### Significant (Key) Findings

The overall goal of this project was to test a surveillance system, which utilizes workers' compensation data for work-related musculoskeletal disorders (WMSDs), to identify high hazard workplaces for prevention efforts. Significant findings include the following:

Work-related non-traumatic musculoskeletal disorders (WMSDs) of the back, upper extremity and knee accounted for 43% of the compensable workers' compensation between 2002 and 2010 in Washington State. Unlike previous analyses of the data, the knee was included.

Combined state-funded and self-insured indemnity costs were \$3.87 billion for this period compared to \$8.22 billion for all compensable claims. The median time loss days averaged 56 for WMSDs.

Workers' compensation claims were most common for the back, accounting for 19.5% of all compensable claims.

Overall, for State Fund compensable claims, WMSD claims significantly decreased by 6.26% by year, which was a greater or faster decrease than that of non-WMSD claims which decreased by approximately 2.25% by year during the report period.

Interviewed injured workers with WC claims in Manufacturing, Wholesale/Retail and Healthcare reported working through injury and heavy workloads as risk factors for WMSD injuries.

A common prevention strategy identified from interviews of injured workers in Manufacturing, Wholesale/Retail and Healthcare industries was increasing staffing levels.

In the healthcare industry, it was found that more workers in companies with high back WMSD claims rates spent more time standing (OR = 1.874, 95%CI: 1.068-3.285) and performed more heavier lifting (OR = 2.580, 95%CI: 1.359 – 4.899) than workers in companies with low back WMSD claims rates based on results from on-site job evaluations.

In the manufacturing industry, high repetition (OR = 1.951, 95%CI: 1.216 – 3.130), high pinch force (OR = 2.666, 95%CI: 1.365 – 5.205) and high Strain Index risk level (OR = 2.238, 95%CI: 1.225 – 4.086) were associated with high hand/wrist WMSD claims rate companies compared to low WMSD claims rate companies according to job evaluation results.

In the wholesale industry, more jobs required prolonged standing for greater than 6 hours (OR = 4.567, 95%CI: 1.916 – 10.888) and lifting in the Washington State's Caution Zone (OR = 15.333, 95%CI: 1.866 – 126.022) among the high back WMSD claim rate companies than those in the low WMSD rate companies.

Based on WMSD risk factor evaluations using validated assessment methods, an industry specific job analysis evaluation checklist was developed for healthcare, manufacturing and wholesale/retail industries. Each tool evaluates exposure to WMSD risk factors and assigns a level of risk of injury to each (low, moderate, high and very high). A summary report is produced which identifies the factors with the highest risk of injury.

## Translation of Findings

The burden of musculoskeletal disorders continues to be overwhelming, for workers' compensation insurers, employers and workers. The WMSD disorder surveillance system provides useful and current data to identify high-risk industry sectors and help focus educational and prevention efforts.

The industry-specific Physical Job Evaluation Checklists will provide employers a tool to quickly and easily assess their work activities for WMSD risk factors. Using the determinations of risk from these checklists, employers will be able to identify high risk jobs and be able to prioritize their injury prevention efforts. These checklists can also be used to evaluate interventions that have been implemented by comparing pre-intervention results to post-intervention results.

Developing effective and feasible intervention solutions applicable to these industries to deal with heavy material handling, including patient handling, is important and can be effective in dealing with the low back problem. In the manufacturing and wholesale industries, it may be important to develop specific solutions that can address intensive hand activity tasks. This may be of help in reducing hand/wrist injuries. Work pace appears to be an important factor associated with high WMSD claim rates in all the three industry sectors. Optimized work organization that establishes an appropriate work pace may be beneficial in reducing WMSD claims.

## Outcomes and Impact

### *Potential Outcomes*

- 1) The Physical Job Evaluation Checklists can identify areas of the work environment that poses a risk of WMSD disease or injury. As the Department of Labor and Industries moves towards reducing WMSDs from manual material handling, the checklists direct identification efforts to only those factors that present a significant risk in a particular industry.
- 2) The WMSD surveillance program continues to provide useful data to promote and develop injury prevention strategies. The additional of an observational evaluation surveillance component will provide more accurate industry-wide data.

### *Intermediate Outcomes*

- 1) A video was produced describing the personal cost of a WMSD to a certified nursing assistant. This video has been posted on YouTube (<http://deptoflaborandindustries.tumblr.com/post/125182524986/the-caretaker-crisis-investigating-work-related>). This video has been viewed 524 times to date. The National Association of Injured and Disable Workers has included a link to this video on their website.

For a number of companies who participated in a job evaluation site visit and received a report summarizing the risk factors identified in their jobs have used the information in their safety meetings and to change their work techniques.

## Section 2

### Scientific Report

#### Background

Work-related musculoskeletal disorders (WMSDs) are soft-tissue disorders of non-traumatic origin that are caused or exacerbated by the interaction with the work environment. Previously estimated annual workers' compensation costs for WMSDs in the United States have varied between \$13 and \$20 billion in direct costs. [1] Estimated annual costs of "overexertion injuries" at work in the United States are now \$9.8 billion, having decreased about 5 percent between 1998 and 2007. Estimated annual costs of repetitive motion injuries are now \$2.1 billion, having decreased about 35.3% during the same time period.

For 2013, the Bureau of Labor Statistics reported 917,090 WMSDs in private industry in the United States -- an annual incidence rate (IR) of 33.5 cases per 10,000 workers. WMSDs accounted for 34 percent of all injuries and illnesses[2]. On average, they resulted in a median of 11 days away from work. Health care and social services industry had one of the highest incidence rates of 50.2 cases/10,000 FTEs, followed by construction (41.9), retail (41.8), agriculture (41.5) and wholesale (37.0). Nursing assistants reported a WMSD incidence rate of 202.4 (19,760 cases), while stock clerk and order fillers and retail clerks had IRs of 84.7 and 28.4, respectively.

Incidence and direct costs for workers' compensation cases of WMSDs by body area and specific conditions have been reported by Washington State. In a 2007 report of WMSDs of the upper extremity, between 1997 and 2005, WMSDs of the neck, back and upper extremity represented more than 25% of all state fund claims, more than 40% of all lost time claims and 45% of all costs[3]. In Washington State, within the same industry sectors (designated by a 4-digit NAICS code), the WMSD claim rates can vary significantly (Table 1). Possible contributing factors may be the size of the industry in the region, the distribution of company sizes within the industry and how varied the processes utilized by the companies within an industry. However, no research has been done to investigate this.

**Table 1. Washington State WMSD Claims Rates (claims/10,000 FTEs) by 4-digit NAICS Code Industry, 2002-2010.**

<b>Industry (4-digit NAICS)</b>	<b>Back</b>	<b>Shoulder</b>	<b>Hand/Wrist</b>	<b>Knee</b>
Agriculture, Forestry & Fishing	15.1- 98.6	5.7-22.2	2.4-29.6	3.5-56.4
Construction	35.0-117.7	9.3-33.0	7.0-63.8	2.3-27.6
Transportation, warehousing & utility	4.8-137.4	1.3-66.2	3.2-96.9	3.2-45.6
Wholesale and retail trade	10.4-116.4	2.7-31.5	3.6-36.4	1.5-17.4
Services (except public safety)	0.7-123.3	0.2-58.3	1.4-39.7	0.4-81.4
Healthcare & social assistance	8.4-135.6	5.6-34.6	3.8-28.7	3.0-21.2
Manufacturing	3.2-271.0	2.8-65.7	3.2-36.4	1.5-17.4

While under-reporting of cases in the BLS and workers' compensation data has been examined[4], lost work time and earnings probably continue much longer than reported in official statistics[5]. When workers' compensation cases for upper extremity fracture to WMSDs were compared, on average, those

with fractures generally returned to pre-claims earnings within one quarter, whereas, workers with carpal tunnel syndrome did not recovered to pre-claim annual earnings even 7 years after filing a claim<sup>[6]</sup>.

While there have been different national and state estimates of the magnitude of WMSDs, there has been very little work on working population estimates of exposures to risk factors or hazards for WMSDs. WMSDs are associated with a number of risk factors in workplaces due to work methods, processes and organization<sup>[7]</sup>. These risk factors include high hand force, high repetition, awkward postures, static postures and hand-arm and whole body vibrations<sup>[7]</sup>. Environmental factors such as high and/or low temperatures may contribute to the development of WMSD as well. In order to quantify the risk level of these risk factors, one needs to consider not only the level of these risk factors (such as level of force, amount of repetition and extent of awkward postures), but also the duration and frequency of these risk factors occurring. The duration and frequency of risk factors can be influenced by the work organization (duration of task/job, job rotation, working hours etc.).

There is an ongoing need for hazard surveillance of WMSDs. Developing and testing health and hazard surveillance methods and tools for WMSDs that can be used in workplaces to assess and address WMSD risk factors is a valuable asset for WMSD surveillance. There is also increasing evidence that the organizational culture in which work takes place has a strong influence on perceived risk and willingness to report and fix hazards and is a leading indicator for occupational injuries<sup>[8,9,10]</sup>. Organizational culture is the interaction between the organization and individuals, where employees' behavior can change through mutual interaction. Choudhry et al<sup>[11]</sup> suggested that safety culture is quite a complex construct that can be seen in the structure of the organization including policies, working procedures, management systems while behavioral aspects can be measured via peer observations, self-reporting and outcome measures using checklists. However, the culture is not fixed.

### Specific Aims

The overall goal of this project was to develop and test a surveillance system for work-related musculoskeletal disorders (WMSDs) like carpal tunnel syndrome or tendonitis of the shoulder, hand/wrist, back and knee using workers' compensation data to identify high hazard workplaces for prevention efforts. Within this framework, the specific aims of this project were:

1. To characterize the magnitude and distribution of WMSD workers' compensation (WC) claims frequency, incidence and cost by industry (NAICS) and size.
2. To conduct WMSD injured worker telephone interviews within one month of their identification as a compensable claim (4 or more lost workdays) (n = 320.) These interviews will be conducted over the first four years regarding perceived WMSD risk factor exposures and safety culture. Information obtained from these interviews will be paired with information from specific aim 5 to inform WMSD hazard surveillance tool development.
3. To conduct 64 paired site visits (paired on industry and size but one with high (upper quartile) and the other with low (bottom quartile) incidence rates for shoulder/hand/wrist and back/knee WMSDs to identify potential differences in exposures, management culture, and safety issues awareness via site walkthroughs .
4. To conduct manager/union or safety committee member interviews among high (top quartile) and low (bottom quartile) incidence rate companies by industry group within each NORA sector regarding injury experience (perceived frequency, severity, causes and consequences), WMSD risk factors, training, employment patterns (temporary or seasonal workers, overtime work, etc.), safety culture, and turnover to identify potential explanations for differences in WC claims' rates. Information obtained from these interviews will be paired with information from specific aim 4 to inform WMSD

hazard surveillance tool development.

5. To use the information from specific aims 2, 3, and 4 to develop and disseminate a WMSD hazard surveillance tool for public/occupational health practitioners and worksites to assist them in focusing their WMSD prevention efforts.

The underlying hypothesis of this project is those companies with high workers' compensation WMSD claim rates of the back, shoulder, hand/wrist and knee will have higher exposures to physical risk factors of WMSDs and a worse organizational culture than those companies with lower claims rates

## Methodology

### ***Magnitude and Distribution of WMSD Workers' Compensation Claims***

#### *Workers' Compensation Data*

Workers' compensation (WC) claims data and employment data for the years 2002-2010 were obtained from Washington State Department of Labor and Industries' (L&I) files for non-traumatic cumulative back, elbow, shoulder, hand, wrist and knee disorders. In Washington State, employers (except the self-employed) are required to obtain workers' compensation insurance through the Department of Labor and Industries' (L&I) industrial insurance system (L&I State Fund) unless they are able to self-insure. L&I's State Fund covers approximately two-thirds of the workers in Washington State. The remainder work chiefly for the approximately 400 largest employers and are covered by their Self-Insured (SI) employers. Washington is the only state in which workers contribute monetarily to the medical aid portion of the State Fund.

Medical treatment and diagnosis records were extracted from the Medical Information and Payment System (MIPS) database including Current Procedure Terminology (CPT) codes and physician diagnoses by International Classification of Disease, version 9 (ICD-9) codes. The Occupational Injury and Illness Classification System (OIICS) coding was determined for claims received after July 01, 2005. Records for wrist, hand, elbow, shoulder back, and knee conditions were extracted from the Labor and Industries' Industrial Insurance System (LINIIS) claim history dataset by using the ANSI z16.2 codes for body are. LINIIS contains all data necessary for the administration of State Fund claims (e.g., claim type, nature, occupation, employer information, status, and progress). Only those Self-Insured compensable claims resulting in 4 or more days of lost time are coded in the LINIIS system. Rarely are there ICD-9 codes or medical billing information in the MIPS database for the Self-Insured claims. Thus, the Self-Insured data are not comparable to the State Fund data in terms of magnitude or cost.

Though a workers' compensation claim in Washington State may include disorders in more than one body part, only the primary site was assigned a ANSI Z16.2 code. Traumatic and non-traumatic onset was categorized to differentiate cumulative trauma exposures from acute exposures. A combination of body part, nature codes and injury type codes were required. First date of injury was used to estimate claims incidence.

All Washington WC claims coded for occupation injury or illness were reviewed. This included all State-Fund claims, and all Self-Insured claims that were not rejects or were not medical aid only claims. The claims were then evaluated by body part – back, shoulder, elbow, hand/wrist and knee. There were three potential ways to classify a WMSD:

- 1) A restrictive body part code and a more general diagnosis – such as the body part coded wrist with a diagnosis code of 727.00 (tenosynovitis),
- 2) A more generalized body part code with a diagnosis that clearly indicates the specific body part, such as a body part coded arm with a diagnosis code of 727.05 (tenosynovitis of the hand and wrist),
- 3) The coding alone clearly indicated a WMSD, such as nature code 1241 (carpal tunnel syndrome)

Claims were further assessed for specific conditions: sciatica, rotator cuff syndrome, epicondylitis, tendonitis, carpal tunnel syndrome and bursitis. This assessment was based on specific diagnosis codes or relevant surgical procedures. Certain diagnoses, such as carpal tunnel syndrome, could be classified as either a diagnosis code or a nature code.

WC claims data were extracted from L&I databases as of 7/18/2012. Information collected from each claim is described in Table 2. Claim costs reflected actual totals for closed claims. For State Fund claims that were not closed, costs reflected the actual totals to this date *plus* the additional case reserve estimated by agency staff. Costs for these claims were expected to develop further. For Self-Insured compensable closed claims, data tended to be more incomplete than State-Fund data, including costs and time loss. Consequently, the distinction between traumatic and non-traumatic onset was not as clearly delineated.

**Table 2. Washington Workers' Compensation Data Extracted, 2002-2010**

<b>Claims Data</b>	<b>Definition</b>
Claim status	Compensable lost time claim of 4 or more days
Body Area	ANSI z16.2
Nature of Injury	ANSI z16.2, OIICS
Accident Type	ANSI z16.2, OIICS
Washington Industrial Code (WIC)	4 digit
North American Industrial Classification System (NAICS)	6-digit
Date of Injury	
Birthdate	
Gender	
Total Cost of claim	Indemnity costs only
Lost time days	7-day work week, does not include kept on salary
Time Loss Payments	
Medical aid payments	

### ***Washington State Employment***

Employment information is reported by State-Fund employers as the number of hours worked by their employees. Hours by age and gender are not available. The number of employees working per year was calculated assuming that each full-time employee worked 2,000 hours per year (40 hours per week for

50 weeks per year). Hours were converted to full time equivalent workers (FTEs) as: Total Hours Reported / 2,000.

Claims data were analyzed by industry group. To eliminate unstable rates, only those North American Industrial Classification System (NAICS) codes and Washington Industrial Codes (WIC) codes with an average of 50 FTEs per year or more over the 9-year period were included in the industry group analyses. In addition to analyzing industry groups by 4-digit NAICS we also used NORA sector groupings as a level of analysis.

### ***Statistical Analysis***

General descriptive analyses were conducted and included the frequency of claims by year, by age, by gender and by direct workers' compensation costs. Incidence rate (number of new claims per 10,000 full-time equivalent employees), severity rate (number of lost days per 10,000 FTEs), lost time and industry group distribution of work-related musculoskeletal disorders was also determined.

Specific rates for industry sub-groups were compared to the industry level rate and a crude incident rate ratio or relative risk was calculated. A test for trend of incidence rates over time was performed using a Poisson regression analysis in SAS Software<sup>[12]</sup>. Differences between rates were tested by Poisson regression with an interaction term for the compared rates. WMSD claims were compared to all claims, excluding WMSDs. The different categories within WMSDs were compared to all claims. Rates were also compared by the Prevention Index (PI), an index that considers both frequencies of claims and relative risk.

$$\text{Prevention Index (PI)} = \frac{\text{Frequency Rank} + \text{Incidence Rank}}{2}$$

### ***WMSD Injured Worker Interviews***

#### *Identification of potential interviewees*

The recruitment goal for injured worker interviews was ten claimants, male or female, for each of six industry sectors (manufacturing, construction, wholesale/retail trade, service (excl. Public Safety), agriculture and healthcare & social assistance) and each of four body regions (10 x 6 x 4 = 240 total). Injured workers were selected for recruitment using a two-stage process. First, a query was developed to extract key data fields from the Washington State Department of Labor and Industries' workers' compensation claims data warehouse. The data warehouse is a single-source collection of agency data which provides easily accessible information in support of tactical and strategic decision-making. This query was run monthly to identify all new claimants whose:

- Employers' 4-digit NAICS code matched one of twenty-three target industries;
- Injury diagnosis met Washington State Department of Labor and Industries definitions for WMSDs;
- Injury body region was back, shoulder, hand/wrist or knee;
- Claim status was compensable (4 or more days paid time loss); and

- Telephone number field was not blank.

The agency definition of a WMSD is derived from a combination of the body part with the nature and type of injury (ANSI z16.2 codes). Non-traumatic type codes include those caused by repetitive motion, overexertion, bodily reaction, etc. Key data for each claim included claimants' name, age, phone number, mailing address, date of injury, nature and type of injury, body area, physician diagnosis, claim status, employer, industry, and time loss days paid. The second step involved flagging all new claimants whose sector/body region quota of ten had not yet been achieved.

### *WMSD Injured Worker Survey instrument*

Areas of inquiry included past and present work experience, typical daily task characteristics, descriptions of injury onset and potential preventive measures, as well as self-reported exposures for WMSD risk factors and demographics. We followed an interview approach used successfully in SHARP's Trucking Injury Reduction Emphasis through Surveillance (TIRES) project where we have conducted more than 420 injured worker interviews over 4 years. The interview guide included a mix of discreet (numeric) and open-ended questions that allowed interviewees to describe their experiences in detail. Following the completion of 66 interviews, preliminary review of the interview data revealed the need to modify several items. One question ("Did this injury happen suddenly, or were you having symptoms over time?") did not offer participants mutually exclusive answer options because a person may both tolerate certain symptoms over time as well as perceive their injury as having happened suddenly. This question was removed and a new series of questions was added to ascertain (1) the existence and nature of WMSD symptoms prior to the date of injury, (2) the frequency and (3) the duration of their occurrence. Two questions from the original instrument, though worded differently, asked for the same information, and as such, only one question was kept ("Please describe how the problem occurred--what were the circumstances?") For the same reason, an item regarding injury location was also removed. Finally, one item ("Was this injury the result of something going wrong with: the equipment, the process, or was there another upset condition?") was removed due to the ambiguity of the question and the resulting range of responses. This question may have prompted participants to frame their responses around working conditions which were "going wrong", either directly or indirectly as a result of their own actions or complacency. The final interview guide is located in Appendix A. An additional 96 interviews were to be conducted in years 4 and 5 of the study, amending the interview based on insights from site visits. However, following the preliminary review of interview responses, it was determined that the initial sample size of 320 would provide a representative sample of injured workers and that the modifications to the interview provided an adequately robust and insightful instrument.

### *Recruitment methods*

Introductory recruitment letters (Appendix B) were sent out to interview candidates within 1-2 weeks of identifying each compensable (lost time) case that met selection criteria. Calls were initiated within one to two weeks after letters were sent. At least four calls were made before discontinuing all attempts to contact them; at which point their record was removed from the list of claimants to be called (the "call list"). New claims were added to the call list with each monthly claims extract, and those claimants whom we were unable to reach after four calls were removed. Interviews were conducted over a land-line telephone and recorded using a digital hand-held recorder. Each interview began by soliciting verbal consent from the candidate following an approved script. Once consent was gained, the interview proceeded using the approved interview guide.

## Data analysis

Audio files were transcribed verbatim, and both text and numeric data were entered into a Microsoft Access database. All data were then exported to QSR Nvivo 9<sup>[13]</sup> to be reviewed and systematically coded for thematic content. Open coding of interview data was performed using a cross-case analysis process to help identify patterns or trends among responses to specific questions. This process began by reviewing interview transcripts—and assigning short, meaningful codes to passages of text based on the theme(s) they most pertinently conveyed. Codes regarding risk factors were initially divided into two categories: a priori and emergent. A priori codes were identified in advance, and consisted of all major musculoskeletal risk factor categories to be measured empirically during employer site visit job observations (e.g. lifting, carrying, vibration, stress, etc.). Emergent codes were those risk factors which were reported by interviewees as significant but which were not identified by the physical assessment methods used in this study. Each passage of text was assigned at least one code, and most passages were assigned multiple codes. There was no set limit to the number of codes which could be assigned to a passage of text. Categories and concepts were then related to each other through an axial coding process by grouping associated concepts together into major themes. Sub-themes that supported (or otherwise comprised sub-divisions of) overarching concepts were grouped together under these major themes, resulting in a branching structure of related topics. Once this process was complete, exemplar quotes of major themes were flagged for reference to be used in future publications. Exemplar quotes are excerpts from interviews which succinctly capture and convey the essential aspects of a key theme or code. Using an interview with an injured worker from the Services industry, Table 3 illustrates how interview responses were interpreted during the coding process.

## Physical Exposure Assessment

### Selection and Recruitment of companies for Site Visits

Employers were identified for inclusion through a multi-step process using claims data extracted from the Labor and Industries' Workers' Compensation data warehouse. Of the ten industry sectors described in the NORA program, six industry sectors included in this study.

**Table 3 - Major Themes, Examples of Sub-Themes, and Exemplar Interview Excerpts**

<b>Major theme</b>	<b>Theme(s)</b>	<b>Interview excerpt</b>
A priori risk factors	<ul style="list-style-type: none"><li>• Pinch grip</li><li>• Repetitive hand/wrist motion</li><li>• High hand force</li></ul>	<i>"They were giving me more of the electrical stuff that come in tiny bags and the little drill bits that come in 12 in a pack. The hardest part was once you get everything in the bigger boxes, then you've got the weight. And it was still a lot of that pinching and grabbing."</i>
Emergent risk factors	<ul style="list-style-type: none"><li>• Working through injury</li><li>• Compensating for injury</li><li>• Returning to work too soon</li><li>• Peer pressure</li></ul>	<i>"I was at work one day and I messed up my left thumb. I went back to work with a splint on doing light duty, but my overuse of my right hand, trying to make up for my left hand, eventually wore on my right hand and made that a problem. The pace of work that they make people work down there is not right. Every time you don't get to the 40 lines you</i>

		<i>get, 'I'm upset because you're not up to 40 lines per hour, and we need that otherwise we can't have you here.' So it pushes you to do more when you keep getting pressured like that."</i>
Potential prevention measures	<ul style="list-style-type: none"> <li>• Slower work pace</li> <li>• Management support</li> <li>• Increased staffing</li> </ul>	<i>"Let people work how they want to work. Don't push them. Look more at accuracy. She keeps complaining to them about how they're not going fast enough, but when they get too many errors they let them go. I think if somebody would just look at what they're putting everybody through, get one of those guys down from the top and let him go down and see if he wants to pick items off the floor and put them onto a cart. He wouldn't do it."</i>

The NORA sectors were: (1) Agriculture, (2) Construction, (3) Manufacturing, (4) Wholesale and Retail Trade, (5) Services (except Public Safety), and (6) Health Care and Social Assistance. Both Mining and Oil and Gas Extraction were excluded because of their relatively small presence in Washington State; Public Safety was excluded to avoid research activities potentially compromising the critical nature of their work; Transportation, Warehousing, and Utilities was excluded due to the logistical challenges of conducting job observations of drivers covering long distances in and out of state.

Next, we identified sub-industries within the NORA sectors, at the 4-digit NAICS level (NAICS-4). Within individual industries, we determined a count of WMSD claims for each of four body areas (back, shoulder, hand/wrist, and knee) for employers during years 2000-2008. Injury rates were calculated using the average number of full-time equivalents (FTE) of each employer over that time period. Employers within each NAICS-4 industry were then further stratified into three size groupings: small (20-49 FTEs), medium (50-99 FTEs), and large (>100 FTEs). Employers with fewer than 20 FTEs were excluded, as these companies are not required by law to maintain a safety committee.

Within each sub-group (NAICS-4 x size), employers were ranked by back, shoulder, hand/wrist, and knee WMSD injury rates. For each body area, those employers in the upper quartile were designated as high WMSD rate companies while those in the lower quartile were designated as low WMSD rate companies.

From this established pool of eligible potential participants, we selected companies for recruitment for exposure assessment based on several criteria. Our goal was to recruit companies in pairs, such that each pair matched on:

- 4-digit NAICS code,
- size category (small, medium, or large), and
- body area (one high WMSD rate company and one low WMSD rate company in the same body area category).

Within each industry sector, we selected two company pairs for each body area category. We also sought to recruit a similar number of company pairs in each size category. To accomplish this goal, we employed several tactics. We strategically selected 4-digit NAICS categories within each sector that supplied a large number of companies in all size categories from which to recruit. We also created a hierarchy of companies based on the body area claims rate rankings; companies with high WMSD rate or low WMSD

rate designations in all four body area categories were ranked highest in this category, as they yielded the most possibilities for pair matching. Participation was voluntary, therefore many different companies were contacted before each place in the pairing scheme was established and filled. Also, if a company declined participation in the exposure assessment, we attempted to recruit them for participation in management/labor interviews only.

Following years one and two of the study, we found that to ensure we could meet our recruitment goals, it was necessary to increase our pool of eligible participants. We found that the anticipated size (FTE) of recruited employers did not always match their actual size. This could have been a result of the timing of the study coinciding with the Great Recession of 2008; it was possible that while many employers had let go workers, other companies had gone out of business entirely, while still others had grown as a result of acquiring competitors. Therefore, at the outset of year three, we updated our employer sample frame dataset to include injury rates based on claims filed between years 2002 to 2010. The methods used to obtain these data were identical to those used at the outset of the project.

Other practical factors influenced our selection. We limited recruitment of companies with many locations dispersed across the state. Several companies were disqualified due to a mismatch between their NAICS classification and the type of work their workers perform (assessed through phone conversations). Throughout the recruitment process, we discovered the difficulty of recruiting companies from certain industry groups (e.g. janitorial – disinclination of employers to allow site visits on private sites), and adjusted our selection strategies by recruiting from a more accessible industry group.

To recruit companies for voluntary participation, we employed several strategies. Most recruitment occurred through phone contact, but some recruitment occurred at company sites when telephone contact was ineffective or in order to build rapport. Frequently, introductory letters describing the objectives and methods of the study were mailed to potential employer participants either prior to or following a telephone conversation. Often, upon contacting an employer via telephone, they requested additional information about the project to share with their coworkers. In most cases, we obtained an email address from them and sent them a standard description of the study including research objectives, methods, and statements regarding confidentiality and the voluntary nature of participation. If a company did not respond to voicemails and we felt the recruitment was taking too long, we moved on to contact another company to fill that spot. Successful recruitment often required navigating through multiple gatekeepers to find a safety-committed individual and/or the person with decision-making authority. We began phone contact by asking “May I speak with the person at your company who is in charge of employee safety?”

### *Job evaluation (physical exposure assessment)*

The main objectives of the job evaluations were (1) to determine the existence of musculoskeletal disorder risk factors among the typical jobs in the workplaces of the selected industries, (2) to determine the risk levels of these typical jobs, (3) to study the differences in job risk levels between low and high WMSD claim rate paired companies, and (4) to develop an industry-specific job evaluation tool for each of the selected industries. These objectives were accomplished by evaluating a sample of jobs in the selected paired companies using a battery of job assessment methods. Worksite visits were conducted to collect needed information so that risk identification and job evaluation could be performed. Data analyses were performed to determine job risk levels, and summarized by industries. From the assessment results, industry specific job evaluations were developed. Analyses were also performed

between paired companies in order to identify patterns that might result in the disparity in WMSD claims rate observed from the workers' compensation databases.

### *Job evaluation tool development*

A comprehensive job evaluation tool was developed, using existing exposure assessment tools, to achieve the job evaluation objectives (Appendix C). Criteria for selection of existing exposure assessment methods were:

- (1) The method needed to address at least of the MSD risk factors and/or determine the risk level (e.g. duration and frequency),
- (2) The method has been previously published,
- (3) The method is popularly used by researchers and practitioners in the WMSD community,
- (4) The method evaluates without the need of sophisticated instruments (e.g. electromyography) or complicated mathematical calculations (e.g. biomechanical modeling), and consequently, can be used among a relatively large population with minimal interruptions to the workers
- (5) The method quantifies risks related to injuries of the low back, shoulder/neck, hand/wrist and knee.

The job evaluation process was two-step process. The first step was to identify whether a risk factor presented a "potential concern". The operational definition of a "potential concern" used the "caution zone" definitions of the Washington State's (WA) Caution Zone Checklist <sup>[17]</sup> risk factors (e.g. pinch hand force, lifting, hand overhead etc.). For those risk factors which were not included in the WA Caution Zone Checklist, such as prolonged sitting and standing, trigger limit values based on either textbook or consensus among professional ergonomists were used. When a risk factor did not exist or was at a lower level than trigger limit value in a worker's job, no further evaluation was needed for that risk factor.

When a risk factor in a job reached trigger limit value, a further evaluation or the 2<sup>nd</sup> step was then required. A set of well published assessment methods together with some complimentary methods were then followed.

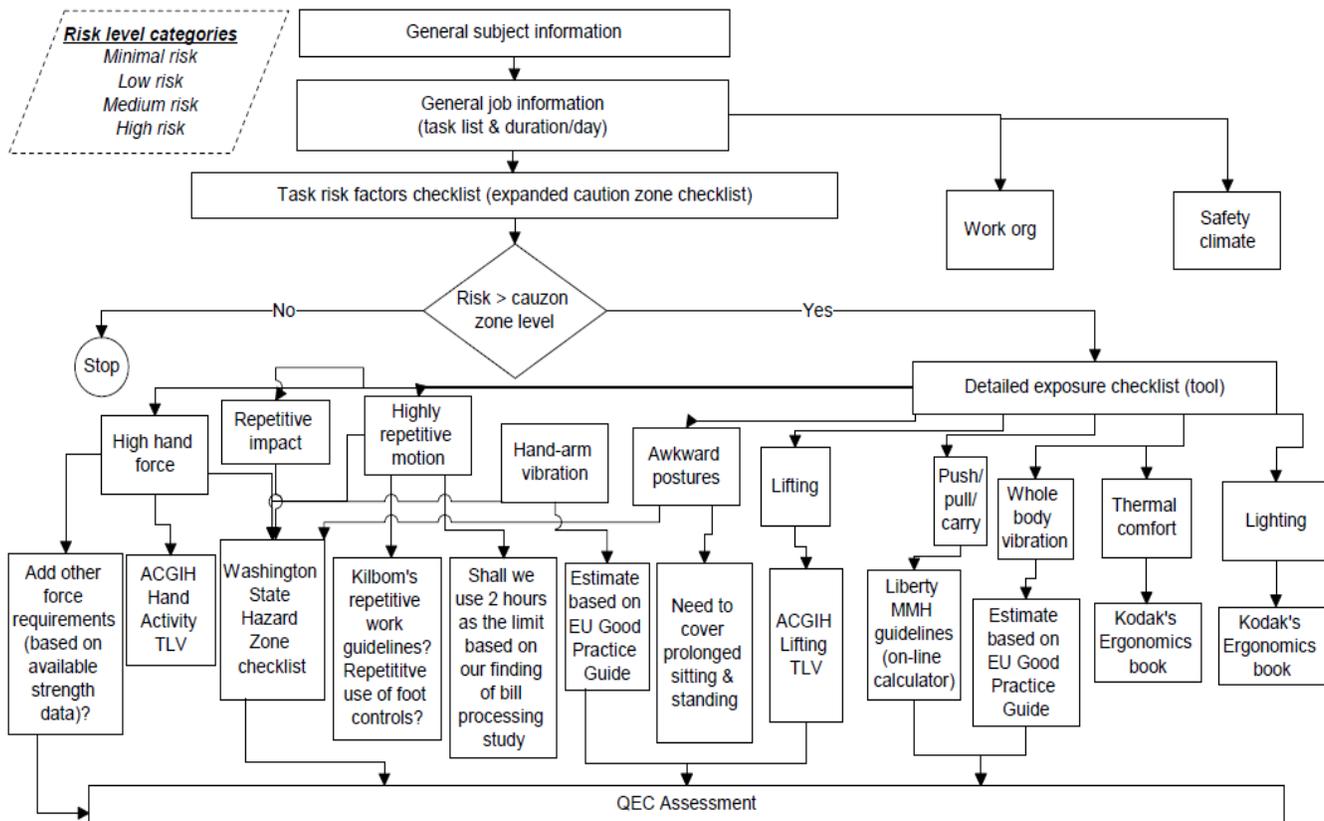
The WMSD risk factors considered in this project included:

- High hand exertions (pinch, grip and other hand forces),
- Repetitive impacts of the hand and knee,
- Highly repetitive motions of the hand/wrist, elbow, shoulder, neck and foot),
- Intensive keying (computer work),
- Awkward postures (upper arm/shoulder, neck, back, lower extremity and hand/wrist postures),
- Prolonged sitting/standing,
- Lifting,
- Pushing/pulling,
- Carrying,
- Hand/arm vibration (power tool use),
- Whole body vibration (driving vehicle),
- Environmental factors (visual demands, noises, temperature, and moisture),
- Psychosocial and work organizational factors (stress level, job constraint, and work pace).

Several job assessment methods were selected, based on the criteria mentioned above, to assess these risk factors when they reached trigger limit levels. The methods under consideration during the evaluation tool development stage and the corresponding risk factors they address are shown in Figure 1.

The **Strain Index (SI) method**<sup>[14]</sup> was used when jobs involved high hand forces and/or repetitive movements. This method has been widely used by researchers and industrial practitioners. A recent survey among certified professional ergonomists showed that almost 40% of them used this tool<sup>[15]</sup>. The SI method involves measuring or estimating six different exposure parameters: intensity of exertion (IE), duration of exertion (DE), efforts per minute (EM), hand/wrist posture (HWP), speed of work (SW, an estimate of perceived pace of the task) and duration per day of the job (DD). Multipliers with different weights are developed for each of the exposure parameters<sup>[14]</sup>. The final SI score is a product of the six multipliers.

The SI method was originally designed for “mono-task” jobs<sup>[14]</sup>. A mono-task job is strictly defined by the SI authors as a single-force exertion job. This means that the SI method would not apply if a worker’s job involves multiple forces, such as using a pair of pliers with power grip force and lifting a heavy part. In actuality, workers often apply many different forces in a single task. To complicate the situation further, workers often perform multiple tasks in a job, as happen in job rotation. Different forces may be used in different tasks. Therefore, the application of the SI method in its original format is limited. To overcome the limitations of the original SI method, and also avoid complicated calculations such as the Composite Strain Index calculation method<sup>[16]</sup>, the present study used a simplified approach by calculating SIs in two situations, namely the most common and



**Figure 1. Job evaluation tool development**

worst situations. The most common situation represented the task where the most common forceful exertion applied, and the worst situation represents the peak force used in a task<sup>[16]</sup>. The larger SI among the two calculations was used to represent the risk level of the job.

The **Washington State Caution Zone/Hazard Zone checklists**<sup>[17,18]</sup> were used to quantify several risk factors of WMSD. These included:

- Awkward postures (shoulders, neck, back, and lower extremities),
- High hand force (pinching, power gripping),
- Highly repetitive motion (repetitive motions of neck, elbows, wrists and hands, and intensive computer keying),
- Repeated impact,
- Heavy, frequent or awkward lifting, and
- Moderate to high hand-arm vibration.

Using this tool categorized each risk factor into three (3) risk levels; safe, caution zone and hazard zone levels.

The **ACGIH Lifting TLV**<sup>[19]</sup> was included in the job evaluation when lifting tasks exceeded the trigger limit values. Using a lifting task's frequency and duration together with the horizontal and vertical distances of the lift, this method determines the Lifting TLVs (threshold limit values). These TLVs recommend workplace lifting conditions under which it is believed nearly all workers may be repeatedly exposed, day after day, without developing work-related low back and shoulder disorders associated with repetitive lifting tasks.

The push/pull and carry tasks were evaluated using the **Liberty Mutual (or Snook's) Manual Material Handling (MMH) guidelines from 1991**<sup>[20]</sup>. These guidelines are arranged by pushing, pulling and carrying tasks, respectively. For evaluations of pushing and pulling tasks, the input task variables include: frequency of push/pull, hand position during the task performance, and distance the object is pushed/pulled. The tables in the guidelines provide population percentage data of workers with different capabilities at various initial push/pull force levels for male and female workers. Similarly for carrying task evaluations, the input task variables include: frequency of carrying, hand positions of object held during the carrying task, and distance the object is carried. Again, the carrying tables in the guidelines provide population percentage data of workers with different capabilities of carrying of different object weights for male and female workers respectively. With the population percentage data, we calculated the maximal allowed initial and sustained forces for the push and pull tasks as well as the maximal allowed weight of an object for a carrying task for the 75<sup>th</sup> percentile female workers. These values were used as the maximal forces in the corresponding MMH task. When a task involved both push and pull, the lower of the allowed initial or sustained push/pull forces was used.

The **Quick Exposure Check (QEC) method**<sup>[21,22]</sup> was also selected to be included in the job evaluations. The QEC is a task based tool (rather than job based as most of the other methods). It covers risk factors related to awkward postures, manual material handling tasks (lifting, pushing/pulling and carrying), awkward or static postures of the shoulder, hand/wrist, back and neck, forceful hand exertions, vibrating tool use and driving a vehicle. It also includes the visual demands of a task, the work pace and general stress level. The QEC method uses the level of these risk factors together with task duration and frequency information to quantify task risk levels. The input information is gathered through a combination of analyst observation/estimation and workers' interviews. A scoring system is used to determine risk levels for the back, shoulder/arm, wrist/hand and the neck. In addition to risk levels for the different body regions, separate risk levels are determined for driving (whole body vibration), hand vibration (vibration tool use), work pace and stress. Based on the scores, risk levels of three or four categories/levels are determined using a matrix system.

Job-level hand-arm vibrations were also evaluated using the **EU Hand-arm vibration guidelines**<sup>[23,24]</sup> as well as the Washington State Caution Zone and Hazard Zone checklists<sup>[17,18]</sup> and the above mentioned QEC method<sup>[21,22]</sup>. Vibration values were estimated by the types of tools. Hand-arm vibration levels were

determined based on the reported/estimated tool operation duration in a typical work day. The daily exposure action and limit values of 2.5 and 5 m/s<sup>2</sup> (eight-hour equivalent) were used respectively to determine the job hand-arm vibration risk levels.

Job-level whole-body vibration was evaluated using the **EU Whole-body vibration guidelines** [23, 25] as well as being evaluated in the QEC method [21, 22]. Vehicle vibration levels were estimated by the types of vehicles. Whole-body vibration levels were determined based on the reported/estimated vehicle driving duration in a typical work day. The daily exposure action and limit values of 0.5 and 1.15 m/s<sup>2</sup> (eight-hour equivalent) were used respectively to determine the job-level whole-body vibration risk levels.

Guidelines on **thermal comfort** (temperature and moisture) and **lighting** were referenced from an ergonomics textbook [26]. Since there is no available information about limit values on **prolonged sitting and standing**, cut-points (<2 hours, 2-4, 4-8, >8 for sitting, and < 1, 1-2, 2-6, and >6 for standing) were used based on consensus of the ergonomists.

In addition to the lack of limit values for prolonged sitting and standing, there are no available guidelines regarding forceful hand exertions other than pinch and power grips and the use of foot controls. Forceful hand exertions included the use of the thumb, operating triggers and pushing objects across a surface. From the consensus of the ergonomists, limit values were established for forceful hand exertions as 1-59 min, 1-2 hours and >2 hours. Risk levels for use of foot controls were established as: (1) ≤2 hours/day, (2) > 2 hours but ≤4 hours/day, (3) >4 hours or use with awkward leg/foot postures and/or high forceful foot exertions >2 hours/day or little or no variation >6 hours/day.

### *Site visit protocol*

Job evaluations were performed from data collected at site visits. Representative jobs were sampled from the overall worker population in a participating company. Job lists with job titles and numbers of employees at each job title were requested from participating companies. The job sampling strategy was based on company size and a proportional number of employees at each job:

- Small (20-49 employees): 50% of employees
- Medium (50-100 employees): 30% of employees, minimum of 25
- Large (>100 employees): 20% of employees, minimum of 30

This information was communicated to coordinators at the participating companies prior to site visits so that logistics could be determined. Two to three ergonomists were assigned to each site visits. Efforts were made to have the same ergonomists assigned to both companies of a pair and the same ergonomists to the same industry sectors. This effort was aimed to reduce the inter-rater variations on the job evaluation results.

On the site visit day, the company coordinator briefed the ergonomists about the company and jobs. An orientation tour was given. The ergonomists then took the responsibilities to locate the workers who fit into each job title and were willing to participate. These responsibilities included coordinating with dispatchers or supervisors to find workers who were assigned to off-site locations. In such cases, the ergonomists would plan to travel to those sites to interview and observe those workers. Workers were randomly selected. Prior to observations, workers provided verbal informed consent.

The job evaluations of participating workers was most often started by a study ergonomist interviewing the workers and/or their supervisors about their job functions and tasks, tools used, objects handled, task frequencies and durations, work experiences with the company, self-reported stress levels, work pace information and any other details that might help to get overall pictures about the job content so as to guide job observations and measurements.

On-site job observations followed, especially for jobs that were performed cyclically. For those jobs with varied or non-cyclic tasks that might not have occurred on the site visit days, descriptions and demonstrations were sought from the workers to understand the operational sequences and involved risk factors, if any. Information gathered from these observations was used to better understand the job content and guide corresponding measurements required for different job evaluation methods.

