NOIRS

National Occupational Injury Research Symposium

Preventing Workplace Injuries in a Changing World

May 10-12, 2022

National Institute for Occupational Safety and Health
NIOSH®

SPECIAL ACKNOWLEDGEMENT

NOIRS would not be possible without the support of our co-sponsors:

American Society of Safety Professionals

Board of Certified Safety Professionals (BCSP) and BCSP Foundation

National Safety Council

West Virginia University (WVU) Board of Governors

WVU School of Public Health

WVU Benjamin M. Statler College of Engineering and Mineral Resources

WVU Safety and Health Extension

May 2022

NOIRS 2022 Participants:

I would like to welcome you to the 2022 National Occupational Injury Research Symposium (NOIRS 2022). We are proud of the high-quality scientific program supporting this year's symposium theme, *Preventing Workplace Injuries in a Changing World*. NOIRS is the only forum exclusively dedicated to the presentation and discussion of the latest methods, findings, and translation activities related to occupational acute traumatic injury research and prevention. The conference brings together researchers, academicians, labor union representatives, safety professionals, industry leaders, and students from multiple disciplines and fields to advance the public health mission of keeping workers safe on the job.

Now more than ever, it is evident how a changing world can impact the workplace. Many of us have adapted how and where we work due to the COVID-19 pandemic. Work stress and mental health concerns have expanded, and fatigue is a greater concern due to nonstandard schedules and increased demands. An aging workforce makes the issue of healthier workers more pressing, and emerging technologies have transformed the work environment. What does all of this mean for how we approach preventing workplace injuries?

To address this question, the NOIRS 2022 conference agenda features emerging issues in occupational safety and cutting-edge occupational injury research findings from leading experts. Conference topics range from occupational safety during the COVID-19 pandemic, to mental health, substance use, engineering controls for fatigue, sleep, and work hours, and industry-specific presentations related to the construction, agriculture, and public safety sectors. Special sessions will further explore these topics and many more highlighted in the agenda below.

Although NOIRS 2022 is going virtual, we hope by hosting online we can welcome more attendees who may not have been able to join us in person. Please share your feedback via our conference evaluation link available at the end of this conference book.

NOIRS 2022 would not be possible without the support of our co-sponsors: American Society of Safety Professionals, Board of Certified Safety Professionals (BCSP) and BCSP Foundation, National Safety Council, West Virginia University (WVU) Board of Governors, WVU School of Public Health, WVU Benjamin M. Statler College of Engineering and Mineral Resources, and WVU Safety and Health Extension. Each contributed to planning the scientific program and outreach for the symposium. Also, thanks to the National Safety Council, a special issue of the Journal of Safety Research will highlight research presented at NOIRS 2022.

While progress is being made in reducing the toll of workplace injury and death, NOIRS 2022 provides an opportunity to re-energize our efforts to improve the safety of all workers. I offer my best wishes for a productive interchange of science and prevention strategies and the development of new partnerships as we work toward our common goal to prevent acute traumatic injuries and fatalities in the workplace. Enjoy NOIRS 2022!

John Howard
Director, National Institute for Occupational Safety and Health

ACKNOWLEDGEMENTS

NOIRS 2022 is being convened by the NIOSH Division of Safety Research
Dawn N. Castillo, Director
Timothy J. Pizatella, Deputy Director

We gratefully acknowledge our co-sponsors for their contributions and support:
American Society of Safety Professionals
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National Safety Council
West Virginia University (WVU) Board of Governors
WVU School of Public Health
WVU Benjamin M. Statler College of Engineering and Mineral Resources
WVU Safety and Health Extension

Special acknowledgements are made to the following for their support and dedication to planning NOIRS 2022

Conference Management Committee

Tim Pizatella [Chair], Dawn Castillo,
Gene Hill, Christine Schuler, Christina Socias-Morales, Rebecca Knuth, Kelly Henkins

Scientific Program Committee

Christine Schuler and Sergey Sinelnikov [Chairs]
Christina Socias-Morales [Co-Chair]
Angela Giotto, Gordon Smith, Jan Wachter,
Hugo Camargo, James Collins, Hongwei Hsiao, Jennifer M. Lincoln, Audrey Reichard

Symposium Support Services

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Symposium Planning Support

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GENERAL INFORMATION

Symposium Goal

The goal of NOIRS is to provide a forum for researchers and other professionals to share their findings and experiences aimed at preventing traumatic occupational injury through research and prevention. In addition to presenting current research findings, NOIRS also seeks to foster collaboration among researchers from a broad range of disciplines and perspectives; showcase innovative and state-of-the-art approaches to research and prevention; demonstrate the effectiveness of transferring research results to the workplace for prevention; and promote further research that will advance the goals of the National Occupational Research Agenda.

How to Access Bizzabo

Google Chrome is the preferred browser for accessing Bizzabo, the virtual platform for NOIRS 2022. You need to enable third party cookies to access Bizzabo. See the FAQ/Troubleshooting Guide and Third Party Consent guidance for more information.

You can also do a Technology Check to make sure your computer, internet connection and related equipment are working properly before accessing Bizzabo for NOIRS 2022.

> *Your link to access NOIRS 2022 is unique to the email address you used to register, so please do not share it with anyone else. If the link is shared, you will not be able to access the presentations during the symposium. If you did not receive an email from Bizzabo with your unique conference link by May 9, 2022, please contact Kelly Henkins at (304) 285-5904 or ocy1@cdc.gov.*

How to Access the Poster Session

A one-hour poster session will take place at 4:00 p.m. on May 11, 2022. You can access the session using the Poster Session Zoom link.

> Meeting ID: 160 099 5398
> Passcode: NOIRS2022!

A link to the poster session is also available on the NOIRS 2022 Bizzabo page.

Questions?

If you have any issues during the symposium, please contact Tim Pizatella (tjp2@cdc.gov) or Christina Socias-Morales (wzo4@cdc.gov).

NOIRS 2022 AGENDA AT A GLANCE

DAY 1	TUESDAY – MAY 10, 2022			
12:00 – 1:00 pm	**Opening Plenary Session**			
1:00 – 2:00 pm	**Concurrent Sessions A**			
	A1: Human-Robot Interaction in the Workplace	**A2:** Work-Related Injuries Related to Substance Use	**A3:** Research to Practice in the Construction Industry	**A4:** Surveillance in Agriculture, Forestry, and Fishing
2:00 – 3:00 pm	**Concurrent Sessions B**			
	B1: Using Workers' Compensation Systems to Conduct Injury Surveillance	**B2:** Work-Related Mental Health Considerations to Reduce Injuries	**B3:** Research in the Construction Industry Part 1	**B4:** Special Topics in Agriculture, Forestry, and Fishing
3:00 – 4:00 pm	**Concurrent Sessions C**			
	C1: NIOSH Fatality Investigations	**C2:** Occupational Safety During the COVID-19 Pandemic	**C3:** Emerging Protective Technology in Construction	**C4:** High-Risk Workers in Agriculture, Forestry, and Fishing

DAY 2	WEDNESDAY – MAY 11, 2022			
12:00 – 1:00 pm	**Concurrent Sessions D**			
	D1: Advancing Surveillance Efforts to Improve EMS and Firefighter H&S Outcomes	**D2:** Occupational Stress and Work Organization	**D3:** Understanding and Visualizing Recent Construction Safety and Health Trends	**D4:** Robotics in Agriculture
1:00 – 2:00 pm	**Concurrent Sessions E**			
	E1: Occupational Injury Surveillance in the US Military	**E2:** Fatigue, Sleep, and Work hours	**E3:** Helmet Research on Work-Related Traumatic Brain and Musculoskeletal Injuries	**E4:** Interdisciplinary Approaches Along the Translational Research Continuum to Reduce Children's Injuries in Agriculture
2:00 – 3:00 pm	**Concurrent Sessions F**			
	F1: Occupational Injury Surveillance, Part 1	**F2:** Crew Resource Management: Critical Decision Making in The Hazard Zone	**F3:** Research in the Construction Industry Part 2	**F4:** All-Terrain Vehicle Safety in Agriculture
3:00 – 4:00 pm	**Concurrent Sessions G**			
	G1: Occupational Injury Surveillance, Part 2	**G2:** Ergonomics and Musculoskeletal Disorders	**G3:** Efforts to Document and Address the Risk of Fatigue in the Agriculture, Forestry, and Fishing Sector	
4:00 – 5:00 pm	**Zoom Poster Breakout Session**			

DAY 3	THURSDAY – MAY 12, 2022			
12:00 – 1:00 pm	**Concurrent Sessions H**			
	H1: Work-Related Vehicle Crashes	**H2:** Industrial Mobile Robots: Best Practices for Worker Safety	**H3:** Special Considerations for High-Risk Workers	**H4:** Participatory Self-Management to Promote Safety Culture/Climate and Sustainability in Hazardous Work Environments
1:00 – 2:00 pm	**Concurrent Sessions I**			
	I1: Use of Workers' Compensation Claims to Advance Safety	**I2:** Measuring and Predicting Footwear Slip Risk	**I3:** The Role of Worker Age in Occupational Injuries	**I4:** Connecting Safety Climate/Culture to Safety Management: A Brief Summary
2:00 – 3:00 pm	**Concurrent Sessions J**			
	J1: New Bureau of Labor Statistics Office of Safety and Health Program Methods and Approaches	**J2:** Laboratory Studies to Reduce Work-Related Injuries	**J3:** Special Topics in Work-Related Injuries	
3:00 – 4:00 pm	**Closing Plenary Session and Remarks**			

NOIRS 2022 SESSIONS AGENDA

DAY 1: TUESDAY, MAY 10, 2022

12:00 – 1:00 pm OPENING PLENARY SESSION

Preventing Workplace Injuries in a Changing World

Opening

Dawn N. Castillo, MPH
Director, Division of Safety Research
National Institute for Occupational Safety and Health

Plenary Speakers

John M. Howard, MD
Director
National Institute for Occupational Safety and Health

Lorraine M. Martin, MS
President and CEO
National Safety Council

Ron Gantt, M Eng, CSP
Director and Principal Consultant
Reflect Consulting Group

Christopher J. Martin, MD, MSc
Director, Occupational Medicine Residency Program
West Virginia University

Discussion

1:00 – 2:00 pm **CONCURRENT SESSIONS A**

A1 **Human-Robot Interaction in the Workplace**
Moderator: Hongwei Hsiao

1:00 A1.1 Safety Challenges of Human-Robot Interaction at the Future of Construction Work
Idris Jeelani

1:15 A1.2 Real-Time Adjustment of Moving Trajectories for Collaborative Robotic Devices
Marvin Cheng

1:30 A1.3 Assessing Challenges and Technology Needs for Safe Self-Escape from Underground Coal Mines
Eugene Gyawu

A2 **Work-Related Injuries Related to Substance Use**
Moderator: Hope Tiesman

1:00 A2.1 Census of Fatal Occupational Injuries (CFOI): 10 years of Drug and Alcohol Surveillance Pilot Data
Christen Byler

1:15 A2.2 Opioid Overdose Deaths by Worker Industry Groups and Demographic Characteristics, United States, 2007-2014
Andrea Steege

1:30 A2.3 Investigating the Shooting Death of a Firefighter Who Responded to an Opioid Overdose
Stephen Miles & Sophia Chiu

A3 **Research to Practice in the Construction Industry**
Moderator: Scott Earnest

1:00 A3.1 Stand-Downs to Raise Awareness and Prevent Fatalities in Construction
Elizabeth Garza

1:15 A3.2 Identifying Common Root Causes of Work-Related Falls from Heights Through Self-Reported Data from Individuals Who Experienced, Witnessed, or Investigated Fatal and Nonfatal Falls
Jessica Bunting

1:30 A3.3 Behavioral Economics in the Construction Industry: Use of Choice Architecture Techniques to Accelerate Acceptance and Adoption of Health and Safety Research Findings and Solutions
Sue Ann Sarpy

A4 **Surveillance in Agriculture, Forestry and Fishing**
Moderator: KC Elliott

1:00 A4.1 Challenges in Regional Surveillance for Commercial Fishing Injuries: The Utility of State Trauma Registry Data
Viktor Bovbjerg

1:15 A4.2 Fatal Agricultural Injuries in Florida: Building an Injury Surveillance System
Serap Gorucu

1:30 A4.3 Using Machine Learning on Pre-Hospital Care Report Data to Identify Occupational Injuries in Agriculture
Erika Scott

2:00 – 3:00 pm CONCURRENT SESSIONS B

B1 Using Workers' Compensation Systems to Conduct Injury Surveillance

Moderator: Steven Wurzelbacher

2:00 B1.1 How Workers' Compensation Claims Can Inform Health and Safety in the Landscaping Services Industry
Barbara Alexander

2:15 B1.2 Construction Industry Workers' Compensation Injury Claims Due to Slips, Trips, and Falls – Ohio, 2010-2017
Christina Socias-Morales

2:30 B1.3 Workers' Compensation Injury Claims Among Firefighters in Ohio, 2001-2017
Tyler Quinn

B2 Work-Related Mental Health Considerations to Reduce Injuries

Moderator: Eric Carbone

2:00 B2.1 Circumstances Contributing to Construction Worker Death from Suicide
Jonathan Davis

2:15 B2.3 Suicides Among First Responders— National Violent Death Reporting System, 27-37 U.S. States or Territories, 2015-2017
Leslie Carson

B3 Research in the Construction Industry Part 1

Moderator: Douglas Trout

2:00 B3.1 Job Hazard Analysis in Construction: Challenges and Solutions
Babak Memarian

2:15 B3.2 Assessing the Potential of Passive Exoskeletons in Construction
Carisa Harris Adamson

2:30 B3.3 Construction Trainer and Trainee Perspectives on the Quality and Effectiveness of the OSHA 10 Construction Course
Mark Fullen

B4 Special Topics in Agriculture, Forestry and Fishing

Moderator: KC Elliott

2:00 B4.1 Confined Space: Reducing Grain Bin Related Injuries and Fatalities
Linda Fetzer, Michael Dyer & Serap Gorucu

2:15 B4.2 Epidemiology of Diving-Related Fatalities in the U.S. Commercial Fishing Industry
Samantha Case

2:30 B4.3 Slips, Trips and Falls in the Pacific Northwest Commercial Fishing Industry
Laurel Kincl

3:00 – 4:00 pm **CONCURRENT SESSIONS C**

C1 **NIOSH Fatality Investigations**
Moderator: Jeffrey Funke

3:00 C1.1 Case Study: One Firefighter Dies and Another Injured in High Pressure Natural Gas Line Explosion – NIOSH Fire Fighter Fatality Investigation and Prevention Program
Karis Kline-Field

3:15 C1.2 Fatality Assessment and Control Evaluation (FACE) Program – Law Enforcement Officer Struck-by Fatality Investigations
Melanie Fowler

C2 **Occupational Safety During the COVID-19 Pandemic**
Moderator: Lisa Steiner

3:00 C2.1 How COVID-19 Changed Law Enforcement: Voices from Those who Serve
Yoon-Sung Nam

3:15 C2.2 COVID-19 Perceptions and Practices Among Agricultural Producers and Stakeholders: The Need for Tailored Communication Campaigns
Josie Rudolphi

3:30 C2.3 Response to the COVID-19 Pandemic in the Construction Industry
Douglas Trout

C3 **Emerging Protective Technology in Construction**
Moderator: Justin Haney

3:00 C3.1 Effects of Wearing Unpowered Upper and Lower Body Exoskeletons on Visual Attentional Performance During Simulated Overhead and Squatting Peg-in-Hole Tasks
HeeSun Choi

3:15 C3.2 Suspension Systems with Air-Bubble Cushioning Liner for Improved Shock Absorption Performance of Type I Industrial Helmets
John Wu

3:30 C3.3 Characterization of Shock Absorption Performance of Construction Helmet in Top Impacts
Chris Pan

C4 **High-Risk Workers in Agriculture, Forestry and Fishing**
Moderator: Miranda Dally

3:00 C4.1 Injury and Severity in Greenhouse and Nursery Workers: Using Data and Collaboration to Drive Prevention Through Engineering Design
Katherine Schofield

3:15 C4.2 A Pilot Study of Personal Risk Factors Moderating the Relationship Between Occupational Heat Exposure and Injury Risk
Miranda Dally

3:30 C4.3 Timber-Safe – Reduction of WV Logging Hazards through the Implementation of a Logging Operations Safety and Health Management System
Mark Fullen

4:00 pm **Adjourn Day 1**

DAY 2: WEDNESDAY, MAY 11, 2022

12:00 – 1:00 pm **CONCURRENT SESSIONS D**

D1 **Advancing Surveillance Efforts to Improve EMS and Firefighter H&S Outcomes**
Moderator: John H. Oates

12:00 D1.1 EMERG-ing Data - Multi-City Surveillance of Violence Against EMS Responders
Jennifer A. Taylor

12:15 D1.2 Descriptive Epidemiology of the Fire Service Organizational Culture of Safety (FOCUS) Beta-Test Data: Differences by Safety Climate
Ashley Geczik

12:30 D1.3 Firefighter Exposure Tracking: Challenges and Opportunities
David Bernzweig

D2 **Occupational Stress and Work Organization**
Moderator: Douglas Myers

12:00 D2.1 Passive Safety Leadership, Stress, Anxiety and Diminished Firefighter Safety Behavior Outcomes
Todd Smith

12:15 D2.2 Safety Climate and Noncombat Injury Events Among United States Air Force Workers
Christina Socias-Morales

12:30 D2.3 Psychological Strains as Mediators of the Relationship Between the Work Environment and Work Injuries
Nathan Bowling

D3 **Understanding and Visualizing Recent Construction Safety and Health Trends**
Moderator: Richard Rinehart

12:00 D3.1 Visualizing and Disseminating Data on Fatal and Severe Injuries in the U.S. Construction Industry
William Harris

12:15 D3.2 Mental Health Among Construction Workers in the United States
Samantha Brown

12:30 D3.3 Prescription Opioid Use and Stigmatized Attitudes Among Apprentice Construction Workers
Ann Marie Dale

D4 **Robotics in Agriculture**
Moderator: Jennifer M. Lincoln

12:00 D4.1 Literature Review: Does Improved Agriculture Technologies Mean Improved Safety?
Darlene Weaver

12:15 D4.2 Livestock Technology Review - Application to Worker Safety & Health
Marie Hayden

12:30 D4.3 Severe Occupational Injuries from Food Packaging and Movement in the U.S. Supply Chain
Judd Michael

1:00 – 2:00 pm **CONCURRENT SESSIONS E**

E1 **Occupational Injury Surveillance in the U.S. Military**
Moderator: Melody Gwilliam