For push/pull task, push/pull force gauges were used to measure the forces, if warranted. These force gauges were also used to measure a sampling of object weights for lifting and carrying task evaluations. Pinch and power grip dynamometers were utilized if pinch and power grip forces were present in the jobs. If physical measurements were not possible, the ergonomists estimated these hand forces using the Borg rating scales [27], or asked the workers who performed the tasks to self-report the hand force levels using the Borg rating scales [27]. Exertion frequency and duration information was gathered from observations and/or interviews. Distances and location dimension parameters were measured with measuring tapes or estimated based on on-site observations. All required parameters of selected job evaluation methods were collected during these worksite visits.

Briefings were conducted after the worksite visits in order for the ergonomists to become familiar with all the jobs from that participating company. This was necessary because ergonomists were assigned to observe different jobs in the participating company. These briefings occurred more often at the beginning of the project. Later in the project, briefings were not always necessary because ergonomists assigned to the same industry sectors were familiar with most of the jobs already.

#### *Data collection/entry forms and company reporting program*

Exposure data necessary to complete the job evaluations were collected during the site visits. On site, the exposure data were recorded using a paper copy of the job evaluation tool or through field notes, detailed enough to complete the job evaluation tool. Following the site visits, exposure data were entered into an electronic data collection/entry program that was developed for this project (Figure 2). The job exposure data collection form and electronic data collection/entry program were arranged by categories of risk factors. The data elements in these risk factor categories were the data elements from all the exposure assessment methods chosen for this project. The job evaluations were based on the results of these various assessment methods, which were calculated automatically in the electronic data collection/entry program. The data in this job exposure data collection/entry program were then cleaned and exported for two subsequent uses: (1) company job evaluation reports and (2) industry sector data analyses.

Company job evaluation reports were a courtesy to the participating companies. The exported job exposure data and job evaluation result were transmitted to a company job evaluation reporting program. The job information and corresponding evaluation results for each assessed job were grouped into job categories based on their job titles and actual work contents. Based on the job evaluation results, study ergonomists who observed the jobs during the site visits wrote summaries about the job category and the tasks involved, the variations between different workers under the same job category, and risk factors identified and their corresponding risk levels. If the identified job risk was moderate or high, suggested corrective actions were provided.

The primary purpose of the exported job exposure data was to help understand the disparity of WMSD claims between companies in the same industry sectors, and to develop industry-specific job hazard evaluation tools. The data were consolidated into a single file with identifiers for industry sector codes, and company codes (or pair codes).

The screenshot displays two main sections of the software interface:

- General Information:** This section contains several input fields:
  - Company:** A dropdown menu with a yellow background, accompanied by 'Edit' and 'Delete' buttons.
  - Job title:** A dropdown menu with a yellow background, accompanied by 'Edit' and 'Delete' buttons.
  - Copy data from:** A dropdown menu with a yellow background and an 'OK' button.
  - Department:** A text input field.
  - Years on job:** Radio buttons for categories: 0-5, 5-10, 10-20, and > 20.
  - Analyst:** A dropdown menu with a yellow background.
  - Date:** A text input field containing '8/26/2015'.
- At-A-Glance Assessment:** This section features a checklist of job risk factors. Each item has a checkbox and a corresponding risk level code in a box. A 'Finished' label is at the top right.
 

Assessment Item	Checkbox	Risk Level
Company and job information	<input checked="" type="checkbox"/>	G1
Task definition	<input type="checkbox"/>	T1
Elevated hand/elbow	<input type="checkbox"/>	P1
Neck bent	<input type="checkbox"/>	P2
Back bent	<input type="checkbox"/>	P3
Squatting/Kneeling	<input type="checkbox"/>	P4
Deviated/bent wrist	<input type="checkbox"/>	P5
Prolonged sitting or standing	<input type="checkbox"/>	P6
Repetitive neck, shoulder, elbow motion	<input type="checkbox"/>	R1
Repetitive hand/wrist motion	<input type="checkbox"/>	R1 F4
Intensive keying	<input type="checkbox"/>	R2
Repetitive use of foot controls	<input type="checkbox"/>	R3
Hand or knee as hammer	<input type="checkbox"/>	R4
Pinching	<input type="checkbox"/>	F1 F4
Gripping	<input type="checkbox"/>	F2 F4
Forceful hand exertions	<input type="checkbox"/>	F3 F4
Strain Index	<input type="checkbox"/>	F4
Pushing or pulling	<input type="checkbox"/>	M1 M4
Carrying	<input type="checkbox"/>	M2 M4
Lifting	<input type="checkbox"/>	M3 M4
Lifting/Pushing/Pulling QEC	<input type="checkbox"/>	M4
Hand arm vibration	<input type="checkbox"/>	V1
Whole body vibration	<input type="checkbox"/>	V2
High visual demands	<input type="checkbox"/>	E1
Noise	<input type="checkbox"/>	E2
Temperature	<input type="checkbox"/>	E3
Moisture	<input type="checkbox"/>	E4
Overall Work Environment	<input type="checkbox"/>	O1
Save data and quit evaluation	<input type="checkbox"/>	I1

At the bottom of the 'At-A-Glance Assessment' section, there are 'Return' and 'Test' buttons, a dropdown menu, and a 'Note' button. The 'General Information' section also includes 'Browse Old Data', 'Read Only', and 'Quit' buttons. The app version '2.83b' is noted at the bottom left.

**Figure 2. Sample pages of the electronic job exposure data entry program**

*Data analysis by industry sectors*

Job exposure data were analyzed by industry sector. There were two purposes for this type of data analysis. The first was to compare the job risk factors between paired companies within an industry sector.

This was used to explain the historical WC claim rate disparities observed between paired companies. The second purpose was to identify common job risk factors and their associated risk levels by job categories in a particular industry sector. This information was the foundation to developing industry-specific hazard evaluation tools.

Prior to these analyses, for each worker and using the collected data, we calculated risk levels based on the various job exposures methods. A 4-level or 3-level risk system was used. Table 4 shows the risk level categories for the various risk factors according to the different job exposure methods.

To compare job risk factors between paired companies within an industry, we conducted univariate logistic regression analyses. The independent variables were the job risk level variables shown in Table 4. The dependent variable was the claim rank status (high vs. low rank) of the companies in a pair by body

regions (back, shoulder, hand/wrist and knee). This analysis showed whether a job risk level variable assessed by a specific job exposure method was associated with the WMSD claim rank status in a particular industry sector. The frequency counts of jobs in the different job risk level categories were computed by historical WMSD claim rank status and body region for the different industry sectors.

**Table 4. Job Risk level categories using different job assessment methods**

Risk Factor Description	Risk level variable	Risk level definition
<b>WASHINGTON STATE CAUTION AND HAZARD CHECKLISTS [17,18]</b>		
Hands above head	WA_hands_above	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Awkward neck postures	WA_neck	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Awkward back postures	WA_back	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Prolonged kneeling/squatting	WA_knee	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Highly repetitive wrist movements	WA_rep	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Intensive Keying	WA_computer	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Repeated impact of hand or knee	WA_impact	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
High hand force-pinch grip	WA_pinch	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
High hand force-power grip	WA_grip	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Heavy, frequent or awkward lifting	WA_lifting	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
Hand/Arm vibration	WA_HA_vib	<b>1:</b> <caution zone, <b>2:</b> -caution zone, <b>3:</b> -hazard zone
<b>STUDY ERGONOMIST CONSENSUS</b>		
Prolonged sitting	Sitting_L	<b>1:</b> < 2 hours, <b>2:</b> 2-4, <b>3:</b> > 4
Prolong standing	Standing_L	<b>1:</b> < 2 hours, <b>2:</b> 2-6, <b>3:</b> > 6
Repetitive use of foot controls	Foot_control	<b>1:</b> ≤4 hrs/d, <b>2:</b> >4hr w/o. other risks, <b>3:</b> w. other risks
<b>QUICK EXPOSURE CHECKLIST [21,22]</b>		
Static back postures	QEC_backS	<b>1:</b> 8-14, <b>2:</b> 16-22, <b>3:</b> 24-28, <b>4:</b> 30-40
Dynamic back movements	QEC_backD	<b>1:</b> 10-20, <b>2:</b> 22-30, <b>3:</b> 32-40, <b>4:</b> 42-56

Back combination	QEC_back	Max(QEC_backS, QEC_backD)
Awkward shoulder/arm postures	QEC_ShldArm	<b>1:</b> 10-20, <b>2:</b> 22-30, <b>3:</b> 32-40, <b>4:</b> 42-56
Awkward wrist/hand postures	QEC_WristHand	<b>1:</b> 10-20, <b>2:</b> 22-30, <b>3:</b> 32-40, <b>4:</b> 42-56
Awkward neck postures	QEC_neck	<b>1:</b> 4-6, <b>2:</b> 8-10, <b>3:</b> 12-14, <b>4:</b> 16-18
Prolonged Driving-WBV	QEC_driving	<b>1:</b> 1, <b>2:</b> 4, <b>3:</b> 9
Vibrating tool use	QEC_vibTool	<b>1:</b> 1, <b>2:</b> 4, <b>3:</b> 9
Work pace	QEC_pace	<b>1:</b> 1, <b>2:</b> 4, <b>3:</b> 9
Work-related stress	QEC_stress	<b>1:</b> 1, <b>2:</b> 4, <b>3:</b> 9, <b>4:</b> 16
LIBERTY MUTUAL (OR SNOOK'S) MANUAL MATERIAL HANDLING GUIDELINE <sup>[20]</sup>		
Push/pull, ver 1 - init/sust forces	Push_pull_overall1	<b>1:</b> ≥75%ile, <b>2:</b> 10-75%ile, <b>3:</b> ≤10%ile
Push/pull, ver 2 - init/sust forces	Push_pull_overall2	<b>1:</b> ≥75%ile, <b>2:</b> 50-75%ile, <b>3:</b> 25-50%ile, <b>4:</b> ≤25%ile
Push/pull, ver 3- Actual/permissible (init/sust forces)	Push_pull_overall3	<b>1:</b> ≤1, <b>2:</b> 1-2, <b>3:</b> 2-3, <b>4:</b> >3
Carry, ver 1-population capable	Carry_v1	<b>1:</b> ≥75%ile, <b>2:</b> 10-75%ile, <b>3:</b> ≤10%ile
Carry, ver 2 -population capable	Carry_v2	<b>1:</b> ≥75%ile, <b>2:</b> 50-75%ile, <b>3:</b> 25-50%ile, <b>4:</b> ≤25%ile
Carry, ver 3 - Object/permissible weight	Carry_v3	<b>1:</b> ≤1, <b>2:</b> 1-2, <b>3:</b> 2-3, <b>4:</b> >3
ACGIH LIFTING TLV <sup>[19]</sup>		
Frequent lifting - object weight/TLV	Lifting_L	<b>1:</b> ≤1, <b>2:</b> 1-2, <b>3:</b> 2-3, <b>4:</b> >3
ALL MANUAL MATERIAL HANDLING COMBINED		
MMH combination, ver1	MMH_v1	Max(Push_pull_overall1, Carry_ver1, Lifting)
MMH combination, ver 2	MMH_v2	Max(Push_pull_overall2, Carry_ver2, Lifting)
MMH combination, ver 3	MMH_v3	Max(Push_pull_overall3, Carry_ver3, Lifting)
STRAIN INDEX <sup>[14]</sup>		
Hand Activity - SI score	SI_L	<b>1:</b> <3, <b>2:</b> 3-5, <b>3:</b> 5-7, <b>4:</b> ≥7
EUROPEAN UNION VIBRATION GUIDELINES <sup>[23,24,25]</sup>		

Hand/Arm vibration	EU_HA_vib	1: $\leq 2.5 \text{ m/s}^2$ , 2: 2.5-5, 3: $>5$
Whole body vibration	EU_WB_vib	1: $\leq 0.5 \text{ m/s}^2$ , 2: 0.5-1.15, 3: $>1.15$

In order to understand the risk factors present in typical jobs in the different industry sectors, frequency counts were calculated for the various job risk level variables. Job risk level variables with high frequencies in the higher risk levels were considered the main risks in the specific industry sector and may need more attention in routine job evaluations. When all jobs were distributed at risk level = 1 for a particular job risk level variable it was determined that, normally, no elevated risk was present for the most common jobs in that particular industry sector. This was reflected in the industry-specific hazard identification/job evaluation tool.

#### *Industry-specific hazard identification/job evaluation checklist development*

The industry-specific hazard identification/job evaluation tool development was based on the industry sector data analysis results as mentioned above. Based on the job risk level frequency distributions, we excluded those job risk variables which never occurred among typical jobs in that industry sector.

A job risk level variable with a risk level frequently higher than minimal risk (risk level  $>1$ ) indicated that that risk factor would be included in the industry-specific hazard identification/job evaluation tool. Since we included multiple assessment methods in the job evaluation data collection, there were several risk factors assessed by multiple methods, such as awkward neck postures (WA\_neck, QEC\_neck), awkward shoulder postures (WA\_hands\_above, QEC\_ShldArm) and back postures (WA\_back, QECback). In these cases, the following criteria was referenced to select one item that was best suited for the industry-specific/job evaluation tool:

- Protectiveness – different methods may have different threshold levels. While one assessment method may have determined the job risk to be at a safe level, another method considered the risk level to be unsafe. That meant one assessment method may have been more protective than the other.
- Scientific foundation – some job assessment methods were developed using MSD injury data. Others may not be validated using health outcome data.
- Reliability – using the same method, two or more different job evaluators may obtain the same risk level determination. Reliability can be done through a well-designed reliability study where more than one evaluator independently provides their determinations on the same jobs. Specific statistical procedures are then followed to quantify the reliability. In the present study, it was not possible to perform such reliability testing due to the study design. Qualitative reliability assessment in the present study involved consensus through discussion whereby the two ergonomists assigned to the same industry sectors reached agreement on evaluation determinations for certain jobs both were familiar with. This reliability criterion was close to a consensus among the ergonomists who used a specific job evaluation tool for those jobs.
- Ease of interpretation – this is a subjective judgment determined by ergonomists. Elements from different assessment methods may have different interpretations in different job situations. If there were multiple methods that addressed the same risk factors, we choose the element that was easiest to understand with less ambiguity.

For those job risk variables with rare occurrences or outliers of moderate to high risk levels (risk level  $>1$ ) a pre-screening process was used. From the industry-specific analysis results, the situation under which these higher risk levels occurred was determined. In the industry-specific hazard

identification/job evaluation tool, “exceptional” job risk variables were added based on these specific situations. Evaluation of these job risk variables would only occur if those specific situations were present.

## ***Management and Labor Organizational Climate Interview***

### *Management/Labor Interview Development*

Interviews of management and labor representatives at each company were intended to characterize additional aspects of the work environment other than WMSD risk factor exposure. The interview instrument included questions about organizational factors, including safety climate. We interviewed one management representative and one labor representative from each company in order to identify any discord between high and low levels of power in the company.

To evaluate the safety climate, the Hahn and Murphy [28] six-statement measure was utilized. Unlike Hahn and Murphy, however, we did not customize the wording of the six items for each industry. Each statement uses a 4-point evaluation scale where participants either strongly disagree, disagree, agree or strongly agree.

The Organizational Culture Profile (OCP) by Sarros et al [29] was utilized to identify values that characterize an organization. The intent of this measure was to explore if the differences in WC claims experience between high and low WMSD rate companies was impacted by factors other than physical exposures, such as the values of a company. The OCP consists of 28 items, using a 5-point scale (not at all, minimally, moderately, considerably, very much) to characterize the extent to which values are perceived as characteristic of a company. The resulting organization culture profile is comprised of seven factors: Performance Orientation, Social Responsibility, Supportiveness, Emphasis on Rewards, Stability, Competitiveness and Innovation.

Other potential factors included management turnover, worker turnover, responsibility for identification and solution development, cooperation and conflict between management and staff regarding safety and health, workers’ compensation experience (involvement in a retro program, use of the third party administrator), the use of safety incentives, employee involvement in hazard identification and remediation, and methods of managing injured workers (return-to-work, light duties). In 2012 additional questions were added to characterize the impact of the Great Recession on a company. Questions included changes in production levels/volume, changes in production technologies, changes in products or services offered and changes in staffing levels.

### *Selection and Recruitment of Companies for Interviews*

Companies for management/labor interviews were selected for recruitment from the same pool used to recruit physical exposure assessment companies (see Physical Exposure section above). Companies were recruited to either participate in an exposure assessment site visit which included management/labor interviews or participate in the management/labor interviews only. The goal was to recruit companies in pairs, such that each pair matched on 4-digit NAICS code, size category (small, medium, or large), and body area (one company having a high WMSD rate rank and the other a low WMSD rate rank in the same body area category), with a similar number of company pairs in each size category and two pairs for each body area category in each sector. To accomplish our goal, we employed the same tactics and strategies used for recruiting companies for exposure assessments (see Physical Exposure Assessment section),

however, geographical factors were not a limiting factor because interviews were conducted over the phone. The type of management representative and labor representative from each company varied depending on the structure of each individual company. For the management role, we interviewed the main safety contact/manager, or if they chose another manager, then we interviewed that person. For the labor role, the interviewee was not randomly selected. We interviewed the person selected by the main safety contact whom they identified as knowledgeable about the safety practices at the company.

#### *Administration of Management/Labor Interviews*

Management and labor interviews were conducted over the phone using the SHARP Program WMSD Management/Labor Questionnaire (Appendix D), lasting 15-25 minutes per interview. Interviewers from the research team either:

- a) Noted responses on a paper form and subsequently entered data into an electronic database, or
- b) Entered data during the interview into the electronic database and subsequently checked the completeness of the form. The identity of the interviewer was recorded for each interview in order to account for individual differences.

#### *Data Analysis of Management/Labor Interviews*

Analyses of the management/labor interview data has been completed for three industry groups: health care, wholesale/retail trade and manufacturing.

Analysis of the management and labor interviews was accomplished by comparing the answers of the management interviewees to those of the labor interviewees. The data were analyzed by NORA industry sector (health care, wholesale/retail trade, manufacturing) and by body region (back, shoulder, hand/wrist, knee).

Two of the organizational factors from the interviews analyzed were:

- 1) Cooperation: "How much cooperation is there between management and workers around health and safety issues"
- 2) Conflict: "How much conflict is there between management and workers around health and safety issues".

These two factors were measured on a 4-point scale (none, a little, some, a lot). The conflict measure was reversed-measured from the cooperation factor. As mentioned previously, the safety climate was assessed using the Hahn and Murphy measure<sup>[28]</sup>. Based on the score, the Safety Climate was characterized as poor (9-15), fair (16-20), or good (21-24), using the score ranges described by NIOSH<sup>[30]</sup>. Comparisons of the management and labor scores between high and low WMSD rate companies were made using the Fisher's Exact test ( $p < 0.05$ ).

The score for the each of the seven factors of the OCP were calculated for each interviewee. The mean score for management and for labor was then determined and comparisons were made between these groups using the Wilcoxon Mann-Whitney test ( $p < 0.05$ ). An additional comparison was made of the OCP factors between the management scores only of the high and low WMSD rate companies.

## Results

### *Magnitude and Distribution of WMSD Workers' Compensation Claims*

Between 2002 and 2010 there were 409,711 compensable claims and 176,033 of them (43%) were for work-related non-traumatic musculoskeletal disorders of the back, upper extremity and knee in Washington State. Table 5 displays the general descriptive analyses of the claims data.

**Table 5. Washington State Compensable Claims. All Claims & Non-Traumatic Musculoskeletal Disorders (WMSDs) of the Back, Upper Extremity and Knee, 2002-2010.**

	All Compensable Claims	Non-Traumatic Soft-Tissue Disorders (WMSDs)
Total Compensable Claims (SF+SI)	409,711	176,033
% of ALL Compensable Claims	100.0%	43.0%
Combined SF+SI Indemnity Costs (\$Millions)	\$8,223.5	\$3,869.2
State Fund Medical Costs (\$Millions)	\$4,306.5	\$1,802.8
Average # Claims per Year (SF+SI)	45,523	19,559
Percent Female (SF+SI)	35.2%	40.1%
Median Age(SF+SI)	42	43
Median Body Mass Index, BMI (SF)	27.5	27.9
Median Tenure Months (SF)	29	29
Claims Rate per 10,000 FTE (SF+SI)	209.4	90
SF Severity (TL days per 10,000 FTE)	37,909.0	18,397.5
SF Average Tl Days per Claim	231.9	266.5
SF Median Tl Days per Claim	43	56
SF Average Total Direct Costs per Claim	\$40,800	\$44,687
SF Median Total Direct Costs per Claim	\$8,636	\$11,183

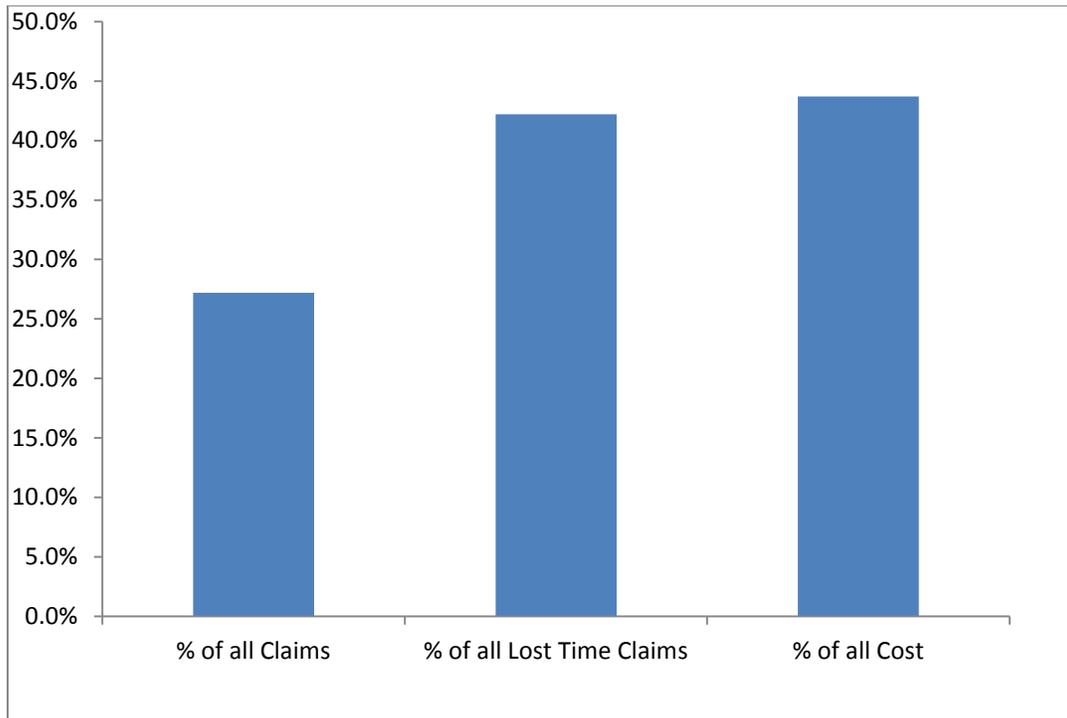
SF: State Fund, SI: Self-Insured

BMI=weight in kilograms/height in m<sup>2</sup>

\*Hgt/Wgt was available for 91.4% of SF Comp

\*\*Tenure was available for 76.6% of SF Comp

The combined costs for WMSDs were about half of all compensable claims costs (Figure 4). Overall, WMSDs accounted for approximately 40% of costs, whereas the average and median costs for all compensable claims were roughly \$40,800 and \$8,636; the costs were higher for WMSDs (\$44,687 and \$11,183, respectively).



**Figure 4. State Fund WMSD, 2002-2010**

Median time loss days averaged 43 for all compensable claims and 56 for WMSDs. By body area, claims for “Back” were the most common, with 29,990 compensable claims accounting for 19.5% of all compensable claims and median costs were highest for the shoulder (\$28,228) and lowest for the back (\$6,032).

Overall, the Top 10 industry groups for all WMSD claims were:

1. Scheduled Air Transportation (NAICS 4811)
2. Foundation, Structure, & Building Exterior Contractors (NAICS 2381)
3. Building Equipment Contractors (NAICS 2382)
4. Couriers & Express Delivery Services. (NAICS 4921)
5. Nursing Care Facilities (NAICS 6231)
6. General Medical & Surgical Hospitals (NAICS 6221)
7. Building. Finishing Contractors (NAICS 2383)
8. General Freight Trucking (NAICS 4841)
9. Grocery Stores (NAICS 4451)
10. Residential Building. Construction (NAICS 2361),

In terms of specific diagnoses, only State Fund (SF) data were available. The SF carpal tunnel syndrome (CTS) incidence rate (IR) was 6.4 per 10,000 FTEs and the Severity Rate (SR) was 2,654 time loss days per 10,000 FTE. The highest incidence rates were in Construction. The CIR for hand/wrist tendonitis was 3.4 and the SR was 1,457 per 10,000 FTE, respectively, whereas compensable knee bursitis and sciatica had considerably lower rates (CIR= 0.2 and 2.3 per 10,000 FTEs, respectively).

Based on industry, the Healthcare and Social Assistance sector was first on the Prevention Index (PI) with a CIR of 108.4 claims/10,000 FTEs and a SR of 12,085 lost workdays/10,000 FTE. Transportation and Utilities was second with a CIR of 174.5 and a SR of 18,545 lost work days per 10,000 FTEs.

There was a significant decrease in total compensable claims rate, primarily between 2002 and 2007, and then a leveling off in every sector. The slope continued to decline for all compensable claims but flattened out for WMSD claims from 2007 forward. Overall, for State Fund compensable claims, WMSD claims decreased by 6.26% by year ( $p < 0.0001$ ), which was a greater or faster decrease than that of non-WMSD claims which were decreasing by approximately 2.25% by year ( $p < 0.0001$ ) during the report period.

We looked at several specific diagnostic codes (ICD-9) for WMSDs in the State Fund. For rotator cuff syndrome, there were 12,056 compensable claims in the State Fund with an average CIR of 8.6 and a SR of 3,436 days per 10,000 FTEs. The CIR for rotator cuff syndrome has stayed relatively flat over the report period. For epicondylitis, there were 3,057 compensable claims in the State Fund with an average CIR of 2.2 and a SR of 781 days per 10,000 FTEs. The CIR for epicondylitis decreased slightly from 2002-2006, and has since flattened. The average compensable claims cost was \$55,121 per claim. For hand/wrist tendonitis, there were 6,562 compensable claims in the State Fund over the report period with an average CIR of 4.7 and a SR of 1,480 per 10,000 FTEs. The overall CIR decreased significantly over the report period, but began to flatten between 2009 and 2010. There was an average cost of \$30,930 per compensable claim. For carpal tunnel syndrome, there were 12,420 compensable claims in the State Fund over the report period with a CIR of 8.9 and a SR of 2,704 days per 10,000 FTEs with an average direct cost of \$49,481 per claim. The average time loss per claim was 321 days. Among State Fund compensable claims, CTS incidence has decreased slightly since 2006 except in the manufacturing which decreased more than half since 2004. Finally for sciatica, there were 4,517 compensable claims in the State Fund over the report period with a CIR of 3.2 and a severity rate (SR) of 1,876 days per 10,000 FTEs. Sciatica claims were extremely costly - \$319,147,531 dollars and 2,620,692 lost work days. The overall CIR for sciatica decreased slightly over the report period. The CIR for Construction decreased by half since 2002; however, the overall Construction CIR for sciatica is more than twice the state rate. For bursitis of the knee, there were 480 compensable claims in the State Fund over the report period with a CIR of 0.3 and a severity rate (SR) of 99 days per 10,000 FTEs. The CIR for knee bursitis in Construction decreased between 2003 and 2006 and flattened thereafter; the Construction CIR overall for knee bursitis is 4 times the state rate.

The rate ratio for each industry sector was calculated (Table 6) by comparing the CIR for each industry with the overall state CIR for all WMSD claims and by body part and by specific condition. Construction and Transportation & Utilities had the highest rate ratios.

**Table 6. WC Claims Rate Ratio for NORA Sector Industries**

SECTOR	Overall Rate Ratio
Construction	1.9
Transportation & Utilities	1.9
Health Care	1.2
Manufacturing	1.2
Trade	1.1
Agriculture	0.7
Services	0.7

## WMSD Injured Worker Interviews

From the original goal of 240, we interviewed 239 injured workers from six industry sectors (Table 7).

**Table 7. Injured Worker Interview totals by NORA sector and body region.**

<b>NORA Sector</b>	<b>Back</b>	<b>Shoulder</b>	<b>Knee</b>	<b>Hand/Wrist</b>	<b>Total</b>
Agriculture, Forestry & Fishing	10	10	10	6	36
Construction	10	11	10	10	41
Manufacturing	10	11	10	8	39
Wholesale and Retail Trade	10	10	10	10	40
Services (except Public Safety)	10	10	10	10	40
Healthcare & Social Assistance	13	10	10	10	43
<b>Total</b>	<b>63</b>	<b>62</b>	<b>60</b>	<b>54</b>	<b>239</b>

Among the injured workers interviewed 63.6%% were male. Interviewees were among eight ethnicities/races, 71.1% being white. Table 8 describes the demographics of the interviewed workers.

Currently, 165 interviews from three industry sectors (healthcare, manufacturing, and wholesale/retail) have been analyzed in full. For all interviews, major themes were identified from a priori and emergent categories of potential injury risks and potential prevention measures as identified by interviewees. Table 9 provides a list of the top five themes, by industry sector, for each of these three major categories.

From the original list of a priori risk factors, lifting, work pace, and repetitive hand/wrist motions each ranked in the top five of all three industry sectors (by number of interviews where each theme was mentioned). High hand forces were common to both manufacturing and health care, while awkward shoulder postures were common to both wholesale/retail and manufacturing. Out of the list of emergent risks reported by interviewees, working through injury and heavy workloads each ranked in the top five for all three industry sectors. Experiencing years of cumulative trauma and awkward knee postures were also common to both wholesale/retail and manufacturing.

**Table 8 - Ethnic and gender composition of interviewees**

	<b>Female</b>	<b>Male</b>	<b>Overall</b>
<b>Gender</b>	87	152	239
<b>Ethnicity</b>			
White	59	111	170
Other	17	19	36
Refused	4	10	14
Black	1	6	7
American Indian, Alaskan Native	2	4	6
Asian	2	0	2
Hispanic	0	2	2
Native Hawaiian, Pacific Islander	2	0	2
<b>Mean Age</b>	45	44	45
<b>Education</b>			
Refused	0	2	2
Never attended school	1	3	4
Grades 1-8	5	9	14
Grades 9-11	9	21	30
Grades 12 or GED	27	45	72
College 1-3 years	38	62	100
College 4 or more years	7	10	17
<b>Income</b>			
< \$10,000	1	1	2
\$10,000 - \$14,999	5	7	12
\$15,000 - \$19,999	8	9	17
\$20,000 - \$24,999	6	13	19
\$25,000 - \$34,999	19	27	46
\$35,000 - \$49,999	10	26	36
\$50,000 - \$74,999	11	22	33
>\$75,000	10	27	37
Not sure	11	11	22
Refused	6	9	15

**Table 9 - Major themes and sub-themes; Top 5 for each industry sector**

<b>Themes</b>	<b>Health Care</b>	<b>Manufacturing</b>	<b>Wholesale/Retail</b>
A priori risk factors	Lifting	Lifting	Lifting
	Work pace	Work pace	Work pace
	Repetition, hand wrist	Repetition, hand wrist	Repetition, hand wrist
	Hand forces, high	Hand forces, high	Awkward posture, shoulder
	Lifting\Patient Handling	Awkward posture, shoulder	Repetition, lifting
Emergent risk factors	Working Through Injury	Working Through Injury	Working Through Injury
	Workload, heavy	Workload, heavy	Workload, heavy
	Catching falling object	Cumulative trauma, years of exposure	Cumulative trauma, years of exposure
	Person, other than worker	Awkward posture, knee	Awkward posture, knee
	Short staffed	Work processes, unorganized	Age, old worker
Prevention strategies	Staffing, increased	Staffing, increased	Staffing, increased
	Communication, better	Work pace, slower	Work pace, slower
	Tools Equipment, appropriate	Communication, better	Work space, layout, modified
	Work space, layout, modified	Tools Equipment, appropriate	Support, more management
	Support, more management	Rotation, Job Task	Support, coworker, more

***Physical Exposure Assessment***

*Characteristics of Companies Completing Exposure Assessment*

We collected physical exposure assessment data for 96 companies, reaching 100% of our goal. Within the 6 selected NORA sectors, companies participated from 16 different 4-digit NAICS designation categories, and 28 different 6-digit NAICS designation categories (Table 10). Companies were paired at the 4-digit NAICS level, and where possible, companies were also paired at the 6-digit NAICS level (10 pairs do not match at this level).

*Physical exposure characteristics between high and low WMSD claim companies*

The job evaluation results allowed us to compare job risk level differences between paired companies for each industry sector. Results from 3 NORA industry sectors are described below. These sectors are Manufacturing, Wholesale & Retail Trade, and Healthcare & Social Assistance (Healthcare).

Healthcare

In the healthcare industry, it appeared that more workers in high back WMSD rate companies spent more time standing (2 to 6 hours), and performed more heavier lifting (object weights were 3 times heavier than the ACGIH Lifting TLV) compared to low back WMSD rate companies (OR = 1.874, 95%CI: 1.068-

3.285 for the standing, and OR = 2.580, 95%CI: 1.359 – 4.899 for the lifting, Table 11). Forty percent (40%) jobs were at risk level 2 (2 to 6 hours) of prolonged standing in the high back claim companies compared to 26% in the low claim companies. Twenty-one percent (21%) of the jobs with high lifting risk (level 4) in the high back WMSD rate companies compared to only 9% in the low rate companies.

Workers in high shoulder WMSD rate companies often had higher stress risk levels than those in low shoulder WMSD rate companies (OR = 2.019, 95%CI: 1.046 – 3.892), Table 11). Nineteen percent (19%) of jobs reported having very high stress risk (risk level= 4) in high shoulder WMSD rate companies compared to about 10% in the low shoulder WMSD rate companies.

**Table 10. Description of Companies Completing Both Exposure Assessment and Management/Labor Interviews.**

Sector	Co. Size	Co. Pairings	Body Area Paired For	NAICS category (6-digit)	NAICS category description (6-digit)	
Agriculture, Forestry & Fishing	Lrg	A	Hand/Wrist	115114	Postharvest Crop Activities (except Cotton Ginning)	
				115114	Postharvest Crop Activities (except Cotton Ginning)	
		B	Shoulder	111422	Floriculture Production	
				111421	Nursery and Tree Production	
	Med	C	Shoulder	111332	Grape Vineyards	
				111332	Grape Vineyards	
		D	Hand/Wrist	115114	Postharvest Crop Activities (except Cotton Ginning)	
				115114	Postharvest Crop Activities (except Cotton Ginning)	
		E	Back	111421	Nursery and Tree Production	
	111421			Nursery and Tree Production		
	Sm	F	Knee	111331	Apple Orchards	
				111331	Apple Orchards	
		G	Knee	111331	Apple Orchards	
				111331	Apple Orchards	
	H	Back	111339	Other Non-citrus Fruit Farming		
			111331	Apple Orchards		
Construction	Lrg	A	Hand/Wrist	238220	Plumbing, Heating, and Air-Conditioning Contractors	
				238210	Electrical Contractors	
		B	Back	238210	Electrical Contractors	
				238210	Electrical Contractors	
		C	Shoulder	238210	Electrical Contractors	
				238210	Electrical Contractors	
	Med	D	Shoulder	238220	Plumbing, Heating, and Air-Conditioning Contractors	
				238220	Plumbing, Heating, and Air-Conditioning Contractors	
		E	Back	238210	Electrical Contractors	
				238220	Plumbing, Heating, and Air-Conditioning Contractors	
	Sm	G	Hand/Wrist	238160	Roofing Contractors	
				238160	Roofing Contractors	
		H	Knee	238160	Roofing Contractors	
				238160	Roofing Contractors	
	Manufacturing	Lrg	A	Hand/Wrist	321999	All Other Miscellaneous Wood Product Manufacturing
					321912	Cut Stock, Resawing Lumber, and Planing
B			Back	321113	Sawmills	
				321113	Sawmills	
C			Knee	321113	Sawmills	
				321113	Sawmills	
D			Hand/Wrist	332322	Sheet Metal Work Manufacturing	
				332312	Fabricated Structural Metal Manufacturing	
Med		E	Shoulder	326199	All Other Plastics Product Manufacturing	
				326199	All Other Plastics Product Manufacturing	
		F	Back	326121	Unsupported Plastics Profile Shape Manufacturing	
				326121	Unsupported Plastics Profile Shape Manufacturing	
Sm		G	Shoulder	332312	Fabricated Structural Metal Manufacturing	
				332323	Ornamental and Architectural Metal Work Manufacturing	
		H	Knee	332312	Fabricated Structural Metal Manufacturing	
				332312	Fabricated Structural Metal Manufacturing	

Sector	Co. Size	Co. Pairings	Body Area Paired For	NAICS category (6-digit)	NAICS category description (6-digit)	
Wholesale & Retail Trade	Lrg	A	Hand/Wrist	445110	Supermarkets and Other Grocery (except Convenience) Stores	
				445110	Supermarkets and Other Grocery (except Convenience) Stores	
		B	Shoulder	444130	Hardware Stores	
				444190	Other Building Material Dealers	
	Med	C	Shoulder	423830	Industrial Machinery and Equipment Merchant Wholesalers	
				423830	Industrial Machinery and Equipment Merchant Wholesalers	
	Sm	D	Knee	444190	Other Building Material Dealers	
				444190	Other Building Material Dealers	
		E	Back	423830	Industrial Machinery and Equipment Merchant Wholesalers	
				423830	Industrial Machinery and Equipment Merchant Wholesalers	
		F	Hand/Wrist	423830	Industrial Machinery and Equipment Merchant Wholesalers	
				423830	Industrial Machinery and Equipment Merchant Wholesalers	
		G	Back	444190	Other Building Material Dealers	
				444190	Other Building Material Dealers	
	H	Knee	444190	Other Building Material Dealers		
			444190	Other Building Material Dealers		
	Services (excl. Public Safety)	Lrg	A	Back	561730	Landscaping Services
					561730	Landscaping Services
B			Shoulder	721110	Hotels (except Casino Hotels) and Motels	
				721110	Hotels (except Casino Hotels) and Motels	
Med		C	Knee	561730	Landscaping Services	
				561730	Landscaping Services	
		D	Shoulder	721110	Hotels (except Casino Hotels) and Motels	
				721110	Hotels (except Casino Hotels) and Motels	
E		Knee	721110	Hotels (except Casino Hotels) and Motels		
			721110	Hotels (except Casino Hotels) and Motels		
Sm		F	Back	561720	Janitorial Services	
				561720	Janitorial Services	
		G	Hand/Wrist	561740	Carpet and Upholstery Cleaning Services	
				561730	Landscaping Services	
H	Hand/Wrist	721110	Hotels (except Casino Hotels) and Motels			
		721110	Hotels (except Casino Hotels) and Motels			
Health Care and Social Service	Lrg	A	Knee	623110	Nursing Care Facilities	
				623110	Nursing Care Facilities	
		B	Shoulder	623110	Nursing Care Facilities	
				623110	Nursing Care Facilities	
	Med	C	Knee	623312	Homes for the Elderly	
				623312	Homes for the Elderly	
		D	Back	623311	Continuing Care Retirement Communities	
				623312	Homes for the Elderly	
		E	Hand/Wrist	623110	Nursing Care Facilities	
				623110	Nursing Care Facilities	
	F	Hand/Wrist	623312	Homes for the Elderly		
			623312	Homes for the Elderly		
	Sm	G	Shoulder	623110	Nursing Care Facilities	
				623110	Nursing Care Facilities	
H		Back	623110	Nursing Care Facilities		
			623110	Nursing Care Facilities		

Workers in high hand/wrist WMSD rate companies often had tasks with higher repetition risk levels (OR: 2.256, 95%CI: 1.257-4.050, Table 11) and higher work pace (OR=2.195/1.999, 95%CI: 1.064-4.526/1,322-3.021 for level 3 vs. 1, and level 2 vs. 1 respectively, Table 11). When the jobs were evaluated using the Strain Index method, jobs in the companies with high hand/wrist WMSD rates had more jobs in the higher risk categories (higher SI risk level) compared to those in companies with low hand/wrist WMSD rates (OR = 2.471, 95%CI: 1.268-4.817, Table 11). Nineteen percent (19%) of the jobs were considered having higher repetition (level 2) among high hand/wrist WMSD rate companies compared to 9% among the low WMSD rate companies. More than seventeen percent (17%) jobs in high hand/wrist WMSD rate companies were rated having higher risks (risk level= 2, 3) determined by the Strain Index method compared to about 10% among the low WMSD rate companies.

No risk factors were statistically different between the high and low knee WMSD rate companies in the healthcare industry.

### Manufacturing

In the manufacturing industry, it appeared that more jobs had higher levels of prolonged standing (2 to 6 hours) and heavy lifting (WA\_lift≥2, caution zone) among the high back WMSD rate companies than in the low back WMSD rate companies (OR = 3.429 with 95%CI: 1.144-10.279 for the standing and OR = 4.667, 95%CI: 1.233 – 17.655 for the lifting, Table 12). Twenty-seven percent (27%) of jobs among the high back WMSD rate companies required standing 2 to 6 hours/day compared to only 10% jobs among the low WMSD rate companies.

**Table 11. Comparison between high/low WMSD rate companies in the healthcare industry**

Job risk level variable	Risk Level comparison*	Odds Ratio (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
WA_neck	2:1	-	0.765 (0.231-2.528)	-	-
WA_back	2:1	0.920 (0.528-1.603)	-	-	-
Sitting_L	3:1	1.715 (0.777-3.788)	-	-	-
	2:1	1.372 (0.555-3.393)	-	-	-
Standing_L	3:1	0.974 (0.569-1.666)	-	-	0.646 (0.366-1.139)
	2:1	<b>1.874</b> <b>(1.068-3.285)</b>	-	-	0.885 (0.488-1.604)
WA_rep	3:1	-	-	0.891 (0.440-1.803)	-
	2:1	-	-	<b>2.256</b> <b>(1.257-4.050)</b>	-
WA_computer	2:1	3.928 (0.405-38.104)	5.292 (0.545-51.341)	-	-
WA_pinch	3:1	-	-	/	-
	2:1	-	-	/	-
WA_lifting	3:1	1.284 (0.833-1.978)	1.295 (0.854-1.964)	-	-

	2:1	1.712 (0.554-5.291)	2.333 (0.756-7.198)	-	-
Job risk level variable	Risk Level comparison*	Odds Ratio (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
QEC_backS	4:1	1.048 (0.170-6.472)	-	-	-
	3:1	1.267 (0.201-7.980)	-	-	-
	2:1	1.235 (0.199-7.653)	-	-	-
QEC_backD	4:1	0.827 (0.368-1.858)	-	-	-
	3:1	0.508 (0.202-1.273)	-	-	-
	2:1	1.267 (0.201-7.980)	-	-	-
QEC_back	4:1	1.048 (0.170-6.472)	-	-	-
	3:1	1.267 (0.201-7.980)	-	-	-
	2:1	1.235 (0.199-7.653)	-	-	-
QEC_WristHand	4:1	-	-	/	-
	3:1	-	-	0.648 (0.237-1.778)	-
	2:1	-	-	0.642 (0.235-1.751)	-
QEC_neck	4:2	-	0.549 (0.211-1.428)	-	-
	3:2	-	0.717 (0.377-1.363)	-	-
QEC_driving	3:1	/	-	-	/
	2:1	/	-	-	/
QEC_vibTool	2:1	-	-	/	-
QEC_pace	3:1	1.290 (0.554-3.000)	1.498 (0.710-3.157)	<b>2.195</b> <b>(1.064-4.526)</b>	1.191 (0.503-2.822)
	2:1	1.136 (0.734-1.759)	1.002 (0.654-1.534)	<b>1.999</b> <b>(1.322-3.021)</b>	0.854 (0.548-1.331)
QEC_stress	4:1	1.384 (0.695-2.754)	<b>2.019</b> <b>(1.046-3.898)</b>	1.816 (0.952-3.463)	1.310 (0.660-2.597)
	3:1	0.846 (0.494-1.448)	1.070 (0.635-1.803)	0.937 (0.566-1.550)	0.924 (0.536-1.595)
	2:1	1.153 (0.651-2.041)	0.958 (0.536-1.714)	1.071 (0.621-1.847)	1.071 (0.590-1.945)
Lifting_L	4:1	<b>2.580</b> <b>(1.359-4.899)</b>	1.076 (0.596-1.945)	-	-
	3:1	0.689 (0.392-1.213)	1.476 (0.901-2.417)	-	-

	2:1	1.251 (0.602-2.599)	0.848 (0.352-2.040)	-	-
Job risk level variable	Risk Level comparison*	Odds Ratio (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
SI_L	4:1	-	-	0.558 (0.232-1.340)	-
	3:1	-	-	0.419 (0.109-1.606)	-
	2:1	-	-	<b>2.471</b> <b>(1.268-4.817)</b>	-
WA_HA_vib	2:1	-	-	/	-
EU_WB_vib	2:1	/	-	-	/

\*Risk level ranking: 1=low, 2=moderate, 3=high, 4=very high

-: Not compared because physiologically it does not apply.

/: Compared but the number of counts in one or more categories were too small to calculate reliable odds ratio.

**Bold text** – Significant effect.

Among the high back WMSD rate companies, 20% jobs were in the Washington State caution zone for the lifting compared to only 5% jobs among low WMSD rate companies. However, the high back WMSD rate companies had fewer jobs requiring longer sitting periods (2 to 4, and > 4 hours) than that in the low WMSD rate companies (OR = 0.283, 95%CI: 0.122-0.657 vs OR=0.081, 95% CI: 0.009-0.693 for risk level 3 vs. 1 and 2 vs. 1 respectively, Table 12). Among the high back WMSD rate companies, 78% of the jobs required less than 2 hours of prolonged sitting compared to 46% of jobs in the low back WMSD rate companies.

Based on the Washington State checklists, the high shoulder WMSD rate companies had fewer jobs with more lifting (OR = 0.103, 95%CI: 0.025-0.422 vs OR=0.103, 95%CI: 0.030-0.712 for risk level 3 vs. 1 and 2 vs. 1 respectively, Table 12) compared to the low shoulder WMSD rate companies. Only 19% of the jobs were in the Washington State caution zone (risk level=2) and hazard zone (risk level=3) categories in the high shoulder WMSD rate companies compared to 60% in the WMSD rate group. Similar results were found when using the ACGIH Lifting TLV method (OR = 0.049, 95%CI: 0.10 – 0.239 for level 2 vs. 1, Table 12). There were fewer than 5% jobs in the level 2 risk category as evaluated by the ACGIH Lifting TLV among the high shoulder WMSD rate companies compared to about 50% among the low shoulder WMSD rate companies. There were also fewer workers (38%) reporting moderate stress levels in the high shoulder WMSD rate companies compared to those (61%) in the low shoulder WMSD rate companies (OR = 0.264, 95%CI: 0.094 – 0.744, Table 12).

High repetition, high pinch force and high Strain Index (SI) risk levels were associated with high hand/wrist WMSD rate companies compared to low WMSD rate companies, (OR = 1.951, 95%CI: 1.216 – 3.130, OR = 2.666, 95%CI: 1.365 – 5.205 and OR = 2.238, 95%CI: 1.225 – 4.086, respectively). Among the high hand/wrist WMSD rate companies, almost 21% of the jobs had an SI score  $\geq 7$  compared to only 10% among the low WMSD rate companies. High hand/wrist WMSD rate companies also had more jobs with a moderate risk from pace (risk level=2) and higher risk from stress (risk level  $\geq$  level 2)( Table 12). High hand/wrist WMSD rate companies had statistically fewer jobs in the moderate grip force risk category (OR = 0.185, 95%CI: 0.053 – 0.648) and fewer jobs using vibrating tools (OR = 0.422, 95%CI: 0.206 – 0.864, Table 12). Fewer than 11% of the jobs used vibrating tools in the high wrist WMSD rate companies compared to more than 21% in the low WMSD rate companies.

Jobs in the high knee WMSD rate companies required less standing (47%) and less use of foot controls (8.2%) compared to those in the low knee WMSD rate companies (68% for standing, and 27% for use of

foot controls for > 4 hours without other risk factors). Corresponding odds ratios were 0.346 (95%CI: 0.128 – 0.934) and 0.228 (95%CI: 0.066 – 0.790), respectively (Table 12). However, more workers in the high knee WMSD rate companies reported sometimes having difficulty keeping up with the work (OR = 3.946 (1.498 – 10.394), Table 12) with higher stress levels (OR = 8.700 (95%CI: 1.664 – 45.488) for level 3 vs. 1 and 3.287 (95%CI: 1.210 – 8.928) for level 2 vs. 1, Table 12). Almost 71% workers in the low knee WMSD rate companies reported their jobs had no stress at all. This figure was less than 31% in the high knee WMSD rate companies.

**Table 12. Comparison between high and low WMSD rate companies in the manufacturing industry**

Job risk level variable	Risk Level comparison*	Odds Ratio (OR) (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
WA_neck	3:1	-	1.250 (0.306-5.114)	-	-
	2:1	-	3.500 (0.672-18.241)	-	-
WA_back	3:1	/	-	-	-
	2:1	0.328 (0.380-4.637)	-	-	-
Sitting_L	3:1	<b>0.283</b> <b>(0.122-0.657)</b>	-	-	-
	2:1	<b>0.081</b> <b>(0.009-0.693)</b>	-	-	-
Standing_L	3:1	1.179 (0.523-2.655)	-	-	<b>0.346</b> <b>(0.128-0.934)</b>
	2:1	<b>3.429</b> <b>(1.144-10.279)</b>	-	-	0.589 (0.143-2.424)
WA_rep	3:1	-	-	<b>1.951</b> <b>(1.216-3.130)</b>	-
	2:1	-	-	<b>0.482</b> <b>(0.268-0.867)</b>	-
WA_computer	3:1	5.184 (0.587-45.827)	/	-	-
	2:1	-	1.795 (0.156-20.664)	-	-
Foot_control	3:1	-	-	-	0.419 (0.066-2.670)
	2:1	-	-	-	<b>0.228</b> <b>(0.066-0.790)</b>
WA_pinch	3:1	-	-	<b>2.666</b> <b>(1.365-5.205)</b>	-
	2:1	-	-	0.860 (0.667-2.769)	-
WA_grip	3:1	-	-	0.858 (0.463-1.627)	-
	2:1	-	-	<b>0.185</b> <b>(0.053-0.648)</b>	-
WA_lifting	3:1	1.167 (0.316-4.308)	<b>0.103</b> <b>(0.025-0.422)</b>	-	1.556 (0.576-4.198)
	2:1	<b>4.667</b> <b>(1.233-17.655)</b>	<b>0.206</b> <b>(0.030-0.712)</b>	-	1.600 (0.464-5.516)
QEC_backS	4:1	/	-	-	-
	3:1	/	-	-	-

	2:1	/	-	-	-
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Job risk level variable	Risk Level comparison*	Odds Ratio (OR) (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
QEC_backD	4:1	4.164 (0.606-28.594)	-	-	-
	3:1	3.747 (0.623-22.555)	-	-	-
	2:1	2.131 (0.384-11.814)	-	-	-
QEC_back	4:1	/	-	-	-
	3:1	/	-	-	-
	2:1	/	-	-	-
QEC_ShldArm_L	4:1	-	/	-	-
	3:1	-	/	-	-
	2:1	-	/	-	-
QEC_WristHand	4:1	-	-	1.571 (0.198-12.470)	-
	3:1	-	-	0.884 (0.122-6.416)	-
	2:1	-	-	0.864 (0.119-6.296)	-
QEC_neck	4:2	-	/	-	-
	3:2	-	/	-	-
QEC_driving	3:1	3.240 (0.625-16.801)	-	-	0.409 (0.071-2.363)
	2:1	3.240 (0.326-32.175)	-	-	2.455 (0.245-24.620)
QEC_vibTool	3:1	-	-	0.475 (0.187-1.209)	-
	2:1	-	-	<b>0.422</b> <b>(0.206-0.864)</b>	-
QEC_pace	3:1	2.129 (0.517-8.775)	-	2.816 (0.989-8.017)	/
	2:1	0.421 (0.192-0.926)	0.491 (0.185-1.304)	<b>3.509</b> <b>(2.204-5.586)</b>	<b>3.946</b> <b>(1.498-10.394)</b>
QEC_stress	4:1	0.947 (0.269-3.342)	0.364 (0.020-6.527)	<b>2.874</b> <b>(1.174-7.035)</b>	/
	3:1	0.603 (0.236-1.540)	0.218 (0.042-1.130)	<b>2.078</b> <b>(1.173-3.682)</b>	<b>8.700</b> <b>(1.664-45.488)</b>
	2:1	0.372 (0.128-1.077)	<b>0.264</b> <b>(0.094-0.744)</b>	<b>3.035</b> <b>(1.845-4.991)</b>	<b>3.287</b> <b>(1.210-8.928)</b>
Lifting_L	4:1	1.475 (0.314-6.937)	1.333 (0.129-13.821)	-	-
	3:1	/	0.444 (0.026-7.559)	-	-
	2:1	2.213 (0.387-12.640)	<b>0.049</b> <b>(0.10-0.239)</b>	-	-
SI_L	4:1	-	-	<b>2.238</b> <b>(1.225-4.086)</b>	-

	3:1	-	-	1.663 (0.831-3.329)	-
	2:1	-	-	0.584 (0.293-1.162)	-
Job risk level variable	Risk Level comparison*	Odds Ratio (OR) (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
WA_HA_vib	3:1	-	-	0.475 (0.187-1.209)	-
	2:1	-	-	<b>0.422</b> <b>(0.206-0.864)</b>	-
EU_WB_vib	2:1	0.0474 (0.042-5.379)	-	-	0.551 (0.087-3.468)

\*Risk level ranking: 1=low, 2=moderate, 3=high, 4=very high

-: Not compared because physiologically it does not apply.

/: Compared but the number of counts in one or more categories were too small to calculate reliable odds ratio.

**Bold text** – Significant effect.

### Wholesale

In the wholesale industry, it appears that more jobs required prolonged standing (> 6 hours) and heavy lifting (lifting in the Washington State’s caution zone, risk level=2) among the high back WMSD rate companies than those in the low WMSD rate companies (OR = 4.567, 95%CI: 1.916 – 10.888 for the standing and OR = 15.333, 95%CI: 1.866 – 126.022 for the caution zone lifting, Table 13). Almost 65% of the jobs among the high back WMSD rate companies required standing longer than 6 hours compared to fewer than 23% of jobs in the low WMSD rate companies. High back WMSD rate companies had fewer jobs where workers could sit longer (OR = 0.078, 95%CI: 0.029 – 0.214 for level 3 vs. 1, and OR = 0.048, 95%CI: 0.010 – 0.233 for level 2 vs. 1, Table 13). Almost 20% of the jobs among the high back WMSD rate companies were in the WA Checklist lifting caution zone compared to less than 2% among the low WMSD rate companies. The QEC method showed similar results; more jobs in the high back claim rate companies had higher back risk than those in the low WMSD rate companies (OR = 3.091, 95%CI: 1.106 – 8.634 for level 3 vs. 2, Table 13). The high back WMSD rate companies also had fewer jobs requiring moderate driving (OR = 0.036, 95%CI: 0.005 – 0.276) and moderate levels of stress (OR = 0.156, 95%CI: 0.060 – 0.407).

The high shoulder WMSD rate companies had fewer jobs within the WA Checklist caution zone for neck postures (OR = 0.321, 95%CI: 0.118 – 0.870, Table 13) and fewer jobs where it was difficult to keep up (OR = 0.464, 95%CI: 0.249 – 0.864, Table 13) compared to the low WMSD rate companies.

High repetition, high pinch force and high power grip force seems to be characteristics of jobs among the high hand/wrist claim rate companies (Table 13). The results from the QEC and the Strain Index methods had similar findings. Based on the QEC wrist/hand score, more jobs among the high hand/wrist WMSD rate companies were in the very high risk category, risk level=4 (20%) compared to those (5%) in the low WMSD rate companies (OR = 9.778, 95%CI: 1.876 – 50.965, Table 13). The SI method resulted in the following: OR = 5.817 (95%CI: 2.899 – 11.673), 4.254 ((95%CI: 2.408 – 7.517) and 2.105 (95%CI: 1.359 – 3.260) for risk level 4 vs. 1, 3 vs. 1 and 2 vs. 1, respectively. There were also more jobs in the high hand/wrist claim companies having a moderate risk from work pace, risk level=2 (OR = 1.787, 95%CI: 1.204 – 2.652, Table 13). According to the QEC vibration score, fewer jobs (1%) in the high hand/wrist WMSD rate companies used vibrating tools compared to 9% of jobs in the low WMSD rate companies (OR = 0.132, 95%CI: 0.044 – 0.398, Table 13).

No risk factors were statistically different between the high and low knee WMSD rate companies in the wholesale industry.

**Table 13. Comparison between high/low claim companies in the wholesale industry**

Job risk level variable	Risk Level comparison*	Odds Ratio (OR) (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
WA_neck	3:1	-	0.917 (0.261-3.225)	-	-
	2:1	-	<b>0.321</b> <b>(0.118-0.870)</b>	-	-
WA_back	3:1	/	-	-	-
	2:1	0.734 (0.224-2.399)	-	-	-
Sitting_L	3:1	<b>0.078</b> <b>(0.029-0.214)</b>	-	-	-
	2:1	<b>0.048</b> <b>(0.010-0.233)</b>	-	-	-
Standing_L	3:1	<b>4.567</b> <b>(1.916-10.888)</b>	-	-	1.424 (0.752-2.698)
	2:1	0.228 (0.047-1.112)	-	-	0.730 (0.357-1.493)
WA_rep	3:1	-	-	<b>10.768</b> <b>(5.497-21.091)</b>	-
	2:1	-	-	<b>2.345</b> <b>(1.561-3.524)</b>	-
WA_computer	3:1	-	/	-	-
	2:1	/	1.826 (0.253-13.178)	-	-
Foot_control	3:1	-	-	-	/
	2:1	-	-	-	0.896 (0.361-2.226)
WA_pinch	3:1	-	-	<b>5.362</b> <b>(2.750-10.455)</b>	-
	2:1	-	-	<b>21.569</b> <b>(5.174-89.926)</b>	-
WA_grip	3:1	-	-	<b>5.794</b> <b>(2.242-14.978)</b>	-
	2:1	-	-	<b>1.901</b> <b>(1.036-3.491)</b>	-
WA_lifting	3:1	1.124 (0.455-2.776)	1.172 (0.601-2.286)	-	0.719 (0.349-1.479)
	2:1	<b>15.333</b> <b>(1.866-126.022)</b>	0.943 (0.470-1.891)	-	1.132 (0.561-2.284)
QEC_backS	4:1	/	-	-	-
	3:1	/	-	-	-

	2:1	/	-	-	-
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Job risk level variable	Risk Level comparison*	Odds Ratio (OR) (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
QEC_backD	4:2	1.630 (0.667-3.979)	-	-	-
	3:2	<b>3.091</b> <b>(1.106-8.634)</b>	-	-	-
QEC_back	4:2	1.630 (0.667-3.979)	-	-	-
	3:2	<b>3.091</b> <b>(1.106-8.634)</b>	-	-	-
QEC_ShldArm_L	4:1	-	/	-	-
	3:1	-	/	-	-
	2:1	-	/	-	-
QEC_WristHand	4:1	-	-	<b>9.778</b> <b>(1.876-50.965)</b>	-
	3:1	-	-	3.157 (0.692-14.403)	-
	2:1	-	-	0.687 (0.148-3.191)	-
QEC_neck	4:2	-	1.103 (0.412-2.955)	-	-
	3:2	-	0.923 (0.366-2.327)	-	-
QEC_driving	3:1	1.636 (0.382-7.005)	-	-	1.422 (0.710-2.850)
	2:1	<b>0.036</b> <b>(0.005-0.276)</b>	-	-	1.783 (0.815-3.903)
QEC_vibTool	2:1	-	-	<b>0.132</b> <b>(0.044-0.398)</b>	-
QEC_pace	3:1	0.556 (0.153-2.011)	1.200 (0.451-3.190)	1.637 (0.797-3.364)	1.281 (0.455-3.605)
	2:1	<b>0.156</b> <b>(0.060-0.407)</b>	<b>0.464</b> <b>(0.249-0.864)</b>	<b>1.787</b> <b>(1.204-2.652)</b>	0.788 (0.426-1.458)
QEC_stress	4:1	0.598 (0.156-2.266)	0.917 (0.362-2.319)	1.409 (0.637-3.120)	1.691 (0.502-5.694)
	3:1	0.577 (0.232-1.435)	1.222 (0.674-2.217)	1.171 (0.772-1.778)	0.775 (0.411-1.460)
	2:1	0.595 (0.206-1.722)	0.859 (0.419-1.764)	1.237 (0.751-2.039)	0.564 (0.270-1.178)
Lifting_L	4:1	2.500 (0.218-28.684)	1.298 (0.397-4.239)	-	-
	3:1	0.972 (0.330-2.865)	1.557 (0.683-3.549)	-	-
	2:1	1.071 (0.31-3.470)	0.636 (0.257-1.577)	-	-

Job risk level variable	Risk Level comparison*	Odds Ratio (OR) (95% confidence Interval)			
		Low back	Shoulder	Hand/wrist	Knee
SI_L	4:1	-	-	<b>5.817</b> (2.899-11.673)	-
	3:1	-	-	<b>4.254</b> (2.408-7.517)	-
	2:1	-	-	<b>2.105</b> (1.359-3.260)	-
WA_HA_vib	3:1	-	-	0.862 (0.143-5.205)	-
	2:1	-	-	/	-
EU_WB_vib	2:1	/ (0.042-5.379)	-	-	0.933 (0.287-3.037)

\*Risk level ranking: 1=low, 2=moderate, 3=high, 4=very high

-: Not compared because physiologically it does not apply.

/: Compared but the number of counts in one or more categories were too small to calculate reliable odds ratio.

**Bold text** – Significant effect.

### *Company Job Analysis Reports*

Company job evaluation reports were a courtesy to the participating companies. Among the six industries of interest in this study, we have completed 76 reports. Eighteen remain. The reports were initially intended to be a 1-2 page summary of the physical exposure assessments; instead the reports identified all the physical factors observed and their corresponding risk level. Appendix E shows a sample of the report. Potential interventions were suggested for any physical factor that posed a moderate or high risk of injury.

### *Industry-specific hazard identification/job evaluation checklist development*

Based on the frequency distribution of the various job risk level variables for each of the industry sectors and applying criteria for selection, a short variable list was obtained. The selection criteria included the followings:

- There was variance in the job risk levels among all the jobs in the industry sector. If there was no variance and all the jobs had risk level = 1, the risk factor was considered to be insignificant for jobs in this industry and was excluded from the industry-specific tool.
- When there were less than 3 jobs in a higher risk level (job risk level > 1), an examination of the site visit data was performed to determine which job activities produced the risk level. This item was included in the industry-specific tool as an optional item – only to be considered if the specific job activities were present.
- All job risk level variables that did not fall into the above two categories, were included in the industry-specific tool. When more than one item examined a similar job risk aspect, we followed the criteria discussed in the methods section to select only one item for inclusion in the industry-specific tool.

## Healthcare

Table 14 lists the job risk level variables included in the healthcare industry-specific tool, along with information for inclusion or exclusion. The resulting tool, the Healthcare Physical Evaluation Checklist, was created to allow users to collect job observations, input the information from those observations into a form that produces a summary report identifying those factors that pose a high or very high risk (Appendix F).

**Table 14. Job risk variables to be included, excluded or optional for the healthcare industry-specific tool**

Job Risk Level Variable	Included (I) Optional (O) Excluded (E)	Explanation
WA_hands_above	O	QEC_ShldArm chosen
WA_neck	E	QEC_neck chosen
WA_back	E	QEC_back chosen
WA_knee	E	No risk levels >1
Sitting_L	I	Good frequency distribution across risk levels
Standing_L	I	Good frequency distribution across risk levels
WA_rep	E	SI_L chosen: SI_L considers repetition
WA_computer	I	Small frequency in risk level 3
Foot_control	E	No risk levels >1
WA_impact	E	No risk levels >1
WA_pinch	I	Small frequency in risk level 3 & 4
WA_grip	E	No risk levels >1
WA_lifting	E	Lifting_L chosen
QEC_back	I	Chosen over WA_back:
QEC_ShldArm_L	I	Chosen over WA_hands_above:
QEC_WristHand	E	SI_L chosen: SI_L considers wrist posture
QEC_neck	I	Choose over WA_neck: better distribution across risk levels, more sensitive to higher risk levels
QEC_driving	I	Chose over EU_WB_vib: easier to use, better distribution across risk levels
QEC_vibTool	O	Chosen over WA_HA_vib and EU_HA_vib: same frequency distribution but easier to use
QEC_pace	I	Good frequency distribution across risk levels
QEC_stress	I	Good frequency distribution across risk levels
Push_pull_overall1	E	Push_pull_overall2 chosen
Push_pull_overall2	I	Chosen over Push_pull_overall 1 &3: Better distribution across risk levels
Push_pull_overall3	E	Push_pull_overall2 chosen
Carry_v1	I	Carry_v2 chosen
Carry_v2	E	Better distribution across risk levels
Carry_v3	E	Carry_v2 chosen
Lifting_L	I	Good frequency distribution across risk levels
SI_L	I	Chosen over QEC_WristHand and WA_rep: validated tool with injury data, considers

		posture and repetition
WA_HA_vib	E	QEC_vibTool chosen
EU_HA_vib	E	QEC_vibTool chosen i
EU_WB_vib	E	QEC_driving chosen

### Manufacturing

Table 15 lists the job risk level variables included in the manufacturing industry-specific tool, along with information for inclusion or exclusion. The resulting tool, the Manufacturing Physical Evaluation Checklist, was created to allow users to collect job observations, input the information from those observations into a form that produces a summary report identifying those factors that pose a high or very high risk (Appendix G).

**Table 15. Job risk variables to be included, excluded or optional for the manufacturing industry-specific tool**

Job Risk Level Variable	Included (I) Optional (O) Excluded (E)	Explanation
WA_hands_above	E	QEC_ShldArm chosen
WA_neck	I	Good frequency distribution across risk levels
WA_back	E	QEC_back chosen
WA_knee	I	Small number of cases in risk level 2
Sitting_L	I	Good frequency distribution across risk levels
Standing_L	I	Good frequency distribution across risk levels
WA_rep	E	SI_L chosen
WA_computer	I	Small number of cases in risk level 2 & 3
Foot_control	I	Frequency distribution across risk levels
WA_impact	O	Cases $\leq 3$ for risk level 3
WA_pinch	I	Good frequency distribution across risk levels
WA_grip	I	Good frequency distribution across risk levels
WA_lifting	E	Lifting_L chosen
QEC_back	I	Chosen over WA_back
QEC_ShldArm	I	Chosen over WA_hands_above
QEC_WristHand	E	SI_L chosen- considers postures and force
QEC_neck	E	Frequency skewed towards higher risk levels
QEC_driving	I	Good frequency distribution across risk levels
QEC_vibTool	I	Good distribution across risk levels; ease of completion
QEC_pace	I	Good frequency distribution across risk levels
QEC_stress	I	Good frequency distribution across risk levels
Push_pull_overall1	E	Push_pull_overall2 chosen
Push_pull_overall2	I	Chosen over Push_pull_overall 1 & 3: Better distribution across risk levels
Push_pull_overall3	E	Push_pull_overall2 chosen
Carry_v1	E	Carry_v2 chosen

Carry_v2	I	Better distribution across risk levels
Carry_v3	E	Carry_v2 chosen
Lifting_L	I	Good frequency distribution across risk levels
SI_L	I	Chosen over QEC_WristHand and WA_rep: validated tool with injury data, considers posture and repetition
WA_HA_vib_L	E	QEC_vibration chosen; easier to complete
EU_HA_vib	E	QEC vibration chosen; easier to complete
EU_WB_vib	I	Distribution across risk levels

### Wholesale

Table16 lists the job risk level variables included in the wholesale/retail industry-specific tool, along with information for inclusion or exclusion. The resulting tool, the Wholesale/Retail Physical Evaluation Checklist, was created to allow users to collect job observations, input the information from those observations into a form that produces a summary report identifying those factors that pose a high or very high risk (Appendix H).

**Table 16. Job risk variables to be included, excluded or optional for the wholesale industry-specific tool**

Job Risk Level Variable	Included (I) Optional (O) Excluded (E)	Explanation
WA_hands_above	E	QEC_ShldArm chosen
WA_neck	I	Good distribution across risk levels
WA_back	E	QEC_Back chosen
WA_knee	I	Cases (n>3) in risk levels>1
Sitting_L	I	Good distribution across risk levels
Standing_L	I	Good distribution across risk levels
WA_rep	E	SI_L chosen
WA_computer	I	Cases (n>3) in risk levels>1
Foot_control	I	Cases (n>3) in risk levels>1
WA_impact		No risk level >1
WA_pinch	I	Good distribution across risk levels
WA_grip	I	Good distribution across risk levels
WA_lifting	E	SI_L chosen
QEC_back	I	Chosen over WA_back; better distribution across risk levels
QEC_ShldArm	I	Chosen over WA_hands_above: better distribution across risk levels
QEC_WristHand	E	SI_L chosen
QEC_neck	E	WA_neck chosen
QEC_driving	I	Good distribution across risk levels

QEC_vibTool	E	WA_HA_vib chosen
QEC_pace	I	Good distribution across risk levels
QEC_stress	I	Good distribution across risk levels
Push_pull_overall1	E	Push_pull_overall2 chosen
Push_pull_overall2	I	Chosen over Push_pull_overall 1 &3: Better distribution across risk levels
Push_pull_overall3	E	Push_pull_overall2 chosen
Carry_v1	E	Carry_v2 chosen
Carry_v2	I	Better distribution across risk levels
Carry_v3	E	Carry_v2 chosen
Lifting_L	I	Good distribution across risk levels
SI_L	I	Good distribution across risk levels
WA_HA_vib	I	Chosen over QEC_vibration: Good distribution across risk levels
EU_HA_vib	E	WA_HA_vib chosen
EU_WB_vib	I	Cases in risk levels >1

## ***Management and Labor Organizational Climate Interview***

### *Description of Recruited Companies*

We collected labor and management interview data from a total of 189 companies; our goal was 192 (Table 17). This includes interviews completed for interview-only participant companies as well as site visit job assessment participants. Each participating company completed two interviews (one management interview and one labor interview). Our goals were met in all selected NORA sectors except for the Agriculture, Forestry & Fishing sector. The three uncompleted companies provided one or none of the two interviews; these three companies are management/labor interview-only companies. All three come from the industry group “Support Activities for Crop Production” (4-digit NAICS code).

**Table 17. Complete Management/Labor Interviews by NORA Industry Sector**

NORA Sector	Individual interviews completed	Interviews goal	% of goal completed	Companies with both management and labor interviews completed	Companies goal	% of goal completed
Agriculture, Forestry & Fishing	60	64	94%	29	32	91%
Construction	64	64	100%	32	32	100%
Manufacturing	64	64	100%	32	32	100%
Wholesale & Retail Trade	64	64	100%	32	32	100%

Services (except Public Safety)	64	64	100%	32	32	100%
Healthcare & Social Assistance	64	64	100%	32	32	100%
TOTAL	381	384	99%	189	192	98%

More than half (n=96) of the companies with both management and labor interviews completed also participated in on-site job assessments. The remaining 93 companies participated in the study through interviews only (Table 10 and Table 18). Within the 6 selected NORA sectors, interview-only companies participated from 17 different 4-digit NAICS designation categories, and 31 different 6-digit NAICS designation categories. Companies were paired at the 4-digit NAICS level (except for one pair in health care), and where possible, companies were also paired at the 6-digit NAICS level (11 pairs did not match at this level).

*Comparison of Management/Labor Interviews, By Industry Sector*

No one industry consistently showed statistically significance differences in scores of organization factors between management and labor groups in either WMSD rate grouping.

Across **all industries**, a comparison of management and labor scores for the organization factors of cooperation and safety climate between high and low WMSD rate companies found no statistically significant difference in scores (Table 19). However, the conflict scores did differ significantly (P=0.02). In the high WMSD rate companies, 90.1% of management and 96.8% of labor indicated little or conflict between management and workers on health and safety issues. In contrast, for low WMSD rate companies, 78.8% of management and 91.6% of labor indicated little or no conflict. When management and labor OCP scores were compared between high and low WMSD rate companies, across all industries (Table 20), the labor scores, regardless of WMSD rate grouping, were consistently higher (better).

**Table 18. Description of Companies Completing Management/Labor Interviews Only**

Sector	Co. Size	Co. Pairings	Body Area Paired For	NAICS category (6-digit)	NAICS category description (6-digit)
Agriculture, Forestry & Fishing	Lrg	A	Back	111332	Grape Vineyards
				111331	Apple Orchards
		B	Back	115114	Postharvest Crop Activities (except Cotton Ginning)
	Med	C	Shoulder	111422	Floriculture Production
				111422	Floriculture Production
		D	Knee	111331	Apple Orchards
				111331	Apple Orchards
		E	Hand/Wrist	115114	Postharvest Crop Activities (except Cotton Ginning)
		F	Knee	111331	Apple Orchards
	111331			Apple Orchards	
	Sm	G	Hand/Wrist	111421	Nursery and Tree Production
				111421	Nursery and Tree Production
Construction	Lrg	A	Back	238220	Plumbing, Heating, and Air-Conditioning Contractors
				238220	Plumbing, Heating, and Air-Conditioning Contractors
		B	Shoulder	238220	Plumbing, Heating, and Air-Conditioning Contractors

	Med	C	Knee	238220	Plumbing, Heating, and Air-Conditioning Contractors
				238220	Plumbing, Heating, and Air-Conditioning Contractors
				238220	Plumbing, Heating, and Air-Conditioning Contractors
		D	Back	238210	Electrical Contractors
				238210	Electrical Contractors
		E	Hand/Wrist	238120	Structural Steel and Precast Concrete Contractors
				238120	Structural Steel and Precast Concrete Contractors
		F	Hand/Wrist	238130	Framing Contractors
238120	Structural Steel and Precast Concrete Contractors				

Sector	Co. Size	Co. Pairings	Body Area Paired For	NAICS category (6-digit)	NAICS category description (6-digit)	
Manufacturing	Sm	G	Knee	238130	Framing Contractors	
				238130	Framing Contractors	
		H	Shoulder	238160	Roofing Contractors	
				238160	Roofing Contractors	
	Lrg	A	Shoulder	321113	Sawmills	
				321113	Sawmills	
			B	Shoulder	326199	All Other Plastics Product Manufacturing
					326199	All Other Plastics Product Manufacturing
		C	Back	332312	Fabricated Structural Metal Manufacturing	
				332311	Prefabricated Metal Building and Component Manufacturing	
		Med	D	Knee	321113	Sawmills
					321113	Sawmills
			E	Back	321920	Wood Container and Pallet Manufacturing
					321999	All Other Miscellaneous Wood Product Manufacturing
		Sm	F	Hand/Wrist	332322	Sheet Metal Work Manufacturing
					332323	Ornamental and Architectural Metal Work Manufacturing
G	Hand/Wrist		332322	Sheet Metal Work Manufacturing		
			332312	Fabricated Structural Metal Manufacturing		
H	Knee	326199	All Other Plastics Product Manufacturing			
		326122	Plastics Pipe and Pipe Fitting Manufacturing			
Wholesale & Retail Trade	Lrg	A	Shoulder	445110	Supermarkets and Other Grocery (except Convenience) Stores	
				445110	Supermarkets and Other Grocery (except Convenience) Stores	
		B	Back	424480	Fresh Fruit and Vegetable Merchant Wholesalers	
				424480	Fresh Fruit and Vegetable Merchant Wholesalers	
		C	Knee	444190	Other Building Material Dealers	
				444190	Other Building Material Dealers	
		Med	D	Shoulder	444190	Other Building Material Dealers
					444190	Other Building Material Dealers
	E		Back	423830	Industrial Machinery and Equipment Merchant Wholesalers	
				423860	Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers	
	F	Hand/Wrist	424450	Confectionery Merchant Wholesalers		
			424430	Dairy Product (except Dried or Canned) Merchant Wholesalers		
	Sm	G	Knee	423830	Industrial Machinery and Equipment Merchant Wholesalers	
				423830	Industrial Machinery and Equipment Merchant Wholesalers	
		H	Hand/Wrist	423830	Industrial Machinery and Equipment Merchant Wholesalers	
				423830	Industrial Machinery and Equipment Merchant Wholesalers	
721110	Hotels (except Casino Hotels) and Motels					

		B	Shoulder	721110	Hotels (except Casino Hotels) and Motels
				721110	Hotels (except Casino Hotels) and Motels
				721110	Hotels (except Casino Hotels) and Motels
	Med	C	Back	721110	Hotels (except Casino Hotels) and Motels
				721110	Hotels (except Casino Hotels) and Motels
				721110	Hotels (except Casino Hotels) and Motels
	D	Hand/Wrist	721110	Hotels (except Casino Hotels) and Motels	
			721110	Hotels (except Casino Hotels) and Motels	

Sector	Co. Size	Co. Pairings	Body Area Paired For	NAICS category (6-digit)	NAICS category description (6-digit)		
	Sm	E	Back	561730	Landscaping Services		
				561730	Landscaping Services		
		F	Shoulder	721110	Hotels (except Casino Hotels) and Motels		
				721110	Hotels (except Casino Hotels) and Motels		
		G	Knee	561730	Landscaping Services		
				561730	Landscaping Services		
		H	Knee	721110	Hotels (except Casino Hotels) and Motels		
				721110	Hotels (except Casino Hotels) and Motels		
		Health Care and Social Services	Lrg	A	Back	623311	Continuing Care Retirement Communities
						623110	Nursing Care Facilities
Med	B		Knee	623110	Nursing Care Facilities		
				623110	Nursing Care Facilities		
	C		Hand/Wrist	623110	Nursing Care Facilities		
				623110	Nursing Care Facilities		
	D		Hand/Wrist	623110	Nursing Care Facilities		
				623110	Nursing Care Facilities		
E	Shoulder		623311	Continuing Care Retirement Communities			
			623311	Continuing Care Retirement Communities			
F	Back		623110	Nursing Care Facilities			
			623110	Nursing Care Facilities			
Sm	G		Knee	623311	Continuing Care Retirement Communities		
				623312	Homes for the Elderly		
	H		Shoulder	623311	Continuing Care Retirement Communities		
623311				Continuing Care Retirement Communities			

Only the OCP factor of performance orientation showed a significant difference in scores between high and low WMSD rate companies (Table 20). When only management OCP scores were compared between high and low WMSD rate companies (Table 21), only Stability showed a statistically significant difference (0.02) with a higher mean score of 4.08 (SD=0.59) for the low WMSD claim companies than for the high WMSD rate companies, 3.91 (SD=0.57).

Within the **healthcare** industry, a comparison of management and labor scores for the organization factors of cooperation, conflict and safety climate between high and low WMSD rate companies, showed no statistically different scores (Table 22). For the OCP factors, when comparing the mean scores of management and labor groups between the low and high WMSD rate companies, there were no statistically significant differences (Table 23). In comparing the OCP scores between management interviews only, for all but Supportiveness, the low WMSD rate companies had higher mean scores though the differences were not statistically significant (Table 24). For the factor Competitiveness the mean score for low and high WMSD rate companies, respectively, were 4.34 (SD 0.55) and 3.95 (SD 0.61) and though not statistically different (p=0.06) by our criterion (Table 24).

For the **manufacturing** industry, a comparison of management and labor scores for the organization factors of cooperation, conflict and safety climate between high and low WMSD rate companies found no statistically different scores (Table 25). Labor had higher mean scores across all OCP factors for both low

WMSD rate companies while the higher OCP score varied between management and labor groups for the high WMSD rate companies. The difference in mean score for Competitiveness between management and labor in the low WMSD rate companies was statistically significant ( $p=0.03$ ), while it was not significantly different in the high WMSD rate group (Table 26). The mean scores for the low WMSD rate companies were 4.23 (SD 0.50) for management and 4.63 (SD 0.48) for labor. The corresponding mean scores for the high WMSD rate companies were 4.00 (SD 0.37) for management and 3.94 (SD 0.59) for labor. When OCP scores were only compared between the management groups of low and high WMSD rate companies, no statistically significant differences in scores were found (Table 27).

For **wholesale and retail trade**, no statistically significance differences were found between management and labor scores for the factors Cooperation, Conflict, Safety Climate and all OCP factors when low and high WMSD rate companies were compared (Table 28, 29, 30). In the comparison of OCP scores between management groups of the low and high WMSD rate companies, the low WMSD rate companies scored higher across all OCP factors, though the differences were not statistically significant (Table 30)

#### *Comparison of Management/Labor Interviews, By Body Region*

No one body region consistently showed statistically significance differences between management and labor groups in either WMSD rate group.

For the **back**, a comparison of management and labor scores for the organization factors of cooperation and safety climate between high and low WMSD rate companies, showed no statistically different scores (Table 32). However, the conflict scores did differ significantly ( $P=0.01$ ). In the high WMSD rate companies, 91.67% of management and 95.65% of labor indicated little or conflict between management and workers on health and safety issues. In contrast, for low WMSD rate companies, 95.83% of management and 87.50% of labor indicated little or no conflict. Labor had higher mean scores on all OCP factors except Social Responsibility for both low and high WMSD rate companies; however, the differences were not significantly different within each WMSD rate grouping (Table 32). In comparing the OCP scores between management interviews only, for all but Social Responsibility, the low WMSD claim companies had higher mean scores though the differences were not statistically significant (Table 33). For the factor Competitiveness the mean score for low and high WMSD claim companies, respectively, were 4.33 (SD 0.47) and 4.07 (SD 0.45) and though this was not statistically different ( $p=0.06$ ) (Table 33).

For the **shoulder**, a comparison of management and labor scores for the organization factors of cooperation, conflict and safety climate between high and low WMSD rate companies found no statistically different scores (Table 34). Labor had higher mean scores on all OCP factors for both low and high WMSD rate companies, though the difference in mean score between management and labor in the low WMSD rate companies was statistically significant ( $p=0.04$ ), Table 35. The mean scores for the low WMSD rate companies were 3.99 (SD 0.64) for management and 4.34 (SD 0.47) for labor. The corresponding mean scores for the high WMSD rate companies were 4.10 (SD 0.52) for management and 4.25 (SD 0.75) for labor. When OCP scores were compared between the management groups of low and high WMSD rate companies, no statistically significant differences in scores were found (Table 36).