1:00 E1.1 Beginning to Grasp Finger, Hand and Wrist Injuries in the U.S. Air Force
Melody Gwilliam

1:15 E1.2 Estimated Costs of Lower Extremity Fractures Among U.S. Army Soldiers
Michelle Canham-Chervak

1:30 E1.3 The Impacts of the Transition to ICD-10-CM on U.S. Army Injury Surveillance
Anna Schuh-Renner

E2 **Fatigue, Sleep and Work Hours**
Moderator: Karl Sieber

1:00 E2.1 Assessing the Impact of Work Hours on Worker Safety and Health in the Stone, Sand and Gravel Mining Industry
Todd Smith

1:15 E2.2 Findings from a Systematic Review of Fatigue Interventions in Industrial Settings
Zoe Dugdale

1:30 E2.3 Survey of Working and Sleeping Time by Industry and Occupation of Fulltime Workers in the U.S.
Guang Chen

E3 **Safe Helmet Research on Work-Related Traumatic Brain and Musculoskeletal Injuries**
Moderator: Chris Pan

1:00 E3.1 Assessment of Fall Protection Performance of Type I Industrial Helmets
Chris Pan

1:15 E3.2 Evaluation of Hard Hats for the Reduction of Head Injuries due to Falls
Steve Rowson

1:30 E3.3 Designing a Safe Envelope of Weight and Center of Gravity of Firefighting Helmet Through Biomechanical Measurements and Modeling
Suman Chowdhury

E4 **Interdisciplinary Approaches Along the Translational Research Continuum to Reduce Children's Injuries in Agriculture**
Moderator: Florence Becot

1:00 E4.1 25 Years of Progress and Persistent Challenges in Childhood Agricultural Safety
Barbara Lee

1:15 E4.2 Surveillance of Medically Attended Agricultural Injuries in Farm Children
Jeffrey VanWormer

1:30 E4.3 Agricultural Youth Work Guidelines
Andrea Swenson

2:00 – 3:00 pm CONCURRENT SESSIONS F

F1 Occupational Injury Surveillance, Part 1

Moderator: Audrey Reichard

2:00 F1.1 Time Series, Seasonality and Trend Evaluation of 6-Year (2015-2020) OSHA Severe Injury Data
Harold Gomes

2:15 F1.2 Using Multiple Surveillance Systems to Understand Potential SARS-Co-V-2 Exposures Among EMS and Firefighters
Emily Haas

2:30 F1.3 SOII vs. MarketScan: What Can Alternative Data Tell Us About the Seasonality of Injuries?
Benjamin Raymond

F2 Crew Resource Management: Critical Decision Making in the Hazard Zone

Moderator: Murrey Loflin

2:00 Presenters: Dennis L. Rubin, Murrey Loflin

F3 Research in the Construction Industry Part 2

Moderator: Scott Earnest

2:00 F3.1 Improving Residential Construction Safety Through Safety Leadership and Fall Prevention Training
Bradley Evanoff

2:15 F3.2 Development of a Mast Climbing Work Platform Visual Inspection Tool
Bryan Wimer

2:30 F3.3 Highlights from the CPWR Small Studies Program and Future Priorities and Opportunities
Richard Rinehart

F4 All-Terrain Vehicle Safety in Agriculture

Moderator: Christine Schuler

2:00 F4.1 ATV Safety Design Features: Examining Cultural Awareness and Piloting an Educational Program Among U.S. Young Adults in Agriculture
Jenna Gibbs

2:15 F4.2 Protecting Farmworkers in Agricultural All-Terrain Vehicle Rollover Incidents
Farzaneh Khorsandi

2:30 F4.3 Evaluating Youths' Capability to Ride Agricultural All-Terrain Vehicles Using Computer Simulations
Guilherme De Moura Araujo

3:00 – 4:00 pm CONCURRENT SESSIONS G

G1 Occupational Injury Surveillance, Part 2

Moderator: Kitty Hendricks

3:00 G1.1 A Time Series Analysis of Nonfatal Occupational Injuries Treated in United States Emergency Departments from 2012 to 2019
Eric Lundstrom

3:15 G1.2 Surveillance of Acute Nonfatal Occupational Inhalation Injuries Treated in US Hospital Emergency Departments, 2014-2017
Kitty Hendricks

3:30 G1.3 Severe Injuries in the Oil and Gas Industry: An Analysis of OSHA's Severe Injury Reporting System from 2015-2020
Vidisha Parasram

G2 Ergonomics and Musculoskeletal Disorders
Moderator: Bradley Evanoff

3:00 G2.1 Use of a Job Exposure Matrix to Study Both Recent and Past Work Exposures on the Incidence of Carpal Tunnel Release Surgery in the CONSTANCES Cohort
Bradley Evanoff

3:15 G2.2 Iterative Design of Novel Aerosol Containment Hood Using Ergonomic Assessment
Katrina Cernucan

3:30 G2.3 Occupational Demands Associated with Rotator Cuff Disease Surgery: Results from a Novel Linkage of a Job-Exposure Matrix to the U.K. Biobank
Elizabeth Yanik

G3 Efforts to Document and Address the Risk of Fatigue in the Agriculture, Forestry and Fishing Sector
Moderator: David Douphrate

3:00 Presenters: KC Elliott, Jeff Levin, Athena K. Rowan, Erika Scott, Julie Sorensen, Laurel Kincl, and Leigh McCue

4:00 – 5:00 pm **Zoom Poster Session**
Moderator: Christina Socias-Morales

P1 Response Time Following Local Vibration in Tasks Mimicking Truck Drivers Performance
Juan Manuel Castellote

P2 A Mixed-Methods Approach to Examining Safety Climate Among Truck Drivers
Emily Yueng-Hsiang Huang

P3 Accidents in the Truck Driver Sector and the Health Paradox of this Demanding Occupation
Juan Manuel Castellote

P4 A Hard Day's Night: Shift Work, Fatigue and Cardiovascular Risk Factors Among Maine's Logging Workforce
Erika Scott

P5 Investigation of a Fatality that Occurred when a Logging Processor Lost Traction and Rolled Down a Hillside
Jennifer E. Lincoln & Jeff R. Funke

P6 The NIOSH Fatality Assessment and Control Evaluation (FACE) Program – Law Enforcement Officer Motor Vehicle Fatality Investigations
Melanie Fowler

P7 Use of the CDC's Social Vulnerability Index to Characterize Firefighters' and Medical First Responders' Potential Exposure to SARS-CoV-2 During Routine Emergency Responses
Alexa Furek

P8 Reliability and Validity of a Safety Hazard and Management Assessment Questionnaire
Libby Moore

P9 Workplace Violence Training among Young Workers 14–24 Years of Age in the U.S.
Camryn Lopez

P10 Perceptions of Workplace Hazards in a Sample of West Virginia Sawmill Employees
Wayne Lundstrom

P11 Polypropylene Honeycomb in Industrial Safety Helmets
Shengke Zeng

P12 What's Stopping You? Organizational Constraints as a Multi-Facet Work Stressor
Nathan Bowling

5:00 pm **Adjourn Day 2**

DAY 3: THURSDAY, MAY 12, 2022

12:00 – 1:00 pm **CONCURRENT SESSIONS H**

H1 **Work-Related Vehicle Crashes**
Moderator: Eva Shipp

12:00 H1.1 Driver Injuries in Heavy vs. Light and Medium Truck Local Crashes, 2010- 2019
Terry Bunn

12:15 H1.2 Trends in Work-Related Fatalities Due to Motor Vehicle Crashes, United States, 2011–2019
Srinivas Konda

12:30 H1.3 Lessons Learned from Using Crash Records for Injury Surveillance in the AFF Sector
Eva Shipp

H2 **Industrial Mobile Robots: Best Practices for Worker Safety**
Moderator: Carole Franklin

12:00 Presenters: Carole Franklin, Mark Lewandowski, Jeremy Marvel, Aaron Prather, Federico Vicentini

H3 **Special Considerations for High-Risk Workers**
Moderator: Tamara Small

12:00 H3.1 Promoting Safety and Well-Being Among Sheet Metal Worker Women Through Mentoring
Marissa Baker

12:15 H3.2 Evaluating the Accidents and Level of Compliances in Construction Sites
Somendra Rana

12:30 H3.3 Revisiting Formative Research to Identify Gaps in Hazard Recognition Research for High-Risk Workers
Brianna Eiter

H4 **Participatory Self-Management to Promote Safety Culture/Climate and Sustainability in Hazardous Work Environments**
Moderator: Ted Scharf

12:00 H4.1 A Brief History of Worker Engagement in Safety Initiatives
Lisa Kath

12:12 H4.2 "Non-compliance," "Complacency," and Other Explanations for Unsafe Work Practices that Blame Workers for Systemic Failures: One Psychologist's Perspective
Ted Scharf

12:25 H4.3 The Promise Of, and Problems With, Worker Participation
Scott Schneider

12.37 H4.4 Using Close Call Reports to Empower Worker-Led Interventions
Emily Haas

12:50 Discussion
David LeGrande

1:00 – 2:00 pm CONCURRENT SESSIONS I

I1 Use of Workers' Compensation Claims to Advance Safety
Moderator: Steven Naber

1:00 I1.1 The Impact of a State-Based Workers' Compensation Insurer's Risk Control Services on Employer Claim Frequency and Cost Rates
Steven Wurzelbacher

1:15 I1.2 Surveillance of Agricultural Injuries: Comparison of State Trauma and Workers' Compensation Data Sources
Marizen Ramirez

1:30 I1.3 Workers' Compensation Claim Counts and Rates by Injury Event/Exposure Among State-Insured Private Employers in Ohio, 2007-2017
Steven Wurzelbacher

I2 Measuring and Predicting Footwear Slip Risk
Moderator: Jennifer Bell

1:00 12.1 A Portable Device for Measuring Shoe-Floor Coefficient of Friction in Situ
Kurt Beschorner

1:15 12.2 Predicting Footwear Slip Risk Using a Low-Cost, Portable, Shoe Tread Scanner
Sarah Hemler

1:30 12.3 Predicting the Friction Performance of Footwear Based on Outsole Features
Kurt Beschorner

I3 The Role of Worker Age in Occupational Injuries
Moderator: James Collins

1:00 13.1 Risk of Work-Related Reinjury Among Older Workers With and Without a Work-Related Permanent Impairment: Are Work-Related Injury Rates Differentially Underestimated for Workers Aged 65 and Older?
Jeanne Sears

1:15 13.2 Environmental Factors of Ladder Overreaching in Older Adults
David Williams

1:30 13.3 Traumatic Injuries and Fatalities Among Young Workers in Alaska: 2014-2018
Richard Evoy

I4 Connecting Safety Climate/Culture to Safety Management: A Brief Summary
Moderator: Ted Scharf

1:00 Presenters: Ted Scharf, Lisa M. Kath, and Emily J. Haas

2:00 – 3:00 pm CONCURRENT SESSIONS J

J1 New Bureau of Labor Statistics Office of Safety and Health Program Methods and Approaches
Moderator: Elizabeth Rogers

2:00 Presenters: Daniel Friel, Julie Krautter, Christen Byler, and Imani Drayton-Hill

J2 Laboratory Studies to Reduce Work-Related Injuries
Moderator: Jennifer Bell

2:00 J2.1 Developing a Test for When Worn Shoes Should be Replaced - Research to Practice
Kurt Beschorner

2:15 J2.2 The Relationship Between Weight Shifts, Discomfort and Seated Breaks During Standing
Julie Rekant

J3 Special Topics in Work-Related Injuries
Moderator: James Collins

2:00 J3.1 Work Schedules, Commutes, and Risky Driving Behaviors from a Cross-Sectional Survey of U.S. Oil and Gas Extraction Workers
Kaitlin Wingate

2:15 J3.2 Demonstrating the Impact of Interventions to Prevent Work-Related Injuries
James Collins

2:30 J3.3 Occupational Injury in Group Homes
Adam Moskowitz

3:00 – 4:00 pm **CLOSING PLENARY SESSION & REMARKS**

Change for the Better: Improving Safety Equity Through a Diverse Workforce and Research

Moderated by **Dawn N. Castillo, MPH**
Director, Division of Safety Research
National Institute for Occupational Safety and Health

Plenary Speakers

Michael Flynn, PhD
Social Scientist, Division of Science Integration
National Institute for Occupational Safety and Health

Jack O. Ogutu, PhD
Associate Professor
Occupational Safety & Environmental Health Program Coordinator
Millersville University of Pennsylvania

Richard Olawoyin, PhD, CSP
Associate Professor, Industrial and Systems Engineering
Oakland University

Amy K. Liebman, MPA, MA
Director of Environmental and Occupational Health
Migrant Clinicians Network

Discussion

4:00 pm **Adjourn Day 3**

NOIRS 2022 OPENING AND CLOSING PLENARY SPEAKERS

Dawn Castillo, MPH

Director, Division of Safety Research

National Institute for Occupational Safety and Health

Dawn Castillo is the Director of the Division of Safety Research at the National Institute for Occupational Safety and Health (NIOSH) in Morgantown, West Virginia. The Division serves as the focal point for traumatic occupational injury research and prevention programs at NIOSH.

Ms. Castillo began her NIOSH career in 1991 as an epidemiologist. Between 1998 and 2011, she served as Chief of a Division Branch responsible for occupational injury data collection, analysis, and interpretation. Ms. Castillo was the fourth recipient, in 2000, of the James. P. Keogh award, an annual NIOSH award recognizing a current or former NIOSH employee for exceptional service to the field of occupational safety and health. Ms. Castillo was appointed as Director of the Division of Safety Research in July 2011. She manages two NIOSH virtual Centers: Center for Motor Vehicle Safety and Center for Occupational Robotics Research. She also co-chairs the National Occupational Research Agenda (NORA) Traumatic Injury Prevention Council.

Ms. Castillo has authored numerous articles, book chapters, and technical documents on a variety of occupational injury topics, including occupational injuries among young workers, older workers, fire fighters, and workplace violence. Ms. Castillo received her B.S. in Biology from the University of California, Irvine and her Masters of Public Health in epidemiology from the University of California, Los Angeles.

John Howard, MD

Director

National Institute for Occupational Safety and Health

John Howard is the Director of the National Institute for Occupational Safety and Health, and the Administrator of the World Trade Center Health Program in the U.S. Department of Health and Human Services.

Dr. Howard was first appointed NIOSH Director in 2002 during the George W. Bush Administration and served in that position until 2008.

In 2009, Dr. Howard worked as a consultant with the US-Afghanistan Health Initiative. In September of 2009, Dr. Howard was again appointed NIOSH Director, and was reappointed for a third six-year term in 2015 and a fourth six-year term in 2021.

Prior to his appointments as NIOSH Director and WTC Health Program Administrator, Dr. Howard served as Chief of the Division of Occupational Safety and Health in the State of California's Labor and Workforce Development Agency from 1991 through 2002.

Dr. Howard earned a Doctor of Medicine from Loyola University of Chicago; a Master of Public Health from the Harvard University School of Public Health; a Doctor of Law from the University of California at Los Angeles; and a Master of Law in Administrative Law and Economic Regulation, and a Master of Business Administration in Healthcare Management, both degrees from The George Washington University in Washington, D.C.

Dr. Howard is board-certified in internal medicine and occupational medicine. He is admitted to the practice of medicine and law in the State of California and in the District of Columbia, and he is a member U.S. Supreme Court bar. He has written numerous articles on occupational health, policy, and law.

Lorraine M. Martin, MS

President and CEO

National Safety Council

Lorraine Martin is the president and CEO of the National Safety Council, a nonprofit with a century-long legacy of eliminating preventable deaths and injuries from the workplace to anyplace. Throughout her 35 years of experience in aerospace, including leading and developing global and international businesses as an executive at Lockheed Martin, Lorraine has been singularly focused on showing up for safety and supporting employees to reach their full potential.

As a leader of the National Safety Council, Lorraine is passionate about helping people live their fullest lives. She is the chair of the Road to Zero Coalition, with more than 900 organizations focused on eliminating roadway fatalities by doubling down on proven measures, advancing technology, and building safe systems. She is spearheading national conversations on eliminating workplace fatalities through promising technologies, addressing impairment and safety leadership.

Over her career she has led global aircraft and complex system development and manufacturing, always with a focus on the safety of employees and those who used the products, often in high consequence environments. Among her top achievements, Lorraine led the largest defense program for the F-35 Lightning II stealth fighter aircraft. She also spearheaded the successful operational and cultural integration of Sikorsky, a global leader in helicopters.

Lorraine is the co-founder and president of the Pegasus Springs Foundation, a nonprofit organization dedicated to providing opportunities for educators, students, and community members to collaborate on learning models. She is an enthusiastic advocate for school, community, and national resource engagement. As a proud champion for advancing women and girls in STEM, Lorraine was named among STEMConnector's 100 Corporate Women Leaders. She has worked with numerous organizations in support of this mission including Girls Inc., Girls Who Code and Blue Ribbon Schools of Excellence, where she also served on the Board of Directors. In addition, she has served on the Board of Directors for INROADS and Big Brothers, Big Sisters of Orlando.

Lorraine currently serves on the Board of Directors and Audit Committee for Kennametal, a $2.4 billion global materials science firm that serves customers across aerospace, earthworks, energy, general engineering, and transportation. She is honored to have served as an officer in the U.S. Air Force, where she held various leadership positions for software-intensive technology and development programs. She has earned a M.S. in Computer Science from Boston University and a B.A. in Computational Mathematics from DePauw University.

Ron Gantt, M.Eng, CSP

Director and Principal Consultant

Reflect Consulting Group

Ron Gantt is the Director and Principal Consultant for Reflect Consulting Group in San Ramon, California. Reflect is a consulting firm specializing in helping organizations improve systems and processes related to safety management, leadership, culture, organizational learning, and resilience. Ron has over 20 years' experience in health and safety management, working with industries such as construction, utilities, and chemical manufacturing. He has undergraduate degrees in psychology and occupational safety, as well as a graduate degree in advanced safety engineering and management from the University of Alabama at Birmingham.

Ron is also currently finishing his PhD in resilience engineering at the Ohio State University. He is a Certified Safety Professional and a Certified Instructional Trainer. Ron has been named a Rising Star in Safety by the National Safety Council in 2013, a Young Talent by the Resilience Engineering Association in 2014, and Safety Professional of the Year by the American Society of Safety Professionals San Francisco chapter in 2017.

He has authored numerous articles and book chapters on topics such as disaster psychology, the safety profession, human performance, human factors, and managing safety differently.

Christopher J. Martin, MD, MSc

Director, Occupational Medicine Residency Program

West Virginia University

Dr. Christopher Martin is a Professor of Medicine and Public Health and Director of the Global Engagement Office for the Health Sciences Center (HSC) at West Virginia University (WVU). He is a Fellow of the Royal College of Physicians of Canada in Occupational Medicine, a Fellow of the American College of Occupational and Environmental Medicine (ACOEM) and is board certified in occupational medicine by the American Board of Preventive Medicine.

Dr. Martin has collaborated with NIOSH on two large studies demonstrating increased mortality among cohorts with disabling occupational injuries and has authored or co-authored five book chapters and numerous peer-reviewed publications. He maintains an active clinical practice and has served as a consultant to the US federal government (NIOSH, Vaccine Injury Compensation and Radiation Exposure Compensation Act Programs).

Dr. Martin oversees global partnerships for the HSC and is an active educator and scholar within WVU, nationally and internationally. He serves as Program Director for the Occupational Medicine residency and Designated Institutional Official with responsibility for Graduate Medical Education in the WVU School of Public Health. He is the Principal Investigator of a Training Project Grant from NIOSH and a Preventive Medicine Residency Training Program Grant from the Health Resources and Services Administration.

He is currently a member of the NBME and also serves on the Global Advisory and Evidence-Based Medicine Item Review Committees. He has served as a member of the Education Committee of the Consortium of Universities for Global Health.

Dr. Martin is the 2022 recipient of ACOEM's *Excellence in Education or Research Award*.

Michael A. Flynn, PhD

Social Scientist, Division of Science Integration

National Institute for Occupational Safety and Health

Michael Flynn is an applied anthropologist with over 25 years of experience working on issues related to social inequality both domestically and abroad. His interests include health equity, organizational culture change, translation research and social determinants of health. He currently serves as a Lead Research Social Scientist with the National Institute for Occupational Safety and Heath where he coordinates the Occupational Health Equity program. He is also the project officer for a research program to better understand and improve the occupational health of immigrant workers.

Before coming to NIOSH in 2004, he worked for ten years in non-governmental organizations in the United States and Latin America. Michael is the NIOSH representative to the CDC Health Equity Leadership Network, a Research Fellow of the Consortium for Multicultural Psychology Research at Michigan State University and a member of the *Ventanillas de Salud* National Advisory Board, a program of the Ministries of Health and Foreign Affairs of Mexico. He holds a master's degree in Anthropology from the University of Cincinnati and is currently pursuing a PhD in Anthropology at the University of Kentucky. His awards include the CDC Health Literacy Hero Award, the Mexican Foreign Ministry Ohtli Award, and the NIOSH Director's Intermural Award for Extraordinary Science.

Jack O. Ogutu, PhD

Associate Professor, Occupational Safety & Environmental Health Program Coordinator

Millersville University of Pennsylvania

Jack O. Ogutu, Ph.D., is Associate Professor and Program Coordinator of Occupational Safety & Environmental Health (OSEH) at Millersville University. In addition, Dr. Ogutu serves as the Program Director for the NIOSH Training Program Grant (TPG), and the Program Director for OSHA's Susan Harwood Training Grant (SHTG) Program at Millersville University. The SHTG program's target audience includes Limited-English speakers, small businesses, and at-risk worker populations.

Dr. Ogutu obtained his BS in Mechanical Engineering from The University of Nairobi (2004) and his MS and PhD in Industrial & Systems Engineering with a concentration in Occupational Safety & Ergonomics from Auburn University, Alabama (2013). Dr. Ogutu has published peer-reviewed articles and book chapters in the areas of Occupational Ergonomics, Biomechanics, Risk Platforms, and Safety Engineering. Dr. Ogutu is an authorized OSHA 10- & 30-hour general industry trainer.

Dr. Ogutu serves as faculty advisor to several student organizations at Millersville University including the American Society of Safety Professionals (ASSP), National Society of Black Engineers (NSBE), and the African & Caribbean Student Association (ACSA).

Dr. Ogutu serves as Commissioner for the ABET-ANSAC commission. He is a member American Society of Safety Professionals' Education Standards Committee and Professional Development Chair of ASSP's Environmental Practice Specialty. Dr. Ogutu was named the "Environmental Safety Professional of the Year – 2022".

Richard Olawoyin, PhD, CSP

Associate Professor, Industrial and Systems Engineering

Oakland University

Dr. Richard Olawoyin is Associate Professor in Industrial and Systems Engineering at Oakland University. Dr. Olawoyin is a scientist and an engineer with multidisciplinary research interests in stochastic system optimization, functional system safety analysis, biomechanics and ergonomics, environmental and energy systems modeling - using machine learning, intelligent mapping, and other computational techniques. His teaching efforts include engineering risk analysis, statistical methods in engineering, safety engineering and occupational biomechanics at Oakland University, Statistics for Industrial Engineers at Changchun University of Technology, China, and Human Factors/Ergonomics and Advanced Safety Engineering at Texas Tech. University, Costa Rica. He holds a bachelor's degree in Geology from the University of Calabar – Nigeria, master's and Ph.D. degrees in Energy Engineering from the Pennsylvania State University, University Park.

He serves as the faculty adviser for the National Society of Black Engineers at OU since 2014. He serves on the ABET Inclusion Diversity and Equity Advisory (IDEA) Council, ABET Accreditation Council Training Committee and on the ABET ANSAC Executive Committee. He was elected in 2018 as the administrator for the ASSP Environmental Practice Specialty. He received the ASSP Charles V. Culbertson Outstanding Award in 2019, the Fulbright Scholarship 2022-2023, among other awards.

He serves as the Regional Lead for Recognition and Appreciation for the American Red Cross Disaster Workforce Engagement in the Michigan Region. He is a book chief editor, book author and has authored numerous peer-reviewed journal publications. He is passionate about broadening participation in STEM, particularly in OSH education.

He has presented at several international & national conferences on quality education, engineering, systems safety, environmental, and intelligent automation solutions.

Amy Liebman, MPA, MA

Director, Environmental and Occupational Health

Migrant Clinicians Network

Amy K. Liebman has devoted her career to improving the safety and health of disenfranchised populations through research, policy, advocacy, and education. She has served as Migrant Clinicians Network's Director of Environmental and Occupational Health since 1999, establishing nationally recognized training and technical assistance programs for community groups and health centers throughout the country. She has been a national leader in applying culturally appropriate train-the-trainer programs based on the Community Health Workers model. She has authored journal articles, training curricula and educational materials.

Prior to her current position, Liebman directed programs on both sides of the US-Mexico Border, including an award-winning, community-based hygiene education program that reached thousands of families living without water or sewer services. She advocates for improved policies to protect workers and immigrant families, spearheading several national efforts including strengthening the Worker Protection Standard, a key federal regulation to protect farmworkers from pesticide exposure. She has been a strong advocate for worker health and safety during the COVID-19 pandemic, pursuing regulatory protections for workers and leading programs to improve access to care and education for migrants and immigrants.

Her programs have won awards including the EPA Children's Environmental Health Champion Award and the National Safety Council Research Collaboration Award. In 2011, Liebman received the Lorin Kerr Award, an American Public Health Association honor recognizing public health professionals for their dedication and sustained efforts to improve the lives of workers. She is past Chair of APHA's Occupational Health and Safety Section and recently ended her term on the Pesticide Program Dialogue Committee, a federal advisory committee to the US EPA Office of Pesticide Programs. Liebman holds a master's degree from the LBJ School of Public Affairs at the University of Texas at Austin, and a M.A. from the Institute of Latin American Studies at the University of Texas at Austin.

NOIRS 2022 ABSTRACTS

(Presenters Underlined)

Although the abstracts in this publication were proofread to eliminate obvious errors in spelling, punctuation, and grammar, they were neither edited nor officially cleared by the National Institute for Occupational Safety and Health (NIOSH). Therefore, NIOSH is not responsible for the content, internal consistency, or editorial quality of the abstracts. That responsibility lies solely with the individual authors. Any use of company names and products throughout this publication does not imply endorsement by NIOSH, the Centers for Disease Control and Prevention, the Public Health Service, or the Department of Health and Human Services.

Session A1

Human-Robot Interaction in the Workplace

Moderator: Hongwei Hsiao

A1.1

Title: Safety Challenges of Human-Robot Interaction at the Future of Construction Work

Authors: Idris Jeelani, Masoud Gheisari

As the U.S. economy continues to grow, advancements in technology continue to reshape how Americans work, where they work, and who they work with. According to the International Federation of Robotics, the use of robots in the U.S. workplace has more than doubled in the last decade. As construction has been struggling with a shortage of skilled workers, robots are steadily but increasingly making their way into construction sites.

We have already seen a tremendous increase in the use of aerial robots or drones on construction that has grown more than 200% in just one year. Similarly, unmanned ground robots such as quadrupeds are also becoming increasingly popular in construction. With the predicted increase in construction activities to address the nation's growing infrastructure needs, coupled with the rising demand for automation due to labor shortages, it is expected that there will be more interaction between human workers and robots on construction sites. Construction is already the most dangerous industry to work in.

Every year about 60,000 fatalities are reported from construction jobsites worldwide. In the U.S., the construction industry accounts for about 20% of all workplace fatalities while employing just over 5% of the workforce. While beneficial, the integration of robots in construction raises novel occupational safety and health issues for construction workers, which are critical to identify, understand, and evaluate. Risks arise from unintended physical contact between these robots and human workers or due to the cognitive interaction between workers and Robots that may affect worker's attentional and psychological states.

Every interaction, cognitive or physical, creates the potential for an accident. In this presentation, we discuss the safety challenges of human workers working with or near two specific types of commonly used robots on construction jobsites: (1) Drones: owing to their small size, precise maneuverability, and ability to operate in hard-to-reach areas are very popular on construction sites (2) Quadrupeds: These four-legged robots due to their stability on rough terrains, ability to climb multiple levels, and carrying different payloads and sensors are becoming very popular in construction.

In this presentation, we first envision a future of construction work where human workers constantly interact and collaborate with these collaborative robots to do their work on the construction jobsites. We then discuss the novel health and safety risks that result from these worker-drone-quadruped interactions. We will mainly focus on the physical risks, attentional cost, and psychological impacts of such interactions on human workers who work directly or indirectly with or around these robots. Finally, we will provide recommendations and guidelines to ensure the safe integration of these robots in construction.

A1.2

Title: Real-Time Adjustment of Moving Trajectories for Collaborative Robotic Devices

Authors: Marvin Cheng, Justin Haney

Introduction: The factory of the future will be characterized by complex products, flexible production, and competitive cost with various collaborative and mobile robots, which work alongside with human workers in the same workspace. Current practices consistent with industrial standards require that collaborative robots work in a reduced speed mode or stop while human workers are present within a certain range, which can greatly affect production efficiency. Though sensors are available to detect the presence of human workers, most collaborative robot control strategies are not designed to navigate around human workers while they are present. Instead, the functions of most safety sensors are to monitor specific regions for human worker presence and signal the robots to slow down or stop when a human worker's presence is detected. For a working environment in which human workers need to work with robots, such a safety procedure can undoubtedly affect the productivity of collaborative robots. This research aims to fill the emerging human-robot interface gap through the development and validation of a smart path planning algorithm to ensure adequate protection of workers from the safety risks associated with new and emerging types of collaborative robots, while honoring human workers' versatility and maintaining manufacturing efficiency.

Methods: Safety controls through speed and separation monitoring have been adopted in the ANSI/RIA 15.06 and ISO/TS 15066 standards with inherent reductions in robot work efficiency. To restore the working efficiency of the robotic devices, a path planning algorithm that determines the contact-free trajectory of the tool center point (TCP) from its current position to the targeted destination with adequate moving speed is necessary. In this study, an enhanced three-dimensional A* search method has been developed to find the waypoints of the TCP to avoid the potential contacts between existing human workers and the robotic devices. The proposed method divides the workspace into evenly distributed cells. Cells occupied by body parts of human workers and components of involved robotic devices were marked as contact-avoidance zones. Once the waypoints were identified, the trajectory generation algorithms, Kalman filter, and forward/backward kinematics were applied to generate the moving trajectories for individual joints. This method ensures that adequate paths can be implemented by the adopted robotic devices. The procedures were repeated if the human workers changed their postures or motions until the TCP of the robot reached its destination. With this approach, moving trajectories of a collaborative robot can be generated automatically to avoid potential contacts with human workers and other components by maintaining its optimal moving speed.

Results: With the integration of motion acquisition devices and the robotic device, the contact avoidance zones of the human workers can be identified in real-time. Based on the current physical setup, the TCP trajectory of the collaborative robotic device can be updated within one second. The computation efficiency can be further improved by grouping the related joints. The proposed methodology has been tested in an emulated environment. The physical experimental environment and the robotic device will be adjusted to simplify the required calculation and motion acquisition procedures based on the emulated results.

Discussion/Conclusions: The proposed approach allows the collaborative robotic device to actively avoid potential injuries of human workers due to unexpected contacts while maintaining the desired working efficiency. Such a path planning method can serve as a useful tool in the control software for robot manufacturers and robotics system integrators to advance robot movement path planning for improved worker safety, and for the ANSI/RIA R15.06 and R15.08 consensus standard committees to refine the voluntary standards.

A1.3

Title: Assessing Challenges and Technology Needs for Safe Self-Escape from Underground Coal Mines

Authors: Eugene Gyawu, Kwame Awuah-Offei, Denise Baker

Disasters in underground coal mines in the United States, such as those at the Sago and Upper Big Branch Mines in 2006 and 2010, respectively, are rare but can be devastating. There has been increased research and use of safety technologies to aid miners during mining emergencies. However, much of these efforts have not been driven by user-centered, or in this case miner-centered, human factors design. This research elicited direct feedback from miners to identify and understand their perceptions about the potential efficacy of proposed self-escape technologies. The research also examines how these perceptions related to a miner's personal beliefs about their knowledge, skills and abilities (KSAs) to perform related self-escape tasks for which such technologies might be used. Using a scenario-based online survey, 29 miners from five coal mines in the United States were asked to read and consider a hypothetical mining emergency. At critical points in the emergency scenario, miners responded to closed and open-ended questions about potential technological interventions. Among those technological interventions that participants felt would be highly useful were a self-contained self-rescuer (SCSR) that allows verbal communication while wearing, improved SCSR switchover that prevents breathing contaminated air, and refuge alternatives (RA) with information display capabilities such as location of other miners, and gas and temperature data in the mine. Surprisingly perceptions about confidence in performing a skill were not correlated with usefulness of the related technology, however, importance of a KSA and usefulness of the related technology were generally positively correlated. The results suggest there is a need for technological improvements in technology, usability and comfort of safety equipment's required to self-escape during an emergency. Findings from this study will be directly applied to a series of proof of concept and prototype studies as part of an ongoing CDC-funded project aimed at improving self-escape technologies through human-centered research and design.

Session A2

Work-Related Injuries Related to Substance Use

Moderator: Hope Tiesman

A2.1

Title: Census of Fatal Occupational Injuries (CFOI): 10 Years of Drug and Alcohol Surveillance Pilot Data

Author: Christen Byler

Background: In 2011, the Census of Fatal Occupational Injuries (CFOI) began collecting pilot drug and alcohol data. Two variables indicate whether drugs or alcohol were present in fatally injured workers' systems at the time of incident and the specific substance(s) found. The addition of 2020 data, to be released in December 2021, will mark 10 years of this series. This presentation will examine the trends and changes in findings of drug and alcohol data over this 10-year period (2011-2020).

Methods: Data were aggregated for reference years (RY) 2011-2019; RY2020 will be added upon its release in late 2021. From 2011-2019 the CFOI identified 4,782 out of 44,483 fatally injured workers (11 percent) who tested positive for drugs at the time of fatal incident. These cases were verified by an authoritative medical source (e.g., autopsy, medical examiner, and toxicology reports) to have had any legal or illegal drug or substance present in their system. Free form text fields containing information about the specific type of drug or substance were classified into major drug type categories. Descriptive statistics and relative risk were generated for demographics, drug type, fatal event type, occupation, and industry.

Results: Preliminary results (excluding 2020 data) show that the number of recorded CFOI drug deaths in 2019 was more than 3 times higher than in 2011 (206 compared to 924). The proportion of drug-positive cases over all CFOI cases increased steadily over the study period from 4 percent in 2011 to 17 percent in 2019. Thirty six percent (1,711) of workplace deaths were the result of drug overdoses. The remaining 64 percent (3,071) of deaths were due to accidents at work where drugs or alcohol was found in the worker's system at the time of the incident. The most frequently identified drug type in overdose deaths was opiates, including fentanyl (1,521 workers), followed by alcohol (1,249 workers) and methamphetamine (1,051 workers).

Conclusions: A decade of drug data provides opportunity to evaluate trends of drug-related work fatalities over a significant period of the ongoing opioid epidemic. The data show a steady increase of drug-related work incidents since the start of collection in 2011. They also reflect variation in the types of substances used over the study period. CFOI drug data also provides surveillance information on the presence of drugs in other fatal workplace events besides just overdose deaths. With the addition of RY2020 data, we hope to gain additional insight into the effects of the 2020 labor market changes on drug use at work compared to prior years. While geographic differences in posthumous drug testing limit conclusions from these pilot data, they still provide a nationally representative perspective of how drugs affect American workers.

A2.2

Title: Opioid Overdose Deaths by Worker Industry Groups and Demographic Characteristics, United States, 2007-2014

Authors: Sarah Fryman, Andrea Steege

Background: The United States continues to suffer through an opioid epidemic. Changes in the availability, utilization, and prescription practices over the past two decades have escalated opioid abuse in America. U.S. industry has been affected by opioids, including by loss of productivity, workplace injuries, absenteeism, and other worker-specific personal factors like decreased morale and increased illness. Work-related injuries and other occupational and personal risk factors connected to employment have been found to increase exposure to opioids, and therefore are associated with opioid-related deaths.

Objective: Determine the distribution of opioid-involved overdose deaths of U.S. workers by usual industry and demographic characteristics (2007-2014).

Methods: Mortality data from 21 U.S. states reported to the National Occupational Mortality Surveillance (NOMS) system was used to examine opioid-related mortality within 20 industry groups.

Results: Natural/semi-synthetic prescription opioids were the most frequent opioid type involved in opioid-related deaths from 2007-2014 (49.4% of opioid deaths). Of these, the majority were in males (70.0%) and non-Hispanic White decedents (88.0%). Deceased workers aged 35-49 years accounted for 5.9% of total deaths in the NOMS 2007-2014 data, however, they accounted for the majority (38.1%) of opioid-related deaths. Elevated overall opioid-related proportionate morality ratios include: 1)

Construction (1.30 [95% CI 1.27, 1.33]); 2) Administrative and Support and Waste Management and Remediation Services (1.08 [1.03, 1.13]); 3) Health Care and Social Assistance (1.14 [1.11, 1.18]); 4) Arts, Entertainment, and Recreation (1.15 [1.08, 1.22]); 5) Accommodation and Food Services (1.16 [1.12, 1.20]); and 6) Other Services (except Public Administration) (1.09 [1.05, 1.13]).