For the **hand/wrist** region, no statistically significance differences were found between management and labor scores for the factors Cooperation, Conflict, Safety Climate and all OCP factors when low and high WMSD rate companies were compared (Table 37, 38, 39)

For the **knee**, no statistically significance differences were found between management and labor scores for the factors Cooperation, Conflict, Safety Climate and all OCP factors when low and high WMSD rate companies were compared (Table 40, 41, 42). In the comparison of OCP scores between management groups of the low and high WMSD rate companies, the low WMSD rate companies scored higher across all OCP factors, though the differences were not statistically significant (Table 42)

**Table 19. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: ALL INDUSTRIES**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	48 (50.53%)	48 (50.00%)	1 (1.05%)	1 (1.06%)
	A little cooperation or conflict/ Fair climate	2 (2.11%)	4 (4.17%)	38 (40.43%)	42 (43.75%)	33 (34.74%)	32 (34.04%)
	Some cooperation or conflict/ Good climate	28 (29.47%)	25 (26.04%)	8 (8.51%)	5 (5.21%)	61 (64.21%)	61 (64.89%)
	A Lot cooperation or conflict	65 (68.42%)	67 (69.79%)	0 (0.00%)	1 (1.04%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	65 (69.89%)	59 (62.11%)	0 (0.00%)	1 (1.04%)
	A little cooperation or conflict/ Fair climate	4 (4.17%)	1 (1.05%)	25 (26.88%)	28 (29.47%)	37 (39.78%)	29 (30.21%)
	Some cooperation or conflict/ Good climate	29 (31.18%)	28 (29.47%)	3 (3.23%)	7 (7.37%)	56 (60.22%)	66 (68.75%)
	A Lot cooperation or conflict	60 (64.52%)	66 (69.47%)	0 (0.00%)	1 (1.05%)	-----	-----
	<i>p-value</i>	<i>0.70</i>	<i>0.43</i>	<b><i>0.02</i></b>	<i>0.19</i>	<i>0.5466</i>	<i>0.82</i>

Boldface= statistically significant

**Table 20. Comparison Between Management and Labor Mean Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: ALL INDUSTRIES**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	4.0372	4.1603	4.0591	4.1168	4.0931	4.1114	3.8883	3.9022	3.9122	4.0625	4.1596	4.1658	3.5798	3.7011
	SD	0.5300	0.6130	0.5558	0.5795	0.6013	0.7209	0.6409	0.7940	0.5676	0.5949	0.4621	0.5733	0.5200	0.6475
	<i>p-value</i>	<i>0.10</i>		<i>0.48</i>		<i>0.59</i>		<i>0.62</i>		<i>0.06</i>		<i>0.77</i>		<i>0.25</i>	
Low WMSD Rate	mean	4.1079	4.2632	4.1094	4.2553	4.0443	4.1947	3.9115	3.9763	4.0807	4.1579	4.2917	4.3237	3.6536	3.6895
	SD	0.5598	0.5559	0.6436	0.5846	0.6113	0.6505	0.6283	0.7230	0.5910	0.5158	0.5074	0.5957	0.6452	0.6849
	<i>p-value</i>	<b>0.05</b>		<i>0.13</i>		<i>0.07</i>		<i>0.36</i>		<i>0.43</i>		<i>0.35</i>		<i>0.56</i>	

**Boldface**= statistically significant,  $p \leq 0.05$

**Table 21. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: ALL INDUSTRIES**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	4.0372	4.1079	4.0591	4.1094	4.0931	4.0443	3.8883	3.9115	3.9122	4.0807	4.1596	4.2917	3.5798	3.6536
SD	0.5300	0.5598	0.5558	0.6436	0.6013	0.6113	0.6409	0.6283	0.5676	0.5910	0.4621	0.5074	0.5200	0.6452
<i>p-value</i>	<i>0.24</i>		<i>0.32</i>		<i>0.55</i>		<i>0.94</i>		<b>0.02</b>		<b>0.04</b>		<i>0.18</i>	

**Boldface**= statistically significant,  $p \leq 0.05$

**Table 22. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: HEALTHCARE**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	12 (75.00%)	9 56.25%)	1 (6.25%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	1 (6.25%)	1 (6.25%)	4 (25.00%)	6 (37.50%)	6 (37.50%)	5 (31.25%)
	Some cooperation or conflict/ Good climate	5 (31.25%)	6 (37.50%)	0 (0.00%)	1 (6.25%)	9 (56.25%)	11 (68.75%)
	A Lot cooperation or conflict	10 (62.50%)	9 (56.25%)	0 (0.00%)	0 (0.00%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	10 (62.50%)	7 (46.67%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	1 (6.25%)	0 (0.00%)	5 (31.25%)	6 (40.00%)	5 (31.25%)	2 (12.50%)
	Some cooperation or conflict/ Good climate	8 (50.00%)	8 (50.00%)	1 (6.25%)	1 (6.67%)	11 (68.75%)	14 (87.50%)
	A Lot cooperation or conflict	7 (43.75%)	8 (50.00%)	0 (0.00%)	1 (6.67%)	-----	-----
	<i>p-value</i>	<i>0.7224</i>	<i>0.7224</i>	<i>0.7043</i>	<i>0.9209</i>	<i>0.7160</i>	<i>0.3944</i>

**Table 23. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: HEALTHCARE**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	3.9333	4.2031	4.0833	4.2188	4.2500	4.1719	3.8333	3.8281	3.9000	4.1094	3.9500	4.0938	3.5333	3.5625
	SD	0.5936	0.5861	0.4190	0.4732	0.5345	0.5966	0.5483	0.9392	0.4982	0.4279	0.6138	0.5234	0.4898	0.6801
	<i>p-value</i>	0.21		0.52		0.67		0.86		0.21		0.59		1.00	
Low WMSD Rate	mean	4.2813	4.2969	4.3438	4.3906	4.1250	4.2031	3.8594	3.7500	4.2188	4.1250	4.3738	4.3125	3.7813	3.5156
	SD	0.4460	0.3561	0.4270	0.5161	0.5000	0.5494	0.5161	0.5701	0.4732	0.5000	0.5543	0.4425	0.6834	0.5437
	<i>p-value</i>	0.86		0.76		0.58		0.50		0.66		0.65		0.16	

**Table 24. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: HEALTHCARE**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	3.9333	4.2813	4.0833	4.3438	4.2500	4.1250	3.8333	3.8594	3.9000	4.2188	3.9500	4.3438	3.5333	3.7813
SD	0.5936	0.4460	0.4190	0.4270	0.5345	0.5000	0.5483	0.5161	0.4982	0.4279	0.6138	0.5543	0.4898	0.6801
<i>p-value</i>	0.10		0.10		0.51		0.89		0.08		0.06		0.08	

**Table 25. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: MANUFACTURING**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	9 (56.15%)	8 (50.00%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	1 (6.25%)	4 (25.00%)	7 (43.75%)	6 (37.50%)	3 (21.43%)
	Some cooperation or conflict/ Good climate	7 (43.75%)	3 (18.75%)	3 (18.75%)	1 (6.25%)	10 (62.50%)	11 (78.57%)
	A Lot cooperation or conflict	9 (56.25%)	12 (75.055%)	0 (0.00%)	0 (0.00%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	10 (62.50%)	10 (62.50%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	2 (12.50%)	0 (0.00%)	5 (31.25%)	6 (37.50%)	10 (62.50%)	3 (18.75%)
	Some cooperation or conflict/ Good climate	7 (43.75%)	3 (18.75%)	1 (6.25%)	0 (0.00%)	6 (37.50%)	13 (82.25%)
	A Lot cooperation or conflict	7 (43.75%)	13 (81.25%)	0 (0.00%)	0 (0.00%)	-----	-----
	<i>p-value</i>	<i>0.72</i>	<i>0.72</i>	<i>0.70</i>	<i>0.92</i>	<i>0.72</i>	<i>0.39</i>

**Table 26. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: MANUFACTURING**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	3.9375	3.7969	4.0000	3.8281	3.9531	3.6563	3.7813	3.5469	3.7344	3.6406	4.0000	3.9375	3.7188	3.6094
	SD	0.4610	0.5494	0.5845	0.5141	0.5101	0.8360	0.7465	0.7540	0.6675	0.6453	0.3651	0.5881	0.5468	0.7244
	<i>p-value</i>	<i>0.48</i>		<i>0.46</i>		<i>0.36</i>		<i>0.43</i>		<i>0.69</i>		<i>0.86</i>		<i>0.63</i>	
Low WMSD Rate	mean	4.0781	4.3333	4.1250	4.3137	3.8438	4.3167	3.8281	4.0500	4.0625	4.2137	4.2344	4.6167	3.6719	3.9000
	SD	0.5456	0.4296	0.5000	0.6085	0.6115	0.5547	0.5301	0.8671	0.4233	0.5250	0.5039	0.4806	0.5532	0.5654
	<i>p-value</i>	<i>0.27</i>		<i>0.22</i>		<i>0.06</i>		<i>0.26</i>		<i>0.69</i>		<b>0.03</b>		<i>0.63</i>	

**Boldface**= statistically significant,  $p \leq 0.05$

**Table 27. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: MANUFACTURING**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	3.3975	4.0708	4.0000	4.1250	3.9531	3.8438	3.7813	3.8281	3.7344	4.0625	4.0000	4.2344	3.7188	3.6719
SD	0.4610	0.5456	0.5845	0.5000	0.5101	0.6115	0.7465	0.5301	0.6675	0.4233	0.3651	0.5039	0.5468	0.5532
<i>p-value</i>	<i>0.33</i>		<i>0.49</i>		<i>0.63</i>		<i>0.78</i>		<i>0.57</i>		<i>0.14</i>		<i>1.00</i>	

**Table 28. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: WHOLESALE/RETAIL**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	6 (37.50%)	9 (56.25%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	0 (0.00%)	9 (56.25%)	7 (43.75%)	6 (37.50%)	4 (25.00%)
	Some cooperation or conflict/ Good climate	3 (18.75%)	2 (12.50%)	1 (6.25%)	0 (0.00%)	10 (62.50%)	12 (75.00%)
	A Lot cooperation or conflict	13 (81.25%)	14 (87.50%)	0 (0.00%)	0 (0.00%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	12 (75.00%)	11 (68.75%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	0 (0.00%)	4 (25.00%)	3 (18.75%)	6 (37.50%)	7 (43.75%)
	Some cooperation or conflict/ Good climate	5 (31.25%)	2 (12.50%)	0 (0.00%)	2 (12.50%)	10 (62.50%)	9 (56.25%)
	A Lot cooperation or conflict	11 (68.75%)	14 (87.50%)	0 (0.00%)	0 (0.00%)	-----	-----
	<i>p-value</i>	<i>0.69</i>	<i>1.00</i>	<i>0.07</i>	<i>0.15</i>	<i>1.00</i>	<i>0.46</i>

**Table 29. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: WHOLESALE/RETAIL**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	3.8438	3.9063	4.0167	3.9688	3.9688	3.9219	3.7500	3.8125	4.0156	4.1719	4.1406	4.1406	3.5156	3.5468
	SD	0.6511	0.6824	0.53	0.4990	0.5692	0.4977	0.6897	0.5204	0.6389	0.4155	0.5699	0.4079	0.5662	0.6339
	<i>p-value</i>	0.79		0.75		0.81		0.89		0.35		0.86		0.88	
Low WMSD Rate	mean	4.0000	4.2813	4.0781	4.2656	4.0469	4.1875	4.0625	4.0781	4.0625	4.2969	4.3438	4.3594	3.6094	3.6719
	SD	0.4916	0.6824	0.6306	0.6612	0.5494	0.5123	0.4425	0.6036	0.5881	0.4303	0.4644	0.6581	0.6322	0.7229
	<i>p-value</i>	0.10		0.31		0.46		1.00		0.25		0.70		0.80	

**Table 30. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: WHOLESALE/RETAIL**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	3.8438	4.0000	4.0167	4.0781	3.9688	4.0469	3.7500	4.0625	4.0156	4.0625	4.1406	4.3438	3.5156	3.6093
SD	0.6411	0.4916	0.5300	0.6306	0.5692	0.5494	0.6892	0.4425	0.6289	0.5881	0.5699	0.4644	0.5662	0.6322
<i>p-value</i>	0.45		0.77		0.70		0.22		0.83		0.28		0.66	

**Table 31. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: BACK**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	10 (41.67%)	11 (45.83%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	1 (4.17%)	12 (50.00%)	12 (50.00%)	4 (16.67%)	7 (30.43%)
	Some cooperation or conflict/ Good climate	8 (33.33%)	5 (20.83%)	2 (8.33%)	1 (4.17%)	20 (83.33%)	16 (69.57%)
	A Lot cooperation or conflict	16 (66.67%)	18 (75.00%)	0 (0.00%)	0 (0.00%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	19 (82.61%)	13 (54.17%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	2 (8.70%)	0 (0.00%)	3 (13.04%)	8 (33.33%)	8 (34.78%)	9 (37.50%)
	Some cooperation or conflict/ Good climate	9 (39.13%)	11 (45.83%)	1 (4.35%)	3 (12.50%)	15 (65.22%)	15 (62.50%)
	A Lot cooperation or conflict	12 (52.17%)	13 (54.17%)	0 (0.00%)	0 (0.00%)	-----	-----
	<i>p-value</i>	<i>0.33</i>	<i>0.12</i>	<b>0.01</b>	<i>0.35</i>	<i>0.19</i>	<i>0.76</i>

**Boldface**= statistically significant,  $p \leq 0.05$

**Table 32. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: BACK**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	3.9271	4.1630	4.0833	4.1196	4.0625	4.0326	3.8750	3.9130	3.9271	4.0326	4.0729	4.0761	3.4800	3.6848
	SD	0.5965	0.6012	0.5928	0.6301	0.6090	0.8538	0.6427	0.9403	0.6189	0.6627	0.4513	0.5956	0.5770	0.6450
	<i>p-value</i>	0.19		0.83		0.89		0.64		0.54		0.90		0.49	
Low WMSD Rate	mean	4.1146	4.2188	4.0625	4.1458	4.0729	4.1875	3.9167	3.8646	4.0938	4.0833	4.3333	4.3750	3.6979	3.7396
	SD	0.4944	0.4442	0.6767	0.5690	0.6489	0.6563	0.7135	0.7939	0.5701	0.5789	0.4701	0.5663	0.5709	0.6736
	<i>p-value</i>	0.63		0.82		0.59		0.94		0.79		0.68		0.68	

**Table 33. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: BACK**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	3.9271	4.1146	4.0833	4.0625	4.0625	4.0729	3.8750	3.9167	3.9271	4.0326	4.0729	4.3333	3.4800	3.6848
SD	0.5965	0.4944	0.5928	0.6767	0.6090	0.6489	0.6427	0.7135	0.6189	0.5701	0.4513	0.4701	0.5709	0.6736
<i>p-value</i>	0.24		0.98		0.88		0.83		0.34		0.06		0.22	

**Table 34. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: SHOULDER**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	11 (47.83%)	10 (41.67%)	0 (0.00%)	1 (4.17%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	1 (4.17%)	9 (39.13%)	12 (50.00%)	12 (52.17%)	8 (33.33%)
	Some cooperation or conflict/ Good climate	3 (13.04%)	7 (29.17%)	3 (13.04%)	1 (4.17%)	11 (47.83%)	15 (62.50%)
	A Lot cooperation or conflict	20 (86.96%)	16 (66.67%)	0 (0.00%)	1 (4.17%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	14 (60.87%)	15 (62.50%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	1 (4.35%)	0 (0.00%)	8 (34.78%)	6 (25.00%)	13 (56.52%)	7 (29.17%)
	Some cooperation or conflict/ Good climate	7 (30.43%)	4 (16.67%)	1 (4.35%)	2 (8.33%)	10 (43.48%)	17 (70.83%)
	A Lot cooperation or conflict	15 (65.22%)	20 (83.33%)	0 (0.00%)	1 (4.17%)	-----	-----
	<i>p-value</i>	<i>0.17</i>	<i>0.32</i>	<i>0.57</i>	<i>0.31</i>	<i>1.00</i>	<i>0.76</i>

**Table 35. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: SHOULDER**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	4.0543	4.3523	4.1087	4.125	4.0978	4.25	3.8804	4.1477	3.8804	4.1818	4.1304	4.2614	3.5979	3.6364
	SD	0.4883	0.5491	0.5213	0.5656	0.5208	0.752	0.6164	0.6252	0.5684	0.5299	0.405	0.526	0.4443	0.7017
	<i>p-value</i>	<i>0.04*</i>		<i>0.90</i>		<i>0.22</i>		<i>0.14</i>		<i>0.08</i>		<i>0.18</i>		<i>0.94</i>	
Low WMSD Rate	mean	4.0417	4.3646	4.1563	4.3854	3.9792	4.3438	3.8333	4.1042	4.0000	4.1354	4.2396	4.4375	3.5625	3.9479
	SD	0.6455	0.5053	0.7619	0.5466	0.6338	0.4652	0.7097	0.6507	0.5566	0.4483	0.6489	0.4959	0.7983	0.5106
	<i>p-value</i>	<i>0.06</i>		<i>0.28</i>		<i>0.04</i>		<i>0.19</i>		<i>0.21</i>		<i>0.26</i>		<i>0.11</i>	

**Boldface**= statistically significant,  $p \leq 0.05$

**Table 36. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: SHOULDER**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	4.0543	4.0417	4.1087	4.1563	4.0978	3.9792	3.8804	3.8333	3.8804	4.0000	4.1304	4.2396	3.5979	3.5625
SD	0.4883	0.6455	0.5213	0.7919	0.5208	0.6338	0.6164	0.7097	0.5684	0.5566	0.4050	0.6489	0.4443	0.7983
<i>p-value</i>	<i>0.94</i>		<i>0.45</i>		<i>0.50</i>		<i>0.91</i>		<i>0.47</i>		<i>0.49</i>		<i>0.75</i>	

**Table 37. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: HAND/WRIST**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	14 (56.00%)	13 (56.52%)	1 (4.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	2 (8.00%)	1 (4.35%)	9 (36.00%)	7 (30.43%)	10 (40.00%)	9 (39.13%)
	Some cooperation or conflict/ Good climate	9 (36.00%)	5 (21.74%)	2 (8.00%)	3 (13.04%)	14 (56.00%)	14 (60.87%)
	A Lot cooperation or conflict	14 (56.00%)	17 (73.91%)	0 (0.00%)	0 (0.00%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	17 (70.83%)	12 (52.17%)	0 (0.00%)	1 (4.35%)
	A little cooperation or conflict/ Fair climate	1 (4.17%)	1 (4.55%)	6 (25.00%)	10 (43.48%)	7 (29.17%)	5 (21.74%)
	Some cooperation or conflict/ Good climate	8 (33.33%)	7 (31.82%)	1 (4.17%)	1 (4.35%)	17 (70.83%)	17 (73.91%)
	A Lot cooperation or conflict	15 (62.50%)	14 (63.64%)	0 (0.00%)	0 (0.00%)	-----	-----
	<i>p-value</i>	<i>1.00</i>	<i>0.75</i>	<i>0.57</i>	<i>0.46</i>	<i>0.46</i>	<i>0.34</i>

**Table 38. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: HAND/WRIST**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	4.2188	4.0521	4.1042	4.1563	4.1563	4.1146	4.0208	3.9167	3.9688	4.0625	4.2708	4.2292	3.7396	3.8438
	SD	0.4506	0.6552	0.5985	0.5796	0.7402	0.6875	0.6381	0.8031	0.6648	0.6309	0.5363	0.6381	0.5238	0.6026
	<i>p-value</i>	0.37		0.95		0.76		0.72		0.61		0.83		0.69	
Low WMSD Rate	mean	4.2045	4.1364	4.1304	4.2273	4.0543	3.9886	4.0543	3.7955	4.1848	4.0455	4.2826	4.125	3.663	3.3409
	SD	0.4918	0.6442	0.5323	0.5612	0.5885	0.7499	0.5274	0.7816	0.5946	0.5755	0.4903	0.7144	0.5621	0.7926
	<i>p-value</i>	0.88		0.59		0.93		0.30		0.40		0.67		0.17	

**Table 39. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: HAND/WRIST**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	4.2188	4.2045	4.1042	4.1304	4.1563	4.0543	4.0208	4.0543	3.9688	4.1848	4.2708	4.2826	3.7396	3.663
SD	0.4503	0.4918	0.5985	0.5323	0.7402	0.5885	0.6381	0.5274	0.6648	0.5946	0.5363	0.4903	0.5238	0.563
<i>p-value</i>	0.86		0.93		0.33		0.77		0.23		0.71		0.70	

**Table 40. Comparison of Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Factors of Cooperation, Conflict and Safety Climate: KNEE**

Interview Level	Factor Description	Cooperation		Conflict		Safety Climate	
		High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
Management	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	13 (59.09%)	14 (56.00%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	1 (4.00%)	8 (36.36%)	11 (44.00%)	7 (30.43%)	8 (33.33%)
	Some cooperation or conflict/ Good climate	8 (34.78%)	8 (32.00%)	1 (4.55%)	0 (0.00%)	16 (69.87%)	16 (66.67%)
	A Lot cooperation or conflict	15 (65.22%)	16 (64.00%)	0 (0.00%)	0 (0.00%)	-----	-----
Labor	No cooperation or conflict/ Poor climate	0 (0.00%)	0 (0.00%)	15 (65.22%)	19 (79.17%)	0 (0.00%)	0 (0.00%)
	A little cooperation or conflict/ Fair climate	0 (0.00%)	0 (0.00%)	8 (34.78%)	4 (16.67%)	9 (39.13%)	8 (32.00%)
	Some cooperation or conflict/ Good climate	5 (21.74%)	6 (24.00%)	0 (0.00%)	1 (4.17%)	14 (60.87%)	17 (68.00%)
	A Lot cooperation or conflict	18 (78.26%)	19 (76.00%)	0 (0.00%)	0 (0.00%)	-----	-----
	<i>p-value</i>	<i>0.33</i>	<i>0.54</i>	<i>0.87</i>	<i>0.06</i>	<i>0.76</i>	<i>1.00</i>

**Table 41. Comparison Between Management and Labor Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: KNEE**

		Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
		mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor	mgmt	labor
High WMSD Rate	mean	3.9457	4.0870	3.9318	4.0652	4.0543	4.0543	3.7717	3.6413	3.8696	3.9783	4.1630	4.0978	3.4891	3.6304
	SD	0.5537	0.6334	0.5186	0.5751	0.5981	0.5981	0.6288	0.7379	0.4120	0.5636	0.4498	0.5369	0.5027	0.6609
	<i>p-value</i>	0.30		0.33		0.96		0.60		0.43		0.70		0.46	
Low WMSD Rate	mean	4.0800	4.3200	4.0900	4.2600	4.0700	4.2400	3.8200	4.1200	4.0500	4.3500	4.3100	4.3400	3.6900	3.7000
	SD	0.6069	0.6188	0.6161	0.6633	0.6060	0.6940	0.5543	0.6500	0.6575	0.4270	0.4225	0.5902	0.6506	0.6495
	<i>p-value</i>	0.16		0.30		0.31		0.11		0.11		0.55		0.86	

**Table 42. Comparison Between Management Scores in High and Low WMSD Rate Companies for the Organizational Company Profile (OCP) Factors: KNEE**

	Performance Orientation		Social Responsibility		Supportiveness		Emphasis On Reward		Stability		Competitiveness		Innovation	
	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate	High Rate	Low Rate
mean	3.9457	4.0800	3.9318	4.0900	4.0543	4.0700	3.7717	3.8500	3.8696	4.0500	4.1630	4.3100	3.4891	3.6900
SD	0.5537	0.6069	0.5186	0.6161	0.5381	0.6060	0.6822	0.5543	0.4120	0.6575	0.4498	0.4225	0.5027	0.6506
<i>p-value</i>	0.24		0.22		0.88		0.88		0.13		0.29		0.19	

## *Dissemination of Results*

In addition to informing participating site visit workplaces through job analysis reports, we summarized the findings of the study in industry-specific summaries. To date, three industry summaries have been completed; Healthcare & Social Assistance (Appendix I), Manufacturing (Appendix J) and Wholesale & Retail Trade (Appendix K). Three more industry summaries will be completed– Services (excluding Public Safety), Construction and Agriculture, Forestry & Fishing. These industry-specific summaries briefly describe the workers' compensation data, the physical exposure results, introduction to the Physical Job Assessment Checklist, and additional resources.

It is intended to hold workshops for each industry, offering training to the workplaces that participated in the site visits and management/labor interviews in the use of our Physical Job Assessment Checklist. We have developed one workshop, for healthcare (see Appendix L for the agenda template and Appendix M for the presentation slides). Invitations were sent to all the healthcare facilities, who completed site visits and management/labor interviews. Unfortunately, the workshop was cancelled due to lack of participation. The remaining industry workshops will follow the template created for healthcare. The workshops offer a participatory approach, involving group activities, including a quick knowledge survey (Appendix N)

## Discussion

### ***Magnitude and Distribution of WMSD Workers' Compensation Claims***

#### *Workers' Compensation Data*

Although the US Bureau of Labor Statistics (BLS) has a somewhat different definition of WMSDs, some comparison is reasonable. The BLS reported a 2010 national rate for MSDs of 34 per 10,000 FTEs while Washington State's rate was 63.1 per 10,000. The Washington State combined State Fund and Self-Insured workers' compensation rate for WMSDs between 2002-2010 was 90 per 10,000 FTEs. National BLS figures do not include state or local government whereas the Washington State BLS data does. Washington's compensable WMSDs represented 43% of all compensable claims between 2002-2010 compared to the 2010 BLS reporting of 39% for Washington State.

There has been considerable debate about why Washington State's BLS rates are generally higher than the national average. The BLS data collection methodology has been identified as a source of incomplete case capture. Collecting injury/illness reports within a few months of survey years hinders the reporting of illnesses with long latencies, injuries that worsen over time and those that are difficult to establish work-relatedness <sup>[31, 32]</sup>. Employer recording practices also contribute to BLS underreporting. Non-compliance with OSHA recordkeeping regulations, the use of workplace injury data for job performance evaluations, the recording of injuries for a multiple shift worksite and failure to follow reporting instructions are factors that have been attributed to underreporting of cases <sup>[4]</sup>.

#### *Uses of the WC Data*

We are able to report severity rates (number of lost workdays per 10,000 FTEs) for State Fund employers. This is an important indicator of the serious, debilitating nature of WMSDs that cannot be

captured with claims incidence or rate ratios alone. While WMSDs represent 27% of all claims, they account for more than 48.5% of all lost work days.

The frequency count identifies industries with the most claims, and can be used to direct prevention efforts to reduce the overall number of claims. Large industries with many employees will be impacted the most by the use of this approach. Using frequency count, the top 3 ranked industry groups, identified by their 4-digit NAICS code were:

- 1) General Medical and Surgical Hospitals (NAICS 6221)
- 2) Executive, Legislative and Other General Government Support (NAICS 9211)
- 3) Aerospace Product and Parts Manufacturing (NAICS 3364)

These 3 industry groups employ large numbers of workers in Washington State, however, specific employers may not have a high concentration of risk factors present.

The relative risk (RR) identifies industries at highest risk of injury or illness. It can be expected that a higher concentration of risk factors would be found in most workplaces in these industries. Using relative risk to rank industry groups, the top three were:

- 1) Leather and Hide Tanning and Finishing (NAICS 3161)
- 2) Scheduled Air Transportation (NAICS 4811)
- 3) Interurban and Rural Bus Transportation (NAICS 4852)

Although the risk was high, the number of employees may have small and the overall industry impact of prevention activities would be limited to those few. This might be useful in focusing inspection activities or research where contrasts in claims incidence rates may be important.

The Prevention Index (PI) was developed as a way to obtain a measure that would illustrate the most impact in high-risk industries. It treats frequency and relative risk as equally important. The top 3 ranked industry groups by Prevention Index were:

- 1) Scheduled Air Transportation (NAICS 4811)
- 2) Foundation, Structure & Building Exterior Contractors (NAICS 2381)
- 3) Building Equipment Contractors (NAICS 2382)

These industry groups ranked high both on frequency count and relative risk, allowing intervention activities to impact the greatest number in conjunction with the highest risk.

None of these data take into account the indirect costs to the employer in lost productivity, quality, training replacement workers, recruitment and other administrative costs. Foley et al <sup>[6]</sup> followed Washington State CTS and upper extremity fracture claimants for six years after claim filing and found that CTS claimant earnings losses were substantially greater than for fractures. They were able to recover approximately half of their pre-injury earnings at six years compared to those with fractures and had three times the time loss duration. These data also do not take into account the quantitative and qualitative costs to the claimant and their family, or the workers who suffer from work-related back or upper extremity disorders who never file a workers' compensation claim.

### *Limitations of Using Workers' Compensation Data*

The largest employers in Washington State are self-insured. For Self-Insured compensable closed claims, we extracted body part, nature, and type, however, these data, including costs and time loss, are less complete than State-Fund data. As a result, the distinction between non-traumatic and traumatic onset is not as clear as State-Fund data. Additionally, we did not have access to electronic Self-Insured Medical

records. Consequently, Self-Insured claims could only be identified when the coding clearly indicated a WMSD. This prevented the classification of specific conditions. These limitations likely resulted in an underestimation of the incidence of WMSDs for Self-Insured employers. Self-Insured employers do not report the medical costs of their claims so only the ratio of medical to indemnity costs from the State Fund claims could be determined. Typically medical costs represent about 1/3 of total costs for a WMSD. The ratio varies by industry in the State Fund and may vary between funds (State Fund / Self Insured).

Hours were converted to full time equivalent workers (FTEs) as: Total Hours Reported / 2,000. In those industries where there were high proportions of part-time workers, the denominator may have represented an underestimate, making the incidence rate higher than it would be if they were all full-time workers.

NAICS codes that had an overall average less than 100,000 hours per year (equivalent to 50 FTEs per year) were excluded from the more detailed analysis of 4-digit NAICS. The exclusion criteria reflected the tradeoff between precision and stability. In some respects, because smaller employers are more represented in the State Fund, costs may be overestimated due to the greater capacity of large employers to return employees to work, even in light duty jobs, thereby reducing lost time days and costs.

Finally, there is an inherent bias in claims reporting. The traumatic onset disorders tend to gain more ready acceptance in the workers' compensation system than the more gradual or non-traumatic onset disorders.

### ***WMSD Injured Worker Interviews***

The responses of the injured workers supported the findings of the work site job evaluations. Heavy, frequent, or awkward lifting, working at a fast pace, and hand/wrist repetition were common concerns in healthcare, manufacturing and wholesale/retail. From the injured worker interviews, major risk categories identified as contributing to injury included physical factors (force, posture, repetition) as well as organizational factors (work pace, workload, staffing). Most major risks reported were physical, while suggested prevention measures were most often organizational in nature. This suggests that workers may perceive the physical nature of their jobs as intractable and that, in their view, organizational decisions should play a more practical role in mitigating risk. One exception to this may be the healthcare sector, where the leading prevention strategy described was providing the appropriate tools and equipment to safely handle patients. However, the second most commonly reported prevention strategy in the health care sector was increased staffing (an organizational strategy).

Likewise, in terms of self-reported potential injury-prevention strategies, increased staffing was among the top five themes in all three sectors. A slower pace of work was a top prevention theme in both the wholesale/retail and manufacturing sectors, as may be expected given the goal-oriented nature of production in those work environments. Similarly, better or improved communication practices (between workers and management) and the provision of appropriate tools and equipment were common prevention themes in both the manufacturing and health care sectors, areas where both team-cohesion and equipment-usage can play critical roles in improving workers' health and productivity. Increased support from management and modifications to work space layouts were commonly suggested in both the wholesale/retail and in healthcare sectors, domains where employees may tend to work independently and/or in cramped or cluttered work spaces such as patient bedrooms or grocery aisles.

There was some difficulty in obtaining injured worker claims data in a timely way, especially from self-insured data. In this study, WMSD claims 18 months or older was used in order to represent a truer indication of the costs of a claim and as such, candidates had often returned to work by the time they were first contacted for an interview. There were also difficulties in identifying and contacting injured workers from certain sectors and with certain body area injuries. For example, while claims for back injuries in the health care sector were extremely common, hand/wrist injuries in the manufacturing and agriculture sectors were relatively rare. Other challenges involved contacting workers who had changed phone numbers or for whom their only available phone was a mobile device which charged them by the minute. Other candidates would commit to a date and time to be interviewed, only to not respond to additional follow up calls.

### ***Physical Exposure Assessment***

#### *Use of WC data as outcome measures for exposure*

Using historical workers' compensation claims data as an outcome for physical workload can be problematic. The physical exposure data that we collected for the job evaluations represented the current nature of the jobs. The physical exposure data may not have been the same as what caused the historical workers' compensation claims. In our study, the workers' compensation data between 2002 and 2008 was used to determine outcome group classification, low and high WMSD rate companies. Physical exposure assessment did not begin until 2010. The final site visits in 2015 did not occur until over 10 years from the start of the WC claims data window. Therefore, the outcome may not have been directly related to individual exposure assessments. The assumption was made that the work observed during company site visits was the same as what was performed from 2002-2008. More recent WC data was not used. Additionally, company pairs were chosen based on claims rate ranking in the upper quartile (high WMSD rate company) and bottom quartile (low WMSD rate company) for each type of WMSD (back, shoulder, hand/wrist and knee). The absolute difference in claims rate between a low and high WMSD rate company pair varied between and within group classification for each injury type. It was not possible to determine the effect, if any, from the absolute rate difference between pairs.

#### *Physical Exposure Data collection*

Several well-published job evaluation methods were used in the present study to quantify risk levels of WMSDs for the four different body regions. This provided the possibility to identify major risk factors in the different industry sectors, study the characteristics of risk levels between high and low claim companies, and evaluate the different job evaluation methods used in the different industries.

Due to the nature of being a surveillance study, the exposure data collected for the job evaluations was cross-sectional in nature with limited accuracy. The evaluation of jobs during site visits were based on job observations and supplemented with worker descriptions and recreations. The amount of evaluation based on observation and on self-report may have varied between jobs, between workers within a company, between companies and between researchers. This depended on the nature of the jobs and the feasibility of information gathering. Site visits were conducted over a period of 1-2 days for each company. Occasionally, some job activities did not occur during the time frame of our site visits, for reasons such as seasonal variation. Researchers relied on the descriptions provided by participant workers and supervisors to assess the work not observed. The combination of job observations and

workers' interviews made it possible for us to estimate the overall job exposures although with limited accuracy.

The assessment methods used to evaluate the physical exposure were validated and commonly used by health and safety practitioners. These methods included the Quick Exposure Checklist [21, 22], the ACGIH Lifting TLV [19] and the Washington State Caution and Hazard Zone Checklists [17, 18]. However, researchers found that several potential risk factors could not be evaluated by the methods or the observed activity did not match the traditional definition of the activity. In nursing homes, residents are often rolled on their sides for bed baths or changing clothing and/or sheets. This type of physical exertion was not accounted for in the assessment methods used; it did not fit the traditional definition of a "push" that the methods assessed. Patient transfers also did not meet the traditional definition of manual material handling as defined by the lifting task evaluation tools we used. Lifting assessment methods, such as the ACHIH Lifting TLV and the NIOSH Lifting Equation, examine lifting activities of rigid objects, where the weight is fully supported. However, in many transfer, the resident is able to bear his/her weight in part. The assessment methods do not account for this. In this study, it was assumed that the nurse or certified nursing assistant bared half of the residents' weight during transfers. The methods also did not evaluate potential risk factors such as walking on uneven ground (fruit orchards), climbing up and down steps or stairs (ladders in orchards, or heavy equipment).

While efforts were made to have the same ergonomists assigned to the same jobs in both companies of a pair and the same ergonomists to the same industry sectors, this was not always possible because of time constraints. Briefings were conducted after the worksite visits align ergonomists' evaluations of the same job. Inter-rater variations may have impacted industry analyses. However, since all ergonomists were blinded to the claim status of companies and were assigned to sites randomly, there should be no systematic bias in the comparisons between companies with low and high WMSD rates.

### *Differences in Work Performed between Company Pairs*

Differences in services and product lines provided may partially explain the discrepancies of the job risk levels and the WMSD claim rates between companies within the same 4-digit NAICS code. Patient handling has frequently been identified as a cause of back and shoulder injury [33,34]. However, the amount of patient handling is dependent on the acuity and level of independence of the patient populations. For example a company pair in healthcare consisted of a residential home and a nursing home. The population in the residential home was independent - able to feed, bath and move about with only cueing. In contrast the nursing home was long term care where the resident population ranged between bed-bound or non-weight-bearing to partially weight bearing. Another potential explanation for the differences in claims rate was the contracting of certain work activities to a third party. In agriculture, two plant nurseries were paired together. However, in one nursery, the work of transplanting small seedlings into pots or cells was contracted out to a temporary staffing service. This type of work is very repetitive and the hand activity is very high. Finally, although the companies in a pair may have fit into the same 4-digit NAICS code, the work performed may have been very different. For a company pair matched on 4-digit NAICS code (5617, services to building and dwelling) one provided cleaning services to building parking lots while other provided yard and landscape clean-up. Each uses very different tools and equipment.

### *Checklist Development*

The physical job evaluation checklists included all risk factors that were observed during our site visits. Risk factors identified were typical risk factors common to that particular company since jobs were sampled based on available jobs in those particular companies. The physical job evaluation checklist was developed using observations of physical aspects of the working environments that posed more than a minimal risk of injury, as determined by previously published assessment methods. Therefore, the included risk factors in the industry-specific checklists are typical risk factors for that type of companies within the industry group. However, the number of industry groups the participating companies belongs to accounts for only a small portion of the groups within an industry sector. Within the Manufacturing industry we visited 6 companies involved in metal work and/or fabrication (NAICS 3323), 4 companies producing plastic products (NAICS 3261), 4 sawmills (NAICS 3211) and 2 companies producing wood products (NAICS 3219). Within the Healthcare and Social Services industry, we assessed jobs in 10 nursing care facilities (NAICS 6231) and 6 community care facilities (NAICS 6233). Six machinery and equipment wholesalers (NAICS 4238), eight building material and supply dealers (NAICS 4441) and 2 grocery stores (NAICS 4451) represented the Wholesale and Retail Trade Industry. The checklists developed may not be generalizable to all industry groups. Users of the industry-specific job evaluation checklists should keep this in mind accordingly

There was some duplication between the job assessment methods in the evaluation of risk factors. Although all methods considered frequency, duration and posture, there are differences in how the risk factors are assessed, resulting in differences in frequency distribution across risk levels for each risk factor. Both the QEC and the Washington checklist evaluate awkward neck postures. The Strain Index evaluates hand activity based on wrist posture, repetition, forcefulness of hand grip. The Washington Checklist evaluates forcefulness of hand grip (pinch and power), wrist repetition and awkward wrist postures separately. QEC also evaluates wrist posture. Among the Wholesale and Retail Trade industry jobs assessed, the QEC determined that 66.8% of the jobs posed more than a moderate risk of wrist/hand injury. In contrast, the Strain Index determined 28.6% of the jobs with more than a moderate risk of injury. The Washington State Checklist evaluation resulted in 50.9% of the jobs with more than a moderate risk injury from repetition, 66.8% of the jobs with more than a moderate risk of injury from forceful hand exertions from pinch gripping and 9.2% of jobs with a more than moderate risk of injury from forceful hand exertions from power gripping. The QEC and Strain Index methods choose the duration of the task in which risk factors occur to represent the exposure to a risk factor. The Washington Checklists bases exposure on the actual duration that the risk factor is present and not the duration of the task in which the risk factor is present. Therefore, the QEC and Strain Index may be more protective in some cases than the Washington Checklist.

The Washington State evaluation of shoulder posture may underestimate the risk to this body region while the QEC evaluation may overestimate the risk. The percentage of jobs that posed more than a minimal risk to the shoulder was 0.2%, 0.2% and 6.2% for the wholesale, healthcare and manufacturing industries, respectively. In comparison the QEC determined 99.5%, 94.8% and 92.7% of jobs posed more than a minimal risk in the wholesale, healthcare and manufacturing industries, respectively. The duration of the most extreme shoulder position, working with the hands above the head or elbows above the shoulders for more than four hours total per day (risk level=3), in the Washington Hazard Zone Checklist was established based on the best available research at the time of development but also based on input from industry. As a result, exposure limit may be so high that very few shoulder activities meet this criterion.

No one single assessment methods of those chosen in the development of the Physical Job Assessment Checklist evaluates all the dimensions of the risk factors. This may affect the sensitivity of the methods. The Strain Index does not consider the type of hand exertions (pinch vs. power) in its evaluation while

the WA Caution and Hazard Checklists do. The Strain Index considers the intensity, cycle time, frequency, posture, pace and duration of hand exertions in its evaluation of risk. The Washington Checklist evaluates back posture risk by the magnitude of flexion (30° and 45°). The QEC method evaluates back posture risk based on dynamic or static postures.

The risks identified from the job evaluations for the different industries matched quite well with the reported risk factors from the injured workers' interviews. Heavy lifting, repetitive hand exertions and high work pace were all identified from both the job evaluations and workers' interviews. The job evaluations provided even more specific risk information than that provided by the workers. For example, the injured workers reported work pace as a risk factor. Our job evaluation showed that work pace was only associated with wrist injuries in the higher WMSD claims rate companies. There were no associations with injuries of the other body parts.

While awkward shoulder postures were reported by injured workers as a risk factor in the manufacturing and wholesale/retail sectors, this posture (working with the hands above the head) was not identified as a risk factor in the job evaluations. A possible explanation may be that the risk determination of lifting includes not only the weights lifted but also the position of the hands. While reaching may be considered an awkward shoulder posture during lifting by the injured workers, it was not considered a shoulder posture risk factor in the job evaluation. Therefore, the discrepancy between the job evaluations and the injured workers' interview might merely be the difference in parameter definitions.

The logistic analysis results for some potential risk factors showed lower odds ratios for the high WMSD rate groups. This may be viewed as "protective" effects. However, this may be hard to believe. After an examination of these risk factors, there are several possible explanations to explain this. For the healthcare sector, the moderate risk level (risk level=2) of back posture and the higher risk levels of the neck postures (risk levels=2, 3) all showed odds ratios lower than one. Since these postures were determined by the worst postures, this may indicate that the jobs required the workers to move their backs and necks rather than hold these awkward postures continuously. Therefore, they may not have negative effects on the worker. In the manufacturing and wholesale sectors, moderate sitting and the use of tools with medium vibrations were all associated with jobs in lower WMSD claims rate companies. As an explanation, sitting may be necessary in many industries where prolonged standing may be more problematic. The use of powered tools, even those with moderate levels of vibration, is better than the use of hand tools, which requires higher hand exertions. Some driving (risk level 2) was identified as a protective factor associated with jobs in the lower WMSD back claims rate companies (lower odds ratio). Transporting heavy goods with forklifts and trucks by the yard workers and truck drivers, which may be less hazardous than manually transporting goods, may explain these findings.

### *Management and Labor Organizational Climate Interviews*

Recruiting participants for interviews was especially challenging for multiple reasons, including 1) employers were hesitant to allow workers to leave the production line to conduct the 20-minute interview; 2) some of our contacts explained that workers were paid a piece rate and were themselves reluctant to leave the line for that reason; 3) some of the operations often operated only during high harvest seasons, making them unreachable during the off-season, and "too busy" during harvest.

In the comparison scores of organization scores between management and labor groups within company and between companies, labor scores consistently scored higher. This might suggest that labor had a more optimistic view of the organization. Possibly, labor may have been hesitant to speak truthfully, despite assurances that individual results were not shared. However, since management representatives most often identified the worker to complete the labor interview, safety to speak freely and honestly may not have been felt. Those workers that provided the labor point of view varied in their place in the hierarchy of the company, their education level, safety and health knowledge and their proficiency with the English language. Alternatively, management representatives may have had a more realistic and knowledgeable view of the company's organizational climate.

Organizational/safety climate or culture surveys are most often administered to a sample of targeted group (upper management/supervisors, production workers) in order to identify group perceptions. In this study, due to limited resources, the management/labor interview was administered to only one management representative and one labor representative. The assumption was made that the perceptions would represent the perceptions of the group.