Conclusion: With multiple industry groups associated with significant proportions of opioid deaths, there is a need for alternatives to pain and stress management for workers at high risk of injury and stress. More research is needed on opioid-related mortality among arts and entertainment, personal service, and healthcare industries. Clinical Significance: We identified multiple U.S. industry groups associated with high proportions of opioid overdose deaths during 2007-2014. This study adds to the evidence of a need for the development of alternative plans for pain and stress management for workers at risk of injury and high levels of physical or mental labor.

A2.3

Title: Investigating the Shooting Death of a Firefighter Who Responded to an Opioid Overdose

Authors: Stephen Miles, Sophia Chiu

Background: As the opioid overuse epidemic in the United States continues, first responders might encounter persons experiencing overdose who may require naloxone, an opioid reversal agent. On May 15, 2019, a career firefighter was killed, and a police officer and a civilian were injured after being shot while on an emergency medical services (EMS) incident involving a patient who overdosed. The firefighter was part of a crew dispatched along with a private ambulance company based on the report of a patient who had a seizure on a public bus at a bus terminal. The fire department requested assistance from the National Institute for Occupational Safety and Health (NIOSH) Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) to conduct an independent investigation of the incident.

Methods: In July 2019, NIOSH investigators traveled to Wisconsin to investigate this incident. They met with senior staff officers and representatives of the fire department. NIOSH investigators met with and interviewed the career firefighters, the fire department officers, and the private EMS ambulance crew involved in the incident. NIOSH investigators obtained and reviewed fire department training records, standard operating procedures (SOPs), incident scene photographs and drawings, and medical records. The police officers who responded were not available to be interviewed. However, NIOSH investigators reviewed a redacted version of the official police report and redacted body camera footage.

Results: NIOSH investigators identified the type of medical emergency, the lack of scene safety, and decreased situational awareness as contributing factors to the shooting. When firefighters first responded to the scene, the patient was not breathing adequately and required emergency medical attention. Based on the initial assessment, an opioid overdose was more likely than seizure. Two doses of intravenous naloxone were administered. After the patient exited the bus under his own power, he produced a concealed handgun and fired at firefighters, law enforcement, EMS, other workers, and civilians. Prior to the shooting, police officers made multiple attempts but did not complete a search of the patient. An autopsy confirmed the patient/shooter had methamphetamine, fentanyl, and 4-anilino-N-phenethyl-piperidine (4-ANPP, a metabolite of fentanyl or fentanyl analogues) in his system.

Conclusions: The vast majority of incidents involving persons who overdose do not end in violence against first responders. However, key recommendations based on this investigation can help first responders and agencies as well as authorities having jurisdiction (AHJs) better plan for delivery of medical assistance and scene safety in incidents involving overdose. First responder agencies who deliver medical assistance to patients who overdose should train staff on standard operating procedures for naloxone administration, including an understanding of the objective of naloxone therapy and the possibility, albeit unusual, of agitation and combativeness from persons after receiving naloxone. Fire, EMS, and police departments should take steps to help ensure scene safety including taking all necessary actions to protect themselves when providing lifesaving care to a patient. The fire service and standards setting organizations should consider developing scene safety SOPs and training that provide detailed guidance on the specifics of keeping first responders safe while providing lifesaving care to patients. AHJs, such as municipalities, areas, or departments, should consider developing SOPs or guides that specify when (1) a patient should receive a pat down to identify information that might be useful for patient care or identify items that pose a threat to the patient or responders and (2) a patient might be restrained if the patient poses a threat to themselves or responders.

Session A3

Research to Practice in the Construction Industry

Moderator: Scott Earnest

The construction industry employs more than 11 million workers, is very diverse, and has significant health and safety challenges. Identifying and implementing strategies and evaluation approaches for putting research into practice (r2p) is a central focus of the NIOSH Construction Program, CPWR – The Center for Construction Research and Training (CPWR), and the NORA Construction Sector Council. Together, they strive to ensure that research findings are used by stakeholders to reduce occupational injuries and illnesses on jobsites by developing new translational products, identifying, and testing strategies for reaching targeted audiences, using new technologies to disseminate research findings, and evaluating efforts for formative and sustainable improvement. Partnerships are an integral part of the r2p focus.

The complex task of improving occupational safety and health in the construction industry requires multi-pronged approaches. This session will discuss important national construction industry initiatives, a collaborative effort to learn more about the upstream factors that lead to falls and how to modify them, new methods, including use of "choice architecture" or behavioral economics to positively influence construction employers' and workers' safety and health decisions.

Presentations

1. Stand-Downs to Raise Awareness and Prevent Fatalities in Construction

Presenter: Liz Garza

This presentation discusses important safety hazards in the construction industry and how NIOSH, CPWR, and OSHA worked collaboratively with the NORA Construction Sector Council to develop multiple campaigns and stand-downs – an opportunity for employers to pause work and focus on fall safety with their crews – that encourage industry leaders to act and address persistent industry hazards. We will walk you through steps taken to launch the Falls Campaign and initiate and maintain the NORA Falls and Struck-by Workgroups and two National Stand-Downs. We'll share the successes and challenges of these national initiatives as well as some best practices for others considering developing their own Stand-Downs.

2. Identifying Common Root Causes of Work-Related Falls from Heights Through Self-Reported Data from Individuals Who Experienced, Witnessed, or Investigated Fatal and Nonfatal Falls

Presenter: Jessica Bunting

During this presentation, attendees will hear about the development and dissemination of a Fall Experience Survey for stakeholders in construction and other industries with high rates of falls from heights. This includes findings from the survey and how data are being used to influence resource development, outreach and education efforts, and related actions by ASSP/ANSI voluntary consensus standards committees.

3. Behavioral Economics in the Construction Industry: Use of Choice Architecture Techniques to Accelerate Acceptance and Adoption of Health and Safety Research Findings and Solutions

Presenter: Sue Ann Sarpy

This presentation will: (1) discuss Behavioral Economics concepts used to influence health and safety decisions in the workplace and (2) introduce a pilot study that is testing the use of these concepts in the construction industry. Information will be presented on how to use these concepts (choice architecture techniques; nudges) with decision-makers in the construction industry to accelerate the acceptance and adoption of health and safety research findings and solutions.

A3.1

Title: Stand-Downs to Raise Awareness and Prevent Fatalities in Construction

Author: Elizabeth Garza

Falls have been a leading cause of death for construction workers, with hundreds of fatalities and thousands of injuries each year for many years. These events have remained persistently and tragically elevated over the last decade; for example, 401 construction worker deaths due to fatal falls to a lower level occurred in 2019, accounting for 36% of all construction fatalities in 2019. National efforts to address these events were increased when the National Campaign to Prevent Falls in Construction ("Falls Campaign") was launched in 2012 through the NORA Construction Sector Council with key leadership from NIOSH, OSHA and CPWR – The Center for Construction Research and Training. The NIOSH Construction Program through the NORA Fall Prevention Workgroup has played a pivotal role with this Falls Campaign with the creation, in 2014, of the first Stand-Down to Prevent Falls in Construction. The Stand-

Down concept takes its cue from the military, in which operations stop, or "stand down," when a critical safety problem is identified. Each year as part of the Falls Campaign, a Falls Stand-Down is held to focus on fall prevention. It usually coincides with Construction Safety Week. The primary goal of the Falls Stand-Down is to raise awareness and equip worksites and workers with information to help them prevent falls. Educational materials for the national campaign are available from NIOSH, OSHA, CPWR and other partners at our main campaign site www.stopconstructionfalls.com as well as on the Stand-Down page https://www.osha.gov/stop-falls-stand-down. The Falls Stand-Down has served as a model for other national initiatives inside and outside of construction. Following the establishment of the Falls Campaign and Falls Stand-Down NORA Construction Sector leadership established a "Struck-by Prevention Workgroup" made up of management, labor, academic and other stakeholders with expertise and experience in many aspects of construction safety and health. Struck-by injuries (occurring when a worker is struck by a moving vehicle, equipment, etc.) are the leading cause of nonfatal injuries and the second most common cause of fatalities among construction workers. That workgroup decided to pursue a National Stand-Down to Prevent Struck-by Incidents and in 2020 held the first annual Struck-by Stand-Down taking place during National Work Zone Awareness Week. During this event, construction employers and employees learn about best practices and methods to prevent struck-by incidents. The initial focus was on highway work zone safety. Lift zone safety (working around cranes) was added for the 2021 Stand-Down. This presentation will walk you through steps taken by the NORA Construction Sector Council to launch the Falls Campaign and initiate and maintain the Falls and Struck-by Workgroups and two National Stand-Downs. We'll share the successes and challenges of these national initiatives as well as some best practices for others considering developing their own Stand-Downs. 2022 marks the 10-year anniversary of the launch of the National Campaign to Prevent Falls in Construction. We will be sharing some of our ideas on what next? We look forward to sharing our knowledge and hope to learn from others on how we can continue to increase awareness of these national initiatives and increase impact in the construction industry and save construction lives.

A3.2

Title: Identifying Common Root Causes of Work-Related Falls from Heights Through Self-Reported Data from Individuals Who Experienced, Witnessed, or Investigated Fatal and Nonfatal Falls

Authors: Jessica Bunting, Thomas Kramer, Grace Barlet, Rosa Greenberg

Despite regulations on the use of fall protection and efforts by stakeholders to improve awareness and proper use of fall prevention and protection solutions, falls continue to be the leading cause of death in the construction industry. They are also a top cause of death in industries such as manufacturing, mining, and utilities. In 2019, there were 401 fatal falls to a lower level in construction, accounting for 36% of all construction fatalities, and thousands more were injured (1). Across all industries, fall protection in construction is the most frequently cited standard for violations by the Occupation Safety and Health Administration. To better understand and prevent both fatal and nonfatal falls, the ANSI/ASSP Z359 Full Committee created the Z359 National Work at Heights Task Force. As part of this Task Force, CPWR – The Center for Construction Research and Training led the development of a fall experience survey for stakeholders in construction and other industries with high rates of falls from heights. The survey was created in both English and Spanish using Qualtrics and was available online. There were 671 respondents, 74% of which had been involved in, witnessed, or investigated a fall incident. During this presentation, we will share how the survey was developed and disseminated, and will review the findings, including reported contributors to falls from heights and other underlying factors identified through the survey. We will also discuss how the results are being used to improve fall prevention efforts, including resource development, outreach and education, and the decisions of standards committees for the ANSI/ASSP Z359 Fall Protection Code. (1) https://www.cpwr.com/wp-content/uploads/DataBulletin-February-2021.pdf

A3.3

Title: Behavioral Economics in the Construction Industry: Use of Choice Architecture Techniques to Accelerate Acceptance and Adoption of Health and Safety Research Findings and Solutions

Authors: Sue Ann Sarpy, Eileen Betit, Grace Barlet, Alan Echt, Jessica Bunting

Background: The construction industry continues to experience one of the highest rates of occupational injuries and illnesses of any U.S. industry. The challenge facing safety and health researchers, particularly those involved in translation research, is accelerating acceptance and adoption of evidence-based solutions (e.g., equipment, work practices) that can improve the industry's safety record. Behavioral economics, a relatively new field of study that combines insights from psychology and economics, may have promise for influencing these safety and health decisions. Behavioral economics acknowledges that decisions are made that may not be in an organization's or individual's best interest. It provides choice architecture techniques or nudges that can be used to design an environment that increases the likelihood that more informed and thereby better decisions will be made.

Methods: A literature review was conducted to explore the extent to which behavioral economics concepts have been used to influence health or safety decisions in the workplace. Using PubMed, PsycInfo, and EconLit databases, 62 peer-reviewed journal articles were identified that used behavioral economics to influence health or safety decisions or practices in an occupational setting or were potentially applicable to the construction industry. The literature review synthesized findings from 56 primary studies and 6 meta-analyses/systematic reviews that utilized 12 choice architecture techniques across 3 decision-making categories. The review utilized a common typology to categorize the choice architecture techniques (decision information; decision structure; decision assistance) and included an expanded scope of occupational safety and health interventions.

Results: The primary studies reviewed found that the choice architecture techniques used most often involved using feedback, reminders, incentives, and social norms to enhance: (1) how available information is presented (Decision Information - feedback, social norms); (2) the arrangement of options and effort required or consequences (Decision Structure - incentives); and (3) decision-makers' follow through with their intentions (Decision Assistance - reminders). The studies highlighted in this review demonstrate the appeal of using choice architecture techniques (simple, cost effective, and can be incorporated into existing safety and health interventions), and their effectiveness in supporting a wide array of safety and health decisions and related practices and outcomes across various occupational settings. The results demonstrate that these techniques can be effectively tailored and used in combination to address deficiencies in decision information, structure, and following through with decision-making intentions. The findings also provide evidence of their effectiveness and support across stakeholder groups (employers, supervisors, employees, customers) and, importantly, across diverse worker subpopulations including vulnerable workers.

Discussion: The findings suggest that choice architecture techniques in the form of nudges empower individuals, including employers and employees, by helping them to make more informed safety and health decisions. Information will be presented on how to use these concepts (choice architecture techniques; nudges) with decision-makers in the construction industry to accelerate the acceptance and adoption of health and safety research findings and solutions. Further, a pilot study will be discussed, which includes multiple stakeholder involvement, to design, implement, and test the effectiveness of a health and safety intervention that involves specific choice architecture techniques within the construction industry.

Session A4

Surveillance in Agriculture, Forestry and Fishing

Moderator: KC Elliott

A4.1

Title: Challenges in Regional Surveillance for Commercial Fishing Injuries: The Utility of State Trauma Registry Data

Authors: Viktor Bovbjerg, Jasmine Nahorniak, Amelia Vaughan, Samantha Case, Solaiman Doza, Laurel Kincl

Background: Despite commercial fishing remaining a high-risk occupation, comprehensive injury surveillance for non-fatal injuries remains an elusive goal. Similar to other industries, surveillance efforts are complicated by passive reporting, regional challenges and availability or accessibility of data. Short of conducting primary data collection, merging of complementary data sources holds the greatest promise for achieving greater breadth and depth of commercial fishing injury surveillance. The Risk Information System for Commercial Fishing (RISC) project in the Pacific Northwest assessed the utility of merging state trauma registry data with existing databases

constructed from US Coast Guard injury and vessel incident data.

Methods: As part of the larger RISC project to improve commercial fishing surveillance, we acquired 2009-2016 data from the Oregon Trauma Registry (OTR) for all incidents coded as occupationally related within the agriculture, forestry, and fishing sectors. From those incidents, we used location, activity, and external cause codes, combined with clinical narratives, to identify incidents associated with commercial fishing. We then matched those cases with incidents identified from USCG data contained in the NIOSH Commercial Fishing Incident Database (CFID) supplemented with non-fatal injury data within the RISC project for the equivalent time frame (2009-2016).

Results: From 750 OTR incidents in agriculture, forestry, and fishing, we identified 11 incidents associated with commercial fishing. Of the 11 incidents, 7 matched with the 125 incidents based on USCG data (87 CFID incidents and 48 non-fatal injury incidents). Of the four OTR cases which did not match, two appear to have occurred outside of Oregon, and two may have been related to recreational fishing. For those incidents which matched, OTR data elements contained information not typically captured in USCG data, including detailed description of pre-hospital emergency care, detailed patient care narratives, multiple definitive ICD-9 and ICD-10 diagnostic and external cause codes, hospital and emergency department procedure codes, comorbid conditions, toxicology screens, and patient functional status and disposition at discharge.

Discussion: Consistent with our previous work on non-fatal injuries in commercial fishing, and with the relatively few fishing incidents compared to farming and forestry, trauma registry data on commercial fishing injuries may represent underreporting. Similarly, trauma registry data were available for relatively few of the incidents identified in USCG-based reporting systems. Factors specific to commercial fishing (e.g. distance from care (including hospitals that provide trauma care), delays in obtaining care for emergent conditions at sea, resolution of emergent conditions before returning to shore) and the region (e.g. high proportion of smaller vessels with fewer crew members) may have contributed to relative under-identification of cases in the trauma registry. State trauma system data (and by extension emergency medical services data), while likely to identify emergent injury incidents in terrestrial occupations such as farming and forestry, may be of limited utility in identifying commercial fishing injury incidents.

A4.2

Title: Fatal Agricultural Injuries in Florida: Building an Injury Surveillance System

Author: Serap Gorucu

Background/Introduction: Agriculture, Forestry, and Fishing (AFF) sector is one of the most important economic sectors in Florida and heavily depend on the labor force. The health and safety of the workers are crucial for the sector which is one of the most hazardous industry sectors in the U.S. To prevent agricultural injuries, accurate information on injury sources, injury patterns, and trends as well as workers' demographics are needed. However, existing surveillance for Florida agricultural injuries are lacking detailed information. This study illustrates the effort to build a state-level agricultural fatal injury surveillance data by using multiple data sources.

Methods: To provide information on the occurrence of (AFF) fatalities, available data sources were combined together in a database: Florida Department of Health Vital Statistics data, Occupational Safety and Health Administration's Integrated Management Information System, AgInjurynews.org, Fatality Analysis Reporting System, data obtained through an online web search. Data were coded according to ASABE's Farm and Agricultural Injury Classification (FAIC) code and the U.S. Bureau of Labor Statistics' Occupational Injury and Illness Classification System (OIICS) for source and event or exposure types.

Results/Findings: Between Jan 1, 2015, and December 31, 2020, a total of 151 AFF deaths were identified. Of the 151 deaths, 123 of them were agricultural, 23 of them were fishing and 5 of them were forestry and logging related. Each data source was assessed for the victims' characteristics, available information for AFF relatedness, and coding purposes. Cases from the FL Department of Health Vital Statistics data accounted for the majority of the cases (77%). Death Certificate data by itself was not always detailed enough to assign codes for work-relatedness and injury source and events. Most detailed information for the fatality cases were acquired through the news media and OSHA's IMIS investigations.

Discussion/Conclusions: This study illustrated how multiple data sources were utilized to create a state-level agricultural fatal injury database. By using the multiple data sources, it was possible to identify the risk populations as well as injury agents and contributing events for target intervention programs and efforts.

A4.3

Title: Using Machine Learning on Pre-Hospital Care Report Data to Identify Occupational Injuries in Agriculture

Authors: Erika Scott, Liane Hirabayashi

Purpose: Current injury surveillance efforts in agriculture are considerably hampered by the limited quantity of occupation or industry data in current health records. This has impeded efforts to develop more accurate injury burden estimates and has negatively impacted the prioritization of workplace health and safety in state and federal public health efforts. This abstract describes the development of a Naïve Bayes machine learning algorithm to identify occupational injuries in agriculture using existing administrative data, specifically in pre-hospital care reports (PCR).

Methods: A Naïve Bayes machine learning algorithm was trained on PCR datasets from 2008-2010 from Maine and New Hampshire and tested on newer data from those states between 2011 and 2016. Further analyses were devoted to establishing the generalizability of the model across various states and various years. Dual visual inspection was used to verify the records subset by the algorithm.

Results: The Naïve Bayes machine learning algorithm reduced the volume of cases that required visual inspection by 69.5 percent over a keyword search strategy alone. Coders identified 341 true agricultural injury records (Case class = 1) (Maine 2011-2016, New Hampshire 2011-2015). In addition, there were 581 (Case class = 2 or 3) that were suspected to be agricultural acute/traumatic events but lacked the necessary detail to make a certain distinction.

Conclusions: The application of the trained algorithm on newer data reduced the volume of records requiring visual inspection by two thirds over the previous keyword search strategy, making it a sustainable and cost-effective way to understand injury trends in agriculture.

Session B1

Using Workers' Compensation Systems to Conduct Injury Surveillance

Moderator: Steven Wurzelbacher

Introduction: This thematic research session will describe recent workers' compensation claims surveillance analyses that were conducted through a partnership between the Ohio Bureau of Workers' Compensation (OHBWC) and the National Institute for Occupational Safety and Health (NIOSH) Center for Workers' Compensation Studies (CWCS).

Background: Workers' compensation (WC) involves state-governed systems that were established in the early 1900s in the US to provide medical care and partial income protection to employees who are injured or become ill due to their job. These systems also provide employers risk assessment and control services and incentives to prevent work-related injury and illness. A majority of employers purchase WC insurance coverage through private insurers or state-certified compensation insurance funds. Larger employers may also have the option to self-insure. In 2013, NIOSH established the CWCS maximize the use of WC claims data and systems to improve workplace safety and health through partnerships. A main partnership has been with the OHBWC, which is the largest of the US state-certified WC funds.

Methods and Findings: Studies have demonstrated that large state datasets of WC claims can be successfully linked to state employment data to examine claim counts and rates by industry and cause of injury. OHBWC and CWCS partnered to publish several of these seminal WC claim studies to describe linkage methods, text mining approaches, and analyses to identify prevention priorities in a variety of industries (https://www.cdc.gov/niosh/topics/workercomp/cwcs/publications.html).

A number of recent studies will be presented during this session, featuring a variety of researchers from OHBWC and NIOSH:

Title: How Workers' Compensation Claims Can Inform Health and Safety in the Landscaping Services Industry

Authors: Barbara M. Alexander, Steven J. Wurzelbacher, Rachel J. Zeiler, Steven J. Naber

> Description: This study analyzed 18,037 landscaping services industry WC claims from 2001-2017. Free-text descriptions of claims were used to identify particularly hazardous tasks such arborist work and loading/unloading of work vehicles. Engineering and administrative controls were summarized to prevent future injuries.

Title: Slip, Trip, and Fall Injuries Within Construction Industry Workers' Compensation Claims, Ohio, 2010-2017

Authors: Christina Socias-Morales, Srinivas Konda, Jennifer Bell, Steven J. Wurzelbacher, Steven J. Naber, G. Scott Earnest, Elizabeth P. Garza, and Ted Scharf

Description: This study analyzed 9,517 construction industry slip, trip, and fall (STFs) WC claims from 2010-2017. Risk, contributing factors, and prevention approaches for these claims are discussed.

Title: Workers' Compensation Injury Claims Among Firefighters in Ohio, 2001-2017

Authors: Tyler Quinn, Suzanne M. Marsh, Steven J. Naber, Kierstyn Oldham, Steven J. Wurzelbacher

Description: A total of 33,069 firefighter WC claims from 2001-2017 were identified and included in this analysis. This study provides a descriptive basis for the development of focused firefighter injury prevention programming and training. Prevention efforts focuses on the most frequently reported injury events and diagnoses may be warranted.

Discussion: As with other data sources, there are several limitations associated with the use of WC claims data for occupational safety and health surveillance. This includes underreporting, which differs by industry, especially for illnesses. CWCS and partners have demonstrated that state-level WC claims data can be used to augment other surveillance systems (such as the Survey of Occupational Injuries and Illnesses and the Census of Fatal Occupational Injuries) to understand injury trends by cause and industry. The CWCS and other researchers are also successfully using WC insurer systems to identify evidence-based prevention programs, assess exposure trends, and conduct health services research.

Conclusions: WC systems can be useful for injury surveillance and improving workplace safety and health. CWCS will continue to work partners to tap the potential of these systems to prevent injury and improve injured worker care.

B1.1

Title: How Workers' Compensation Claims Can Inform Health and Safety in the Landscaping Services Industry

Authors: Barbara Alexander, Steven Wurzelbacher, Rachel Zeller, Steven Naber

Background/Introduction: The landscaping services industry (NAICS code 56173) is one of the more dangerous in the U.S., with higher rates of both fatal and nonfatal injuries than the all-industry average. There is a high proportion of vulnerable workers in this industry, with Hispanic workers making up 42.7% of the workforce, as compared to 17.6% of the all-industry workforce.

Methods: This study used claims from the Ohio Bureau of Workers' Compensation (OHBWC) database to identify high rates of serious occupational injuries and illnesses in this industry in Ohio. The causes of those illnesses and injuries are highlighted to identify the most common factors to identify areas where safety can be improved. The OHBWC database includes injured-worker industry identification, occupation, business size, demographics, diagnoses, and free-text descriptions of injury circumstances. We identified landscaping service industry claims from 2001 to 2017 and studied annual claim counts and rates.

Results/Findings: Over the 17-year period studied, 18,037 landscaping services industry claims were accepted by the OHBWC, with "Struck by object or equipment" and "Overexertion involving outside sources" being the most common events or exposures (causes of the injury or illness). Sprains and fractures were the most prevalent of the more serious lost-time (LT) injuries. The OHBWC defines LT claims as those that involve eight or more days away from work. Although the rates of LT claims are slowly decreasing, the percent of claims that are LT are increasing. The total cost of claims to the OHBWC from the landscaping services industry for 2001 – 2017 was over $226,000,000. Almost $214,000,000, or 94.4%, was for LT injuries and illnesses, even though LT claims comprise only 18% of total claims. Reducing these more serious claims could decrease human pain, suffering, and loss of livelihood; save companies money and business disruption; and improve worker morale.

Discussion/Conclusions: Free-text descriptions of claims indicate that arborist work and loading/unloading of work vehicles and trailers are particularly hazardous. Loading and unloading may not have been previously identified as a leading risk for injury. Younger and shorter-tenured workers were injured most frequently, although the average worker's age was higher for LT claims. Engineering and administrative controls are preferred to personal protective equipment to enhance safety for workers in the landscaping services industry. Lifting assist equipment; improved safety features on trucks, trailers, and ramps; good preventive maintenance on tools and equipment; and improved training are strongly recommended to reduce falls, overexertion, and struck-by injuries. Innovative solutions may be needed in areas where no available engineering controls exist.

B1.2

Title: Construction Industry Workers' Compensation Injury Claims Due to Slips, Trips, and Falls – Ohio, 2010-2017

Authors: Christina Socias-Morales, Srinivas Konda, Jennifer Bell, Steven Wurzelbacher, Steven Naber, G. Scott Earnest, Elizabeth Garcia, Ted Scharf

Introduction: Falls are a common cause of fatal and non-fatal work-related injuries. Compared to other industries, construction workers have higher risks for serious fall injuries. The National Institute for Occupational Safety and Health (NIOSH) partnered with the Ohio Bureau of Workers' Compensation (OHBWC) to describe the burden and circumstances surrounding injuries related to compensable slip, trip, and fall (STF) injury claims from private construction industry workers.

Methods: The OHBWC provides workers' compensation insurance for two-thirds of Ohio's workers. OHBWC compensable claims were shared with the NIOSH Center for Workers' Compensation Studies as part of a longstanding research partnership. Construction industry (North American Industry Classification System = 23XXX) claims from 2010-2017 were identified, and STF injury claims were included and manually reviewed by internally trained coders for accuracy. Claims were further classified into four categories by type of fall (falls to a lower level [FLL], falls on the same level [FSL], slips or trips without a fall [STWOF], and other). Claim narratives were reviewed to categorize work-related risk and contributing factors. Demographic, employer, and injury characteristics were examined among STF claims by claim type (medical-only and lost-time (≥8 days away from work)) and the type of fall. Claim rates per 10,000 estimated full-time equivalents (FTE) were calculated using Ohio unemployment insurance data and the Bureau of Labor Statistics Labor Productivity and Costs program data.

Results: In total, 9,517 construction industry STF claims were identified during the 8-year period with an average annual rate of 75 claims per 10,000 FTE construction workers. The overall rate of construction STFs decreased by 37% from 2010 to 2017. About half of the claims were FLL, 29% were FSL, 17% were STWOF, and 3% were other. Nearly 40% of all STF claims were lost-time, and most claimants were male (96%). FLL injury rates were highest in the following industry sectors: Foundation, Structure, and Building Exterior Contractors (52 per 10,000 FTE); Building Finishing Contractors (45 per 10,000 FTE); and Residential Building Construction (45 per 10,000 FTE). The rate of both STWOF and FSL LT claims increased as construction firms became larger. Conversely, the highest rate of FLL LT claims was for the smallest firms (10 or fewer workers), with the rate of FLL decreasing as construction firms became larger. Information on contributing factors was extracted from 93% of the claim narratives (8,822). The top three contributing factors for each type of fall were: slip/trip hazards (21%), floor irregularities (18%), and ice/snow (17%) for STWOF; floor irregularities (37%), trip/slip hazards (21%), and ice/snow (13%) for FSL; and ladders (38%), vehicles (11%), and stairs/steps (8%) for FLL.

Discussion: This study identified circumstances associated with STFs among construction workers' compensation injury claims and highlighted specific contributing factors for multi-faceted prevention efforts such as hazard elimination and improving safety climate. Ladders and vehicles were identified as leading contributing factors for nonfatal FLL. However, ladders, scaffolds, and roofs are often noted as contributing factors in fatal FLL research. Contributing factors for FSL identified in this study resembled previous research such as floor irregularities, ice/snow, and tripping hazards. Limitations of this study include the possibility of incomplete data from unreported claims or self-insured employers (one third of Ohio employers). Ohio results may differ from other states due to regional/legislative differences. Although STF rates declined over time, stakeholders should focus on high-risk subsectors and small construction firms (<10 or fewer employees) which were at highest risk for FLL, the type of fall with the highest risk for severe injury and death.

B1.3

Title: Workers' Compensation Injury Claims Among Firefighters in Ohio, 2001-2017

Authors: Tyler Quinn, Suzanne Marsh, Kierstyn Oldham, Steven Wurzelbacher, Steven Naber

Background: Firefighters are at high risk for non-fatal and fatal occupational injuries. While some past research has quantified firefighter injuries using emergency department data and other data sources, no previous research has utilized the Ohio workers' compensation injury claims data to describe the nature of firefighter injuries.

Methods: Public and private firefighter claims, including volunteer and career firefighters, from Ohio's workers' compensation data for 2001-2017 were identified based on standard occupational classification codes and manual review of the claimant occupation title and injury description. The task being done during the injury (firefighting, patient care, training, other/unknown, etc.)

was manually coded by the researchers based on the injury description. Injury claim counts and associated proportions were described across claim type (medical-only or lost-time), worker demographics, task during injury, injury events, and principal diagnoses.

Results: A total of 33,069 firefighter claims were identified and included in this analysis. The majority of claims were medical only (66.28%, <8 days away from work) and involved males (92.81%) between the ages of 25-54 years (86.54%). While the largest percentage of narratives (45.96%) could not be categorized to the task being done at time of injury, the largest percentage that could be categorized occurred while firefighting (20.48%) and doing patient care (17.60%) The most common injury events were overexertion and bodily reaction (40.95%), contact with objects and equipment (23.28%), and slips, trips, and falls (18.92%). The most frequent principal diagnoses were back sprains (16.02%) followed by lower and upper extremity sprains (14.46% and 11.98%, respectively).

Conclusions: This study provides a preliminary basis for the development of focused firefighter injury prevention programming and training. Obtaining associated denominator data, enabling the calculation of rates, would further strengthen the characterization of risks to this worker population. Based on the current data, prevention efforts focusing on the most frequently reported injury events and diagnoses may be warranted.

Session B2

Work-Related Mental Health Considerations to Reduce Injuries

Moderator: Eric Carbone

B2.1

Title: Circumstances Contributing to Construction Worker Death from Suicide

Authors: Jonathan Davis, Bradley Evanoff, Ling Zhang, Corrine Peek-Asa

Background: Suicide is a leading cause of death for working age adults. The risk of suicide is affected by a person's occupation. The National Violent Death Reporting System (NVDRS) is a surveillance system that collects information on violent deaths including suicides. The NVDRS collects information about a decedent's demographics and circumstances that may have contributed to the death using information from the death certificate, medical examiner report, and law enforcement report. Occupation is identified using autocoding programs that rely on the occupation title included as free text on the death certificate. The classification of occupational groups by autocoding has been evaluated and found to be accurate. Prior calculations of suicide rates by occupation found that construction workers had the highest rate of all occupational groups. Construction workers had a rate of suicide nearly twice as high as the general population. This research compares suicide circumstances, including those related and not related to work, between construction workers and all other occupation groups.

Methods: NVDRS data for individuals aged 16 to 64 was used to identify deaths from suicide occurring during 2013 to 2017. Records with an unknown or unspecified race or sex were excluded, as well as records that did not have any contributing circumstance identified. The likelihood of a circumstance occurring around the death of a construction worker compared to those with a non-construction occupation was compared using logistic regression models controlling for age, sex, race, and education level. Job problem is a circumstance collected in NVDRS. Job problem can be indicated when work related circumstances such as tension with co-workers, poor performance review, increased pressure, or losing the job occur before the death. We further analyzed how deaths with a job problem were related to other circumstance for construction workers using logistic regression to compare those with death from suicide with and without a job problem.

Results: There were 57,531 decedents of suicide that met our inclusion criteria of having an autocoded occupation and at least one circumstance related to their death identified in the NVDRS record. Construction workers made up 14.7% (n=8,483) of the records. Construction workers were less likely to have a job problem identified than other occupations (OR=0.73; 95% CI: 0.68-0.79). Problems related to alcohol (OR=1.24; 95% CI: 1.17-1.31) and substance abuse (OR=1.66; 95% CI: 1.57-1.76) were more frequently found in the construction group when compared to other workers. Within construction workers, a death was more likely to have a job problem identified when financial problems and evictions also occurred around the death.

Discussion: Despite having the highest rate of death from suicide, construction workers were less likely to have a job problem as a contributing circumstance to their death. Construction workers more frequently had drug or alcohol problems as a contributing circumstance. Substance use problems could be related to the decedent's job but not coded as a specific job problem, for example if the substance use was a prescription opioid resulting from job-related pain. Deaths with a job problem also more

frequently had financial issues identified as contributing to the death. The independent contributions of substance use, and financial hardship suggest that financial support during unemployment and substance use recovery support could help prevent job related deaths from suicide.

Conclusions: Prevention of construction worker suicide should incorporate measure to reduce alcohol use, substance abuse, and addiction in these workers. Additionally, programs to support workers after a loss of a job will help reduce occupationally related deaths from suicide.

B2.3

Title: Suicides Among First Responders — National Violent Death Reporting System, 27-37 U.S. States or Territories, 2015-2017

Authors: Leslie Carson, Suzanne Marsh, Melissa Brown, Kate Elkins, Hope Tiesman

Background: First responders, including law enforcement officers (LEOs), firefighters (FFs), emergency medical services (EMS) clinicians, and public safety telecommunicators, are crucial to ensuring public safety, public health, and national security. First responders may be at elevated risk for suicide because of the environments in which they work, including organizational culture and occupational stress. Previous research has documented that first responders have an elevated risk of suicide compared to the general adult population. Many of these studies have been limited by state or only involved specific occupations. While mental health stressors among first responders have been studied, data on suicide deaths among first responders are scarce. This analysis used data from the 2015-2017 National Violent Death Reporting System (NVDRS) to characterize suicides among first responders.

Methods: First responders were identified from NVDRS for 2015-2017, the most recent years available at time of analysis, from 27-37 U.S. states and territories. NVDRS contains detailed information on deaths and potential precipitating circumstances from death certificates, and coroner/medical examiner and law enforcement reports. Occupation codes assigned by the NIOSH Industry and Occupation Computerized Coding System were used to identify LEOs, FFs, EMS, and public safety telecommunicators. We categorized workers as first responders or non-first responders. Descriptive statistics were reviewed for each group by demographics, mental health issues, and associated potential contributing factors. Method of injury for suicide, associated characteristics, suicidal history, and toxicology were also explored. T-tests and chi-square tests identified statistically significant differences at p=0.05 between select demographics, comorbidities, potential contributing factors, and substance use for both groups. We also compared select indicators across types of first responders. The Bonferroni correction and adjustment procedure for multiple comparisons was used to adjust all p-values.

Results: From 2015-2017, first responders made up 1% of the 61,579 suicides captured in NVDRS. Of the 676 first responder suicides identified, 58% were LEOs. Compared to non-first responders, first responders were more likely to have served in the military (23% vs. 11%, $p<0.0001$), used a firearm as the method of injury (69% vs. 44%, $p<0.0001$), and been male (88% vs. 76%, $p<0.0001$). First responders were significantly more likely than non-first responders to have intimate partner problems ($p<0.0001$) and job problems ($p=0.0002$). With few exceptions, first responders were less likely to report suicide risk factors. There were also differences across types of first responders. A greater proportion of EMS (57%) clinicians had a mental health problem than other first responders (37% [LEOs] & 43% [FFs]). History of suicidal thoughts was over twice as common among LEOs than among FFs and EMS (13% vs. 5%). The leading method of injury for suicide across all first responder groups was a firearm.

Conclusions: First responders in our study were more likely to have job and intimate partner problems than non-first responders. This may point to a potential issue with work-life balance and indicate a need for agencies and departments to consider stress management options and fostering a climate conducive to seeking assistance. First responders may be less likely to disclose certain suicidal risk factors than non-first responders, which is not surprising given first responder culture. Because of the lack of national data on first responders, it is unknown whether they were overrepresented among suicides during the study period. More complete data are needed to better define the problem, encourage research, and develop culturally competent, evidence-based interventions to promote first responder wellness.