### Conclusion

The collection of data for this study was a huge undertaking, requiring an extraordinary amount of resources. Over the course of the study, we completed 98% of the injured worker interviews (n=239), 99% of the management and labor organizational climate surveys (n=381) and visited 100% of our target for site visits (n=96). The Great Recession coincided with the start of our data collection which made it more difficult to recruit companies or workers. Additionally, for many companies recruited for site visits, multiple visits to multiple locations were necessary.

This study has quantified the exposures to work-related musculoskeletal disorders (WMSDs) risk factors across a large working population. And with the continuing burden of work-related musculoskeletal disorders (WMSDs) on workers' compensation insurers, employers and workers, the need to characterize the exposures to WMSD risk factors is paramount. The monitoring of WMSDs through the workers' compensation claims system helps employers, researchers and legislatives identify emerging trends and high risk industries. However, the true burden of WMSDs will continue to be an underestimation since indirect costs to employers, workers and society are not included in workers' compensation data.

From our job evaluations, we have shown that the risk factors may not be the same between industry groups and as such industry-specific tools or checklists may simplify the evaluation process.

The interview collection strategies used in this study and datasets derived from injured workers will help researchers uncover potentially fruitful areas of inquiry otherwise unspecified. This type of information is also useful in providing contextual richness to summary reports of findings as well as to evaluation instruments tailored to specific industries.

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## Data Sets

Research resources and data collected under the Washington State Occupational Injury and Illness Surveillance Program grant may be made available to qualified individuals within the scientific community after publication. In Washington State, data sharing is governed by our state public disclosure laws, and additional specific Washington State statutes and administrative regulations associated with the entity owning the data system from which occupational injury and illness data or workforces estimates are ascertained.

### Other Materials available for other investigators

Other research materials or protocols may be available under the conditions described above. Qualified individuals within the scientific community who are interested may contact the Washington State Occupational Injury and Illness Surveillance Program directly.

### Inclusion of gender and minority study subjects

No subjects were excluded on the basis of gender or race/ethnicity. The surveillance project recruited workers based on industry of employment and body part of injury. Race and ethnicity data were captured when available, typically collected when a case follow-up interview occurs. A completed cumulative inclusion enrollment form is attached.

### Inclusion of children

Per the definition provided by NIH, children are less than 21 years of age. Data was collected for persons younger than 21. There were a small number of injured workers less than 21 years of age identified by the surveillance system, but follow-up interviews were not conducted with workers under 18. Care was taken to ensure guidelines for working with small numbers were followed for protection of confidentiality in data analysis and presentation. The number of injured workers and subsequent respondents for children under 18 were too small to make any meaningful conclusions about this population.

## Cumulative Inclusion Enrollment Report

### Using Workers' Compensation Data to Identify High Risk Workplaces for WMSDs

Program Director: Ninica L Howard, MSc, CPE

Grant Number: 5 U60 OH008487

<b>PART A. TOTAL ENROLLMENT REPORT:</b>		<b>Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race</b>		
<b>Ethnic Category</b>	<b>Females</b>	<b>Males</b>	<b>Sex/Gender Unknown</b>	<b>Total</b>
Hispanic or Latino	18	35		53 **
Not Hispanic or Latino	69	113		182
Unknown (individuals not reporting ethnicity)	0	4		4
<b>Ethnic Category: Total of All Subjects*</b>	87	152		239 *
<b>Racial Categories</b>				
American Indian/Alaska Native	2	4		6
Asian	2	0		2
Native Hawaiian or Other Pacific Islander	2	0		2
Black or African American	1	6		7
White	59	111		170
More Than One Race	17	21		38
Unknown or Not Reported	4	10		14
<b>Racial Categories: Total of All Subjects*</b>	87	152		239 *
<b>PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)</b>				
<b>Racial Categories</b>	<b>Females</b>	<b>Males</b>	<b>Sex/Gender Unknown</b>	<b>Total</b>
American Indian or Alaska Native	0	2		2
Asian	0	0		0
Native Hawaiian or Other Pacific Islander	0	0		0
Black or African American	0	1		0
White	0	6		6
More Than One Race	15	18		33
Unknown or Not Reported	3	6		9
<b>Racial Categories: Total of Hispanics or</b>	18	35		53 **

\* These totals must agree. \*\* These totals must agree.

**PFA: NORA Surveillance Projects: Washington State Trucking Injury Reduction  
Emphasis through Surveillance (TIRES)**

Washington Occupational Injury and Illness Surveillance Program

Grant Number 2 U60 OH008487

Project Period: July 1, 2010 - June 30, 2015

Final Report Completed: September 23, 2015

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## **PFA: NORA Surveillance Projects: Washington State Trucking Injury Reduction Emphasis through Surveillance (TIRES)**

Washington Occupational Injury and Illness Surveillance Program

Grant Number 2 U60 OH008487

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**Abstract:** The Washington State trucking industry has some of the highest costs and rates for work-related injuries, however very little is being done to address injuries other than those caused by motor vehicle collisions. The most common and costly injuries in trucking are musculoskeletal disorders, falls, motor vehicle collisions and injuries from being struck by or against an object. These conditions comprise 80% of the industry's workers' compensation claims, costs and lost workdays. TIRES conducted in-depth occupational safety and health surveillance in the Washington State trucking industry to identify work environments that put trucking industry workers at increased risk. TIRES identified four activities where 80% of the most common injuries were occurring (1) enter/exit the cab or trailer, 2) loading/unloading, moving material manually, 3) walking around the truck or jobsite, and 4) securing a load. During this surveillance cycle, our surveillance activities identified five factors associated with these activities that may be amenable to worksite interventions. These factors are: 1) lack of control of the site of work, 2) co-worker support issues, 3) equipment maintenance or mismatch issues, 4) company support, and 5) training.

The TIRES steering committee, a group of industry stakeholders comprised of labor, business, insurance companies, trucking schools and independents, assisted with dissemination of prevention strategies to those who could intervene in the workplace. We used workers' compensation data to identify and monitor all reported work-related claims in the industry. Case follow-up, site visits and information dissemination focused on many of the most common scenarios where truck drivers are getting injured.

The TIRES program, along with the TIRES steering committee, continued to use our collaborative web site, [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org) for publication and information dissemination. Additionally, TIRES has paved the way to interactive training by developing a variety of interactive, simulation training tools. The simulations are being used all over the world and have been downloaded from the web site over 20,000 times and been requested for use by industry safety professionals from all over the country. Two of Washington's major trucking industry groups, the Washington Trucking Associations and the Washington Refuse and Recycling Association have linked to the web site as well as SafetyDrivenCA and others around the world.

## Section 1

### Significant (Key) Findings

**Identified factors correlated with key activities and work-related injuries.** Prior case follow-up surveillance of the top four injury types in trucking: musculoskeletal disorders (MSDs), slips, trips and falls, motor vehicle crashes and struck by injuries led to discovery of four major activities that accounted for over 80% of the of non-motor vehicle collision injuries captured by the TIRES surveillance system. These are: a) loading/unloading (and other manual handling), b) exit/entry from the cab or trailer, c) securing a load, and d) walking around the job site. Data captured and analyzed during this, our current phase (TIRES2), led us to identify the primary factors for the injuries that occurred during these activities. These factors are: 1) lack of control of the site of work, 2) co-worker support issues, 3) equipment maintenance or mismatch issues, 4) company support and 5) training. This will be addressed in the next phase of TIRES.

- **Companies need safety plans.** Our safety specialist visited many sites that were lacking or had to dust off their safety plans. Trucking companies, especially small to mid-sized trucking companies need easy access to relevant safety plan development guidance. This will be addressed in the phase of TIRES.
- **Interactive trainings are sought after.** Our simulations were downloaded over 20,000 times and are being used all over the world. TIRES will continue to develop interactive training.

### Translation of Findings

- **Safety resources should be focused on the most common and costly injuries in trucking.** Resources and legislation are already focused on motor-vehicle crashes; however, little is being done for non-vehicle related injuries. TIRES is meeting this need with production of relevant safety materials focused on the most common and costly injuries in formats easily digestible by the average worker.
- **TIRES technical report** provides the industry with data on fatalities and the most common injury types and causes. The report has been downloaded over 2,500 times since its release in November 2014.
- **The TIRES Force Simulation tool** is a prime example of educating the worker on the strain to the body caused by jumping from the cab or trailer or “riding the door” of the trailer. TIRES developed 7 different interactive trainings to help fill a training gap.
- **Working with industry partners is crucial to success.** The TIRES Steering Committee is comprised of industry stakeholders including business, labor, insurance, and truck driver training schools. The steering committee has been invaluable to the work of TIRES, lending expertise, knowledge, and ideas including reviewing and editing all safety materials produced by TIRES and forwarding ideas for new ones.

### Outcomes/Impact

The TIRES Surveillance Program uses unique Washington State, single source workers' compensation data to more accurately assess the work-related injury burden within the trucking industry. We

supplement our WC data, with in-depth case follow-up interviews, in order to understand the circumstances surrounding time-loss injuries. The richness of this data has allowed TIRES surveillance staff to:

- Identify systemic issues within trucking that are responsible for many of the injuries to drivers, TIRES fills a training gap in the trucking industry.
- Identify and develop prevention materials and recommendations for workplace interventions.
- Help to fill the gaps in current national surveillance systems, by using more complete injury statistics for Washington State, coupled with in-depth case follow up interviews.

#### *Potential Outcomes*

- TIRES publications are distributed through voluntary avenues, meaning people need to sign up to receive our materials or download them from our web pages, therefore, visits to our web sites are an accurate representation of the usefulness of the materials. During the past 5 years, there were over **90,000 visits** to our web pages at [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org) and over **570,550 downloads** from this and <http://www.lni.wa.gov/Safety/Research/Trucking/Pubs/Default.asp> combined.
- The online simulation tools developed in response to stakeholder requests for interactive options have been downloaded over **20,000 times**. Our simulations are also available on external websites (e.g., SafetyDrivenCA) where they can be downloaded. We do not have a count of those downloads.
- Leveraging social media - Our [Twitter account](#) was launched on October 20, 2011. We currently have **1,223 followers**. On a typical week, our exposure is **211,656 accounts** due to other users retweeting (forwarding) our information. A YouTube training video was viewed over **2,000 times**. We blog on a variety of topics and a special is released to honor each truck driver killed in Washington. The [TIRES blog](#) was visited **2,591 times** over the past year.

#### *Intermediate Outcomes*

- TIRES training materials are used as a major component of Washington Teamsters Training, Workers Training Workers program for the trucking and construction industries. More information about this success story can be found at <https://cste.site-ym.com/?SuccessStories>.
- Partners including other states' WC programs, associations, and private employers request our team to collaborate on developing additional materials and present TIRES materials at meetings.

Over 60% of those who responded to our evaluation survey use our materials to train drivers, 55% use our material to teach safe ingress/egress from cab or trailer, 40% use our materials to teach safe loading/unloading.

## Section 2

### Scientific Report

#### *Background*

The U.S. trucking industry has some of the highest rates and costs of work-related injuries, among all industry sectors. In the U.S. trucking industry<sup>i</sup> there were approximately 101,400 recordable non-fatal injuries in 2013, with a rate of lost time injuries that was two to three times higher than the entire U.S. private industry sector.<sup>ii</sup> In Washington State, the trucking industry has more than two times the rate of lost time (compensable) claims compared to all other industries combined <sup>(1)</sup>. The purpose of this surveillance project was to identify key factors related to four priority activities (walking around the truck/job site, ingress/egress from cab or trailer, loading/unloading or manual material handling, and strapping or securing a load), where 80% of the most common non-motor vehicle injuries in trucking occur. These priority activities were identified from our previous TIRES surveillance work.

In Washington State, based on State Fund workers' compensation data, from 2006-2012, there were 6,903 lost work time claims in the trucking industry. The majority were in General Freight, Less than Truckload (29%), followed by General Freight, Truckload (23%). These time loss claims account for \$45 million dollars in claims costs annually. Non-traumatic upper extremity and back musculoskeletal disorders (NT-MSDs) accounted for 35% of the time loss claims, while falls accounted for 21%, struck by compensable injuries were 13%, and motor vehicle related compensable injuries accounted for 8% of the claims. NT-MSDs accounted for approximately 33% of the total medical costs (see Table 1).

**Table 1. Priority Conditions in Washington Trucking Industry**

Injury type	# of compensable claims	Claims rate per 100 FTE	Total medical cost	Total number of lost work days	Total cost of lost work time
Falls from elevation	774	3.1	\$18,069,647	183,142	\$12,358,428
Falls from same level	685	3.2	\$11,336,039	151,373	\$10,773,757
Neck, back and upper-extremity musculoskeletal disorders	2408	11.5	\$37,807,193	541,089	\$36,806,431
Other	1573	1.6	\$20,735,797	241,786	\$16,082,598
Struck by	906	4.1	\$12,194,786	145,808	\$9,227,349
Vehicle related	568	2.3	\$15,334,756	164,317	\$11,437,736

<sup>i</sup> Trucking industry data presented here, uses an expanded definition to match our surveillance definition and includes General Local Freight (484110), Long Distance Freight - Truckload (484121), Long Distance Freight - LTL (484122), Movers (484210), Specialized Local Freight (484220), Specialized Long Distance Freight (484230), Couriers (492110), Local Messengers & Local Delivery (492210), Solid Waste (562111), and Hazardous Waste (562112), Other Waste Collection (562119).

<sup>ii</sup> U.S. Bureau of Labor Statistics, Occupational Injury and Illness Survey, 2013,

<http://www.bls.gov/iif/oshsum.htm#I3Summary> News Release.

Our previous work in the trucking industry identified four priority activities that accounted for 80% of the most common injuries (i.e., non-traumatic neck, back and upper extremity musculoskeletal disorders, falls from elevation, falls from same level and struck-by injuries). These activities are: 1) ingress/egress from cab or trailer, 2) walking around the truck or job site, 3) loading/unloading or manual material handling, and 4) tarping, strapping or securing a load.

The overall goal of this surveillance project was to identify the specific factors that were present during the four priority activities that put truck drivers at risk for injury. The TIRES surveillance system had 5 specific aims which included:

- 1) Expand and maintain partnerships with representatives from both management and labor within the trucking industry,
- 2) Modify the TIRES surveillance system to track claims in the trucking industry, with particular focus on the four key activities where injuries are occurring,
- 3) Revise and implement case follow-up protocols for identifying risk factors and solutions for the key activities,
- 4) Publish a technical report describing injuries, trends and costs within the trucking industry by sector utilizing state workers' compensation data and state economic data,
- 5) Identify opportunities for the use of educational materials and other interventions to reduce hazards and injuries within trucking.

A brief summary for each specific aim, as well as detailed methods, results and a discussion section are provided below. Evaluation results are also provided, when available.

#### Specific Aim 1: Expand and maintain partnerships with representatives from both management and labor within the trucking industry

##### *Methods:*

The TIRES steering committee met twice yearly during the grant period, and communicated monthly via emails and telephone calls. The TIRES steering committee is comprised of representatives of business, labor, insurance companies, and a representative from a publically-funded truck driving school.

TIRES research staff participate in various industry events and are often asked to speak about TIRES and to present safety materials at conferences such as the annual managers' meeting of the Washington Refuse and Recycling Association (WRRRA) and the Washington Trucking Associations (WTA), two of the largest trucking industry associations in Washington State.

TIRES research staff participated in the WTA truck driving championships and also the last Washington State Governor's Safety and Health Conference. These outreach activities are very useful for the dissemination of TIRES materials.

*Results:*

As a result of our expanding partnerships with the industry, we have been asked to speak at more company events (e.g., safety fairs), and our materials have been used in Teamsters’ train the trainer programs. In addition, we have been able to speak honestly and openly with business and labor representatives about issues facing safety managers at companies and issues faced by drivers, all as a result of our continued involvement with the TIRES Steering Committee, and our expanded outreach.

*Evaluation:*

After our last steering committee meeting, we sent out an anonymous online survey for our steering committee members to evaluate how well we met their expectations and asked for input on how we can improve for the next grant cycle. The survey was sent to all former and current steering committee members (n=19). We received 13 responses (response rate 68.4%).

Overall the steering committee was pleased with how effective the team worked together. In evaluating our role on the committee, the majority of comments were positive. See Table 2 for results of the survey.

**Table 2. TIRES Steering Committee Evaluation Results**

<b>1. How well have we done on planning and implementation?</b>				
Sub question	Poor	Fair	Well	Excellent
Follow through on steering committee activities	0	0	5 (38.5%)	8 (62.5%)
Strengths and competence of L&I TIRES Staff	1	0	2	10
TIRES efforts to promote collaborative actions	0	0	4	9
TIRES processes to assess the trucking community’s needs	0	0	7	6
Training and technical assistance provided by TIRES staff	0	1	6	6
<b>2. How well have we done on communication?</b>				
Sub question	Poor	Fair	Well	Excellent
Use of the media to promote awareness of the Steering Committee’s goals, actions and accomplishments	0	1 (7.7%)	4 (30.8%)	8 (61.5%)
Communication among members of the Steering Committee	0	2 (15.4%)	3 (23.1%)	8 (61.5%)
Extent to which Steering Committee members are listened to and heard	0	0	3 (23.1%)	10 (76.9%)

Working relationships with L&I TIRES staff and Steering Committee members	0	0	4 (30.8%)	9 (69.2%)
Information TIRES L&I staff have provided on issues and available resources	0	0	4 (30.8%)	9 (69.2%)
<b>3. To what extent has the steering committee...</b>				
Sub question	Poor	Fair	Well	Excellent
Addressed local concerns in ways that benefit the trucking community?	0	0	6 (46.2%)	7 (53.9%)
Enhanced understanding of issues that affect the trucking community	0	0	7 (53.9%)	6 (46.2%)
Enhanced the capacity of partners	0	1 (7.7%)	8 (61.5%)	4 (30.8%)
Strengthened collaboration among the steering committee members, and other organizations	0	3 (23.1%)	4 (30.8%)	6 (46.2%)
Produced and disseminated information and/or findings to community members in clear language respectful to the trucking community and in ways that will be useful for them.	0	0	3 (23.1%)	10 (76.9%)
Followed the norms of partnership (fostered mutual respect, open communication, and equitable decision making).	0	0	4 (30.8%)	9 (69.2%)
Acknowledged the contribution of partners in presentations and publications.	0	0	4 (30.8%)	9 (69.2%)
<b>4. What aspects of the TIRES Steering Committee work are you most pleased with? Please describe.</b>				
<b>Responses:</b>				
Enthusiastic knowledgeable staff.				
Education materials and outreach				
Production of quality driver training materials.				
The professionalism and efficiency of the organization				
Posters				

Discussing the issues, seeking an answer, and the innovative answers/methods that the L&I staff came up with to address the issues.
Good graphics with the presentations. Excellent statistics.
All aspects it is really nice to see people that truly enjoy doing their jobs.
<b>5. What aspects of your experience on the TIRES Steering Committee would you change? Please describe.</b>
<b>Responses:</b>
Trucking safety in WA involves all workers that are classified as truck drivers and extends quite a way beyond the "industries" that are the focus of this committee's work. I would like to see the grant expanded to include the non-trucking trucking industries.
Create a model safety manual.
I feel the in person mts are important, however a possible 50/50 split between in person and webex might be beneficial.
None
Wouldn't make a change!
I think meeting every other month would only add two meetings, but help the committee keep a little more focused.
Connect with more companies. Information needs to get to the people who need it and can get it to the personnel who can implement it within the companies.
I would have the steering committee meetings in Hawaii.

*Discussion:*

Without the assistance of the TIRES steering committee, the prevention materials TIRES created would not have had the authentic tone and feel required to be successful in engaging and reaching both safety managers (many of whom are retired truck drivers), or truck drivers themselves. Their assistance in creating meaningful documents, posters and other tools cannot be stressed enough. The use of “insiders” was critical to our success.

We will take the comments from the TIRES steering committee evaluation survey and address issues that were raised. We felt the need to ‘disband’ the steering committee and create a new committee because of the industry sector focus (no longer studying Couriers and Messengers, Waste Haul or Movers). Eight of our former Steering Committee members are returning and we have added five new members, some not in the trucking NAICS codes, but who have trucks/drivers, specifically in response to comments from this evaluation.

Specific Aim 2: Modify the TIRES surveillance system to track claims in the trucking industry, with particular focus on the four key activities where injuries are occurring

*Methods:*

**Surveillance system development and maintenance:**

The purpose of the TIRES surveillance system is to identify specific hazards that are associated with the four major activities where the majority of injuries were occurring to truck drivers, for prevention purposes. SHARP relies on workers’ compensation data as the source for case ascertainment. The original case definitions that were used to identify activities, rather than our previous grant cycle, which looked at specific injuries, are listed in the table below.

**Table 3. Case Definitions for surveillance of priority conditions in trucking\***

Activity	Key words search for cases**			
Loading and unloading activities / Manual material handling (not loading/unloading)	Load Lift Carry	Pull Toss Push	Move Trailer Door	Turn Heavy
Securing load	Secure Strap	Chain Toss	Tight Tarp	Binder
Enter/Exit Cab or Trailer	Enter Exit Cab	Truck Trip Fall	Fell Ground	Slip Trailer
Walking on job site	Walk Slip	Ground Trip	Fell	Fall

\* The trucking industry is defined as the following NAICS codes: General Local Freight (484110), Long Distance Freight - Truckload (484121), Long Distance Freight - LTL (484122), Movers (484210), Specialized Local Freight (484220), Specialized Long Distance Freight (484230), Couriers (492110), Local Messengers & Local Delivery (492210), Solid Waste (562111), and Hazardous Waste (562112), Other Waste Collection (562119).

Evaluation of the above case definitions effectiveness at identifying possible injury activities of interest, revealed that the key words were missing some cases and misclassifying other cases. We decided in the first year to change our case identification by downloading all claims within our trucking NAICS codes, with more than 3 days of time loss. A review of the claim text, and Occupational Injury Illness Classification System (OIICS) codes, then determined whether the injured worker was injured while performing one of our priority activities.

Periodic analyses of the data was conducted by industry sector for each of the priority activities to determine root cause of injuries, and to develop relevant prevention materials.

*Results:*

The surveillance system has been invaluable for the TIRES project in systematically identifying injury types, natures, counts and costs for all sub-sectors of the trucking industry. These data have helped to direct TIRES prevention efforts and have helped identify common themes and activities where prevention efforts can be focused to return the most on investment.

Reviewing the narrative along with other pertinent variables (e.g., occupation, injury type, and source), in order to determine whether or not the injured worker was performing one of the four priority activities, was more helpful in targeting our surveillance interviews to the cases where we could glean

the most information. The additional burden of reviewing cases manually, was not large, and had a higher rate of return than relying on key words.

*Discussion:*

The modified surveillance system was invaluable in identifying topics for our prevention materials, and assisted us in identifying potential areas for intervention. Without the surveillance system, we could not have completed other specific aims in this research project.

Using key word searches of employee reported injury description, to identify activities being performed during the course of a workers' compensation injury event, did not work as well as initially planned. Unless the number of claims is burdensome, manually review the narrative of each claim, is more accurate without sacrificing feasibility. In the case of large datasets, Naïve or Fuzzy Bayesian algorithms may work similarly well to manual review, without sacrificing quality or feasibility<sup>(2-4)</sup>.

Specific Aim 3: Revise and implement case follow-up protocols for identifying risk factors and solutions for the key activities

Revisions to both of our case follow-up activities (interviews and site visits), were completed during this project period. Case follow-up interviews were revised from the previous surveillance grant in order to focus on issues relevant to the activities where 80% of compensable (time-loss) injuries were occurring. Additional questions related to work organization (e.g., the way that work was done, were they rushed, and what were conditions at the customer site?) and included additional safety perception questions (e.g., "Workers and management work together to ensure the safest possible conditions"). This information is rarely available from workers' compensation data and was only attainable through the careful probing of an experienced interviewer who is familiar with the trucking industry and vernacular. Review of the case follow-up data spotted injury/incident themes that we addressed in safety materials designed to target specific hazards. Additional themes included location of injury, lack of training, fatigue, maintenance issues and rushing to complete work. Case follow-up site visit protocols were revised to assist in the identification of novel best practices, and to add additional insight into what factors might be related to the four main activities where the majority of injuries occur.

**Case follow-up interviews:**

*Methods:*

Each month, trucking claims for the priority conditions that have reached seven consecutive days of timeloss were identified and telephone interviews were attempted with the first ten (or a random selection of ten) of the claimants for each of the priority conditions (i.e., a maximum of 40 attempted telephone interviews per month). Claims with 7-days of timeloss were selected for follow-up interview, because these may represent potentially more serious hazards, and workers who are off work may be more likely to be reached for the interview. The safety specialist conducted the review of claims data, conducted interviews and entered the interview data into the secured database. The data manager maintained the interview database. Information in the claim file included time of day, hours worked per day and days per week, gender, age, occupation, and a brief description of the incident. Some of the more

important information for injury prevention was rarely in the claim files. Those include environmental conditions (present in ¼ of the claims) surface conditions (1/3), loading or unloading, or physical location of incident (rare). Information collected from the interviews included onset (sudden, gradual), activity/job at time first noticed, circumstances, perceived main causes/conditions leading to injury, contributors (environment, work organization, pay structure, time pressure, psychosocial issues and organizational support, etc.), and prevention ideas.

*Results:*

1,511 cases were downloaded from the workers' compensation claims data, of these 553 did not meet our inclusion criteria (in one of the four activity types, or were not a driver), leaving 958 potential cases to interview. Of these 958, 329 were interviewed, (response rate of 34%). All were qualified workers' compensation claims with 7 or more days of time-loss in the trucking industry NAICS. Of the 329 interviewed, descriptive analyses have been completed for those interviewed as of June 30, 2015.

**Table 4. Descriptive characteristics of interviewed drivers (N=329)**

Characteristic	N	%
Age (mean ± SD)	49.8	(11.4)
Male	305	93.9
BMI		
Underweight (<18.5)	2	0.61
Normal (18.5-24.9)	50	15.2
Overweight (25-29.9)	117	35.6
Obese (30+)	160	48.6
Race/ethnicity	n=328	
White	269	82.01
Black	12	3.7
Other	36	10.9
Refused	11	3.4
Hispanic origin	27	8.5
Educational Level	n=328	%
<High School	37	11.3
High School/GED	109	33.2
>High School	182	55.5
Total Household Income	n=328	%
Less than \$25,000	22	6.7
\$25,000 to less than \$50,000	123	37.5
\$50,000 and over	156	47.6
Don't know/Refused	27	8.2
Type of trucking they do		
Less than truck-load (LTL)	51	15.5
Long Haul	62	18.8
Specialized/Activity-based	118	35.9
Regular Route	71	21.6
Line	27	8.2
Self-rated health prior to injury	n=328	

Excellent	47	14.33
Very good	127	38.72
Good	139	42.38
Fair	14	4.27
Poor	1	0.3
To what degree does your work schedule impact your ability to exercise?		
None	130	39.76
Some	104	31.8
A lot	93	28.44
To what degree does your work schedule impact your ability to get adequate sleep?		
None	136	51.68
Some	100	30.58
A lot	58	17.74
On average, how many hours of sleep do you get in a 24-hour period?		
< 7 hours	136	41.46
7-9 hours	179	54.57
>9 hours	13	3.96
In the last 30 days about how many days have you felt you did not get enough rest or sleep?		
None	141	43.38
≤ 13 days	131	40.31
14-29 days	25	7.69
30 days	28	8.62
To what extent do you have influence over the things that affect you on the job?		
None to very little extent	42	12.8
Little extent	31	9.45
Some extent	83	25.3
Great extent	126	38.41
Very great extent	46	14.02
To what extent do you have input in deciding what tasks or parts of tasks you will do?		
None to very little extent	94	28.66
Little extent	44	13.41
Some extent	73	22.26
Great extent	86	26.22
Very great extent	31	9.45
To what extent do you have the opportunity to take part in making job-related decisions that affect you?		
None to very little extent	86	26.3
Little extent	52	15.9
Some extent	74	22.63
Great extent	85	25.99
Very great extent	30	9.17

To what extent can you set your own work deadlines?		
None to very little extent	129	39.45
Little extent	39	11.93
Some extent	73	22.32
Great extent	65	19.88
Very great extent	21	6.42
To what extent does your job allow you the opportunity for independent thought and action?		
None to very little extent	34	10.37
Little extent	33	10.06
Some extent	86	26.22
Great extent	127	38.72
Very great extent	48	14.63
To what extent do you control the pace and scheduling of your work?		
None to very little extent	90	27.36
Little extent	41	12.46
Some extent	92	27.96
Great extent	78	23.71
Very great extent	28	8.51

In addition, the open-ended questions from the TIRES surveillance interviews with injured truck drivers were very helpful in identifying opportunities for intervention activities. We found that the most common self-reported reasons for the injury event were related to equipment (lack of working equipment or lack of proper equipment), and unsafe behaviors (from rushing, fatigue, demands, and customer site issues). Further, these data are assisting us in developing a systems perspective towards understanding injuries in the trucking industry. We are using this information, along with other data we have gathered over the past ten years, to develop and pilot a safety intervention at small to mid-sized trucking companies.

### **Case follow-up Site Visits:**

#### *Methods:*

The safety and health specialist performed site visits to selected sites, based on the type of trucking and the possibility that root cause information and industry sector best practices could be obtained. The site visits included documentation of environmental conditions, physical, individual, and organizational factors that could influence the outcome.

#### *Results:*

The TIRES project planned site visits as a method to identify and document industry best practices in truck driver safety, and to gather further information about the four priority activities. The project's safety and health specialist conducted the visits at 20 trucking companies between 2013 and 2014, but only 15 contained complete enough data to report. The specialist scheduled the visits through introductory telephone calls and e-mail communications with owners, supervisors, and safety managers who later accompanied him during the visits. The companies varied in fleet size and represented several

trucking industry subsectors (see Table 5). Most companies were located within the I-5 corridor in King and Pierce Counties, a major transportation center in the Pacific Northwest. The specialist conducted structured interviews with safety managers to learn how they investigate non-motor vehicle related employee incidents, review safety programs, and assess safety culture. Work place observations focused on how employees perform the four tasks identified as significant sources of driver injury. Participating companies later received follow-up letters that discussed notable site visit findings and proposed recommendations for improving worker safety.

Managers and supervisors from small and large companies comprised 73 percent of the 15 total interview respondents. Nearly all reported directly to company owners or senior management. While 53 percent had over 5 years of safety and health experience, only one worked exclusively in a safety role, and 66 percent spent less than half of their work time performing safety duties. Sixty percent reported that their companies had written commitments to reducing worker injuries, and most companies did not perform periodic safety program reviews. All companies investigated non-motor vehicle incidents; however, only half used standardized inspection processes, and 60 percent did not have managers trained in incident investigation. While all of the companies maintained safety training profiles for employees, and most sought employee input in safety-related decisions, fifty-three percent did not have employee safety recognition programs. Most companies had dedicated budget lines for safety, considered safety features for new purchases, and performed management reviews of incident trend analysis. Although these percentages indicate an asymmetrical industry-wide pattern that companies have only partially implemented key administrative risk-reducing controls, the vast majority of respondents nevertheless very strongly agreed that their companies demonstrated exceptional safety cultures. The hierarchy of control method ranking scheme places administrative controls as a least effective method to reduce injury and illness incidences while the most effective control method is elimination of the hazard.

Reliance on administrative controls is especially concerning when workers are paid by the mile or load or when rushing to complete work might be a financial incentive. If a company relies on administrative controls for its safety program, it must be supported by a positive safety culture. For the trucking industry, this is essential since the drivers constitute a self-directed workforce as there is no supervisor or manager with them on a day-to-day or hour by hour basis. Once a driver leaves the home terminal, they must be self-disciplined to follow established safety procedures.

Unfortunately no novel “best practices” were identified during these visits.

**Table 5. Description of companies visited by TIRES (n=15)**

<i>Size of company</i>	<i>Trucking industry subsector</i>	<i>Count</i>
Large (more than 25 trucks)	Specialized Freight	5
	General Freight	4
Large Total		9

Small (more than 5 and less than 25 trucks)	General Freight	4
	Moving and Storage	3
Small Total		7

*Evaluation:*

Company contacts where site visits were performed were surveyed in order to see if they were able to obtain useful information from TIRES. Although the primary purpose of the site visits was to identify best practices, not provide consultation, our Safety Specialist was available to answer their questions and provide additional resources.

Responses: 6

Response rate: 26%

**Question 1: On a scale of 1 (very unsatisfied) to 5 (very satisfied) how satisfied were you with the visit we conducted at your company?**

Average 3.33

Very unsatisfied (1)	Unsatisfied (2)	Neutral (3)	Satisfied (4)	Very satisfied (5)
2	0	0	2	2

**Question 2: What did you find the most helpful about this visit?**

	Response
Enjoyed sharing our best practices with the safety engineer	2
Learned about different safety techniques I can use	4
Learned more about L&I rules and regulations for trucking	0
Other (specify)	0

**Question 3: On a scale of 1 (very unsatisfied) to 5 (very satisfied), how satisfied were you with the site visit report we sent you?**

Average 4.3

Very unsatisfied (1)	Unsatisfied (2)	Neutral (3)	Satisfied (4)	Very satisfied (5)
0	1	0	1	4

**Question 4: Do you have any additional comments or suggestions for improvement?**

No comments

*Discussion:*

The case follow-up interviews were invaluable to adding additional information such as work organizational issues and self-reported root causes, as well as specific environmental, physical and equipment issues that may have contributed to the injury. By analyzing the case follow-up interview data, coupled with the workers' compensation data, TIRES was able to determine that the focus of our next grant cycle should contain an emphasis on organizational factors, outside of, but greatly impacting driver's safety and health. Among the issues our case follow-up interviews uncovered are: 1) equipment issues – maintenance or mismatch between equipment available and equipment needed to do the job, 2) lack of driver control over the site of work, 3) co-worker support issues, 4) company support, 5) training and unsafe behaviors. These issues are complex and dynamic, with multiple causes that will require a systems approach to resolve them. This ability to systematically uncover upstream operational issues that can be modified via interventions has been an important contribution to trucking injury surveillance.

Case follow-up site visits, while few, have identified some chronic needs among both small and mid-size (although primarily small) trucking companies. The lack of a written safety and health program, the lack of policies specifically addressing hazards and abatement techniques, and the lack of dedicated safety personnel, prompted the TIRES project team to propose the development of an online, editable safety program, that can be used by small to mid-sized trucking companies that may not have dedicated and formally trained safety personnel.

Specific Aim 4: Publish a technical report describing injuries, trends and costs within the trucking industry by sector utilizing state workers' compensation data.

### *Methods:*

The workers' compensation data for this report is provided by Washington State Department of Labor and Industries (L&I). This report includes workers' compensation claims with injuries occurring from January 1, 2006 to December 30, 2012. Workers' compensation claims are divided into two groups: medical-only and lost work time. Medical-only claims involve only medical expenses. Lost work time claims involve injuries with four or more days of lost work time compensation, total permanent disability, fatality or the worker being kept on salary. Unless stated otherwise all data for costs, injury counts and injury rates are for lost work time claims. Data for this report were extracted on April 5, 2014. Injuries which occurred during the study period may after the extraction date become lost work time claims and have increased costs. This is called 'development'. Therefore, future data extractions for the same time period may reflect slightly increased costs and claim counts. The L&I workers' compensation database includes a complete listing of the Self Insured lost work time claims, but not all medical-only claims, costs or lost work time days. To estimate the number of medical-only Self Insured claims we applied the State Fund medical-only lost work time ratio to the Self Insured lost work time claims. We used the State Fund average lost work time claims' cost and lost work time days to estimate the costs and lost work time for the Self Insured claims. Owner-operators are not required to have workers' compensation coverage so their injury experience is not captured in this report. Truck drivers working in non-trucking industries are not included in this report. Log carriers are included in agriculture and are not captured in this report. Under-reporting of work related injuries to workers' compensation systems is known to occur. Therefore injury rates in this report are likely an underestimate of the true burden of occupational injury in this industry. Employers report hours worked by employees to L&I. We used these hours to estimate a full-time equivalent employee (FTE). A FTE is 2000 hours for one work year. The Washington State Fatality Assessment and Control Evaluation (FACE) program provided the trucking fatality data.

### *Results:*

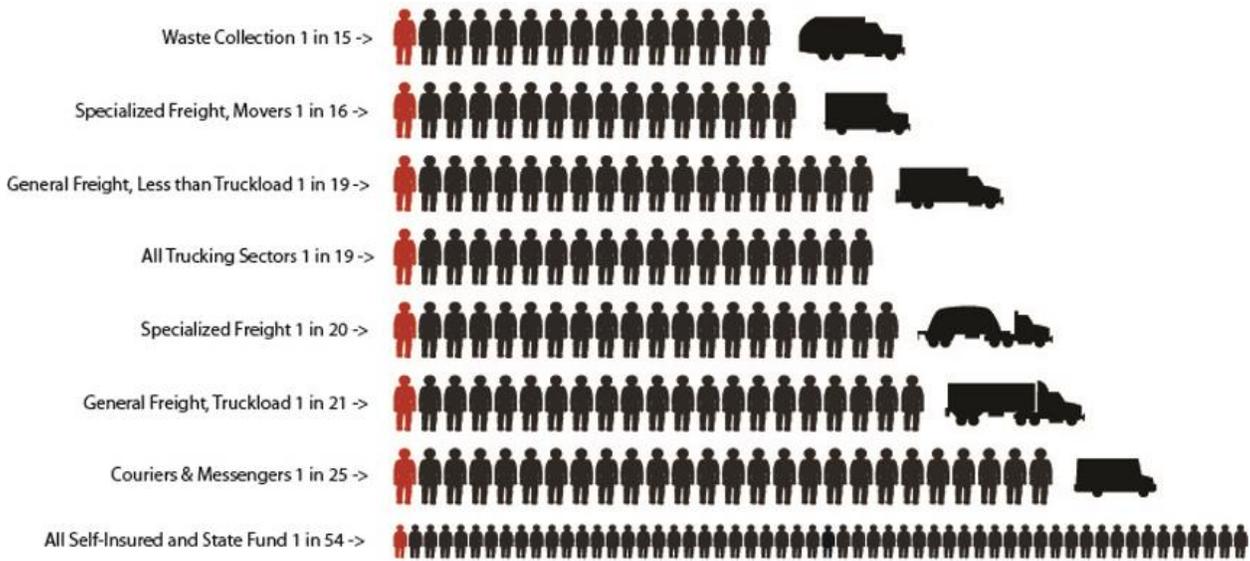
The technical report "Trucking Industry: Examining Injuries for Prevention Washington State, 2006-2012," was published in November of 2014. SHARP Report number 90-148-2014, and detailed injuries and costs for compensable (time-loss) claims by occupation, industry sector and injury type. The report can be downloaded from [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org) or <http://www.lni.wa.gov/Safety/Research/Trucking/Pubs/Default.asp>.

As with many other industries in Washington State and nationally, strain, sprain or overexertion injuries comprise the highest count, injury rate and costs among the largest injury groups. Falls from elevation and falls from same level are also frequent and costly injuries in the trucking industry.

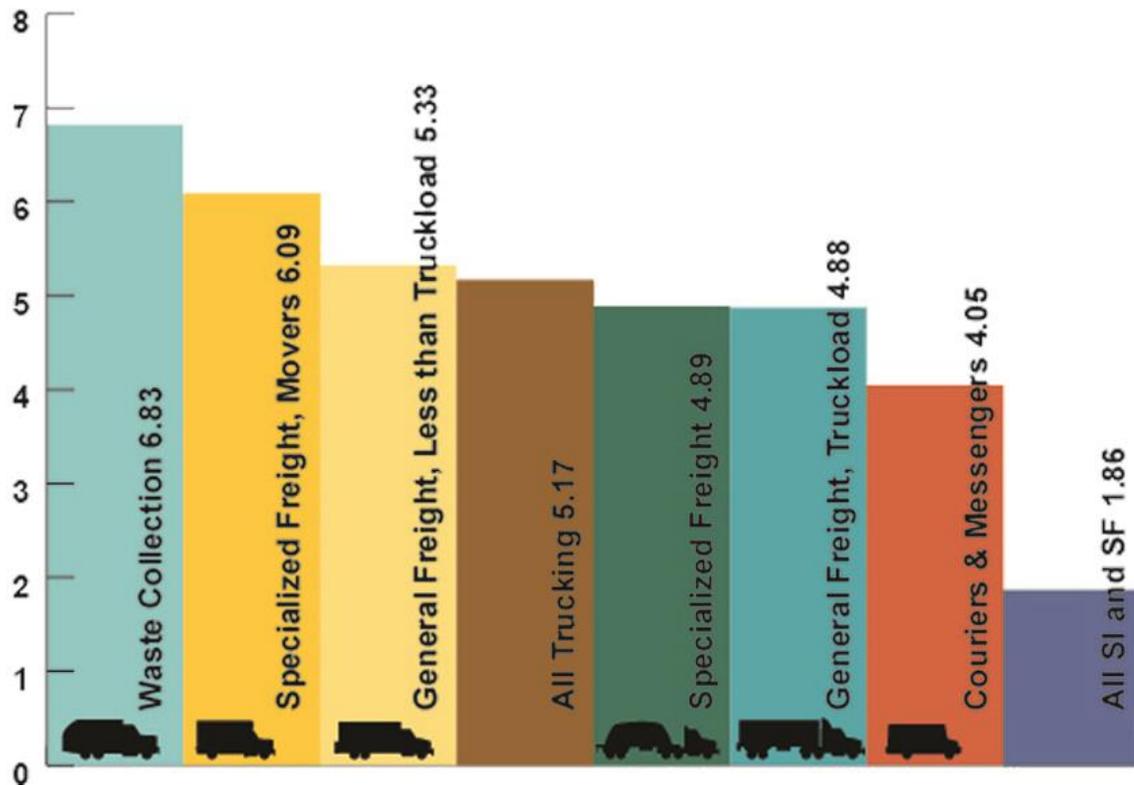
In Washington State, the largest trucking sectors are General Freight trucking, Less than Truckload (25% of FTE) and Couriers and Messengers (24% of FTE). While we acknowledge that there are trucking divisions/truck drivers who are not employed by a trucking industry (North American Industrial Classification System, NAICS) company, data for these drivers is difficult to enumerate, so they are not counted in these statistics or in the report.

From 2006-2012 there were an average of 33,000 workers employed in the trucking industry each year, and among them, there were almost 7,000 lost work time claims totalling over \$316 million dollars in direct workers' compensation costs.