Session B3

Research in the Construction Industry Part 1

Moderator: Douglas Trout

The construction industry employs more than 11 million workers, is very diverse, and has significant health and safety challenges. A consortium of scientists supported by NIOSH, CPWR – The Center for Construction Research

and Training (CPWR), and the NORA Construction Sector Council conduct research on existing and emerging hazards facing the industry. They target NIOSH and NORA constructions goals on persistent and emerging hazards faced by workers on the job, identify causes and solutions for safety and health risks, and test the impact of disseminating effective interventions to the industry that result in evidence-based technologies being applied and good work practices to prevent occupational injuries and illnesses. This session highlights selected research projects on a variety of topics funded by NIOSH and CPWR, through the NIOSH-supported National Construction Center.

Presentations

Job Hazard Analysis in Construction: Challenges and Solutions

Presenter: Babak Memarian

This presentation will summarize the findings of 23 interviews with construction health and safety practitioners on pre-task Job Hazard Analysis (JHA). It will first identify current shortcomings and challenges in developing and implementing JHA. Then, it will present practices and interventions to enhance the efficacy of the JHA process from practitioners' perspectives and conclude with an iterative technique to fill the gap in the process.

Assessing the Potential for Exoskeletons in Construction

Presenter: Carisa Harris Adamson

This presentation will review preliminary results from a current five-year research project on a rapidly emerging wearable technology – exoskeletons (EXOs) – that have the potential to help construction workers lift and move tools and materials and reduce the risks for strain and sprain injuries. The project is designed to provide a comprehensive understanding of who uses them, how they are used, and how the effects of their use can lead to poor practices and unintended consequences to avoid these pitfalls in the future.

Construction Trainer and Trainee Perspectives on the Quality and Effectiveness of the OSHA 10 Construction Course

Presenter: Mark Fullen

The presentation will discuss preliminary findings from an ongoing five-year project to improve OSHA 10-hour construction safety training outcomes. Interviews were conducted with OSHA Training Institute Education Center instructors and trainees to characterize for the first time how the OSHA 10 is being used nationally and to inform future evidence-based recommendations to improve learning outcomes. This presentation will summarize the results of these interviews and how they are being used to formatively design actions for other aims of the research project.

B3.1

Title: Job Hazard Analysis in Construction: Challenges and Solutions

Authors: Babak Memarian, Sara B. Brooks, Jean Christophe Le

Introduction: Construction workers experience a disproportionately high rate of work-related injuries and fatality compared to other sectors. According to the U.S. Bureau of Labor Statistics, the construction industry remained one of the highest-risk sectors in the U.S. in 2019 with a recordable injury rate of 2.8 per 100 full-time employees. While construction workers made up about 5.8% of the U.S. labor force in 2019, they experienced close to seven percent of all recordable injuries. However, research suggests that if hazards are proactively recognized and properly controlled, most of these incidents can be prevented. This emphasizes the importance of pre-task planning and implementing effective job hazard analysis (JHA) to reduce occupational incidents and injuries. JHA is intended to identify and address the existing or potential hazards associated with each step of work and recommend actions to eliminate or mitigate these hazards. However, the construction industry still lacks well-defined guidelines on how to properly design and implement JHA for ease of use by craft workers.

Methods: To help fill this gap, this study pursued two objectives: (1) to identify challenges and shortcomings of current JHA practices and (2) to explore effective practices and interventions to enhance the efficacy of the JHA process from practitioners' perspectives. To this end, 23 construction safety and health practitioners representing 17 companies were interviewed. The range and breakdown of participants' years of industry experience included: 1-10 years: 27%; 11-20 years: 32%; 21-30 years: 14%; and more than 31 years: 27%. The participating companies ranged in size from 90 to 52,000 employees. Interviews took place over a period of three months and lasted an average of 30 minutes each.

Results: Approximately 61% of interviewees cited worker and foreman complacency and pencil-whipping as major challenges to an effective JHA process. Thirteen percent of participants also discussed a lack of worker input as a major stumbling block. According to interviewees, the failure to solicit input from all participants can lead to generic, nonspecific JHAs that do not match actual task

conditions. JHAs that are wordy, overcomplicated, or excessively long were also identified by 22% of respondents as negatively affecting craft ability to recognize and mitigate hazards. Interviews revealed that 65% of respondents preferred using traditional paper JHA forms or whiteboarding over electronic JHA management systems and application of software and mobile devices. However, larger companies were more likely to prefer an electronic system.

Conclusions: The findings of this study emphasized management's role in filling the gap in the current JHA process. To reach optimum outcomes and ensure construction worker safety and health, management should: (1) be present and active on the jobsite, (2) solicit input from workers performing the task, (3) empower workers and give them the opportunity to rotationally lead the pre-task JHA meetings, and (4) continuously update JHA content with specific, clear language and visual aids to reflect current jobsite conditions. Moreover, to facilitate continuous improvement, it is recommended that management teams establish a process to regularly monitor, examine, and update the JHA process and content.

B3.2

Title: Assessing the Potential of Passive Exoskeletons in Construction

Authors: Carisa Harris Adamson, Maury Nussbaum, David Rempel, Alan Barr, Sunwook Kim, Albert Moore, Nancy Gutierrez, Aanuoluwapo Ojelade

Background: Occupational exoskeletons (EXOs) are a rapidly emerging technology with clear potential for beneficial applications in the workplace. Most devices are designed to provide assistive forces/torques about the shoulder and low-back, and thus EXO use may reduce physical demands on the body regions most commonly impacts by work-related musculoskeletal disorders (WMSDs) in construction. However, to facilitate the safe and effective adoption and use of EXOs in construction, workers perceptions about EXOs need to be assessed.

Methods: Between July 2020 and January 2021, construction industry stakeholders completed a self-administered online survey after viewing a 3-minute introductory video on exoskeletons. The survey included 70 open-and closed-ended questions regarding prior exoskeleton knowledge, work history, personal factors, task characteristics, perceived benefits, perceived health and safety concerns, and facilitators for adoption and use of exoskeletons in construction. A summation score method was used to summarize a participant's benefits score, barriers score, (exoskeleton use) perceptions score, and readiness to use score. Spearman correlations and simple linear regression models were used to assess relationships between participants' benefits, barriers, perceptions, and their readiness to use scores. Responses were stratified by race (White vs. Non-White), sex (male vs. female/other), and age (<47 years vs. ≥47 years); Pearson's chi-squared tests were used to assess differences in each stratum.

Results: A total of 361respondents completed the survey. A majority of respondents were White men (46%) over 40 years of age (65%). About three-quarters of respondents thought that exoskeletons would reduce fatigue, 70% noted that it would make their work easier and 62% thought it could make them more productive. Potential barriers to exoskeleton use included numerous safety concerns, such as increased slips/trips/falls, interference with tool belts, hindering movement when climbing poles or ladders, and conductive/dangerous when performing electrical work. A higher benefits score (p-value <0.00) and a higher perceptions score (p-value <0.00) were both significantly associated with a higher readiness to use score. There were significant differences in high vs. low barriers scores by race (White vs. non-White) (p-value = 0.03) and sex (male vs. female/other) (p-value <0.00).

Discussion: While the results demonstrated a large interest and enthusiasm by workers about exoskeleton usage for specific construction tasks, results also highlight the specific concerns and increased demand to understand the most effective and safe way to introduce exoskeleton technology to construction workers, particularly those who are female and non-white. The increased perceived barriers for both non-White and female/other construction workers highlight existing barriers to health and safety among these populations and emphasizes the need to ensure proportionate access to the potential benefits of exoskeleton technology through proper involvement of these populations in the implementation process.

B3.3

Title: Construction Trainer and Trainee Perspectives on the Quality and Effectiveness of the OSHA 10 Construction Course

Authors: Mark Fullen, Brandon Takacs, Eric Lundstrom, Kimberly Rauscher, Wayne Lundstrom, Doug Myers

Background/Objectives: The OSHA Outreach Training Program's 10-hour construction safety training course (OSHA 10) is the most widely utilized foundational construction safety and health (OSH) training course in the industry. Currently, we are conducting one of the first

large scale evaluations of this course. As part of our formative work, we spoke with OSHA 10 authorized trainers with the objective of understanding more about their teaching approaches, the materials, and activities they use, as well as how they view the strengths and weaknesses of the current OSHA 10 course.

Methods: Interviews were conducted with 14 trainers and 14 trainees. Trainers were asked about their training materials, methods and subjects, their evaluation practices, what does and does not work when effectively teaching the OSHA 10, and what barriers they face in teaching the course, specifically around using participatory methods. Interviews with trainees asked about the training methods used by trainers, their view of the practical application of what was taught, safety topics they would like to see added or removed from the course, and what they view as the most effective and impactful training methods they experienced. Interview recordings were transcribed and then independently coded and analyzed by study team members to identify emerging themes and common topics.

Results: While our analysis revealed several themes, the most prevalent for trainers were: (a) trainers self-identify as being engaged and conduct student led learning and resist lecture-based training, (b) trainers do not develop their own curriculum and use existing training materials developed by others, (c) trainers do not conduct student evaluations or engage in knowledge assessments, (d) when asked to re-imagine an OSHA 10 course from the ground up had difficulty in suggesting any major changes to the program. The most prevalent themes from the trainee interviews were: (a) trainees believed that the trainer was effective at teaching the course (b) engaged, hands-on and student led training is the preference, but is not frequently provided (c) seated classroom lecture training is not preferred but is the norm (d) trainees believed the knowledge gained from the course would help keep them safe at work they have used what they have learned on the jobsite. Participants in both groups agreed that the OSHA 10 training program is important and effective. Many stated an interest for more training time, topics and materials.

Conclusions: OSHA 10 trainers must complete and pass an OSHA 500 course. Adult learning methodology is taught in the course so there may be an expectation by those providing the OSHA 10 curriculum OSHA, OTIECs, and others) that the trainer is adequately prepared to deliver the training material using appropriate, effective and engaging techniques without added explanation or instructions. But the reality of OSHA 10 training is that (a) trainers are often consultants that come into an organization with limited knowledge of specific hazards and worksite conditions (b) or have a mixture of trainees from different trades and companies (c) utilize curriculum developed by others without trainer guides or lesson plans (d) curriculum is primarily Microsoft PowerPoint presentations, videos, and handouts (e) the training is not always able to be customized to the audience (f) they are often held in hotel or office conference rooms with little to no opportunity for hands-on training. The trainers strongly desire guidance, material and ideas on how to deliver topic material using more engaging methods beyond what is taught in the OSHA 500 and all trainees prefer more engaging delivery of training material. This provides an opportunity to develop resources on how to convert or make static training material more engaging for trainees that clearly do not prefer to set in a classroom for 10 hours for lecture-based training.

Session B4

Special Topics in Agriculture, Forestry and Fishing

Moderator: KC Elliott

B4.1

Title: Confined Space: Reducing Grain Bin Related Injuries and Fatalities

Authors: Linda Fetzer, Stephen Brown, Roderick Thomas, Randall Bock, Michael Dyer, Serap Gorucu

There are approximately 35 (known and additional suspected unreported) grain bin related fatalities per year. The ANSI/ASABE S64 – Grain Bin Access Design Safety standard was published in August 2018. This standard recommends that grain bins manufactured after 2018 be built to accommodate a bin entry lifeline system. The recommended system includes two anchor attachment points with one located near the roof peak and one near the roof access. Each anchor point must support a minimum ultimate load of 2,000 pounds. Through a research grant from the Northeast Center for Occupational Health and Safety, Penn State University combined computer modeling and experimental measurements to examine safe use of anchor points on a pre-2018 grain bin. Vertical roof deflection of the bin was measured using a precision phase-comparison laser while applying incremental dead loads to the retrofitted rescue anchor points. The measured deflections compared well to defections predicted by finite element analysis (SolidWorks Simulation). The SolidWorks Simulation model may be used to estimate other loading scenarios in a safe and nondestructive way. The model is specific to this grain bin and loading scenarios and is not currently intended for generalization. Based on the research

findings, the project team recommends that the suitability of any bin to safely accommodate a lifeline and anchor point system must be verified on a case-by-case basis. Evaluation by a professional structural engineer and consulting with the manufacturer is recommended. This recommendation extends to all grain bins, including those post-2018. Engineering valuation for safely accommodating a lifeline and anchor point system is essential for bins that are modified, damaged, or have other signs of degradation. The research team developed inspection guidelines to assist professional engineers during their evaluation. Educational efforts will focus on technologies and best practices that can reduce the need for grain bin entry. This presentation will provide an overview of the research approach, recommendations on grain bin inspections for anchor points and lifeline systems, and the use of emerging technologies and best practices to reduce the need to enter grain bins.

Aims/Learning Objectives: 1. Understand the limitations of the ANSI/ASABE S64 – Grain Bin Access Design Safety standard. 2. Understand the need for inspection criteria for new and older grain bins prior to equipping with a lifeline and anchor point system. 3. Understand available technology and best practices to reduce the need for individuals to enter grain bins.

B4.2

Title: Epidemiology of Diving-Related Fatalities in the U.S. Commercial Fishing Industry

Authors: Samantha Case, Richard Evoy

Introduction: Commercial fishing involves harvesting fish or shellfish using a variety of methods, gear, and vessels. Some commercial fishermen conduct dives to collect different species such as urchin, sea cucumber, and lobster. Additionally, some fishermen conduct unplanned dives to perform tasks at sea like clearing a fouled propeller. Dive training and certification are generally not required in the commercial fishing industry. Commercial fishing is the most dangerous job in the United States, with a work-related fatality rate over 40 times higher than the average job. A study of commercial fishing fatalities by Lucas and Case (2017) indicated there were 34 total diving fatalities in the industry nationwide during 2000-2014, and while not a leading contributor to fatalities among fishermen, Alaska dive harvesters had one of the highest fatality rates across all fleets during this period. Additional information on these incidents, such as specific characteristics of the dives, divers, or health risk factors, has not been published. The purpose of this study was to provide in-depth information about the circumstances of dive-related fatalities to identify safety and health risk factors and suggest relevant prevention strategies.

Methods: This study used data from the NIOSH Commercial Fishing Incident Database (CFID) to examine diving-related fatalities in the U.S. fishing industry. CFID is a surveillance system that contains detailed information on work-related fatalities among commercial fishermen. Information about diving-related fatalities was extracted from CFID and descriptive statistics were used to explore the circumstances surrounding diving fatalities and contributing factors. Safe diving practices from recreational and commercial diving sources were identified to determine their use in these incidents.

Results: Preliminary findings show that during the 20-year period 2000-2019, there were 42 diving-related fatalities in the commercial fishing industry. These fatalities most often occurred on the East Coast (28.6%), Gulf of Mexico (26.2%), and Alaska (23.8%). The average age of victims was 42.3 years (22-67 years) and all victims were male. Cause of death was most frequently drowning (78.6%), followed by arterial gas embolism (11.9%), carbon monoxide exposure/poisoning (4.8%), and one case each of cardiac arrythmia and oxygen toxicity. Most fatalities occurred while dive harvesting (73.8%), with the remaining deaths occurring during unplanned dives. Drugs and/or alcohol were contributing factors in seven cases (16.7%). Fourteen victims (33.3%) had pre-existing health conditions that may have affected their ability to dive safely, such as epilepsy, obesity, and coronary artery disease. Other variables that will be examined include diving method/air source used, dive depth, water conditions, and administered treatments.

Conclusions: Diving best practices include training and certification, using proper dive gear, inspecting and maintaining gear and equipment, conducting pre-dive briefings, diving with a partner and/or tender, monitoring sea and weather conditions, and planning for emergency situations. Many of these best practices were absent from the dive operations that resulted in fatalities. Further, diving is physically demanding and requires good respiratory and circulatory health. Chronic health risk factors were identified among many of the victims. Based on these findings, researchers, the US Coast Guard, fishing associations, and marine safety trainers can work with fishermen who dive to increase their awareness of dive-related hazards and adoption of safe diving practices.

B4.3

Title: Slips, Trips and Falls in the Pacific Northwest Commercial Fishing Industry

Authors: Laurel Kincl, Amelia Vaughan, Solaiman Doza, Samantha Case, Viktor Bovbjerg

Objective: Unique slip, trip and fall hazards on commercial fishing vessels result in injury and are preventable. The deck of a vessel may be in constant motion, slippery, uneven, and filled with gear and equipment needed for the fishing. There are also ladders and steps to other levels on a vessel, and fish holds with hatches in the deck. While working on deck, such hazards can potentially result in a fall overboard or on deck. We examined both fatal and nonfatal data from our Risk Information System for Commercial (RISC) Fishing database to identify factors related to slips, trips and falls, and to inform prevention opportunities in the US Pacific Northwest fleets.

Methods: Commercial fishing nonfatal and fatal information for 2000-2018 was obtained for Oregon and Washington waters from the RISC Fishing database, an ongoing injury surveillance project in the Pacific Northwest. Using the Occupational Injury and Illness Classification System (OIICS) event codes adapted in our commercial fishing surveillance (Division 4 for falls, slips, trips) and Incident type (Fall overboard), we identified relevant cases and summarized incident narratives, work process codes and worker information.

Results: Among 245 nonfatal injuries and 93 fatalities involving commercial fishermen in Oregon and Washington from 2000-2018, we found 44 (18%) nonfatal injuries and 18 (20%) fatalities related to slips, trips or falls, including falls overboard. For the nonfatal injuries reported, more than half (55%) took place on the deck (n=24) while others were inside the vessel (n=6, galley, engine room and bunk), on the outrigger (n=6), or coded as unknown. Half of the nonfatal injuries involved deckhands or processors, and 68% involved a fall. The nonfatal cases were distributed across a variety of work tasks, with the greatest number associated with traffic on ladders/stairs with 10 cases, followed by traffic on deck with 4 cases. From the incident narratives, we identified slips & spills, ladders & stairs, poor housekeeping, and open hatches as common hazards for nonfatal injuries. One fatality was an onshore injury involved a fall from a dock resulting in a drowning. Seventeen falls overboard resulted in fatalities, among deckhands (71%) and owner/operators (29%). None of the fall-overboard victims were wearing personal flotation devices. The majority of the falls overboard were a result of a trip/slip or loss of balance (35%) followed by knocked by gear or gear entanglements (29%), while four were due to unknown circumstances. The Dungeness crab fishery accounted for the most fall overboard fatalities (n=7) with tuna, cod, salmon and eel accounting for 1 to 3 fatalities each. The most common contributing factor for the fall overboard fatalities was being alone (n=7).

Conclusion: Slips, trips, and falls are important contributors to both fatal and nonfatal injuries in Pacific Northwest commercial fishing. In developing hazard assessments from the RISC Fishing database, the prevalent events leading to injury, including slips, trips and falls, were the focus. While different factors may result in a fall on deck or fall overboard, addressing common hazards may mitigate the risk of falls or loss of balance. Due to the varying factors related to slips, trips and falls on commercial fishing vessels, we developed different Hazard Sheets, which are being disseminated through social media and regional training of fishermen. Future outreach to promote personal flotation device use in the Pacific Northwest fleets can feature the slip, trip, fall prevention resources and measures. Nationally, further efforts to prevent injuries and fatalities due to slips, trips and falls in commercial fishing must be undertaken.

Session C1

NIOSH Fatality Investigations

Moderator: Jeffrey Funke

C1.1

Title: Case Study: One Firefighter Dies and Another Injured in High Pressure Natural Gas Line Explosion – NIOSH Fire Fighter Fatality Investigation and Prevention Program

Author: Karis Kline-Field

Introduction: The National Institute for Occupational Safety and Health Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) conducts independent investigations of select firefighter line-of duty deaths (LODDs) to identify and define contributing factors, recommend ways to prevent future fatalities and injuries, and disseminate prevention strategies to the fire service. In July 2018, NIOSH investigated an incident in which a 34-year-old paid-on-call/volunteer fire captain died, and another firefighter was injured, in a building explosion while responding to a report of a natural gas leak. This investigation revealed unique hazards that natural gas leaks pose to firefighters, as well as several best practices that fire departments can consider when developing standard operating guidelines and training. The findings highlight the benefits of unified training, community engagement and education, and assessing risk versus gain

when determining fireground strategies during similar incidents.

Methods: The NIOSH FFIPP conducts LODD investigations with cooperation from fire departments, labor organizations and other investigative entities. Investigators collect agent, host, and environmental information about the pre-event, event, and post-event phases of the fatal incident. For this case, investigators interviewed crews from the fire departments that had responded to the original emergency call, along with the police crews, EMS, and the dispatchers who were on shift during the LODD event. The investigators also conducted a site visit to document and understand the scene's layout. At the time of the investigation, much of the cleanup from the blast had already begun; however, the entire area was fenced off and entrance was monitored. Investigators also gathered documents from the fire department, including relevant standard operating guidelines and firefighter training documentation. The information collected was evaluated to identify contributing factors and recommendations aimed at controlling each factor. A narrative report describing the incident, contributing factors, and recommendations was developed. This report was developed with fire service subject matter expert input and disseminated via the FFFIPP web page, the FFFIPP listserv, and through messages on the NIOSH social media pages.

Results: NIOSH investigators identified several factors that contributed to the July 2018 LODD. The best practices identified for the fire service when responding to high pressure natural gas incidents include ensuring continuous situational awareness, using a risk versus gain analysis, and completing regular combined training with utility professionals and community building managers. This investigation found that civilians who were dining in nearby restaurants lingered on-scene despite fire department orders to evacuate, resulting in crews remaining in the "hot zone" longer than necessary and potentially exposing them to life threatening danger. Therefore, investigators also emphasized the importance of community education.

Conclusions: Utility emergencies present a unique set of hazards, and it is every responder's responsibility to continuously size-up the scene and report changes to incident command. Utility employees should be involved in controlling leaks and included when developing standard operating guidelines. Fire departments should engage in pre-incident planning, including coordination with affiliate agencies (EMS, police, and community emergency managers.) Incident Commanders should continuously evaluate the risk versus gain when making operational decisions during evacuation operations. Finally, Fire Departments should ensure that their members are provided training in the latest tactics for responding to hazardous materials situations.

C1.2

Title: Fatality Assessment and Control Evaluation (FACE) Program – Law Enforcement Officer Struck-by Fatality Investigations

Authors: Melanie Fowler

Introduction: There are more than 750,000 state and local law enforcement officers (LEO). These officers face many job hazards, including physical exertion, psychological and organizational stressors, and various other risks to health and well-being. In the last 10 years, on average, one officer per week was killed on our nation's roads. Most years, motor vehicle-related incidents — crashes and being struck by moving vehicles while on foot — are the leading cause of death for officers. From 2010-2019, there were 1,558 officer line-of-duty deaths. Of that total, 393 officer line-of-duty deaths were due to vehicle crashes (25% of total), and 132 officer line-of-duty deaths were due to being struck by a vehicle (8% of total). Although LEO fatalities from motor vehicle incidents are common, detailed information pertaining to these incidents is not routinely analyzed for prevention purposes.

Methods: The National Institute for Occupational Safety and Health's (NIOSH) Fatality Assessment and Control Evaluation (FACE) Program investigates LEO line-of-duty deaths (LODD) due to motor vehicle events. The goal of the FACE program is to prevent occupational fatalities by identifying work situations involving high risk for injury, investigating fatalities that occur in those situations, and formulating and disseminating prevention strategies to those who can intervene in the workplace. Following the public health model, the NIOSH FACE Team works with the fallen officer's department and other agencies at the municipal, state, and federal levels to investigate motor-vehicle LODD. Information is collected on the incident circumstances using a standardized procedure, including interviews with witnesses and department officials as well as review of medical examiner, police, and crash reconstruction reports. Agent, victim, and environmental information is evaluated to identify contributing factors and develop prevention recommendations. A report describing the event, contributing factors, and 'lessons learned' is published on the NIOSH Law Enforcement Officer Motor Vehicle Safety web page and the NIOSH FACE web page for access by police departments, officer organizations, and safety and health researchers.

Findings: In 2013, a Sergeant was fatally injured when he was struck by a motorist while investigating several motor vehicle crashes on an interstate highway. In 2014, a police officer died when he was struck by a motorhome while assisting with traffic control. In 2015, a Trooper was struck by a vehicle while investigating a crash on an interstate highway. Among the three struck-by investigations, the identified contributing factors included: distracted motorists, poor visibility, positioning of patrol units, LEOs decreased situational awareness.

Conclusions: Findings from these investigations help us understand the risks LEOs face and identify ways to prevent similar LEO deaths. These investigations led to several prevention recommendations such as: 1) public awareness campaigns to inform motorists of the risks that law enforcement officers face while operating along the roadside and the need to follow "Move Over" laws; 2) law enforcement officers and emergency responders should work in a safe area within an established temporary traffic control zone and maintain situational awareness; 3) develop a standard operating procedure that includes guidance on how to properly establish a temporary traffic control plan; 4) position patrol units and other emergency vehicles as they arrive on-scene to maximize the protected work zone for the emergency responders; 5) wear an American National Standards Institute (ANSI)-approved high visibility safety vest; and 6) understand the incident command structure.

Session C2

Occupational Safety During the COVID-19 Pandemic

Moderator: Lisa Steiner

C2.1

Title: How COVID-19 Changed Law Enforcement: Voices from Those Who Serve

Author: Yoon-Sung Nam

Background/Introduction: The unique challenges introduced by COVID-19 have significantly disrupted daily operations as law enforcement agencies struggle to strike a delicate balance between serving the community and protecting their workforce. The health and wellness impact from the sudden disruption of COVID-19 remains relatively unknown and may have lasting consequences yet to be identified. This pilot study sought to identify and discuss the impact of COVID-19 on law enforcement.

Methods: A total of 37 civilian and sworn personnel were purposively sampled from two large urban law enforcement agencies. Interviews followed a semi-structured interview guide exploring COVID-19 work-related issues. Inductive coding and thematic analysis were applied to qualitative data.

Results/Findings: Preliminary themes are: (1) COVID-19 protocols impacting services; (2) Personal concerns regarding COVID-19; and (3) Fears of infecting those at home. The first theme describes how COVID-19 protocols have unintentionally created barriers including inability to efficiently interview victims of violence, new challenges of managing outbreaks in close-quarter detention centers, and unique modifications of Personal Protective Equipment that doesn't restrict movement during the response to violent events. The second theme discusses respondents' personal concerns about COVID-19 and how it influenced responses to potential exposures. Some respondents were highly concerned about their risk of infection while others were undeterred and carried out service unbothered. Varying responses to safety workplace protocols ranged from, "think you are crazy if you clean your desk" to "officers aren't concerned about having contact." The third theme highlights the fears of constant exposure to COVID-19 and unknowingly infecting their children and elderly parents.

Discussion/Conclusion: This pilot study identifies obstacles experienced by law enforcement during COVID-19 that have brought changes in public interactions and services. Findings can aid in developing strategies to promote the safety of this unique workforce during pandemics. This pilot study highlights the exploratory themes to generate future hypotheses and inform interventions in response to the global pandemic. In conclusion, this study shows how COVID affects every job position differently. As such, law enforcement agencies must respond in a variety of ways to meet unique needs of the workforce.

C2.2

Title: COVID-19 Perceptions and Practices Among Agricultural Producers and Stakeholders: The Need for Tailored Communication Campaigns

Authors: Josie Rudolphi, Courtney Cuthbertson, Jesus Natividad Sarol, Amandeep Kaur

Introduction/Background: The COVID-19 pandemic has required mass engagement in protective behaviors such as social distancing, wearing face masks, and frequent hand washing to curb the spread of the potentially fatal virus. Several factors may increase risk of COVID-19 among people in agricultural occupations, including that agriculture has been deemed essential and social distancing is not always possible. This study aimed to identify homogeneous groups of agricultural producers

and stakeholders based on their perceptions of effectiveness and use of COVID-19 protective behaviors and demographic and health characteristics that are associated with these groups.

Methods: We conducted an online survey of agricultural producers and stakeholders (N= 1,432) from April to July 2020 through Qualtrics. Participants were recruited from agricultural interest groups. Producers and stakeholders responded to 7 statements about COVID-19 protective behavior effectiveness on a 3-point Likert scale (not, somewhat, very effective), and 7 statements about participation in COVID-19 protective behaviors in the previous two weeks on a 5-point Likert scale (never, rarely, sometimes, usually, always). These statements covered hand washing, disinfecting, refraining from touching face, covering when coughing, staying at home, social distancing and wearing face mask. Additional survey sections included demographics and health history. We performed separate latent class analysis (LCA) to identify clusters of farmers' perceptions and practices of COVID-19 related preventive measures based on their pattern of responses. Chi-square test was used to test the association of clusters of perceptions of effectiveness and practices of COVID-19 related protective measures. We also examined whether these clusters are associated with demographic variables such as sex, education, race, occupation, self-employment, age, residence, and health conditions using chi-square test.

Results: Based on model fit and interpretability of LCA models, we were able to determine 5 distinct clusters based on beliefs in effectiveness and 3 clusters based on use of protective behaviors in the past 2 weeks among respondents. The description and percentage of clusters based of beliefs in effectiveness of protective behaviors are 1) universal believer (33%); 2) believer in protective behaviors for oneself (26%); 3) believer in protective behaviors towards others (16%); 4) moderate believer (17%); 5) skeptical of protective behaviors towards others (8%). For the clusters based on use of protective behaviors, these were high adherence (45%), moderate adherence (15%) and low adherence (40%). Majority (72%) of universal believers are highly adherent, majority (59%) of believers in protective behaviors for oneself are lowly adherent and higher percentages of believers in protective behaviors for oneself (50%), believers in protective behaviors towards others (44%) and moderate believers (54%) are moderately adherent. Those who are females, older, have serious heart condition and diabetes are more likely to be universal believers and highly adherent. Moreover, high adherence is more likely seen among those who live in urban areas, have chronic lung disease and moderate to severe asthma.

Conclusions: Results suggest varying level of adherence to recommended COVID-19 protective behaviors which are associated with perceived effectiveness of protective behaviors and several demographic and health characteristics. Public health campaigns that increase motivation or maintain motivation to comply with protective behaviors should be developed and implemented specific for agricultural populations.

C2.3

Title: Response to the COVID-19 Pandemic in the Construction Industry

Author: Douglas Trout

Background: The construction industry has among the highest percentage of COVID-19 related cases and rates of death among workers of all industrial sectors. There are several factors leading to a disproportionate impact of COVID-19 on construction workers. Construction work continued "in-person" in many jurisdictions during 2020 and 2021, putting workers at greater risk of infection from SARS-CoV-2. Construction work often requires person-to-person interaction, making social distancing difficult. While many construction projects are outside, work commonly occurs indoors where ventilation may be inadequate. Over 90% of construction firms in the U.S. employ 20 or fewer employees; small businesses, with limited resources, face challenges from traditional safety and health hazards and emerging hazards such as COVID-19. Construction workers include persons at greater risk for severe COVID-19 illness. In addition to the traditional hazards, the construction industry has important challenges related to mental health issues (including suicide) and substance use disorders (including opioid use disorder). The challenges presented by the COVID-19 pandemic has presented a convergence of factors significantly exacerbating suicide risk and opioid use among construction workers.

Methods: The NIOSH Construction Program leadership worked directly with the CDC COVID-19 Response structure, and specifically with the NIOSH Worker Safety and Health Team, on construction-related issues related to the pandemic. The Construction Program leveraged existing initiatives and developed others in collaboration with partners and stakeholders, including the OSHA Directorate of Construction, to respond to the challenges presented by the pandemic. The Construction Program also continued and increased ongoing collaborations with CPWR—The Center for Construction Research and Training.

Outputs/Results: Many research, training, and service activities were performed including the following: --

Several Data Reports, such as Construction Employment, Businesses, and COVID-19 Vaccinations During the Pandemic in 2021 to help improve and focus ongoing vaccination efforts U.S. --A series of newly developed interactive data dashboards regarding COVID-19 vaccination data relevant to the construction workforce. --More than 25 live COVID-19 webinars were held in 2020 and 2021 for all stakeholders in the construction industry; the webinars are now available on demand. --The COVID-19 Resources web page for training, education, and research initiatives and resources. The resources include the COVID-19 Construction Clearinghouse which is a central resource for construction employers and workers to find the latest research, guidance documents, training materials, and other resources. -The Office developed guidance and checklists. --Stakeholders and partners published manuscripts in peer reviewed journals. Newly developed collaborations and initiatives included: --Initiation of the NORA Construction Sector Council COVID-19 Workgroup, composed of a wide range of stakeholders and launched in May 2020 to discuss challenges and share solutions/innovative approaches related to COVID-19 and the construction industry. --Participation in the NIOSH COVID-19 Intergovernmental Personnel Act (IPA) Agreement. This program was developed by NIOSH leadership to support (and develop new) extramural partnerships to increase the national capacity to assist employers, workers, and public health officials.

Discussion: This presentation will describe proactive steps being taken by the NIOSH Construction Program and its partners to address and minimize the ongoing risks and future challenges posed by the COVID-19 pandemic in the context of many traditional construction safety and health hazards.

Session C3

Emerging Protective Technology in Construction

Moderator: Justin Haney

C3.1

Title: Effects of Wearing Unpowered Upper and Lower Body Exoskeletons on Visual Attentional Performance During Simulated Overhead and Squatting Peg-in-Hole Tasks

Authors: HeeSun Choi, Daniel Liebman, Daxton Mitchell

Background/Introduction: Rapid technological advances have allowed many workplaces to utilize emerging technologies, such as exoskeletons and wearable robots, to improve worker performance and safety. Exoskeletons enhance the wearer's physical strength and endurance and assist people with load carriage and repetitive movement. Exoskeletons provide great potential for reducing fatigue and work-related musculoskeletal disorders. Despite the apparent benefit of exoskeletons on physical and physiological health and safety, there is limited understanding of how this assistive and augmenting technology may affect our cognitive performance. Only limited research investigated the precise effects of wearing exoskeletons on the wearer's cognitive performances.

Objectives: The current study focused on the effects of wearing exoskeletons on the wearers' attention. Attention allows us to perform everyday activities and job tasks and detect and avoid potential hazards. Thus, decrements in attentional functions have critical impacts on workers' safety. Specifically, this study aimed to examine the effects of wearing an unpowered shoulder or leg exoskeleton on visual attentional task performance during peg-in-hole tasks requiring maintaining an overhead or squatting posture.

Methods: A total of 31 participants completed a series of peg-in-hole tasks, during which they also completed a secondary cognitive task involving visual target detection. The participants completed two types of peg-in-hole tasks, overhead and squatting, and each task was completed once with an exoskeleton worn and once without. Only fifteen participants were able to complete the entire experiment. The participants wore an upper-body exoskeleton (Levitate AIRFRAME) during the overhead task and a lower-body exoskeleton (SuitX LegX) during the squatting task. The secondary visual attention task was administrated using a Head-Mounted Display (HMD) augmented reality headset, Hololens2. Visual stimulus (e.g., flashing light) was presented in a visual field at varying locations and visual eccentricities (i.e., angles). The accuracy and reaction time of responses to the visual targets were measured.

Results: A repeated-measures ANOVA was conducted to compare performance on the visual attention task between with and without wearing an exoskeleton and between during overhead and squatting peg-in-hole tasks. The reaction time results showed there was no main effect of exoskeleton condition nor task condition. However, there was a significant interaction of exoskeleton and task conditions, $F(1, 14) = 5.35$, $p < .05$, $\eta 2 = .28$. The reaction time was faster when wearing an exoskeleton ($M = 723.46$, $SD = 79.48$) compared to the performance without an exoskeleton ($M = 744.64$, $SD = 90.37$) during the overhead task, $p < .05$, but not during the squatting task. Although accuracy measure did not present significant differences, there was a trend showing accuracy was higher when wearing an exoskeleton ($M = .81$, $SD = .08$) compared to performance without an exoskeleton ($M =$

.78, SD = .10) during the overhead task, whereas accuracy was comparable with an exoskeleton (M = .74, SD = .16) vs. without an exoskeleton (M = .75, SD = .16) during the squatting task.

Discussion: The current results suggest that an exoskeleton may affect attentional task performance while assisting the wearer's physical task performance. Interestingly, the effects of wearing an exoskeleton on cognitive performance may differ with different types of physical demands or exoskeletons assisting such tasks. The differential effects may attribute to the fit or comfort of an exoskeleton or the levels of physical task demands that may determine the benefits of an exoskeleton. The findings contribute to understanding how worker assistive technologies affect workers' cognitive performance, which has significant implications for preventing worker injury risks and improving workplace safety.

C3.2

Title: Suspension Systems with Air-Bubble Cushioning Liner for Improved Shock Absorption Performance of Type I Industrial Helmets

Authors: Chris Pan, Bryan Wimer, Mahmood Ronaghi, Mathew Hause, John Wu

Background: Many epidemiological studies suggest that work-related traumatic brain injury (WrTBI) is thought to be one of the most serious injuries among construction workers. The industrial helmet (IH) is the most common and effective personal protective equipment (PPE) to reduce WrTBIs. A traditional IH has a belt-type strap suspension system, which helps absorb and evenly redistribute the impact shock. Air-bubble cushions (ABC) have been used to reduce contact stress or to absorb small impact force in the contact interface between the human head and an impact surface. It is proposed in the current study that the application of the air-bubble cushions in traditional IHs would help improve their performance. The objective of this study was to test if ABCs can be used to improve the shock absorption performance in Type I IH.