**Figure 1. Employees by sector with an accepted, compenable claim per total FTE's from 2006-2012**



**Figure 2. Compensable claim rate per 100 full-time equivalent (FTE) for each trucking sector 2006-2012**



**Injury Rates per 100 FTE for Trucking Industry Groups Compared to All Industries in Washington State.**

*Discussion:*

Since this report was published, in the fall of 2014, it has been downloaded over 2,500 times and has proven invaluable to safety managers in the industry as well as to TIRES staff when considering priorities for the development of prevention materials.

Specific Aim 5: Identify opportunities for the use of educational materials and other interventions to reduce hazards and injuries within trucking.

TIRES goal was to go beyond traditional surveillance activities, and to use the data collected to educate the industry. The trucking industry is a vital, yet aging industry. They are also a high cost, low profit margin industry. Because of the high cost and rate of injuries in the trucking industry, employers are very open to receiving help in reducing their injury rate and eventually their workers' compensation premiums.

Thus, TIRES produced industry-relevant, injury-focused training materials that were at first mailed out to our trucking industry mailing list (developed using industry NAICS codes) and later made available via electronic newsletter and on the collaborative web site [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org). Most of these materials are also available on the L&I site <http://www.lni.wa.gov/Safety/Research/Trucking/Pubs/Default.asp>. Currently 656 industry stakeholders have elected to be added to the distribution list to receive the semi-monthly TIRES/KeepTruckingSafe E-news.

In addition to publications, TIRES responded to requests from the steering committee for online training by developing the TIRES force simulation tool (also available [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org).) TIRES received so many requests for copies of this tool that it has been modified to make it possible for anyone to download the program from the TIRES [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org) web site.

*Methods:*

Using data collected and analyzed from the TIRES surveillance system, coupled with safety expertise and the invaluable assistance of the steering committee, TIRES was able to create meaningful, relevant prevention materials for the industry.

*Results:*

All TIRES publication are distributed through voluntary avenues, meaning people need to sign up to receive our materials or download them from our web pages, therefore, visits to our web sites are an accurate representation of the usefulness of the materials. During the past 5 years, there were over **90,000 visits** to our web pages at [www.KeepTruckingSafe.org](http://www.KeepTruckingSafe.org) (2,300 visitors a month) and over **570,550 downloads** from this and <http://www.lni.wa.gov/Safety/Research/Trucking/Pubs/Default.asp> combined. 656 industry stakeholders subscribe to the TIRES distribution list to receive the TIRES E-News where we publish all of our new safety training materials. The development of these materials are guided by our steering committee and relevant to the industry. These statistics show that TIRES is meeting a need in the industry. The following materials have been published between July 1, 2010 and June 30, 2015:

## ■ Peer reviewed journal articles

Smith, CK, Williams, JM: [2014]. Work related injuries in Washington State's Trucking Industry, by industry sector and occupation. Accident Analysis & Prevention, Volume 65, April 2014, Pages 63-71, ISSN 0001-4575, <http://www.sciencedirect.com/science/article/pii/S0001457513005095>.

- **Online simulation trainings** - Interactive, educational resource to be used by drivers and training personnel. Produced 7. Downloaded over 20,000 times.
  - [Safety Climate](#): teaches Safety Directors and owners how best to impact safety at their companies.
  - [Fall from ladder](#): tells the true story of a driver who was injured falling from a tanker ladder.
  - [Fatal crush from load shift](#): tells the true story of a truck driver who was killed when his load of pipes shifted. Includes prevention tips.
  - [Chaining up](#): find the differences between the novice and professional driver when tire chaining.
  - [What's best? Lever or ratchet binders](#): Test the force of different binders.
  - [Tarping techniques](#): Best practices for safe load tarping. (Regular and Santa versions)
  - [Prevent slips](#): Change your environment, task and footwear to see how your friction levels and risk of slips changes. (Regular and Santa versions)
- **A 'plain talk' summary of our journal article** [Research Findings: Trucking injuries](#) (109 KB PDF).
- **Technical report** – Provides stakeholders with information on claims, claim rates, costs common injury causes and prevention ideas. [Trucking Industry: Examining Injuries for Prevention, Washington State, 2006-2012](#). Downloaded over 2,500 times
- **TIRES/KeepTruckingSafe E-news electronic newsletter** - Introduces and educates managers and safety personnel on the magnitude of specific injury types. [55 produced](#). 656 subscribers.
- **True story narratives** – Actual stories of Washington workers injured on the job. Includes injury prevention tips. **26 produced.**
- **Tip sheets** – Injury prevention tips for specific scenarios. **24 produced.**
- **Posters** – Eye catching and educational posters for employee awareness. **52 produced.**
- **Company corner** – Profiles safety professionals or companies that have made safety at priority. **7 produced.**
- **Spanish translations** – TIRES publications were translated into Spanish on an as-needed basis. **7 translations produced.**

- **Other publications** – A special report for movers and a postcard to promote KeepTruckingSafe.org to previously unreached Washington employers.
- **Social media** - We have expanded marketing and outreach into social media tools such as [Twitter](#), [YouTube](#) and the [TIRES Blog](#).

*Evaluation:*

To better understand the needs of our subscribers and to improve our materials we sent out a feedback survey to subscribers of our E-news.

*Methods:*

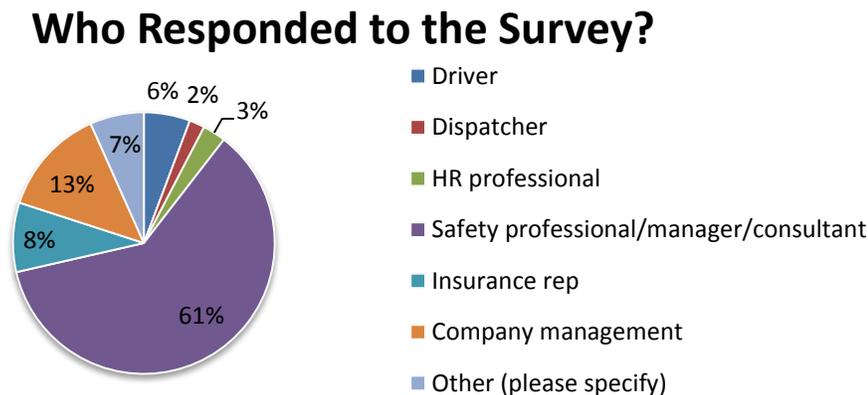
In March 2015, we included a link in our electronic newsletter (TIRES/KeepTruckingSafe E-news) as well as a link on our homepage to a third party survey site (SurveyMonkey). The request went out in both March and April’s E-newsletters and was on the site for 2 months.

A link to an online evaluation survey was sent to all subscribers of the TIRES E-news (at the time of the survey, subscribers=625). We received 105 responses, giving us a response rate of 17%. This is low, but not unexpected in online surveys of this type. Because the link was also posted on our home page, 17% is possibly an inflated response rate, since we do not know how many people viewed the link and again, how many decided to take the survey. Below are some of the results we sent back to all subscribers.

*Results:*

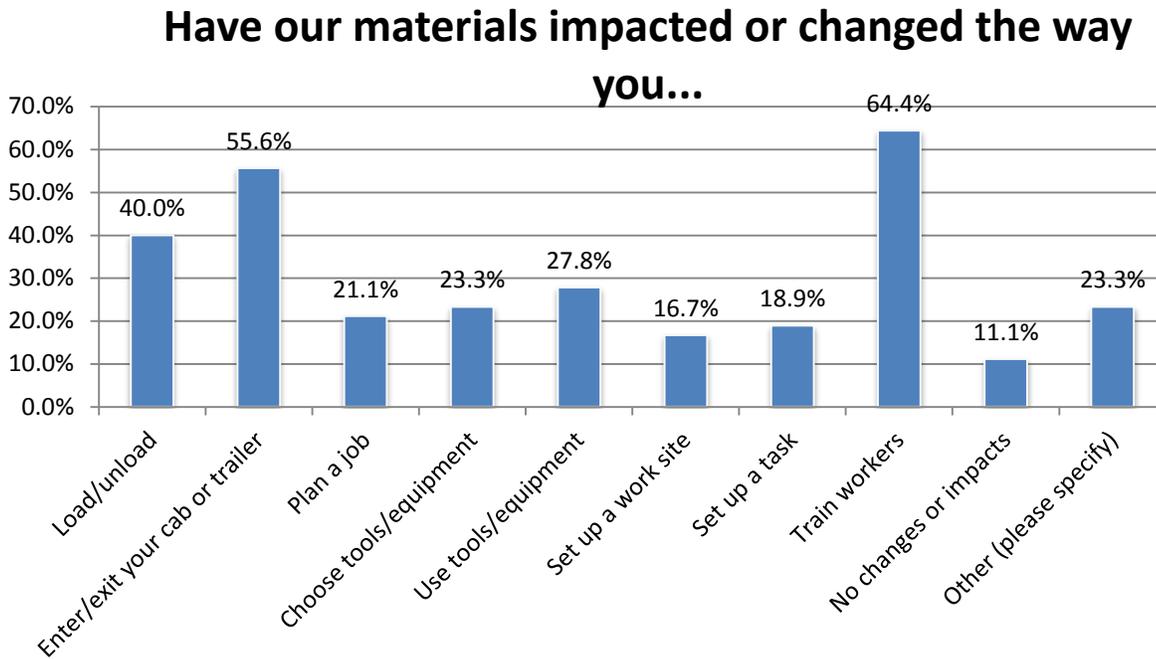
As expected, the majority of our subscribers and the survey respondents are safety professionals.

**Figure 3. Job titles of survey respondents**



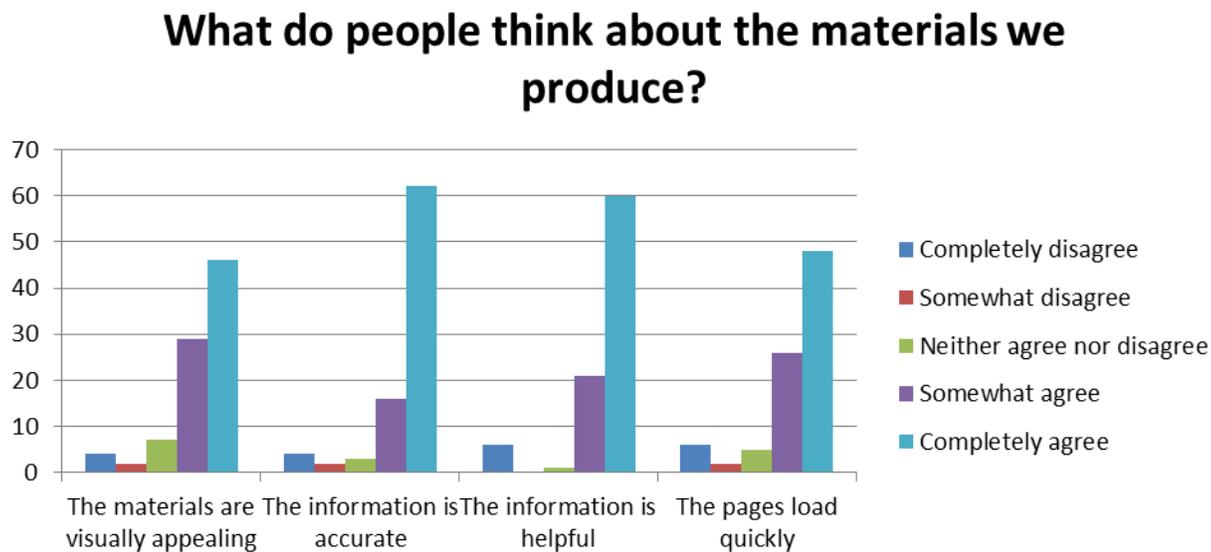
75% of respondents are happy with their safety program. Here is a breakdown on how they use TIRES/KeepTruckingSafe.org materials.

**Figure 4. Impacts of materials**



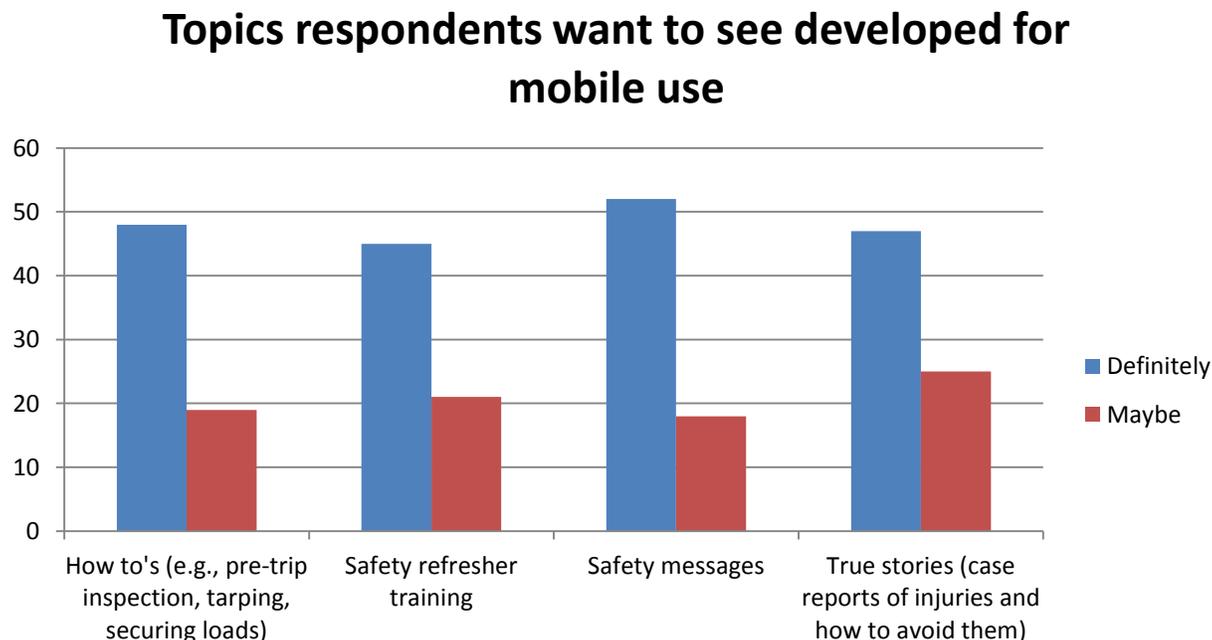
Most of those who responded (88%) think our materials are visually appealing, accurate, and helpful.

**Figure 5. Visual appeal**



For those who want to see mobile technology used for safety, some topics of interest included:

**Figure 6. Mobile technology uses**



*Discussion:*

Overall, the results of the publication evaluation survey were quite positive. There always exists room for improvement, and we will attempt to address any deficiencies in our material to date, in future educational and prevention materials. Table X is most encouraging for our team, as people are using our materials in the ways we had intended – to train their drivers and specifically to load and unload as well enter/exit the cab and trailer in ways that are safe. These are two of the injury activities where we see the most lost-time injuries. We consider these results as evidence that we are having an impact in improving the safety of truck drivers.

*Conclusions*

The TIRES project in the five-year grant cycle 2010-2015, successfully completed all specific aims laid out in the original grant proposal. In addition to creating a successful surveillance system, adding to this data in-depth information from case follow-up interviews and site visits, the TIRES project was able to fill an information and educational niche in the trucking industry, at the state and national levels. Using the surveillance program data, TIRES identified factors associated with our four priority activities where interventions can be implemented in an effort to avoid the injuries from occurring. In the past 9 years, covering two grant cycles of the TIRES surveillance program, we have developed over 200 educational pieces covering many aspects of safety for truck drivers, from fatigue to customer site safety checklists.

We have talked with thousands of drivers, safety professionals, and families of drivers. We believe we are in the best possible position to design and develop comprehensive programs for the industry. The development and piloting of a workplace safety intervention is the aim of the latest TIRES project, currently underway. Along with the intervention, the third wave of the TIRES project will continue to produce the in-demand prevention material, though not at the same volume as previous grant cycles, complete an easy to use and customizable online safety program manual, develop additional simulation tools and continue to reach out to the industry, its' associations and the drivers themselves.

## Publications

### *Journal Articles*

Smith CK, Williams J. 2014. Work related injuries in Washington State's Trucking Industry, by industry sector and occupation. *Accident Analysis and Prevention* 65: 63-71.

### *Technical Report*

Rausser E, Smith CK, Williams, J: [2014] Trucking Industry: Examining Injuries for Prevention. Washington State Department of Labor and Industries, SHARP Program Technical Report number 90-148-2014.

### *Trade Journal Articles*

Pratt J: [2009] Even on Foot, Trucking Is Risky Business. *Transport Topics*, June 8, 2009.

Pratt J: [2009] Trucking Is a Risky Business. *Light & Medium Truck*. September 2009.

Williams J: [2010] Is risk just a part of the job? *The Route*. Washington Refuse and Recycling Association News. September 2010.

Williams J: [2013] TIRES: Helping to Reduce Work Related Injuries in the Commercial Trucking Industries. *Northwest Transporter*, Vol 16, Issue 1, Winter 2013.

## Data Sets

Research resources and data collected under the Washington State Occupational Injury and Illness Surveillance Program grant can be made available to qualified individuals within the scientific community after publication. In Washington State, data sharing is governed by our state public disclosure laws, and additional specific Washington State statutes and administrative regulations associated with the entity owning the data system from which occupational injury and illness data or workforces estimates are ascertained.

### Other Materials available for other investigators

In Washington State, data sharing is governed by our state public disclosure laws and specific Washington State administrative regulations associated with notifiable conditions reporting, both will apply to data collected in our fundamental program. Generally, data is available upon request from qualified researchers.

### Inclusion of gender and minority study subjects

Washington State's population is approximately 83% white, non-Hispanic, 6% Hispanic, 5.4% Asian and Pacific Islander, 3.3% African American. The truck driver and laborers, freight, stock and material mover population is 95% male. Race and ethnicity are predominantly white. All truck drivers will be encouraged to participate. A completed cumulative inclusion enrollment report is attached.

### Inclusion of Children

Commercial truck drivers must be 21 years of age, therefore no children will be included in this surveillance project.

## References

- 1 **Rauser, E., C.K. Smith, and J. Williams:** "Trucking Industry: Examining Injuries for Prevention. Washington State, 2006-2012." Olympia, Washington Washington State Department of Labor and Industries, 2014.
- 2 **Wellman, H.M., M.R. Lehto, G.S. Sorock, and G.S. Smith:** Computerized coding of injury narrative data from the National Health Interview Survey. *Accid Anal Prev* 36(2): 165-171 (2004).
- 3 **Lehto, M., H. Marucci-Wellman, and H. Corns:** Bayesian methods: a useful tool for classifying injury narratives into cause groups. *Inj Prev* 15(4): 259-265 (2009).
- 4 **Marucci-Wellman, H., M. Lehto, and H. Corns:** A combined Fuzzy and Naïve Bayesian strategy can be used to assign event codes to injury narratives. *Injury Prevention* 17(6): 407-414 (2011).

## Cumulative Inclusion Enrollment Report

**This report format should NOT be used for collecting data from study participants.**

**Study Title:** Trucking Injury Reduction Emphasis through Surveillance (TIRES)

Racial Categories	Ethnic Categories									Total
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native		5								5
Asian	1									1
Native Hawaiian or Other Pacific Islander		2								2
Black or African American	1	11								12
White	16	241			6					263
More Than One Race	0	0								0
Unknown or Not Reported	0	13		2	19			1		35
<b>Total</b>	18	272	0	2	25	0	0	1	0	318

## Success Stories

### How Do You Develop A Successful Safety Training?

Trucking Injury Reduction Emphasis through Surveillance (TIRES)  
Washington Occupational Injury and Illness Surveillance and Prevention Program  
Safety and Health Assessment and Research for Prevention (SHARP) Program  
Grant Number U60 OH008487

Caroline Smith, MPH  
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Successful safety training is developed by building credibility. Here's the story of a Washington State organization that partnered with a NIOSH-funded to train workers to become safety leaders.

#### The Challenge

Getting buy-in for safe behavior can be tough. Varying from, "This is the way we've always done it" to "I'm invincible" can stymie even the most dedicated safety Engagement in safety begins with trust. Opinion leaders from the company ranks are in the position to foster changes that lead to injury prevention by increasing trust between management and workers.

#### The Response

Tom George, a Training Coordinator with Teamsters/Associated General Contractors (AGC) of Washington Training Center, recognized an opportunity to address this challenge. Seeing the value in prevention materials developed by the Trucking Injury Reduction Emphasis (TIRES)\* project, he applied for and received a grant called *Safer Drivers – Workers Training Workers\** to provide free training using materials developed by TIRES.



project

attitudes

director.

*Safer Drivers* is based on the idea that a climate of cooperation and trust is easier to achieve when a well-respected worker and a safety manager attend the trainings together. The worker attendee is trained to spot and address hazards at the company and to engage other workers in weekly “toolbox” type trainings using TIRES materials, while the manager who is also a student is now perceived as a partner in safety. In short, the two have become the safety liaison for the company and living proof that the company values employees enough to want them to stay safe.

## **The Impact**

A total of 172 students completed the full two-day training with over 500 more attending large group sessions conducted for individual employers. In all, 75 organizations committed to improving safety and preventing injuries at their companies during the two year grant period. In a labor market that is rapidly shrinking, keeping workers safe is vital since “If you got it – a truck brought it.”

\* Safer Drivers-Workers Training Workers was funded by a Safety & Health Investment Projects (SHIP) grant from (L&I). This story was originally published by the Council of State and Territorial Epidemiologists as an *Occupational Health Success Story*, April 2015.

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*“We firmly believe the key to injury reduction is worker buy-in. By engaging drivers to influence other drivers we stand the best chance of really helping them.” -Tom George, Training Coordinator,  
TEAMSTERS/AGC TRAINING CENTER*

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## **PFA: NORA Surveillance Projects: Temporary Worker Injury Reduction through Surveillance**

Washington Occupational Injury and Illness Surveillance Program  
CDC/NIOSH Cooperative Agreement U60 OH 008487

Project Period: July 1, 2010 - June 30, 2015

Final report completed: September 23, 2015

### **Program Director: Michael Foley, MA**

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## **PFA: NORA Surveillance Projects: Temporary Worker Injury Reduction through Surveillance**

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**Abstract:** The growth of the contingent workforce, both in scale and scope, has become the subject of a increased attention in public policy. When a worker's tenure at a particular workplace is brief there may be several reasons to expect an increased risk for injury: unfamiliarity with new work practices and surroundings, limited safety training, disproportionately younger workers in this category, or an inability to refuse hazardous work or demand appropriate protective equipment for fear of dismissal. Employers may hire temporary workers as a means of shielding permanent workers from risky tasks, and they may invest less time in providing them with appropriate training and protection equipment. Temporary workers hired through an agency have two separate parties who are responsible for their safety, which raises the possibility that neither will take full responsibility to prepare the worker adequately.

This project is focused on workers in the temporary help supply (THS) industry as defined within NAICS code 561320. The overall goal is to evaluate the fundamental risk factors associated with temporary agency employment by 1) further developing our analysis of the administrative databases containing information on temporary workers and their permanent counterparts to generate better controls for potential confounders, and isolating the effect of temporary status on probability of injury, 2) by conducting interviews with recently injured temporary and permanent workers, matched by workplace and demographic characteristics, 3) by conducting interviews with temporary agency managers and, 4) managers of client businesses which use temporary employees, and 5) by developing appropriate educational materials and dissemination methods tailored to each type of industry and to each party in the temporary labor market.

Results have shown that the growth of the temporary industry has moderated in recent years, but its diffusion into higher hazard industries such as light manufacturing and construction continues. Comparison of claims rates by matched industry sectors show that temporary workers continue to have significantly higher claims rates than their permanently-employed counterparts. A survey of 423 injured workers matched by risk class, age, gender and tenure showed a lack of pre-assignment screening, inadequate safety training, and inability to refuse assignments, are concerning. Interviews with managers at temporary agencies appear to show weak oversight of client business workplaces, perhaps due to intense market competition to retain the business of host employers. Currently under development is an online safety awareness teaching tool, viewable on tablets, smartphones or computers which will be an advance over passive-mode videos and printed materials we observed being used in the field. This tool will cover topics such as hazard identification, communication, PPE and what to do when an unexpected condition arises in the worksite.

## Section 1

### Significant (Key) Findings

- **Controlling for industry/occupation, temporary workers consistently incur higher claims rates and higher claims severity than permanently employed workers.** Our results show this gap was especially large for machine and vehicle operations, construction and agricultural services. For both groups of workers the distribution of claim by injury type is similar: non-traumatic musculoskeletal disorders of the back or upper extremities ranked at the top. For temp workers, there is a slightly higher share of claims for “caught” and “struck” injuries, and a lower share of injuries from falls from elevation.
- **When comparing injured temporary workers to permanent workers matched by industry/occupation, age, gender and tenure in a follow-up survey, we found** exposures to perceived injury hazards were reported by claimants to be distributed similarly between temporary and permanent workers, with the total level of hazard exposure slightly *higher* for permanent workers than for temporary workers. Reasons for this may include: remaining uncontrolled difference between temporary and permanent worker cohorts in tenure, differing conceptions of what constitutes a normal level of hazard; and differing levels of personal engagement or ability to voice concerns over workplace conditions.
- **Temporary workers had other significant risk factors at higher levels.** Among these were inadequate and infrequent safety training; lack of screening for experience with the kinds of job assignments they were proposed; lack of control over work schedule and an inability to refuse an assignment if it turns out to be significantly different from what they were expecting.
- **Interviews with agency managers showed that** they conduct site inspections and assess PPE needs for workers only at the start of their contractual relationship with a new host employer; most thought temp work was more hazardous; they provide only general safety training during orientation, relying on host employers to provide specialized job and safety training; market pressures and price competition between agencies result in a lack of leverage over host employers to improve safety practices.
- **Interviews with host employers showed that** host employers confirmed the view of temporary workers on the need for better screening for experience on the part of agencies supplying temporary workers; several host employers emphasized a need for better safety awareness among the temporary employees they have hosted.
- **Temporary workers, agency managers and host employers of temporary workers agreed on the need for more engaging educational materials.** Most agencies relied on printed materials and passive-mode videos. We found there was a need for more interactive, graphics-based, and online-hosted training materials.

### Translation of Findings

- **Temporary workers need educational materials better suited to their itinerant work patterns.** Current training materials used by agencies are not thought to be engaging or adequate for the wide variety of hazards faced by temporary workers moving from workplace to workplace. The Temporary Workers project is addressing this need by developing materials based upon what

we have learned from interviewing the injured workers themselves as well as the agencies and host employers.

- **Selection of job assignments for temporary employees needs to better reflect their previous work experience.** The importance of appropriate job assignment matched to the temporary workers' experience and capacity is vital and will be emphasized in training materials.
- **Safety training performed at temporary agencies needs to better prepare temporary workers to recognize hazards across a variety of industry settings.** We are developing an online safety awareness teaching tool, viewable on tablets, smartphones or computers using any operating system, which we hope will be an advance over the passive-mode videos and printed materials we observed being used in the field.
- **The Temporary Worker Surveillance project provides workers' compensation data on industry sectors where temporary workers are injured that is unavailable in other states or nationally.** Reports include claims rates and severity by risk class, most common injury types. These reports can be used to design and target prevention resources.

#### *Outcomes/Impact*

The Temporary Workers Injury Reduction Surveillance project takes advantage of Washington State's unique ability to track the industry settings to which temporary workers are sent through the State Fund workers' compensation system. We combine this capacity with follow-up interviews with injured temporary workers and permanent workers.

#### *Potential Outcomes*

- Presentations at conferences of occupational health and safety professionals including NORA Services and Manufacturing Sectors, APHA, and CSTE.
- Presentation at conference of Washington State OSHA inspectors and consultants.

## Section 2

### Scientific Report

#### *Background*

The growth of the contingent workforce, both in scale and scope, has become the subject of a burgeoning debate in public policy. There has been a debate as to how rapidly contingency is growing, what the sources of this change are, and whether this change represents a fundamental transformation of the relationship between labor and management. The rise of contingent forms of labor contracting has been seen as one aspect of a larger process of “disarticulation” of organizations where some activities previously done in-house by permanent employees of the firm are contracted out and purchased through the market. The rise of contracting allows businesses to react flexibly to changing market conditions while maintaining a valuable long-term relationship with its core workers in whom the company has invested much in training. Costs of recruitment, screening and training are shifted to temporary agencies who handle the payment of wages, taxes, unemployment and workers’ compensation insurance [Golden and Applebaum, 1992].

When a worker’s tenure at a particular workplace is brief there may be several reasons to expect an increased risk for injury: unfamiliarity with new work practices and surroundings, limited safety training, disproportionately younger workers in this category, or an inability to refuse hazardous work or demand appropriate protective equipment for fear of dismissal. Employers may hire temporary workers as a means of shielding permanent workers from risky tasks, and they may invest less time in providing them with appropriate training and protection equipment. Temporary workers hired through an agency have two separate parties who are responsible for their safety, which raises the possibility that neither will take full responsibility to prepare the worker adequately.

The fundamental issue is whether the increasing share in the labor force of temporary workers leads to deterioration in health and safety outcomes. Outside of the United States, evidence from previous research has varied from no difference in health outcomes [Virtanen et al., 2001, Virtanen et al., 2003; Bardasi and Francesconi, 2004], to significant findings of higher rates and severity of occupational injuries [Saha et al., 2004; Benavides et al., 2006]. Researchers have focused largely on discrepancies in health outcomes rather than on the underlying mechanisms which lead to the differential. Studies have found that temporary workers had higher odds of muscular pain [Benavides et al., 2000]; that in a manufacturing setting, temporary workers had injury rates two to three times higher than permanent workers [Morris, 1999]; and that temporary workers had four to seven times the claim frequency compared to permanent workers [Park and Butler, 2001]. In the 2000 European Survey on Working Conditions, temporary agency workers reported greater exposure to physical hazards and a higher level of work intensity and pace than permanent workers [Paoli and Merllie, 2001]. Most studies have not controlled for differences between temporary and permanent workers in their industrial distribution. Foley [1998], using a large cohort of Washington State workers’ compensation claimants, showed that claim frequency and severity as measured by time loss were higher for temporary workers than for permanent workers even after controlling for occupation and industry. Furthermore, this study found that the excess risk increases with the underlying hazard level of the industry. There were similar findings when the analysis was restricted to claims resulting in more than 4 lost workdays. Smith et al [2009], confirmed these results, finding workers’ compensation claims rate ratios twofold higher than permanent workers in construction and manufacturing. This study went on to look at differences in type of injury and found temporary workers had especially high excess injury rates for “struck by” and “caught in” type injuries in construction (IRR 4.93; 95% CI 2.80-8.08) and manufacturing (IRR 4.05; 95% CI 3.25-5.00). In addition, this study found disparities between THS workers and standard employment workers

in the adjudication of claims, proportion with employer protests, and delays before receipt of time-loss benefits. Finally, since the late 1990s, the THS industry in Washington State has had a known high-risk for upper-extremity musculoskeletal disorders [Silverstein et al., 1998, 2002]. These studies found THS workers assigned to assembly occupations and machine operator jobs had among the highest incidence rates of all industrial groupings for shoulder disorders as well as back disorders.

Even after controlling for occupation or industry, it is important to control for differences between temporary workers and standard employment works in other variables which may be associated with increased injury. First among these would be job tenure. Evidence suggests individuals with shorter job tenure are at higher risk for injury or illness [BLS 1997; Breslin, 2006]. Reasons for this association may include unfamiliarity with physical processes and environment, safety procedures and resources [Mayhew and Quinlan, 2002]. Given the much higher percentage of temporary workers who are at the lower range of job tenure, it will be important to separate the independent contribution of job tenure to injury rate from that of employment arrangement. Much the same reasoning applies to the need to control for the age of the worker. The 1995 CPS Supplement found 25% of temporary workers were under the age of 25, as opposed to 15% of permanent workers. As young age has also been associated with injury/illness it will be important to control for this factor as well [BLS, 1997].

In contrast to studies focusing on health outcomes, relatively few studies have examined directly the antecedent factors leading to the higher injury rates for temporary workers. Among these factors may be: Are temporary workers given the more hazardous jobs in a given worksite? Do they know what to do if they are exposed to hazards? Do they feel unable to refuse unsafe work? What kind of safety training do temporary workers receive at the worksite compared to permanent workers? One study focused on such factors as lack of supervision and training provided to subcontracted employees at a large petrochemical plant which sustained a multiple-fatality explosion in 1989 [Kochan, 1991]. In another study, a sociologist worked as a temporary worker for a year and reported on his experiences, including the assignment of temporary workers to the more hazardous tasks in a given workplace [Parker, 1994]. But these detailed studies of particular incidents and experiences need to be supplemented by a more comprehensive examination which quantifies the relative contribution of the various potential risk factors to the discrepancy that has been observed in health outcomes.

This project is focused on workers in the temporary help supply (THS) industry as defined within NAICS code 561320. Within this segment of contingent work, records of hours worked, industries where temporary workers are deployed and counts of workers' compensation claims filed are available in Washington State. The growth of the THS workforce in Washington State has historically been rapid as compared to that of the standard-arrangement workforce. Though starting from a small base, the growth rate of the THS industry has averaged 5.0% over the period 1990-2007, compared to the growth in total state employment of 2.3% per year. This growth trend also exhibits a very strong pro-cyclical variation, with a rapid shedding of numbers as the business cycle heads into a recession followed by rapid gains early in the recovery period. Employers clearly use temporary workers as a staffing strategy to reduce the costs of varying the size of their permanent workforce in response to market conditions.

For several years, the Safety and Health Assessment and Research for Prevention (SHARP) program has sought to prioritize Washington State industries for injury surveillance and prevention based on the occurrence of high cost, common, workers' compensation claims [Bonauto et al, 2006]. Following the same methods, we updated this analysis for the years 2003 through 2007 in order to compare claims rates and costs in the temporary help supply industry to all industries combined. Along with time-loss claims rate by injury type, the following table shows the claims rate ratio and the "severity ratio"—the ratio of time loss days per 10,000 FTEs in temporary work to that of workers in all industries combined:

**Table 1: Workers' Compensation Time-Loss Claims Rates, Rate Ratios and Severity Ratios: Washington State, Temporary Help Services Industry (NAICS 56132) and All Industries, 2003-2007.**

Injury Type	Time Loss Claims Rate		Rate Ratio	Severity
	<i>Temporary Help</i>	<i>All Industries</i>		
Caught In/Under	17.9	6.7	2.69	2.88
Falls from Elevation	15.6	17.0	0.91	0.81
Falls Same Level	22.3	20.3	1.10	1.01
WMSDs (ex. lower)	97.7	66.5	1.47	1.44
Struck	67.4	35.3	1.91	1.67
Motor Vehicles	2.9	5.6	0.51	0.26
WMSD-Lower	8.1	9.6	0.84	0.81
<b>All Injury Types</b>	<b>282.5</b>	<b>197.9</b>	<b>1.43</b>	<b>1.32</b>

*Source:* Washington State Industrial Insurance data. Claims per 10,000 FTE.

Over all injury types combined, workers in the NAICS 56132 industry experienced 43% more time loss claims than do workers in all industries combined. At the same time they experienced 32% more time loss days per FTE. This excess risk was not evenly distributed across injury types: claims rates for temporary workers were disproportionately high for “caught in/under/between” and “struck by” injuries, whereas rates for motor vehicle-related claims were substantially lower for temporary workers. It should be noted however, that, while most industries in the NAICS classification system are specialized in a particular sector, the temporary help services industry is itself a microcosm of all industries combined. This can create problems when comparing claims rates in temporary help services to that of a particular industry such as construction. In Washington State each employer reports hours worked by their employees for payment of the workers’ compensation insurance premium grouped by a risk-classification system referred to as the Washington Industrial Classification (WIC) system [Washington State, 2007]. The WIC system combines industry and occupation to group workplaces by similar risk of injury for insurance purposes (e.g., a painter and an electrician within the same construction company may have the same NAICS code but will be assigned different risk classes). In all there are 316 “risk classes” in the WIC system, of which 16 are reserved for temporary employees working for temporary help services companies. These include separate classes for office support, technical services, warehousing, retail/wholesale, health care, food processing, agriculture, janitorial services, vehicle operation, machine operators, assembly work and construction. The WIC system allows us to compare claims rates in each particular kind of temporary work to those of other, permanent-worker risk classes as well as all workers combined. We find that certain temporary risk classes, such as machine operators, assembly and construction have among the highest time-loss claims rates of any risk classes for many injury types:

**Table 2: Workers' Compensation Time-Loss Claims Rates: Washington State, Temporary Help Risk Classes and All Industries, 2003-2007.**

<b>Injury Type</b>	<b>Time Loss Claims Rate</b>			
	<u>Temp-Machine Operators</u>	<u>Temp-Construction</u>	<u>Temp-Assembly</u>	<u>All Risk Classes</u>
Caught In/Under	182.0		29.7	6.7
Falls from Elevation		136.5		17.0
Falls Same Level	79.8	99.6		20.3
WMSDs (ex. lower)	501.4	307.6	182.3	66.5
Struck	415.2	331.4	131.4	35.3
Motor Vehicles				5.6
WMSD-Lower		58.5		9.6
<b>All Injury Types</b>	<b>1,612.8</b>	<b>1,230.3</b>	<b>528.3</b>	<b>197.9</b>

*Source:* Washington State Industrial Insurance data. Claims per 10,000 FTE.

The WIC system allows a more detailed view of the particular segments of the THS industry most in need of prioritization for prevention efforts. The above table compares particular temporary risk classes to the entire set of covered employers. A more appropriate comparison would examine the difference between a temporary risk class and a set of permanent-employee risk classes where workers are engaged in similar tasks. This analysis is discussed in the next section.

Beginning in 1998, members of the research team have been tracking the THS industry in Washington State through the workers' compensation claims database. Workers' compensation claims incidence rates, time-loss days, claim costs per 100 FTE and insurance premium levels were compared to those of permanent employees working in comparable industries and occupations. The selection of comparable permanent risk classes was based upon an analysis of occupational codes listed on workers claims. If the SOC codes on at least a majority of claims overlapped with those in a particular temporary risk class, these classes were considered comparable. These comparisons showed that workers who are employed by temporary agencies have a higher claims rate and more lost workdays per 100 FTEs than do their permanently employed counterparts, controlling for industry. The results from this analysis were published in 1998 [Foley, 1998]. In 2006, we repeated the analysis for a more recent set of years and found very similar results and magnitudes of difference between THS workers and permanent workers.

With the exception of Assembly, in every industrial/occupational sector claims rates were higher for temporary workers than for permanent workers. The risk ratio for temporary as compared to permanent status ranges from 0.98 to 3.56, with an overall ratio of 1.40. If one excludes the Office sector, where manual handling tasks are rare, the overall risk ratio rises to 1.86. Furthermore, there is a positive association between the discrepancy in claims rates and the claims rate for the permanent employed workforce, suggesting that differential exposure to hazards is playing some role in the overall story. A similar discrepancy was found with regard to claims involving four or more days of time loss.

Using the workers' compensation database of hours reported by employers, we are also able to compare THS industry employment growth over time with that of standard employment. The results show that THS employment is growing more than twice as fast over the period 1989 through 2005. The strongly pro-cyclical character of THS employment was also quite evident. Growth rates within THS employment were particularly strong in the manual-handling related risk classes: Construction (13.6%/yr); Vehicle Operations (13.2%/yr); Machine Operators (11.1%/yr) and Assembly Work

(8.5%/yr). Office Work (3.9%/yr) is among the sectors of temporary work that is growing more slowly, falling from roughly 60% to 50% of the total share over this period.

We have also recently completed an analysis looking at differences between THS workers and permanent workers by type of injury and found temporary workers had especially high excess injury rates for “struck by” and “caught in” type injuries in construction (IRR 4.93; 95% CI 2.80-8.08) and manufacturing (IRR 4.05; 95% CI 3.25-5.00). In addition, this study found disparities between THS workers and standard employment workers in the adjudication of claims, proportion with employer protests, and delays before receipt of time-loss benefits [Smith et al., 2009].

Finally, since the late 1990s, the particular segments of the THS industry in Washington State have had a known high-risk for upper-extremity musculoskeletal disorders [Silverstein et al., 1998, 2002]. These studies found THS workers assigned to assembly occupations and machine operator jobs had among the highest incidence rates of all industrial groupings for shoulder disorders as well as back disorders. The results clearly indicate that temporary service workers are at increased risk of injury, based on accepted workers compensation claims, compared to their permanent counterparts doing generally the same kind of work. The relative risk (rate ratio) for temporary services workers in assembly ranged between 4.1 and 8.0 when compared to overall industry musculoskeletal disorder claims rates. Similarly, temporary machine operators ranged from 4.8-7.4 times the rate of upper limb and back disorders as overall industry. Temporary service health care workers were at 4.7 times the risk for sciatica and temporary service warehousing workers were at 3 times the risk of gradual onset hand-wrist disorders.

In 2007, we received special State funding to conduct a limited number of focus groups with workers recruited from temporary agencies around Puget Sound to gather information about their experiences and to explore their perspectives on the factors they believe may contribute to increased injuries among temp workers and to generate research hypotheses. We also conducted one focus group with temporary agency managers. Worker focus groups were stratified by occupation, with one group each for workers in construction, assembly, machine operators and health care aides. Question threads were developed dealing with:

- Most common hazards faced and most common injuries.
- How they handled unsafe work situations.
- Whether they felt able/knew how to report hazard.
- Safety trainings provided by the agency and the client businesses.
- Safety equipment provided and by whom.
- Priority given to safety by agency staff and client supervisors.
- Whether temporary workers were given more hazardous work.
- Types and formats of educational materials that would be effective in improving safety.

Similar threads were discussed in the focus group for temporary agency managers. We were particularly interested in points of agreement and disagreement between workers and managers on issues. The following list summarizes these findings:

**Agreement/concordance between temporary employees and management:**

- Temporary employees are given more hazardous jobs than permanent workers.
- Temporary workers are treated with less respect than permanent workers.
- Many temporary workers do not report injuries/hazardous job conditions because:

- Afraid they will lose a day's pay
- Temporary workers don't know there is a hazard present
- Temporary workers are often asked to do jobs that are different from what they were sent to do.
- Construction workers and management feel that construction is just a dangerous industry.

**Disagreement/discordance between temporary employees and management:**

- Level and adequacy of training received by temp agencies and companies they work for.
- Issues regarding PPE.
- Issues regarding intake, assessment of a new job site.
- Issues regarding supervision and follow-up by temporary agency once a job has started.

The findings from this exploratory project provided the basis for shaping the specific aims which we have sought to accomplish in this project.

The overall goal of this expanded surveillance activity is to evaluate the fundamental risk factors associated with temporary agency employment by 1) further developing our analysis of the administrative databases containing information on temporary workers and their permanent counterparts to generate better controls for potential confounders, and isolating the effect of temporary status on probability of injury, 2) by conducting interviews with recently injured temporary and permanent workers, matched by workplace and demographic characteristics, 3) by conducting interviews with temporary agency managers and, 4) managers of client businesses which use temporary employees, and 5) by developing appropriate educational materials and dissemination methods tailored to each type of industry and to each party in the temporary labor market. Areas of focus for educational materials would include hazard awareness, safety practices, protective equipment, employee rights to a safe workplace, and rights to workers' compensation benefits.

*Methods, Results and Discussion by Specific Aim*

**AIM I: Descriptive Analyses of Temporary Worker Injury Risk with Workers' Compensation Claims Data**

*Methods-Aim 1*

We characterize the magnitude of workers' compensation claims incidence among workers employed by temporary agencies grouped by industry sector, as represented by risk class, and compare each of these to that of workers employed under standard employment arrangements working in comparable industries and occupations. This goal involved the following steps:

- Review and re-validate the selection of Washington Industrial Classification risk classes that are to be considered comparable to each Temporary Help Services risk class. The previous analyses discussed above are based upon a selection of comparable risk classes that was developed more than twelve years ago. Over time there can be significant "drift" in the assignment of risk classifications to businesses, which may reduce the comparability of permanent-employment risk classes to the temporary help services risk classes. All accepted claims received over the most recent five-year period were extracted and the occupation code listed on the claim was examined. The distribution of occupational codes (SOC2K codes)

on the “candidate” permanent risk class was compared to that of the particular temporary risk class in question. If there was at least a 50% overlap in these codes, the permanent risk class was selected.

- For the most recent five-year period we compared accepted claims rates, time-loss claims rates, claim rejection rates, average lost workdays per claim, claim costs and frequency of employer protest between each of the following twelve temporary risk classes and their selected comparable risk classes: Office Work, Technical Services, Warehousing, Stores, Health Care, Food Processing, Agriculture, Janitorial Services, Vehicle Operation, Machine Operation, Assembly Work and Construction.
- Continued to track the hours reported by Temporary Help Services sector employers, both by risk class and for NAICS 56132 as a whole.
- Repeat of this analysis for each year from 2011-2015.

In Washington State, employers are required to obtain workers' compensation insurance through L&I, unless they are able to self-insure, are self-employed or are the federal government. The State Fund Insurance program covers two-thirds of the workforce and all but approximately 400 of the 160,000 employers in Washington State. Employers are required to pay workers' compensation insurance premiums based on the number of hours worked by their employees on a quarterly basis. The premium level per hour reported for each employer is based upon two factors: the expected insurable claims costs for work performed in each separate risk classification associated with that employer, and the loss experience accumulated by the employer over the previous several years. The major workers' compensation data system is the Labor and Industries' Industrial Insurance System (LINIIS) Data included in the LINIIS system are worker information (age, gender, date of birth, marital status, social security number), injury or illness information (injury coded by nature, type, source, and body part by OIICS codes), text description of the injury, employer industry codes (NAICS code/SIC code), occupation codes (SOC2K), and ICD-9 codes for the allowed diagnosis of the claim. The Medical Information Payment System (MIPS) captures all financial information associated with a workers' compensation claim, including wage replacement costs, days of lost work-time, costs from permanent and total disability awards, and costs from associated pensions.

One potential problem with relying on workers' compensation data for injury surveillance of temporary workers should be mentioned: it is well-known that work-related injuries and illnesses are underreported to the workers compensation systems [Fan et al., 2006]. To the extent that there is a differential between temporary workers and permanent workers in claims reporting, estimates of the claims rate discrepancy may be inaccurate.

In order to make reasonable comparisons between the injuries of temporary help workers and those of permanent workers it is necessary to control for the occupation of the worker. Of course, occupation is not the only source of variation across workers in their injury outcomes. It is well known that workers in the same occupation, but of different ages or genders or lengths of service will face differing risks of injury. But these other sources of variation pale in comparison to occupation, where for example shipyard workers experience rates of injury many times greater than that of accountants. Though some evidence will be presented on the characteristics of temp workers which distinguish them from permanent workers, these are not the focus of this study.

While the definitions of the risk classes include long text listings of the sorts of occupations and industries covered, no information on the relative frequency of these occupations within each class was available. A way was needed to quantify the degree to which the distribution of occupations in each candidate class matched that in the associated temporary risk class. In this way only those permanent risk classes that had the highest degree of overlap with the occupational distribution within the temporary risk class would be selected.

One source of such information lies in the workers' compensation claims database of the State Fund. When a claim for compensation is presented, two pieces of evidence relevant to our needs are recorded on the claim form: the employers' risk class and the occupation the worker was engaged in at the time she was injured. In the case of the temp worker the risk class is selected from a group of seventeen classes reserved for temp workers. For permanent workers the risk class is that of their employer. The occupation is chosen on the basis of a description of the work being performed by the worker, regardless of their employment status. Using this information it was possible to validate the selection of any given candidate risk class by examining the distribution of occupations among the workers injured in each risk class. While this method is not ideal—it does not tell us the distribution of occupations among *all* workers in the risk class, but only those workers who get injured—it does tell us whether the two populations are involved in comparable activities.

To test a particular candidate risk class, a list of all occupations was drawn up for the associated temp risk class, ranked by the number of claims in each occupation for the years 2007-2010. Then the claim counts were converted to relative frequencies by dividing the occupational claim counts by the total number of claims for that risk class. If occupation was reported as "Invalid" or "Missing", that claim was dropped from both the list and the denominator. We also dropped occupations that accounted for less than 1% of claims. One potential drawback with this method is that the degree of calculated overlap between two risk classes is sensitive to the narrowness of the occupational categories. The more narrowly occupations are defined, the more unlikely it becomes that two workers will be classified as performing the same work. This will result in a low measurement of occupational overlap, even if observers might agree that the two occupations were quite similar. Conversely, if the occupations are defined broadly, they will be considered as matches by our method, even though observers of the work might see significant differences across workers so classified. It is for this reason that the "laborer" category was dropped. This was a prudent way to proceed since it resulted in lower bound estimates of occupational overlap. Inclusion of the "laborer" category would have increased the degree of overlap, but might have resulted in spurious matches.

For each listed occupation in the temporary risk class the claim frequency in the comparison permanent class was calculated. This produced two lists of matching occupations, one for each risk class, together with their relative frequencies. These frequencies were then summed. The sum of relative frequencies of the permanent risk class is the degree to which the two classes "overlap" in their distribution of occupations. The higher this number, the better the degree to which the two classes match. The criterion used to determine whether a candidate permanent risk class would be retained in the analysis was if it had at least a 50% occupational overlap with the associated temporary risk class. These are the permanent risk classes whose workers' compensation data, weighted by employment, were used to make comparisons with their associated temporary risk classes. Out of seventeen temporary risk classes, only twelve were found to have acceptable matches with one or more permanent risk classes.

To test the proposition that temporary workers are at greater risk of work-related injury than permanently-employed workers in similar occupations, we examined the differences between each of the twelve temporary risk classes and their permanent counterparts in claims rate (both medical-only claims and time-loss claims). All measures were computed as averages over the period 2010-2014 to make the numbers more stable.

Claims Rate is defined as the number of accepted State Fund claims per 100 full-time equivalent workers. Since on the permanent-worker side of the comparison there are multiple risk classes grouped together, these were weighted by hours of employment in each component risk class. This procedure was repeated for compensable claims as well, so that a comparison could be made which focused on the more severe class of injuries.

*Results and Discussion-Aim1*

Our comparisons between temporary workers and their permanent counterparts have been made while controlling for *occupation only*. Other factors affecting the probability of injury, such as youth, inexperience or gender, are left uncontrolled. Therefore, the proposition that it is the temporary status of these workers which exposes them to greater hazards than their permanent counterparts cannot be proven with these data. This is because the differences which these data show could simply be due to one or a combination of these other factors. But the magnitude of the differences suggests that youth, inexperience and gender alone or in combination are unlikely to account for all of the difference. One factor suggests temp workers would be expected to be safer than permanent workers in terms of risk attitudes—temp workers were disproportionately female.

**Table 3: Demographic Characteristics of Temporary Workers Compared to All Workers, United States, 2005.**

	All Workers	Temp Workers	Injury Rate for All Workers
Age Distribution	(%)	(%)	
16-19 years	1.2	2.7	1.48
20-24 years	8.5	16.6	2.14
25-34 years	24.0	29.8	1.96
35-54 years	52.1	37.2	1.58
55-64 years	12.6	11.1	1.16
65 and over	1.7	2.7	0.53
Total	100.0	100.0	1.66
Mean Age	40.8	37.4	
Median Tenure	4.9	0.5	
Length of Service:			
< 1 year	23.2	72.7	2.38
> 1 year	76.8	27.3	1.22
Male	53.8	47.2	2.05
Female	46.2	52.8	1.17

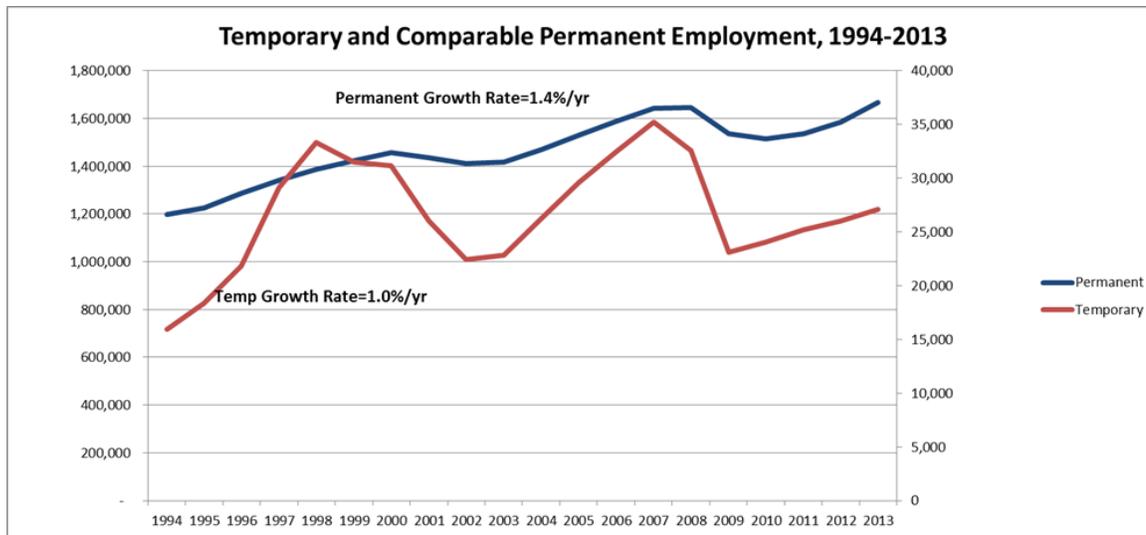
Sources: *Survey of Occupational Injuries and Illnesses, 1995* and US Bureau of Labor Statistics (1996), *Current Population Statistics, February 1995 Supplement*. GAO, *Contingent Workforce: Size, Characteristics, Earnings and Benefits*. GAO-15-168R.

As can be seen in Table 3, temp workers are younger, less experienced and more likely to be female than is the case with all workers combined. And as the evidence in the last column indicates, younger and less experienced workers have higher injury incidence rates than is true of older, more experienced workers. On the other hand the higher proportion of female temp workers might lead one to expect this to reduce temp injury rates.

Over the period 1994-2013 the growth of temporary help supply employment in Washington State has moderated, so that it is now growing roughly at the same rate as that of direct-hire employment

over the long run. However, the strongly pro-cyclical fluctuation in THS employment has continued. THS employment fluctuates much more widely than permanent employment, and its inflection points tend to precede those of the permanent workforce. This has often been explained as being the result of employers' use of temps to buffer fluctuations in their "core" workforce in whom they make costly investments in training. So as a recession begins and product demand slips, the temp workers can be easily let go without separation costs to the host employer. When growth in the economy resumes, employers at first may be wary of offering permanent direct-hire jobs. Temp workers allow for employers to test the waters of increasing their production levels without going through the more costly process of hiring permanent staff.

**Figure 1: Temporary and Comparable Permanent Employment, 1994-2013**



Over the course of this period 1994-2013, the distribution of temporary help supply workers has spread beyond its traditional focus in office administration towards higher hazard sectors such as construction, food processing, light assembly and warehousing/logistics. As of 2013, more temp workers are working in these industries than in office services.

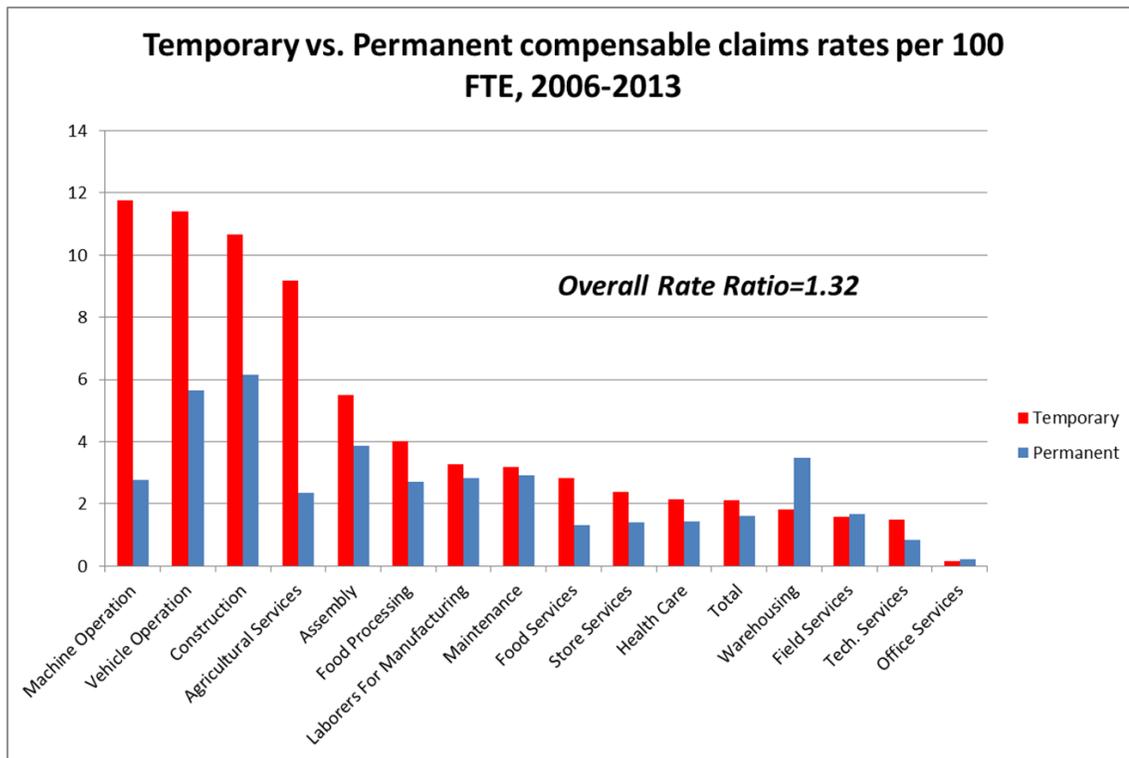
As compared to workers in the matched permanent risk classes, temporary workers are on average younger than their permanent counterparts (median age=37 for temps versus 41 for permanent workers). They are also disproportionately male (75% versus 62% in the matched permanent risk classes). Another important difference between these groups is the length of tenure at the worksite where they were injured. The median number of days on the jobsite for temp workers is about 13% that of permanent workers. This may also reflect greater difficulty in managing the return to work process for injured workers without a regular relationship to a particular workplace.

*Claims Rate*

Figure 2 shows the distribution across the sixteen risk class comparisons in the rate of compensable (i.e. lost work-time) claims per 100 full-time equivalent (FTE) workers. For the period from 2006-2013 we compared claims rates between each of the temporary risk classes and the previously validated comparable permanent risk classes. Results showed that temporary workers experienced higher claims rates than their permanent counterparts when controlling for industry/occupation. The overall rate ratio for temporary status workers relative to permanent counterparts is 1.32. If we exclude the large Office Services sector, the rate ratio rises to 1.81. The gap between the two groups generally grows larger with the underlying level of hazard, with the rate ratio ranging from 0.6 in warehousing to

4.2 in machine operations. The gap was especially large for machine and vehicle operations, construction and agricultural services.

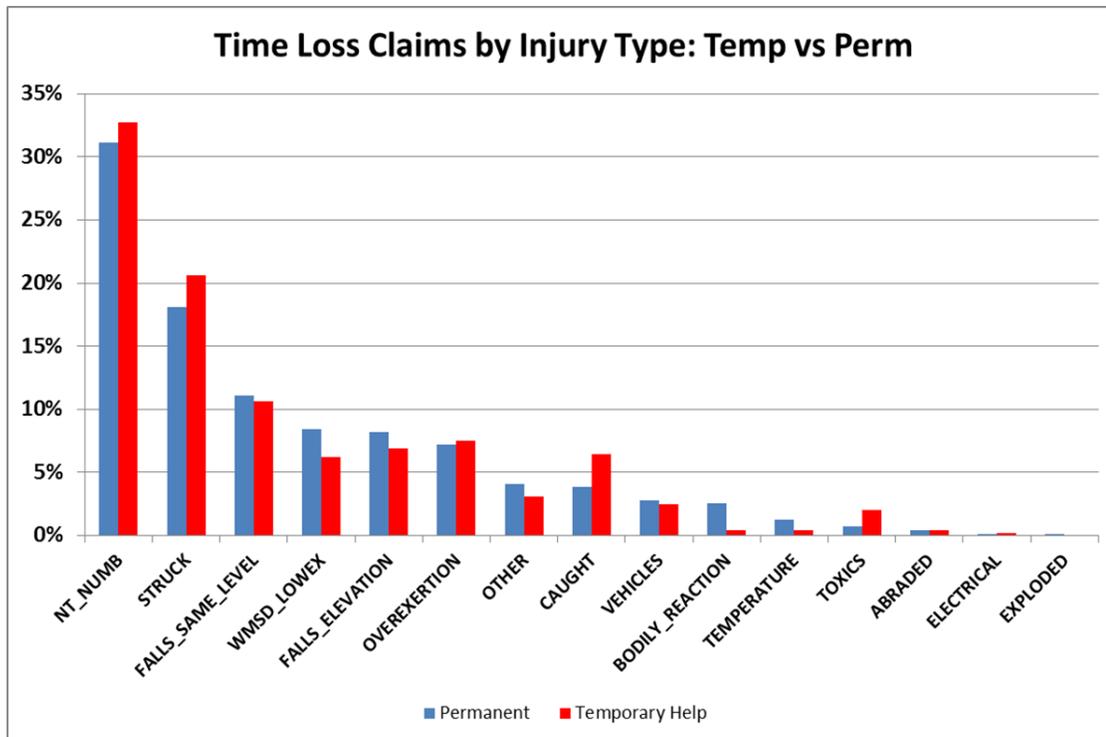
Figure 2: Temporary and Permanent Worker Compensable Claims Rates per 100 FTE, 2006-2013



In addition, we find that median lost workdays per claim are more than 60% higher for temp workers than for peer permanent workers in the matched risk classes.

Finally, we used the Occupational Injury and Illness Classification System (OIICS) codes on the workers' compensation claims filed by these workers to compare temporary and comparable permanent workers by the type of injury sustained. This was done in order to see whether the overall pattern of higher claims rates for temp workers was accounted for by a subset of injury types or if the distribution by injury type was similar between these groups of workers. The results show that for both groups of workers the distribution of claim by injury type is broadly similar: for both groups, non-traumatic musculoskeletal disorders of the back or upper extremities (NT\_NUMB), struck injuries and falls-to-same level injuries rank at the top. For temp workers, there is a slightly higher share of claims for "caught" and "struck" injuries. For permanent workers there is a somewhat higher share of claims for "falls from elevation" relative to temp workers.

**Figure 3: Temporary and Permanent Worker Compensable Claims, Relative Frequency by Injury Type**



*Conclusions-Aim 1*

This comparison of time-loss claims rates is one attempt to represent the differences between temporary and permanent workers’ occupational health and safety experience. It does so while controlling for the largest source of variation across workers in their risk of injury—their occupation, as represented by their risk class. If actual worker injury rates are well-represented by workers’ compensation claims rates, the results show that temporary workers experience a higher rate of injury than their permanently employed co-workers. This gap also appears when looking at claims frequency, claims costs per worker, lost workdays per worker or the workers’ compensation insurance premium paid to cover these workers. Furthermore, this gap widens as the underlying hazard in the industry rises.

While these results describe the dimensions of the excess potential burden injury faced by temporary workers, they cannot confirm the part played by any of several possible risk factors. Earlier studies have focused on poor training (Kochan, 1991), or the assignment of temps to the more hazardous tasks in a given workplace (Parker, 1994). Workers’ compensation claims data don’t allow us to measure the contribution of such factors as the level of exposure to occupational hazards, the quality of training, how many injuries go unreported to workers’ compensation, the role of experience screening or job assignment, the effects of divided employer responsibility for safety, relationships between temporary and permanent workers at the work site, or the workers’ demographic profile. For this we turned to survey methods. A survey instrument, administered to both temporary workers and their permanently-employed counterparts, was our approach to measuring the role played by these factors.

AIM II: Follow-up Interviews with Injured Workers

*Methods-Aim 2*

In order to understand the factors underlying the higher claims rates we have observed for temporary workers, we conducted a total of 423 worker interviews over the course of the study period. The subjects discussed in the interviews are based upon the themes which emerged from the focus groups we conducted with temporary workers and managers in 2007. The telephone interviews will be conducted with temporary workers who have filed a workers' compensation claim in the previous month and with a matching set of standard-employment workers. These interviews focused on:

- the nature of the business at which they were injured;
- the worker's job history;
- the kinds of tasks they performed;
- the hazards they faced;
- how they handle situations they deem to be unsafe;
- the extent and quality of safety training and equipment provided;
- the importance of safety to their managers at both the temp agency and the client workplace;
- the importance of safety to co-workers;
- suggestions for how to reduce injuries to workers;
- suggestions for how best to deliver educational material.

Two versions of the worker survey were used: one for temporary workers, one for permanent workers. These were translated into Spanish for workers who requested the interview be conducted in that language. These questions allowed us to test the role played by a number of factors which have been suggested to explain why temporary workers are exposed to higher levels of occupational safety and health risk: their shorter job tenures relative to their permanently-employed counterparts; their relative youth; a lack of sufficient training by either the agency or the client business, as compared to permanent workers; whether they are assigned tasks that are more dangerous than those done by the permanent workers on-site; and whether it is more difficult for them to refuse unsafe work or ask for more training.

Each month, beginning in January 2011 we selected for interview all workers who filed a claim in the previous month and whose employer reported hours into one or more of the temporary Help Services risk classes in the State Fund database. Each year, about 2800 claims were filed in temporary risk classes. Of this number about 730 per year were "compensable" claims involving at least 4 days off time loss. For standard-employment workers in the comparable risk classes there were about 42,000 accepted claims per year. In order to generate a set of standard-employed claimants who might be matched to the temporary worker cases, the place of injury field must be completed on the worker's claim form. From this information we were able to select an injured standard-employment worker employed either at the same business or in the same risk class as that of the injured temporary worker. Unfortunately, only about 20% of claim forms were found to have this information. This means about 550 temporary worker claims could be matched to standard-employment claims each year, an average of about 45 per month. These were distributed across all temporary risk classes, so information from a wide diversity of industrial settings is available.

Each month we selected all temporary claims received and after filtering out claims without place of injury information we matched each claim to the set of standard-employment claims which opened during the month. Matching to claims filed by standard-employed workers at the same employer in the same month was not possible due to the rarity of such events at all but the largest employers. Instead, we selected claims filed by standard-employed workers within the set of comparable risk classes discussed previously. This much larger set allowed us to apply additional matching filters which made for better

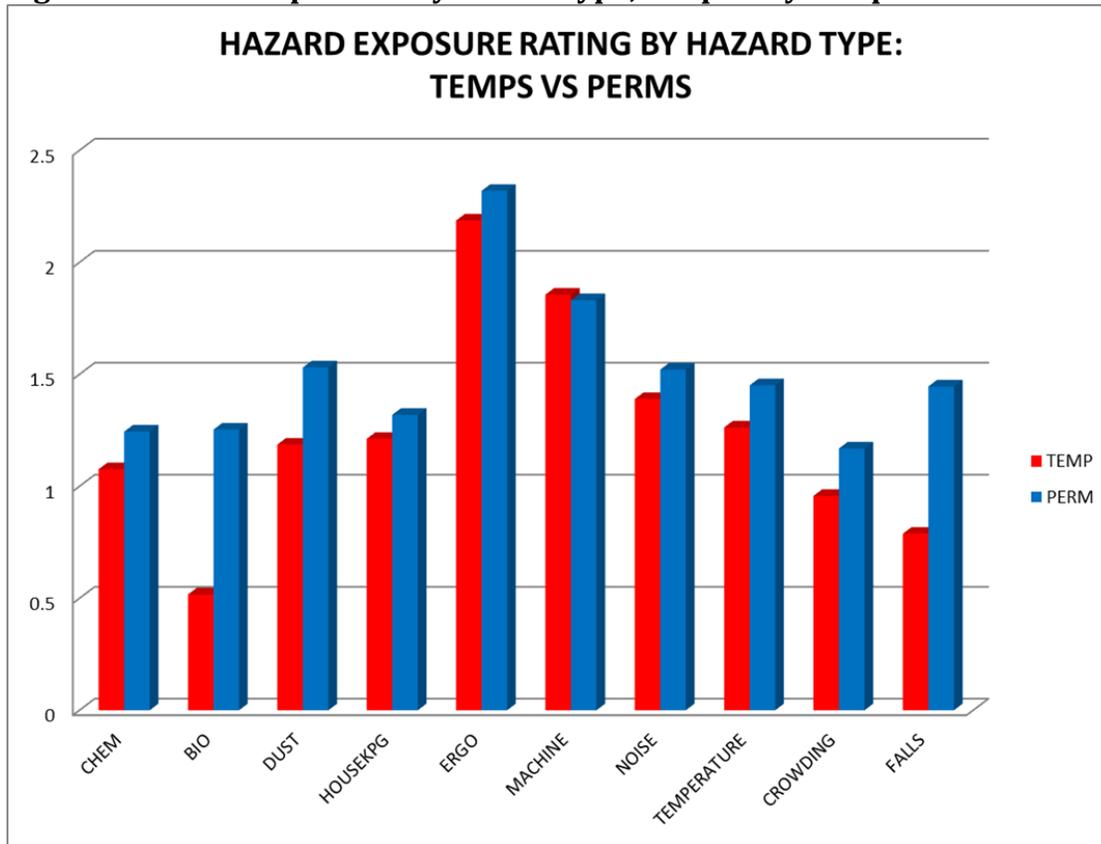
comparisons between temporary and permanent workers. First, in order to control for age we selected permanent workers who were within  $\pm 5$  years of age of the temporary claimant. Since temporary claimants tend to have very short length of service at each given workplace, we also select permanent-employed workers with similarly brief experience. Length of experience at the employer is reported on the claim record. Since occupational segregation by gender is a consideration in many workplaces, the nature of the hazards to which workers are exposed may be expected to vary by gender. Accordingly we matched permanent-employed workers to temporary workers by gender as well. Finally, we matched workers by whether or not their claim involves 4 or more days of time loss. Over the course of the five year study period we interviewed 193 temporary workers and 230 permanent workers. We completed 122 matched sets of interviews with 1 temporary worker and at least 1 permanent worker matched by risk class, gender age and tenure.

### *Results and Discussion-Aim 2*

Over the course of the study we conducted 423 follow-up interviews with temporary workers and a matched set of standard workers to gain information about tasks, hazards, safety training, and ability to identify and report hazards (see Appendices A-1 to A-4). Special emphasis was placed on completing matching interviews with between 1 and 3 permanent workers for each completed interview of a temporary worker. Matching on risk class, age, gender and tenure, our work resulted in 122 matched sets of interviews for analysis.

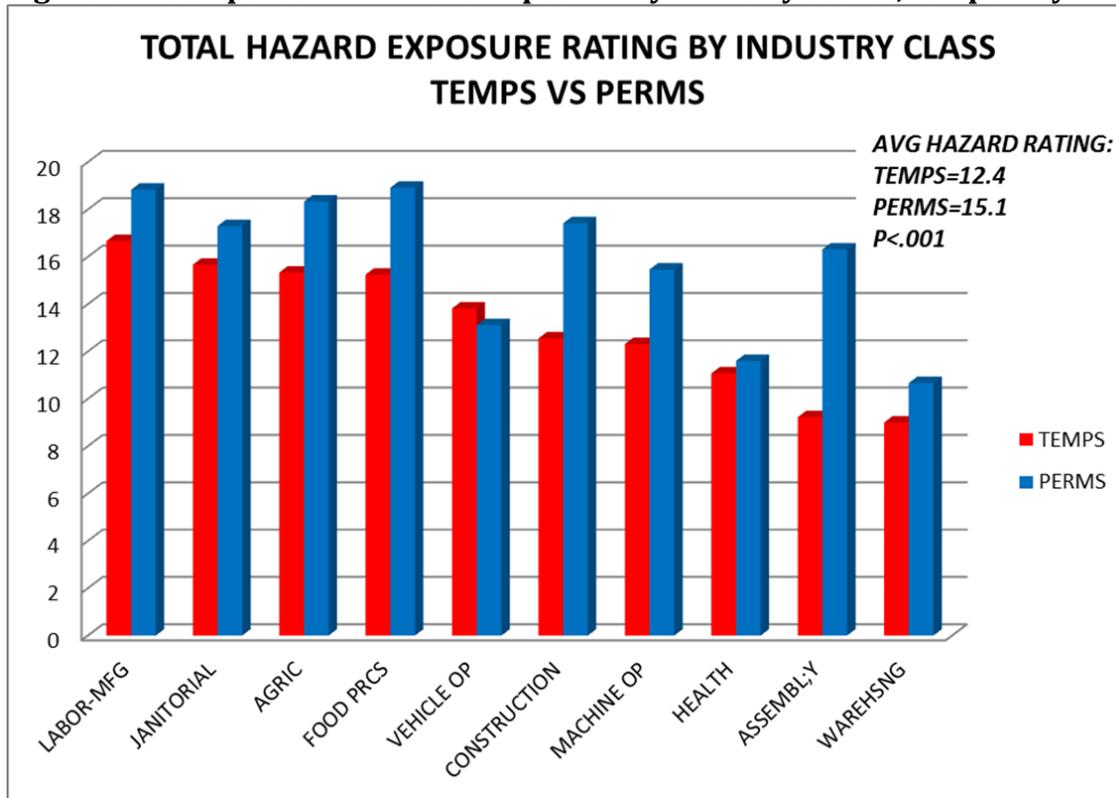
Although we are still conducting analyses of the final set of matched interviews, our preliminary results from interviews with injured temporary workers and their matched counterparts in standard, permanent employment reveal that, contrary to our expectations, exposures to injury hazards were perceived by claimants to be distributed similarly between temporary and permanent workers, with the total level of hazard exposure slightly *higher* for permanent workers than for temporary workers. The highest exposures for both categories of worker were to musculoskeletal risks, machinery hazards and falls:

**Figure 4: Hazard exposures by hazard type, temporary and permanent workers**



When aggregated across hazard types, we find that the total perceived hazard level at their place of employment was on average 20% *higher* for permanent workers than as the case for their temporary counterparts in the same risk class. This difference was statistically significant. This was the case across all risk classes, with the discrepant perception being greatest in assembly, construction and food processing.

**Figure 5: Total perceived hazard exposure by industry sector, temporary and permanent workers**

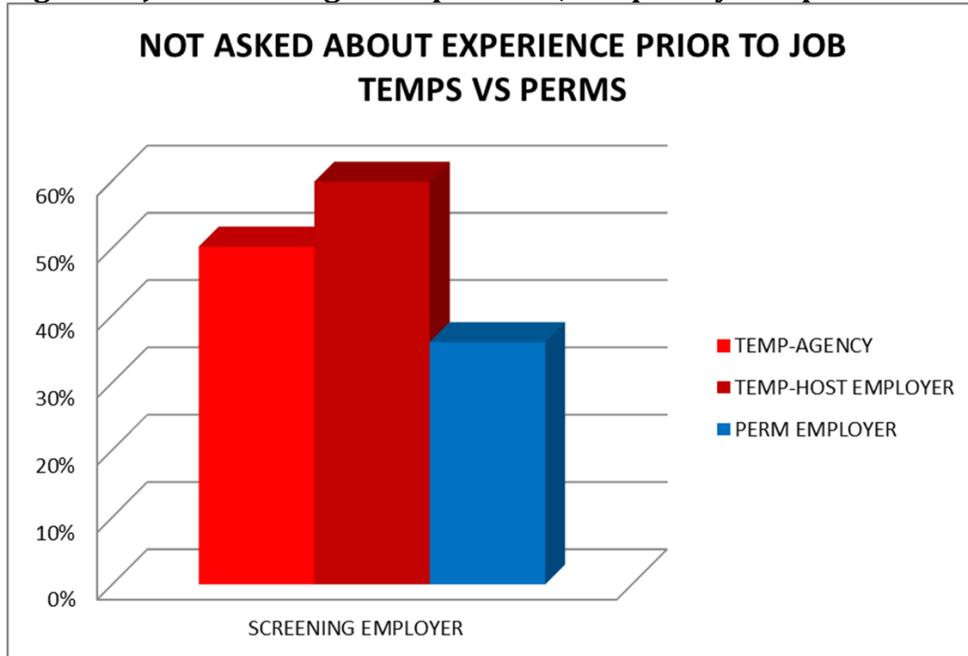


These results were unexpected, given that evidence from an earlier round of focus groups conducted in 2007 had indicated agreement between temporary employees and agency managers that temp workers were given more hazardous jobs than permanent workers. One reason for this result may be that awareness of a job hazard is a function of experience, so the brief length of time a temporary worker spends in a given workplace may mean they are unaware of all of the hazards present. If a temporary worker is assigned a narrow range of task in a workplace, they may be familiar only with the hazards of that task. A more experienced permanent worker will have accumulated enough time to be familiar with a broader range of hazards across the workplace. Although we did try to control for tenure in our matching protocol, it was difficult to find permanent workers who had been injured in the first 2-3 weeks of their assignment, as was often true of temporary workers. Another explanation may be that the temporary and permanent workers differed systematically in what they considered to be “normal” working conditions. If the typical temp workers’ background consists of a series of high hazard occupations, this may affect their sense of what constitutes a “low” vs “high” level of hazard. Finally, because of their limited commitment to any given workplace, temp workers may face more barriers to making changes in that workplace. It has been noted in studies of risk perception that people tend not to focus on hazards that they believe they cannot change (Dorman, 1996). For temporary workers this barrier is compounded by the possibility that voicing their misgivings about a hazard may cost them their assignment or even get them labelled as “difficult” by their agency. Unlike their permanent counterparts, the host employer has made no investments in their skills, and the short length of temporary assignments means the temp workers won’t be able to reap the benefits of any safety improvements made.

We found that temporary workers were much less likely to be asked about their prior skills or experience before starting a job assignment than were permanent workers. Where about 32% of permanent workers reported that their employers had not asked about their prior experience, nearly 50% of temporary workers reported that their agency had not asked about prior experience, and almost 60% reported their host employer did not screen for experience with the tasks they were performing.

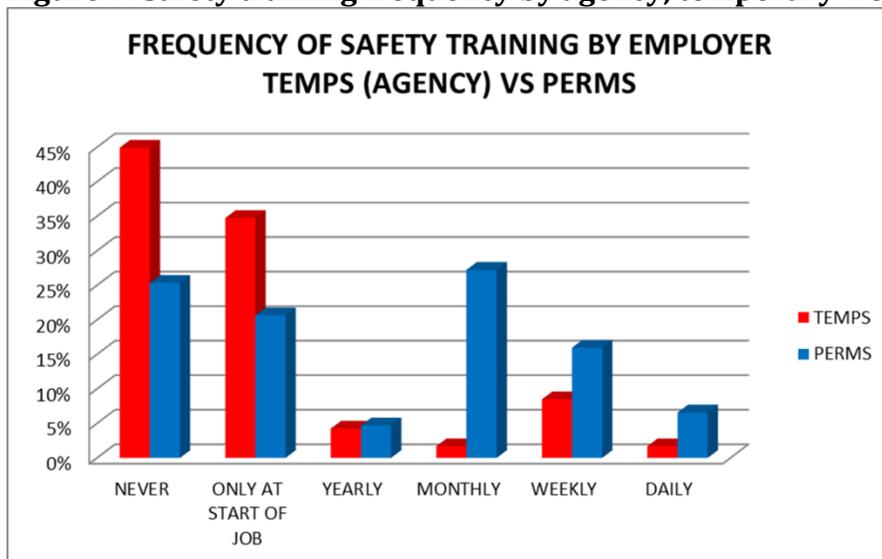
This makes sense from the point of view of the employers, given the short-run nature of the job assignments, but it is a potential driver of the higher claims rates we observe for temp workers.

**Figure 6: Job screening for experience, temporary and permanent workers**



As compared to their permanently-employed peers, temporary workers received training less frequently, both at their agency and at their host employers, and the training they did receive was more often perceived to be of lower quality. In addition, a higher percentage of temporary workers report receiving no safety training from their jobsite employer.

**Figure 7: Safety training frequency by agency, temporary workers and permanent workers**



Temporary workers considered the quality of safety training received at temporary agencies to be inferior to that they received at their host employers. However, they also perceived the quality/adequacy

of the safety training given them at their host employer to be significantly higher and comparable to that reported by permanent workers. Temporary workers were also no more likely than their permanent counterparts to report not receiving “appropriate” personal protective equipment (PPE) from their employer.

**Figure 8: Quality of safety training by agency, host and permanent employers**



On the question of how closely workers were supervised at the job site, we found that 33% of temporary workers versus 27% of permanent workers reported receiving “close” supervision. Another 34% of temporary workers felt their supervision at the job site was “not close”, versus 40% of permanent workers reporting this.

Finally, on the question of how they viewed their agency’s or host employer’s managers’ commitment to safety as compared to that of their permanent counterparts, temporary workers reported very similar levels: most (59%) believed safety was “very important” to their agency managers; somewhat more (63%) believed safety was very important to their host employers. Comparable levels of permanent workers (57%) reported safety as being “very important”.

These last findings are in conflict with what we expected, based on the findings of the focus groups that were conducted in 2007. As with hazard perception, questions that focus on a perception of “quality” or “appropriate” levels of PPE, or perceptions of the importance of safety to management raise issues of differential norms, ability to perceive quality as a function of experience and workers’ ability to voice concerns. One strategy to avoid these difficulties of interpretation may be to focus survey questions on concrete matters such as frequency of training and re-training, what kinds of PPE were supplied, how often did supervisors interact with them at the jobsite, in a way that does not require workers to make subjective judgments. It is interesting that on the more objective questions (job screening for experience and frequency of safety training) we found results that accorded with our expectations of higher risk for temporary workers. But these results may also reflect that in the search for an explanation for the higher rates of injury for temps, we need to focus on better job screening, the low frequency of safety training,

and measures to improve temporary workers' ability to perceive safety hazards at each new job site to which they are sent.

On other issues surveyed we found no significant differences between temporary and permanent workers on such measures as:

- physical/mental exhaustion;
- health status prior to injury;
- frequency of overtime;
- understanding of their rights to workers' compensation.

On this last item we found that about 64% of both groups of workers did not know how to initiate a claim for workers' compensation prior to their injury.

Two items from the survey addressed schedule control and job assignment control, as these are inversely related to stress, which itself is a risk factor for injury. About 28% of temporary workers had experience a "significant" change in their job assignment after they had arrived at a work site. Over half of these said this had happened "frequently" and over half said they did not feel able to refuse the re-assignment. About 63% of temporary workers said they had "no control" over their work assignments or schedule. This issue of schedule control also affected permanent workers, although less frequently: about half of permanent workers felt they had no control over their work schedule.

Finally, we found that workers who self-identified as Latino or Hispanic made up about 35% of the temporary workforce, as compared to 24% for their permanent counterparts in the matched risk classes. This high share may affect temporary workers' risk of injury through its effect on adequacy of training materials used by agencies and hosts and through its effects on jobsite hazard communication between workers and supervisors.

### *Safety conversation*

At the end of each worker survey we conducted asked open-ended questions of each worker to get their impressions on what were their biggest safety concern regarding worksite conditions, what would be the best way to prevent injuries to temporary workers doing the kind of work they were doing when they were injured, and what would be the best way to get safety information to temporary workers.

Temporary workers agree that more should be done to help prevent injuries. Greater awareness and hands-on training are viewed as beneficial toward potential injury reduction. Temporary workers frequently fear re-injury and not fully recovering as one of their biggest safety concerns. Communication is essential to addressing the concerns. A questionnaire that asks workers for their recommendations could help, if the results are communicated back to the staffing agencies during the following survey cycle. This idea would encourage more participation and greater confidence in the confidentiality of their responses.

It is clear that temporary workers need to ask questions, get clear guidelines regarding how to stay safe, and slow down to encourage injury prevention. Taking the time to properly train temporary workers and encourage questions makes workers believe that the companies care. This strengthened relationship could help workers feel safe enough to ask the questions they need answered to remain safe on the job. Temporary workers want additional safety and training information about the jobsites they

will be sent to. This is where collaboration between the staffing agency and the host employer can affect future injuries. FAQ (frequently asked questions) information specific to the industry and tailored to the temporary workforce would be welcomed.

Some workers indicated improved communication could be accomplished through ongoing training offered to temporary workers based on the most frequently encountered hazards the staffing agencies sees (through the review of claims data). Others voiced that the jobsites should have more hands-on training to help workers fully understand the work along with the hazards. Despite disagreement regarding who should be responsible for improve training, workers stressed the importance of continual training at set intervals. Workers suggested many visual and tactile options the training could take: job shadowing, apprentice-like task progression until mastery, demonstration of tasks and testing for comprehension. The ideas we have listed require a coordinated effort between temporary staffing agencies and host employers to meaningfully change the safety of temporary workers.

### AIM III: Management Interviews at Temporary Agencies

#### *Methods-Aim 3*

We conducted interviews with managers responsible for safety and health training at temporary agencies. The information gathered helps to gauge the commitment to safety on the part of agency organizations and complements the data gathered from injured workers. These interviews focused on:

- how temporary agencies provide safety training to temp workers;
- what safety-related issues are covered;
- what kinds of practices do they think are more successful or less successful at preventing worker injuries;
- how they ensure that the workers they send to clients receive the proper on-site training;
- do they visit client worksites to review safety practices and to ensure conformity with contracted tasks.

To provide sufficient coverage to the diversity of industrial settings to which agencies send workers, the agencies were recruited based upon the risk classes they deploy workers into and the number of workers for whom they arrange work. We attempted to recruit both agencies with a relatively low and a relatively high worker' compensation experience rating in order to increase the range of performance observed and to increase the possibility of detecting meaningful differences in safety practices. These interviews were conducted at the agency offices. Two researchers were present. Interviews were transcribed from notes.

#### *Results and Discussion-Aim 3*

We conducted a total of 9 interviews of agency safety or personnel managers across the four largest non-office services industries that had a significant presence of temporary workers: construction, light industrial manufacturing, warehousing/logistics, and health care. For each risk class we attempted to conduct two agency interviews. Often upon arrival we often found that the industry focus of the temp agencies did not exactly match that which we expected from their hours reported for workers' compensation premium collection. Managers were conducted through an interview (see Appendix B) covering what safety training is provided to temp workers; what safety-related issues are covered; what kinds of practices do they think are more successful or less successful at preventing worker injuries; how

they ensure that the workers they send to clients receive the proper on-site training; and whether they visit client worksites to review safety practices and to ensure conformity with contracted tasks. Agencies were recruited from a variety of industrial risk classes they deploy workers into. We recruited agencies from across a broad range of worker' compensation experience ratings in order to increase the range of performance observed and to increase the possibility of detecting meaningful differences in safety practices.

Among the key results found:

- agencies report they conduct site inspections and assess PPE needs for workers only at the start of their contractual relationship with a new host employer
- oversight of worksites in the construction industry is unclear
- most thought temp work was more hazardous
- agencies provide only general safety training during orientation, relying on host employers to provide specialized job and safety training
- market pressures and price competition between agencies result in a lack of leverage over host employers to improve safety practices.

Agency managers place temporary workers in a variety of skilled and unskilled jobs in the following industries; manufacturing, warehouse, administrative, construction and nursing. Often these are short-term ( $\leq 90$  days) placements. Typically, staffing agency personnel conduct an in-person site inspection or collect site safety information over the phone where PPE needs are expressed. Slightly more than half of the agency managers we spoke to believe that temporary workers are assigned more unsafe jobs than permanent workers. In general, very little training is offered to temp workers at the agency, usually because the host employer takes on that role in the employment relationship. When we asked agency managers how the training host employers provide their permanent workers differs from the training host employers provide to temporary workers, many agency managers reported that they were unsure or thought that temporary workers were offered less training, potentially because the host employer considered temporary workers to be a commodity. The most common hazards reported were sprains and strains, cuts and falls. When we asked agency managers what would be the best way to get safety messages out to their workers, they responded that solutions would have to be fast, easy, and cost-free for them to be widely used.

Our visits to temporary staffing agencies revealed that because of intense competition for business in a crowded market, the price they offer client businesses for their services is vitally important. Agency managers welcome quick, easily accessible, no cost solutions that could help reduce injuries and lead to lower workers compensation premiums for them. Injury awareness prevention messages targeting specific industries could help workers understand the hazards they might encounter on the job. Prevention materials that can be passed on to workers at little to no cost were requested. We have a better understanding of the difficulties temporary staffing agencies face given their unequal power relative to host employers within the three-sided employment relationship. We are continuing to gather additional information from host employer interviews to help us generate practical materials that would lead to a reduction of temporary worker injuries.

Many agencies say that host employers increasingly use temp agencies as a way to supply and test candidates for potential permanent positions. This limits host employers' loss of investment in case of poor performance as well as their liability in case of injury.

#### *Methods-Aim 4*

We conducted manager interviews at host employers that use temporary workers. As in Aim III, the information gathered helped to measure organizational commitment to worker safety and any deficit in levels of investment in training and supervision of temporary workers. These interviews covered:

- site-specific hazards and how information about these are communicated to both permanent workers and temporary workers;
- safety training provided to temporary workers;
- nature of tasks typically assigned to temporary workers as opposed to permanent workers;
- how temporary workers are monitored and supervised while they are on-site;
- what managers see as the advantages and disadvantages of using temporary workers;
- why they think temporary workers have higher injury rates;
- ideas they may have for reducing injury rates for temporary workers.

Employers who use temporary workers were identified through the place of injury reported on the temporary workers claims records. A recruitment screening questionnaire ensured that only businesses with recent and sufficient experience with temporary workers were selected. Businesses were selected so that a broad range of industries was represented. A total of ten host employer management interviews were conducted. These interviews were conducted at the host employer worksite. Two researchers were present. Interviews transcribed from notes.

#### *Results and Discussion-Aim 4*

We conducted a total of ten host employer interviews manager interviews at businesses that frequently used temporary workers. Employers who used temporary workers were identified through the place of injury reported on the temporary workers claims records. A recruitment screening questionnaire ensured that only businesses with recent and sufficient experience with temporary workers were selected. Businesses were selected so that a broad range of industries are represented. These interviews were conducted at host employer offices. Two researchers were present and each transcribed the interviews. As in Aim 3, the information gathered covered site-specific hazards and how information about these are communicated to both permanent workers and temporary workers; safety training provided to temporary workers; the nature of tasks typically assigned to temporary workers as opposed to permanent workers; how temporary workers are monitored and supervised while they are on-site; what managers see as the advantages and disadvantages of using temporary workers; why they think temporary workers have higher injury rates; ideas they may have for reducing injury rates for temporary workers.

Among the key results found:

- Host employers emphasize the need for better screening for experience on the part of agencies supplying temporary workers.
- Several employers noted a deficiency of safety awareness among the temporary employees they have hosted as a primary risk factor leading to injuries.

Host employers were not uniform in their reasons for using temp workers. Some clearly see temps as a source of low skill labor to fill less attractive roles in their operations. Little if any investment is made in these workers as they are expected to leave after a short stint. But other employers, particularly in manufacturing and light assembly operations, viewed temp workers as a way to test workers over a 2-3 month period before extending an offer of a permanent position.

## AIM V: Development and Dissemination of Educational Materials

### *Methods-Aim 5*

In collaboration with stakeholders in the temporary labor industry, we are developing educational materials for temporary workers, agencies and host employers tailored to the industries and occupations in which they work. One possibility raised in our previous focus groups was to develop a variety of pocket cards for temporary workers with occupation-specific safety material along with information about how to report a hazard and what to do in case they are injured on the job. After completing our worker surveys and management interviews, however, we believe such printed material may not be as effective in gaining workers' attention and usage as would more interactive materials designed for web platforms that can be accessed by computer or smartphone and downloaded for later access. Materials will be disseminated to workers and client businesses through the temporary agencies with which we interviewed.

### *Results and Discussion-Aim 5*

We are developing educational materials for temporary workers, agencies and client businesses, based upon what we have learned from interviewing the injured workers, the agencies and host employers. The first product is an online safety awareness teaching tool, viewable on tablets, smartphones or computers using any operating system, which we hope will be an advance over the passive-mode videos and printed materials we observed being used in the field. This tool will cover topics such as hazard identification, communication, PPE and what to do when an unexpected condition arises in the worksite. It requires the active participation of the user to move through a set of graphics-based scenarios towards the goal of safety awareness. This tool, and others to follow, will be disseminated to stakeholders in order to obtain feedback on their content and format. We plan to complete development of the first tool in the near future and we have recruited several host employers and temporary agencies to review the tool and evaluate its utility. Investigators will contact temporary agencies that received the materials to obtain their opinions on the utility of the educational tools and whether they intend to adopt them permanently.

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## Publications and Presentations

### *Journal articles*

Foley MP, Ruser JA, Shor G, Shuford H, Sygnatur E. 2014. Contingent workers: workers' compensation data analysis strategies and limitations. *American Journal of Industrial Medicine* 57:764-775.

### *Presentations*

Foley MP. CSTE 2013 Conference (June 11, 2013): "The role of workers' compensation data in occupational health and safety surveillance of temporary workers"

Foley MP. NORA Services Sector annual meeting (April 15, 2014): "The role of workers' compensation data in occupational health and safety surveillance of temporary workers."

Foley MP. Presentation at Washington State OSHA inspectors and consultants annual symposium in Wenatchee, WA on "Occupational Health and Safety Surveillance of Temporary Workers in Washington State".

Foley MP. Presentation at APHA annual meeting (November 19, 2014): "Occupational Health and Safety Surveillance of Temporary Workers in Washington State".

Foley MP. Presentation at NORA Services/Manufacturing Sectors joint annual meeting (April 29, 2015): "Occupational Health and Safety Surveillance of Temporary Workers in Washington State".

### Data Sets

Research resources and data collected under the Washington State Occupational Injury and Illness Surveillance Program grant can be made available to qualified individuals within the scientific community after publication. In Washington State, data sharing is governed by our state public disclosure laws, and additional specific Washington State statutes and administrative regulations associated with the entity owning the data system from which occupational injury and illness data or workforces estimates are ascertained.

### Other Materials available for other investigators

Other research materials or protocols may be available under the conditions described above. Qualified individuals within the scientific community who are interested may contact the Washington State Occupational Injury and Illness Surveillance Program directly.

### Inclusion of gender and minority study subjects

The surveillance project passively collects data, and captured race and ethnicity when available, typically collected when a case follow-up interview occurs. A completed cumulative inclusion enrollment form is

attached.

### Inclusion of Children

Per the definition provided by NIH, children are less than 21 years of age. Data was collected for persons younger than 21, as the study population included persons under 21 employed in the temporary services surveillance system. Due to labor laws in Washington State children under the age of 14 are not allowed to be employed; and those age 14 to 17 have restricted employment status to specific low hazard jobs and restricted hours. No subjects are recruited for this research and thus the distribution of disease by age was an important finding related to the research itself. Care was taken to ensure guidelines for working with small numbers were followed for protection of confidentiality in data analysis and presentation. The number of injured workers and subsequent respondents for children under 18 were too small to make any meaningful conclusions about this population.

## Cumulative Inclusion Enrollment Report

PFA: NORA Surveillance Part 2: Temporary Worker Injury Reduction through Surveillance  
 Program Director/Principal Investigator: Foley, Michael / Bonauto, David K.

<b>PART A. TOTAL ENROLLMENT REPORT:</b>		<b>Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race</b>		
<b>Ethnic Category</b>	<b>Females</b>	<b>Males</b>	<b>Sex/Gender Unknown</b>	<b>Total</b>
Hispanic or Latino	17	71	0	88 **
Not Hispanic or Latino	62	227	0	289
Unknown (individuals not reporting ethnicity)	5	16	0	21
<b>Ethnic Category: Total of All Subjects*</b>	84	314	0	398 *
<b>Racial Categories</b>				
American Indian/Alaska Native	2	4	0	6
Asian	3	3	0	6
Native Hawaiian or Other Pacific Islander	2	9	0	11
Black or African American	6	16	0	22
White	57	205	0	262
More Than One Race	0	0	0	0
Unknown or Not Reported	14	77	0	91
<b>Racial Categories: Total of All Subjects*</b>	84	314	0	398 *
<b>PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled to Date (Cumulative)</b>				
<b>Racial Categories</b>	<b>Females</b>	<b>Males</b>	<b>Sex/Gender Unknown</b>	<b>Total</b>
American Indian or Alaska Native	1	1	0	2
Asian	1	1	0	2
Native Hawaiian or Other Pacific Islander	0	0	0	0
Black or African American	0	1	0	1
White	6	19	0	25
More Than One Race	0	0	0	0
Unknown or Not Reported	9	49	0	20
<b>Racial Categories: Total of Hispanics or</b>	17	71	0	88 **

\* These totals must agree. \*\* These totals must agree.

## **PFA: Maintaining and Improving Pesticide-Illness Surveillance in Washington State**

Washington Occupational Injury and Illness Surveillance and Prevention Program

Grant Number 2 U60 OH008487

Project Period: July 1, 2010 – June 30, 2015

Final Report Completed: September 30, 2015

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<sup>1</sup> Through contract with the Washington State Department of Labor and Industries.

## **PFA: Maintaining and Improving Pesticide-Illness Surveillance in Washington State**

Washington Occupational Injury and Illness Surveillance and Prevention Program

Grant Number 2 U60 OH008487

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**Abstract:** During the five year project, the Washington State Department of Health (DOH) Pesticide Program reviewed more than 5,000 reports of pesticide illness and selected about 1,100 exposure incidents to investigate. Of these, 869 cases of pesticide illness were documented. Data from the investigations were provided to CDC NIOSH, contributing to national efforts to understand and reduce pesticide illness. Additionally, findings enabled us to prioritize issues to address occupational pesticide-related illness and focus our public health prevention efforts.

Antimicrobial pesticides disinfect, sanitize, destroy or suppress the growth of bacteria, viruses, or fungi microorganisms. Work-related exposure to antimicrobial pesticides is associated with asthma, respiratory airway disease, eye injuries, and dermal effects. After evaluating our case reporting system, we found that antimicrobial case reports were missing. We piloted, and then adopted a new coding method for antimicrobial reports.

Despite efforts to prevent agricultural pesticide drift, surveillance identified an upward trend in pesticide illnesses resulting from drift of pesticides applied to crops beginning in 2010, with a large spike in early 2014. By May of 2014, 15 events involving more than 60 people were reported – as many as DOH normally sees in a year. By year's end, 22 separate drift events were documented resulting in acute illness in 129 people, the majority of whom (80 percent) were farmworkers.

The disproportionate incidence of pesticide drift and its impact on farmworker health were identified during this surveillance project. DOH recommended workplace interventions in comments submitted to the federal Environmental Protection Agency (EPA) in August 2014 related to proposed changes to the federal standards for agricultural worker protection. In May 2015, we again commented on EPA's revised health risk assessment for the pesticide chlorpyrifos. Both comment letters included important recommendations for workplace interventions such as increasing the safety zone between applications and workers, setting a federal age-limit for pesticide applicators of 18 years, requirements for improved communication, and special considerations for airblast spray applications and fumigant use.

Drift events were markedly reduced during the spring and summer of 2015 when compared to the previous year. Analysis of surveillance data found Hispanics were disproportionately represented among pesticide-related illness cases. During the study period, about 11% of people living in Washington State were Hispanic. Data shows 42% of plausible illnesses were Hispanic, (19% did not disclose ethnicity).

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<sup>1</sup> Through contract with the Washington State Department of Labor and Industries.

A biomonitoring study of pesticide applicators found higher levels of bifenthrin and other pyrethroids present in their urine when compared to statewide levels. The study indicated that applicators that use backpack sprayers were at increased risk of pyrethroid absorption than those who use other application methods.

Finally, the adoption of the SPIDER database in 2011 improved the efficiency of our surveillance system and reduced data entry errors.

## Section 1

### Significant (Key) Findings

During the five years of the “Maintaining and Improving Pesticide Illness Surveillance” project, the Washington State Department of Health (DOH) Pesticide Program reviewed more than 5,000 reports of pesticide illness and selected about 1,100 exposure incidents to investigate. Of these, 869 cases of pesticide illness were documented. Data from the investigations were provided to CDC NIOSH, contributing to national efforts to understand and reduce pesticide illness. In addition, analysis of results enabled us to prioritize issues to address occupational pesticide-related illness and focus our public health prevention efforts. Priority issues were:

- Higher numbers of agricultural pesticide drift incidents impact farmworkers and other bystanders.
- Pesticide-related illness disproportionately impacts Latino farmworkers in Washington State.
- Pesticides of high concern were identified including acrolein and chlorpyrifos.

Antimicrobial case reports were added to the ongoing surveillance system. After evaluating our occupational case reporting system of workers’ compensation claims, we found that the existing word search was missing antimicrobial pesticides. We piloted, and then adopted a new coding method for antimicrobial reports. A review of the antimicrobial records found that illness cases primarily involved eye, skin and respiratory effects. Bleach was by far the most frequently reported antimicrobial product.

A biomonitoring study of pesticide applicators found higher levels of bifenthrin and other pyrethroids present in their urine when compared to statewide levels. The study indicated that applicators who use backpack sprayers were at increased risk of pyrethroid absorption than those who use other application methods.

### Translation of Findings.

As a result of our findings of the disproportionate incidence of pesticide drift and its impact on farmworker health, DOH recommended workplace interventions in comments submitted to the federal Environmental Protection Agency (EPA) in August 2014 related to proposed changes to the federal standards for agricultural worker protection. In May 2015, we again commented on EPA’s revised health risk assessment for the pesticide chlorpyrifos. Both comment letters included important recommendations for workplace interventions such as increasing the safety zone between applications and workers, setting a federal age-limit for pesticide applicators of 18 years, requirements for improved communication, and special considerations for airblast spray applications and fumigant use.

Department of Health Pesticide Program provided data and participated in work sessions of the Washington State House Committee on Labor and Workforce Development, and the Committee on Health Care and Wellness on issues of farmworker health and agricultural pesticide drift. We plan to continue providing data and recommendations to inform policy makers and others to support strategies for pesticide illness prevention.

We serve on the Governor’s advisory committee for Agricultural Safety Day which hosts an annual training workshop and presented findings in Spanish and English to workers and farm managers. Our findings on worker exposure to pesticides were provided to health care providers in three major venues:

- Annual Midwestern Stream Farmworker Health Forum (San Antonio, TX, Nov. 2014)

- Current Topics and Best Practices in Occupational and Environmental Medicine in Agricultural Communities (Yakima, WA. Feb. 2015)
- Pesticide-Illness Case Studies and Reporting: Central Washington Family Medicine Residency Program (Yakima WA, May 2014 and May 2015)

Analysis of surveillance data found Hispanics were disproportionately represented among pesticide-related illness cases. During the study period, about 11% of people living in Washington State were Latino. Data shows 42% of plausible illnesses were Latino (19% did not disclose ethnicity). The Washington State Commission on Hispanic Affairs used this data in their environmental justice work. DOH applies these findings to inform agency-wide planning and initiatives addressing inequities that impact health.

### Outcomes/Impact

Sharing findings and recommendations has led to improvements in worker safety and health in Washington. Our findings influenced the Washington State Departments of Agriculture and Labor and Industries, leading to increased regulatory response to the problems of pesticide exposures among farmworkers, including higher fines and penalties.

Drift events were markedly reduced during the spring and summer of 2015 when compared to the previous year. Washington state legislators have met with DOH to discuss proposed legislative and policy interventions to reduce pesticide drift and improve pesticide use reporting.

Access to medical records through the secure workers compensation database saved time. This allowed DOH to expand surveillance to include investigation of antimicrobial exposures. Criteria developed for antimicrobial case ascertainment enables the program to capture the most serious of them without overwhelming investigators.

The adoption of the SPIDER database in 2011 improved the efficiency of our surveillance system. SPIDER is used by 11 of 12 other states that conduct pesticide illness surveillance. With SPIDER, our data is more easily shared with other states and with NIOSH. It allows for direct data entry by case investigators and immediate sharing of case data, thus eliminating the need for our investigator in our Yakima office to send case notes and records by Federal Express for data entry in Olympia. This saves significant time and has the added benefit of reducing data entry errors.

## Section 2

### Scientific Report

#### *Background*

The Washington State Department of Health (DOH) has worked to document and prevent pesticide poisoning since 1989. DOH Pesticide Illness Surveillance and Prevention Program investigates about 300 reports of pesticide illness each year. Before the Maintaining and Improving Pesticide-Illness Surveillance in Washington State project, illness reports from antimicrobial pesticides were rarely investigated. Given the existing workload constraints within the program, adding antimicrobial-related illness reports for investigation would have overwhelmed the surveillance system. This project was designed to enhance efficiencies in pesticide illness case ascertainment from reporting sources and to expand our surveillance to include occupational antimicrobial-related illness cases.

Project work focused on improving surveillance practices so that the illness-investigation data collected remained high quality, included antimicrobials and that data dissemination, public health education and other prevention activities continued. To accomplish this, DOH Pesticide Program incorporated modifications to case ascertainment, improved access to medical records and incident information, and adopted a new database to increase efficiency with data entry and data sharing with NIOSH. Additionally, DOH conducted new research to reduce antimicrobial pesticide-related illness by including a carefully chosen subset of illness case reports into the existing illness surveillance and prevention system.

DOH Pesticide Program is required by state law to investigate cases of acute pesticide illness, and to report their findings to the public. We applied DOH Pesticide Program's unique access to high quality occupational injury data, obtained through existing relationships with the Washington State Department of Labor and Industries (L&I), to identify the subset of antimicrobial case reports for follow-up investigation.

Antimicrobial pesticides disinfect, sanitize, destroy or suppress the growth of bacteria, viruses, or fungi microorganisms. Work-related exposure to antimicrobial pesticides is associated with asthma, respiratory airway disease, eye injuries, and dermal sensitization (Quirce and Barranco 2010; Vandenplas et al. 2013<sup>1</sup>).

This scientific report will focus on the new antimicrobial research, addressing what was accomplished, and barriers to significant progress was not made, for each of the specific aims of the grant plan.

#### *Specific Aims*

The five specific aims in the project proposal, can be grouped into two objectives (1) continue to investigate reports of pesticide illness and contribute to illness prevention, and (2) enhance efficiency in the program to enable expanding surveillance to include antimicrobial exposures.

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<sup>1</sup> Quirce S, Barranco P: [2010] Cleaning Agents and Asthma. J Investig Allergol Clin Immunol; Vol. 20(7): 542-550

Vandenplas O, D'Alpaos V, Evrard G, Jamart J, Thimpont J, Huaux F, Renauld JC: [2013] BMJ 3(9):e003568

During the five project years, DOH Pesticide Program successfully completed more than 1000 investigations and provided NIOSH case data for 869 illness cases. Our investigations are of high quality; most include case interview and medical records review. We explore the factors that contribute to illness with stakeholders and partner agencies. We share what we have learned through pesticide-illness surveillance and work with others to apply findings to address the contributing factors and prevent illness. Examples of this include information sharing with regulatory agencies and policy makers about farmworkers' and other bystanders' exposure to pesticide drift, and about pesticide products and ingredients of concern. Another example is prevention education for pesticide applicators that work with our County Irrigation Districts about specific exposure concerns about fumigant use practices. We work with other state agencies, university programs, and health clinics to provide case study detail and illness prevention information to those who need it, including pesticide applicators, and health care providers. In this way, we achieved the original specific objectives:

- Continue to conduct quality pesticide-illness case investigations, collecting information critical to preventing illness and continuing to contribute Washington State data to national aggregate data managed by NIOSH.
- Continue to support and participate in effective pesticide-illness prevention activities in coordination with stakeholders and partner agencies.

During the first year of the project, as a way to enhance efficiency within DOH Pesticide Program, we tried using the scanable data entry forms and piloted optical character reading software. Program staff requested and received training on use of the software and spent hours attempting to get the system to work for us. It didn't. We abandoned that part of the original specific aim. Adopting the SPIDER database was helpful to Program efficiency. SPIDER has many benefits; one of them being that each investigator enters their own case data. Our Investigator in Yakima no longer has to send case information to Olympia to have it entered in our home office. This is time saving and now that we are familiar with SPIDER, it has markedly reduced data entry errors. SPIDER also has facilitated de-identifying the annual datasets that we provide to NIOSH. A process that at one time took a week, now takes a minute.

Efficiency improvements in case identification were achieved by thoroughly studying the new classification system used by Washington State Department of Labor and Industries (L&I) as it codes for pesticides, and antimicrobial type pesticides as well. We found after study, that we did not see an improvement over our current process of case identification using text word searches for all pesticide exposures except for the antimicrobial exposures. After studying the data for the antimicrobial reports, and piloting investigation and data entry for these reports provided through L&I's new coding system, we found that continuing the former system of case identification, with addition of the new coding system for only certain types of antimicrobial reports yielded results desired. Efficiencies were also realized through tightening criteria for ascertainment of Washington Poison Center non-occupational reports. Limiting the non-occupational investigations has allowed for continued investigations of occupational cases. Only those non-occupational reports that represent the more severe illness, novel events, or unusual pesticide products are now referred for investigation. In this way, the following three specific aims, with the exception of using the scanable forms and optical character reader software, were achieved:

- Improve the efficiency of our surveillance system by using scanable data entry forms and piloting optical character reading software to facilitate rapid data entry, and changing our existing database to SPIDER.
- Improve case identification of occupational pesticide poisoning by using Washington Department of Labor and Industries' (L&I) improvements in classification of pesticide exposures.
- Pilot the inclusion of occupational antimicrobial pesticide-related illness into our surveillance program.

## *Methodology*

*Antimicrobial Study:* DOH staff met with L&I's Safety and Health Assessment and Research for Prevention (SHARP) data management staff to consider reporting options for antimicrobial-related workers' compensation claims. The existing text search employed electronically to report claims to DOH weekly intentionally excluded most antimicrobial pesticide-related claims. Modifications to the existing electronic report system based on text search for pesticide-related claims were ruled out because search modifications would be too costly for L&I. Occupational Injury and Illness Classification System (OIICs codes), identified during the initial grant application process, refer to substance designations such as pesticides, disinfectants, and are manually coded by L&I staff based on information provided by the worker and healthcare provider on an initial intake form. DOH requested 3 years' OIICs-disinfectant coded (42-422, 73-732) claims data from L&I, to study for the pilot.

Early in the project period, L&I granted DOH staff access to the confidential worker's compensation (ORION) database; eliminating the need in most cases to ask and wait for medical records from healthcare providers. In addition to medical records, ORION houses chemical information when available, and incident descriptions from worker and employer.

Under the NIOSH grant, the antimicrobial pilot was considered human subjects research and as such, required application to the Institutional Review Board (IRB). Because of the constraints placed by the IRB regarding contacting claimants for interviews, DOH staff reviewed antimicrobial-related reports without conducting an interview, relying on the information provided in ORION. This exercise demonstrated the ability to obtain product information, signs and symptoms, language spoken, exposure route and often, days lost from work.

In the fourth and fifth years of the project, DOH requested more recent data sets from L&I, from which claims were investigated and entered into a database in order to evaluate actual time required to complete tasks. DOH also tested a reporting system where L&I staff send antimicrobial-related claims to a secure electronic file exchange quarterly.

## *Results and Discussion*

*Antimicrobial Study:* In order to maintain the high quality pesticide illness investigations and intervention efforts, the process of introducing more reports made it necessary to establish criteria from which eligible antimicrobial-related claims would be investigated. Three years' claims data were analyzed to describe which industries, occupations, and types of antimicrobial pesticides occur most frequently. Severity, recurring scenarios and workers under 22 years of age were also considered.

Tables 1 and 2 below show claims frequencies for the three year's OIICs-coded data, organized by industry (NAICS code) and occupational category (SOC code).

**Table 1. OIICs disinfectant coded claims 07-09 (n=351) by Industry Category**

NAICS Code	2007	2008	2009	Total
72 Accommodation & Food Services	37	25	16	78
62 Healthcare and Social Assistance	18	19	16	53
61 Educational Services	8	7	9	24
44 Retail Trade	8	7	9	24
42 Wholesale Trade	11	5	7	23
31 Manufacturing	7	9	7	23
11 Agriculture	12	4	4	20
All other NAICS codes < 20 claims each year (13 industry categories*)	-	-	-	106
<b>Total</b>	<b>101</b>	<b>76</b>	<b>68</b>	<b>351</b>

\*includes 4 unknown NAICS

**Table 2. OIICs disinfectant coded claims 07-09 (n=351) by Occupational Category**

<b>SOC</b>	<b>Total n</b>
35 Food preparation & Serving-related occs	73
37 Bldg & Grounds cleaning maintenance occs	47
53 Transportation & material moving occs	33
45 Farming, fishing & forest	23
51 Production occs (incl. laundry & dryclean workers)	22
31 Healthcare support occs	20
39 Personal care & service occs	18
29 Healthcare practitioners and tech occs	15
All other SOC codes <15 claims total (9 occs*)	100
<b>Total</b>	<b>351</b>

\*includes 27 unknown SOCs

L&I identified 351 claims for the three-year period 2007-2009. Based on frequency of reports, we identified the following industries and occupational groups for focusing the antimicrobial case follow-up:

- Accommodation & food Services Industries; Food Preparation & Serving Occupations
- Healthcare and Social Assistance Industries; Bldg. & Grounds Cleaning Maintenance Occupations
- Agriculture Industries; Farming, Fishing, and Forest Occupations.

The case interview is a critical component of DOH's investigations, but if an interview isn't conducted, ORION's database may provide required documentation to classify an occupational-related illness so that it may be counted and used to prevent similar incidents.

The final two years of the pilot involved finalizing criterion for ascertainment and documenting the amount of time necessary to gather data from ORION to document, enter, research toxicity and classify a case. From ascertainment to case classification and data entry, total time averaged between 40 and 50 minutes. Ten of the 13 cases investigated without an interview were classified as definite, probable, or possible. The three remaining cases were classified insufficient information. Sample event descriptions are:

- A 34 year-old male sanitation worker at a food processing manufacturer was cleaning machinery when a caustic degreaser (active ingredient: sodium hydroxide) splashed into his eye. He went to the emergency room and missed 3 days work. He had a chemical burn.
- A 19 year-old male was cleaning equipment in the meat department of a grocery store when bleach splashed in both eyes. He rinsed eye at wash station 15 minutes and went to the ER. He had corneal abrasion.

## *Conclusions*

*Antimicrobial Study:* The DOH Pesticide Program will continue to ascertain cases from the workers' compensation claim data provided by L&I each week. This set is derived from text word searches. Additionally, DOH Pesticide Program will receive quarterly reports of the antimicrobial related claims. Reports that involve one or more of the following criteria: (1) moderate or higher illness severity (2) multiple illness cases in a single exposure event (3) Accommodation and food service industries (4) food processing, food warehousing, and food packing industries.

*Overall Project:* The DOH Pesticide Program has a strong record in using data from illness investigations to educate workers and employers, and to inform regulators of problems at the state and federal level. Funding under this request maintained our capacity to investigate and prevent pesticide illnesses. It preserved our ability to proactively identify and prevent problems among farm workers who are reluctant to file complaints with enforcement agencies. It also provided unique access to high quality occupational injury data antimicrobial pesticides to identify and prevent these important injuries without overwhelming the system.

## Publications

### *Journal Articles*

Calvert GM, Beckman J, Prado JB, Bojes H, Schwartz A, Mulay P, Leinenkugel K, Higgins S, Lackovic M, Waltz J, Mitchell Y, Stover D, Moraga-McHaley M [2016] Acute occupational pesticide-related illness and injury – United States, 2007-2011. *Morbidity and Mortality Weekly Report*, in press.

Calvert GM, Rodriguez L, Prado JB: [2014] Worker Illness Related to Newly Marketed Pesticides-Douglas County, Washington, 2014. *Morbidity and Mortality Weekly Report* 64, 42-44.

Hudson NL, Kasner EJ, Beckman J, Mehler L, Schwartz A, Higgins S, Joanne BP, Lackovic M, Mulay P, Mitchell Y, Larios L, Walker R, Waltz J, Moraga-McHaley S, Roisman R, Calvert GM [2014] Characteristics and Magnitude of Acute Pesticide-Related Illnesses and Injuries Associated with Pyrethrin and Pyrethroid Exposures – 11 States, 2000-2008. *American Journal of Industrial Medicine* 55:15-30.

Tsai RJ, Sievert, J, Prado JB, Buhl K, Stone DL, Forrester M, Higgins S, Mitchell Y, Schwartz A, Calvert GM: [2014] Notes from the Field: Acute Illness Associated with Use of Pest Strips — Seven U.S. States and Canada, 2000–2013. *Morbidity and Mortality Weekly Report* 63(02), 42-43.

Sievert JS, Morrissey BFM, and Calvert GM: [2013] Case Report: Severe acute illness in a toddler exposed to multiple agricultural pesticides and an insect repellent. *Journal of Agromedicine* 18:4, 285-292. Reprinted [2014] *Migrant Clinician Network Streamline*.

Rodriguez L, Prado JB, Holland A, Beckman J, Calvert GM: [2013] Notes from the Field: Acute Pesticide-Related Illness Resulting from Occupational Exposure to Acrolein — Washington and California, 1993–2009. *Morbidity and Mortality Weekly Report* 62(16);313-314

Kasner EJ, Keralis JM, Mehler L, Beckman J, Prado JB, Lee SJ, Diebolt-Brown B, Mulay P, Lackovic M, Waltz J, Schwartz A, Mitchell Y, Moraga-McHaley S, Roisman R, Gergely R, Calvert GM: [2012] Gender differences in acute pesticide-related illnesses and injuries among farm workers in the United States, 1998-2007. *American Journal of Industrial Medicine* Vol. 55, 571-583.

Schwartz A, Walker R, Sievert J, Calvert GM, Tsai RJ: [2012] Occupational Phosphine Gas Poisoning at Veterinary Hospitals from Dogs that Ingested Zinc Phosphide-Michigan, Iowa, and Washington, 2006-2011 *Morbidity and Mortality Weekly Report* Vol. 61 No. 16.

Sievert J, Schwartz A [2011] Exposure to zinc phosphide sickens Washington technician – What you should know. *Washington State Veterinary Medical Association electronic newsletter Sparks*.

Lee SJ, Mehler L, Beckman J, Diebolt-Brown B, Prado JB, Lackovic M, Waltz J, Mulay P, Schwartz A, Mitchell Y, Moraga-McHaley S, Gergely R, Calvert GM: [2011] Acute Pesticide Illnesses Associated with Off-Target Pesticide Drift from Agricultural Applications: 11 States, 1998-2006. *Environmental Health Perspectives* Vol. 119; 1162-1169.

## Data Sets

Data from DOH pesticide illness surveillance is de-identified and uploaded annually to the SENSOR Pesticides Program at CDC-NIOSH. Additional de-identified data and case investigation information is made available upon request. Data is also published annually in reports and articles.

## Other Materials available for other investigators

Other research materials or protocols may be available under the conditions described above. Qualified individuals within the scientific community who are interested may contact the Pesticide-illness Surveillance Program directly.

## Inclusion of gender and minority study subjects

The surveillance project passively collects data, and captured race and ethnicity when available. A completed cumulative inclusion enrollment form is attached.

## Inclusion of children

Per the definition provided by NIH, children are less than 21 years of age. Data was collected for persons younger than 21. Due to labor laws in Washington State children under the age of 14 are not allowed to be employed; and those age 14 to 17 have restricted employment status to specific low hazard jobs and restricted hours. No subjects are recruited for this research and thus the distribution of disease by age was an important finding related to the research itself.

## Cumulative Inclusion Enrollment Report

**Study Title:** Maintaining and Improving Pesticide-Illness Surveillance in Washington State

**Program Director:** Joanne Prado MPH

**Comments:** July 1, 2010 through July 1, 2015.

WA surveillance data groups racial categories of "Asian" and "Native Hawaiian or Other Pacific Islander" as a single category.

Racial Categories	Ethnic Categories									Total
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			
	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	Female	Male	Unknown/ Not Reported	
American Indian/ Alaska Native	3	2		1						6
Asian	3	1		1						5
Native Hawaiian or Other Pacific Islander										0
Black or African American	4	2					1			7
White	129	143		29	52		2	7		362
More Than One Race	2	3		53	85		1	1		145
Unknown or Not Reported	8	11		81	111	1	65	65	2	344
<b>Total</b>	149	162	0	165	248	1	69	73	2	869

## Success Stories

### Occupational Illness Surveillance and Reporting Result in Safer Practices for Pesticide Applicators at County Irrigation Districts

Washington Occupational Injury and Illness Surveillance and Prevention Program  
Maintaining and Improving Pesticide-Illness Surveillance in Washington State  
Grant Number 2 U60 OH008487-06  
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#### The Challenge

Acrolein is an aquatic herbicide used in the western United States to prevent impaired water flow in irrigation canals. Acrolein is extremely irritating to all tissues it contacts. The vapor is highly reactive and when inhaled, can inflame the heart and lungs. Despite its toxicity, few cases of acrolein-related illness have been reported in the literature. On August 15, 2012, an irrigation district notified the Washington State Department of Labor & Industries (L&I) of acrolein-related illness in one of its pesticide applicators. Seven additional cases of acute acrolein-related illness were documented (1993-2009) through the SENSOR-Pesticides program. Five of these cases were also among workers employed by irrigation districts, four of them were pesticide applicators and one maintained pesticide application equipment.

#### The Response

L&I inspected the work site and interviewed the exposed worker, coworkers, and employer. The Washington State Department of Health (DOH) assisted by obtaining and reviewing medical records, interviewing the patient and hospital staff, and reviewing information obtained from L&I. Information from the DOH investigation was submitted to SENSOR-Pesticides program. This case was featured in the CDC's Mortality and Morbidity Weekly Report Vol.62 No.16.

On February 11, 2015, DOH Pesticide Program presented at the Sunnyside and Valley Irrigation Districts for the Public Operator Spray Recertification Conference. We discussed two acrolein cases that occurred in 2012 and 2013. Both cases involved acrolein exposures to irrigation district workers. We discussed the health effects caused by exposure to acrolein with licensed pesticide applicators at the conference. The were interested to learn that one case led to penalties of \$22,000.00 after the employer did not follow process safety management procedures and written operational procedures for acrolein applications in irrigation canals.

Since this exposure the patient has been under continued health care treatment and has suffered permanent physiological impairment due to the exposure. In response to this incident, L&I initiated inspection on process safety management requirements on employers using acrolein in quantities

covered by the standard. The employers told L&I that they would upgrade their compliance with the standard and explore the possible substitution with a less toxic chemical and curtail use if possible.

According to the Health and Safety Coordinator of these two irrigation districts, other herbicides are less toxic than acrolein and don't require personnel to follow such strict compliance standards and training, as acrolein applications require. DOH and L&I will continue to stress the seriousness of exposures to acrolein given its potential to cause severe and permanent illness.

### **The Impact**

The use of acrolein in irrigation districts is being limited, and in some cases eliminated, due to a number of factors including a better understanding of its' toxicity and stringent health and safety compliance requirements for acrolein applications. Applicators must be specifically trained in the use of fumigants, like acrolein, which can behave differently than other liquid or powdered products.

Although there are benefits to using acrolein, irrigation districts in Washington are increasingly choosing to use less toxic methods to address weed problems.

## **Sudden Spike in Pesticide-Related Illness Triggers Public Health Actions to Prevent Drift**

Washington Occupational Injury and Illness Surveillance and Prevention Program  
Maintaining and Improving Pesticide-Illness Surveillance in Washington State  
Grant Number 2 U60 OH008487-06  
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### **The Challenge**

Despite efforts to prevent agricultural pesticide drift, surveillance identified an upward trend in pesticide illnesses resulting from drift of pesticides applied to crops beginning in 2010, with a large spike in early 2014. By May of 2014, 15 events involving more than 60 people were reported – as many as DOH normally sees in a year. By year’s end, 22 separate drift events were documented resulting in acute illness in 129 people, the majority of whom (80 percent) were farmworkers.

### **The Response**

To alert farmers, farmworkers, and pesticide applicators about the spike in early-season drift events, the DOH issued a news release on May 12, 2014. Media throughout the state reported on the topic, broadcasting the issue on radio, online, and in several community and rural newspapers. At the same time, DOH Pesticide Illness Surveillance and Prevention (PISP) staff and agency leaders met and voiced concerns with partners in the agricultural industry, labor advocates, and agencies that license pesticide applicators and have roles in worker health and safety. We discussed improving adherence to state and federal rules designed to prevent drift and explored where rules or commonly accepted practices might need to be changed.

Illness caused by pesticides drifting off-target and on to people is completely preventable. Emerging from the analysis of the drift data and the work sessions that DOH-PISP staff held with many partners, root causes included an ineffective system for alerting nearby orchards, and the inability to predict shifting weather conditions to impact drift. Also noted were workers’ concerns that if they were to leave the work site to escape oncoming drift clouds or move away from detected odors, they would be fired or “have problems” on their jobs.

DOH PISP participated in an advisory capacity, on the Department of Employment Securities Agency Farmworker Advisory Committee. Staff spoke to concerns about farmworker and bystander exposure to pesticide drift. A section with prevention guidance for drift events was included in the Committee’s final report to the Washington State Legislature. PISP also presented case studies in Spanish and English, to audiences of farmworkers and farm managers at the Governor’s Agricultural Safety Day workshops.

PISP illness data agricultural pesticide drift support policy recommendations for stronger protections for farm workers and bystanders. We submitted comments about the Environmental Protection Agency

(EPA) proposed revisions to the Federal Agricultural Worker Protection Standard. Data from illness case investigations support stronger notification requirements and the need to extend no spray zones between application and workers or other bystanders, especially when fumigant type pesticides are used, or when ground airblast sprayer applies any type of pesticide. PISP illness data provided in response to EPA's Revised Health Risk Assessment for Chlorpyrifos Registration Review (2015) showed that applicators, other workers, and bystanders continue to be sickened by chlorpyrifos drift despite efforts to mitigate risk. Data included descriptive narratives that illustrate a pattern of causes that lead to drift exposures. Increasing the safety zone between application and workers or bystanders, requiring applicators to stop immediately upon seeing a person within that application zone, and improvements to communication at many levels, will prevent agricultural pesticides from drifting from the intended crop and onto people.

Finally, DOH PISP is working with researchers at the University of Washington to better understand the impact of weather conditions on pesticide drift, and have initiated research with them.

### **The Impact**

Drift events were markedly reduced during the spring and summer of 2015 when compared to the previous year. Weather patterns and employment statistics appear to have been similar.

<b>Dates</b>	<b>Number Events</b>	<b>Number Illness Cases (People)</b>
March - June 2014	19	59
March - June 2015	6	20

Washington legislators asked PISP staff to participate in a work session of the House Health Care and Wellness Committee about pesticide drift in April of 2015. Legislators contacted DOH to discuss proposed legislation intended to reduce pesticide drift and improve pesticide use reporting.

Like farmers and farmworkers nationally, WA DOH PISP await the new EPA final rules regarding the Agricultural Worker Protection Standards. We are hopeful that they will help to prevent pesticide applications from drifting onto farmworkers and others by expanding safety zones, particularly as concerns airblast spray applications and fumigant use, and providing a federal age limit of no less than 18 years for pesticide applicators.