Methods: IH impact tests were performed according to the Type I impact protocol as outlined in the ANSI Z89.1 standard. A drop tower test machine was used in the tests. The IH was fixed on an aluminum headform. An aluminum impactor was dropped, in a guided rail, from a predetermined height to impact onto the IH at the top of the crown. The transmitted impact forces were measured via a force sensor installed between the base plate and the headform. The accelerations of the impactor were collected via a single axial accelerometer installed near the impactor's mass center. Both force and acceleration data were collected at a sampling rate of 25 kHz. The velocity of the impactor immediately before impact was measured via an optical sensor in the drop tower. Typical off-the-shelf IHs from a manufacturer were used in the study. The IHs were randomly assigned to one of two test groups. IHs tested in Group I were unmodified and served as the control group. IHs in Group II were equipped with ABC. The effect of ABC on the IH's shock absorption performance was evaluated by comparing these two test groups. Commercially available ABC sheets were used for the cushioning liner. In a natural, undeformed state, an individual air bubble had a diameter of approximately 9 mm and a height of approximately 4 mm. The ABC liner was made of two layers of ABC wrap sheets, with their bubble sides placed against each other. Drop impact tests were performed at six drop heights. Four replications were performed for each of the tests in both Group I and II.

Results/Discussion: Results show that the effects of ABCs on the shock absorption of IHs is dependent on the impact magnitude. At lower drop heights, $h<1.63$ m, adding an ABC did not reduce the impact force for a typical IH with a strip-type suspension system. The effects of the ABC on shock absorption were only seen at higher drop height, $h\geq1.73$ m. At the highest drop height, 1.93 m, as tested in the study, adding ABCs to a typical Type I IH reduced the peak impact force magnitude by over 80%. Results also show that the endurance of a typical IH under repeated impacts was improved substantially by adding an ABC liner. A typical IH can be subjected to repeated impacts of a drop height of 0.61 m without compromising its shock absorption performance. When the IHs are equipped with ABC liners, this number increased from 0.61 m to 1.52 m. Using a concept of an IH endurance limit for repeated impacts, adding an ABC liner helped increase the IH's shock absorption performance by 145%. In summary, adding an ABC liner to a basic Type I IH will substantially increase the shock absorption performance for large impacts and increase its endurance limit for repeated impacts. These findings can help helmet manufacturers improve their IH designs, thereby reducing WrTBIs.

C3.3

Title: Characterization of Shock Absorption Performance of Construction Helmet in Top Impacts

Authors: Chris Pan, Bryan Wimer, John Wu

Background: Work-related traumatic brain injury (WrTBI) is one of the most common occupational injuries among construction workers, resulting in extensive medical care and rehabilitation, multiple days away from work, permanent disability, or death. Multiple construction

industry trades have been identified as being at the greatest risk for an occupational fatality caused by impact-related head injuries. Presently, construction helmets are considered the most common and effective personal protective equipment available to protect against WrTBI in the US construction industry. The Occupational Safety and Health Administration (2012) regulation requires that a helmet must be worn when working in areas where there is potential for injury to the head from falling objects. The purpose of this study was to develop an approach that could determine the performance characterization of a construction helmet. We hypothesized that the shock absorption performance of a construction helmet is dependent on the magnitude of the impact force or impact kinetic energy; specifically, the helmets' shock absorption performance will decrease with increasing magnitude of the impact force or impact kinetic energy.

Methods: Impact force transmission tests of the helmets were performed using a commercial drop tower test machine, which complies with the ANSI Z89.1 standard. The drop tower consisted of a pedestal, a headform, linear bearing rail, drop carriage, drop impactor, and lift mechanism. The forces transmitted to the headform were measured using a force cell with a single axis in the impactor drop direction. The force cell was installed between the base of the tower and the headform. The acceleration was measured using a single axis accelerometer, which was installed at the mass center of the impactor. The impact velocity was measured at approximately 0.5 in (12.5 mm) before the impact via an optical laser velocity gate; the recording frequency of the gate was 25.6 kHz. The impactor had a mass of 3.6 kg and was semispherical with a radius of 48 mm at the striking face. According to ANSI Z89.1, an ISEA-certified headform was used. The headform was made of aluminum and has a mass of 3.64 kg. The force and acceleration data were collected at a sampling rate of 25 kHz. A total of 31 drop impact tests, using a representative type I helmet model, were performed at drop heights from 0.30 to 2.23 m, which were estimated to result in impact speeds from 2.4 to 6.6 m/s. The time-histories of force were processed using a custom program developed using MATLAB software to find the maximal peaks, which appeared in the initial impact.

Results/Discussion: Based on our results, we identified a critical drop height that was used to evaluate the performance of helmets. The peak impact forces and peak accelerations varied non-proportionally with the drop height. When the drop height was less than the critical height, both the peak force and peak acceleration increased gradually with increasing drop height. When the drop height was greater than the critical height, the peak force and peak acceleration increased steeply with even a slight increase in drop height. Based on the critical drop height, we proposed an approach to determine the safety margin of a helmet. The proposed approach would make it possible to determine the performance characteristics of a helmet and to estimate the safety margin afforded by the helmet if the helmet first passes the existing standardized tests. The proposed test approach would provide supplementary information for consumers to make knowledgeable decisions when selecting construction helmets.

Session C4

High-Risk Workers in Agriculture, Forestry and Fishing

Moderator: Miranda Dally

C4.1

Title: Injury and Severity in Greenhouse and Nursery Workers: Using Data and Collaboration to Drive Prevention Through Engineering Design

Authors: Katherine Schofield, Abigail Clarke-Sather

Introduction: Greenhouse and nursery (GH&N) hazards may be similar to those in other agricultural sectors, but also include areas of highly mechanized operations, shipping and loading, dynamic buildings, and a sizable percentage of indoor working environments. Engineered controls to reduce risk of worker injury would be well-suited for this work environment. Injury research and prevention priorities for GH&N establishments can be combined with curriculum-based undergraduate engineering capstone projects as a means to put research-into-practice and assist workplaces, otherwise unable to dedicate resources, in reducing risk of worker injury through engineering design and innovation. The goal of this research was to ascertain injury rates in a GH&N population, evaluate comparative risk factors for injury and severity based on worker, job, and injury event characteristics, and determine areas of high injury prevention priority and engineering design feasibility for student projects.

Methods: Workers' compensation (WC) and payroll data (2000-2017) calculated injury rates and determined risk factors for injury and severity based on worker, job, and injury event characteristics. Text fields were analyzed for details on circumstances surrounding injury. We recruited an industry partner and deployed an undergraduate mechanical engineering design team and faculty members to the host site. Hazards, challenges, and potential solutions were noted during multiple site visits.

Twenty-two employees were interviewed (English and Spanish) to determine their concerns and injury risk factors. Potential projects were evaluated on multiple factors and scoring criteria.

Results: Results indicate 61 establishments incurred a combined 1229 injuries with an overall injury rate of 4.9 per $1million of payroll, 13.5% of which resulted in lost-time. Workers under age 30 suffered 37% of all injuries; 29% of injuries were to women. High-severity injuries involved: moving/loading trees, erecting/maintaining greenhouses, and material handling. Frequent injuries involved: hand tools, material-handling, hand-digging, lifting/moving equipment, and operation of motorized vehicles. Ergonomic, material handling, and lifting-related injuries caused the largest percentage of injuries (38%). Tool and equipment-related causes resulted in 9% of total injuries. Two projects were selected to reduce the worker risks of repetitive hole-punching in hanging basket pots with unsafe equipment, and repetitive lifting and carrying methods of plant inventory movement on greenhouse tables over uneven surfaces and narrow walking paths. The team designed, prototyped, and tested solutions specific to these problem areas, developing a greenhouse plant transport cart and a plant pot hole-puncher. The cart reduced physical demands and made loading easier. Additionally, the cart allowed a greater number of plants (4-6 more) to be transported simultaneously. Together, these factors should improve navigation of walkways between tables and reduce risk of strain, trips, falls and contusions and lacerations caused by collision with tables. The hole-puncher eliminated electrical hazards, unguarded moving parts, and dust generation. The new, manual design improved ergonomic positioning and reduced force/grasp requirements, and reduced hole-generation from14 seconds to ~2 seconds. These design solutions are currently implemented into practice.

Discussion: The research provided a greater understanding of risk factors in GH&N workers. We were able to pilot an interdisciplinary approach to rapidly deploy and implement engineered intervention to reduce injury risk. This methodology could be widely used and would be especially impactful in agricultural, high-risk, under-served, and/or small business establishments. Additionally, site-specific engineering solutions/prototypes may have a wider industry translation to other agricultural or applicable operations.

C4.2

Title: A Pilot Study of Personal Risk Factors Moderating the Relationship Between Occupational Heat Exposure and Injury Risk

Authors: Miranda Dally, Krithika Suresh, Mike Van Dyke, Kathy James, Lyndsay Krisher, Lee Newman

Background: Crop production is one of the most hazardous jobs in the agriculture, forestry, and fishing sector. Recent research suggests that for crop production, the number of daily recorded occupational injuries increases 3% for every 1°C in wet blub globe temperature (WBGT) beyond 30°C. Individual vulnerabilities such as preexisting or chronic health conditions, age, and immigration status can increase susceptibility to the adverse health consequences of ambient heat exposure. In this pilot study we examine how these vulnerabilities amplify the risk of occupational injuries in hot environments.

Methods: We obtained pre-employment health screening data, daily productivity data, and occupational injury logs from a large agribusiness in Southwest Guatemala for the 2014 and 2015 harvest seasons. Meteorological data was obtained from a weather station centrally located near the harvest fields and daily mean and daily max WBGT were calculated. We used generalized linear mixed models to assess the association between WBGT measure and odds of injury at the daily, individual level. Stratified models for BMI < 18.5 and BMI ≥ 25, blood pressure ≥ 130/80 mmHg, and both BMI ≥ 25 and blood pressure ≥ 130/80 mmHg, and whether an individual smoked tobacco, consumed alcohol, or was in their first sugarcane harvest season were assessed.

Results: There were 4521 unique workers who were employed for the entirety of either the 2014 or 2015 harvests. All workers were male over the age of 18. There were 84 (2%) of workers who had at least one injury recorded during the observation period. Overall, for each 1°C in daily average WBGT the odds of injury increased 1.8% (95%CI: -13%, 19%; p-value: 0.82). Stratified analyses suggest a differing effect between WBGT, and injury risk based on individual risk factors. For workers with either low or high BMI for each 1°C in daily average WBGT the odds of injury increased 25% (95%CI: -5%, 64%; p-value: 0.11). For workers with high blood pressure, for each 1°C in daily average WBGT the odds of injury increased 22% (95%CI: -5%, 58%; p-value: 0.13). For workers with both high blood pressure and high BMI, for each 1°C in daily average WBGT the odds of injury increased 37% (95%CI: -2%, 92%; p-value: 0.06). New workers, and workers who reported either smoking or

alcohol consumption were less likely to be affected by increases in daily average WBGT. Results based on daily max WBGT were similar.

Discussion: While no results were statistically significant this pilot analysis provides valuable effect size estimates to power future studies. The results from this analysis suggest that personal risk factors may increase the vulnerability of crop producers in hot environments and should be incorporated into risk communication between employers and employees. There is a need to better understand these risk factors and the mechanisms for which increasing temperatures impact the risk of occupational injury among agricultural workers.

C4.3

Timber-Safe – Reduction of WV Logging Hazards Through the Implementation of a Logging Operations Safety and Health Management System

Authors: Mark Fullen, Eric Lundstrum, Doug Myers, Wayne Lundstrum, Patrick Donnelly

Background: Logging is one of the most dangerous occupations in the United States. In 2018, workers in the logging industry experienced approximately 153 workplace fatalities per 100,000 workers, which is 43.7 times higher than the national average for all workers. West Virginia loggers consistently have a fatal injury rate higher than the national rate. West Virginia's mountainous terrain requires a much higher use of manual felling of trees as opposed to the safer mechanized timber harvesting equipment which is thought to be some of the cause for the higher fatality rate. West Virginia, along with many states and regions, has implemented safety certification and training programs for loggers with little to no impact on the fatality or injury rates. OSHA regulations, which are more stringent in logging compared to other industries have also not led to a reduction in injuries or deaths among West Virginia loggers. In this study, we evaluated a safety and health management system program for logging operations developed by researchers from West Virginia University. The program was designed to educate small, primarily family-owned West Virginia logging companies on the importance of truly implementing all aspects of a safety and health management program. The intervention included training all company employees on the safety and health management program, implementing the program, training a site auditor, and establishing a regular routine for gathering data on hazards and implementing controls. The site hazard audits are designed to gather evidence that can be used to determine whether known hazards that lead to injury and death have been reduced or eliminated following the intervention. Data collection is on-going but is approximately 85% complete. Here we report on preliminary findings.

Methods: An experimental design was employed; 31 logging companies participated in the study. Data on each site were gathered via on-site safety audits every 9 weeks over a 108-week period (to date; data will be gathered through week 144). Half of the sites were randomly assigned at baseline to the experimental (n=16) and control groups (n=15). Experimental sites' baseline data were gathered prior to implementation of the program. The control sites will receive the intervention (and follow-up measures) after a 'control' observation period, allowing all sites access to the tool and improving efficiency of the study analyses. Analysis of safety program implementation scores are presented for baseline (audits 1-3) and intervention scores (audits 3-12); differences in scores were assessed via one-way repeated measures analysis of variance (ANOVA).

Results/Findings: Preliminary results show that both control and intervention safety intervention scores improved between baseline and intervention periods; intervention and control scores were not significantly different at baseline ($p = 0.37$). Post-intervention scores were higher for intervention companies (43.8%) than controls (36.4%) ($p = 0.06$). Data collection and analysis is ongoing.

Discussion/Conclusions: Though the present study is ongoing, preliminary results suggest intervention companies improved in their implementation of safety management programs compared to the control group. While this difference was outside of the traditional range of significance, further data collection and analysis may alter these results; ongoing analysis of pre- and post-intervention field safety audit scores will further explore program effectiveness. Given the hazardous nature of the West Virginia logging industry, the improvements observed in participant companies are promising. Implications for further research and practice will be discussed.

Session D1

Advancing Surveillance Efforts to Improve EMS and Firefighter H&S Outcomes

Session Chair and Discussant: John H. Oates

This session was originally proposed by Lori Moore-Merrell, who has since been appointed U.S. Fire Administrator. The newly appointed CEO for the International Public Safety Data Institute (IPSDI), John H. Oates, is now moderating this session to discuss cohesive and coordinated surveillance efforts at the local department, state, and federal levels to offer a comprehensive view of firefighter and EMS workers' risks on the job. U.S. firefighters respond to a diverse range of medical and emergency incidents. Consequently, fire-based Emergency Medical Service (EMS) responders have a dynamic, mobile workplace that contributes to additional job stressors, including burnout, fatigue, stress, reduced performance, and negative health and safety outcomes [1-5]. Recently, it has been argued that a primary barrier to improving firefighter and EMS worker safety, health, and wellbeing is the paucity of surveillance data at the national level [6].

Specifically, current surveillance systems capture different data points in diverse ways, each with nuanced exclusion/inclusion criteria [7-8]. National surveillance systems within firefighting include those overseen by the National Fire Protection Association, the International Association of Fire Fighters, the Bureau of Labor Statistics' Census, and case data from NIOSH's Fire Fighter Fatality Investigation and Prevention Program. Additionally, there are private entities (i.e., International Public Safety Data Institute [IPSDI]) as well as university research centers (i.e., the Center for Firefighter Injury Research and Safety Trends) that aim to support or conduct research that advances data collection and translation to support firefighter and EMS worker safety and health. Finally, individual computer-aided dispatch (CAD) systems are often unique to a municipality and fire departments often opt to collect and report varying information, usually based on the type of software system being used within a department. These varying systems make it difficult to collect accurate and timely information, much less be able to inform prevention efforts.

The Centers for Disease Control and Prevention has discussed the availability of timely surveillance data as a primary goal in its future of work data modernization initiative. To this end, it is necessary to ascertain what has been learned through existing surveillance systems, efforts, and resulting data as well as what can be gleaned for future data modernization. This thematic session contains three presentations that collect, examine, and/or use existing datasets that stem from varying systems. The first presentation uses a reporting system led by the Center for Leadership, Innovation, and Research in EMS to address and describe the incidence and prevalence of workplace violence among three metropolitan fire departments. Free-text and categorical data were analyzed to describe perpetrator characteristics, mental and physical injuries, and risk factors. The outcome of this research showed support for other national data sources to collaborate on data collection of violence exposure data.

In the second presentation, results of data collected through the Fire Service Organizational Culture of Safety (FOCUS) beta-test survey will be reported using descriptive statistics and regression analyses. FOCUS is a psychometrically validated tool for the surveillance of the industry-specific safety climate of the US fire and rescue services. The last presentation illustrates how the Columbus Fire Department uses exposure surveillance at the incident vs. individual firefighter levels. Individual data collection allows more granularity and higher resolution, adding to the quality of the data. However, encouraging individual firefighters to consistently provide exposure information after an incident remains a primary barrier to the department's application of their findings.

These presentations provide practical advancements in worker safety and health, elucidate gaps in current data surveillance, and how improvements in data modernization can benefit the public safety sector to proactively identify and mitigate job-related risks. Following the presentations, a discussion will be facilitated to help tie in the presentations and ensure any additional audience questions are answered by the presenters.

1. EMERG-ing Data - Multi-City Surveillance of Violence Against EMS Responders

Presenter: Jennifer Taylor, PhD

2. Descriptive Epidemiology of the Fire Service Organizational Culture of Safety (FOCUS) Beta-Test Data: Differences by Safety Climate

Presenter: Ashley M. Geczik, MPH

3. Firefighter Exposure Tracking: Challenges and Opportunities

Presenter: David Bernzweig

Chair and Discussant: John H. Oates

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D1.1

Title: EMERG-ing Data – Multi-City Surveillance of Violence Against EMS Responders

Authors: Jennifer Taylor, Rozhan Ghanbari, Regan Murray, Andrea L. Davis

Background: Emergency Medical Service (EMS) responders deliver patient care in high-risk, high-stress, and highly variable scenarios. This unpredictable work environment exposes EMS responders to many risks, one of which is violence. While physical violence is captured in many national data systems, verbal violence is not. And there is no system that captures violence exposures (whether physical or verbal) when injury does not result. While prior research identified reasons why firefighters and EMS responders would not report violence, the degree of underreporting of violence and violence-related injury in EMS is unknown.

Objectives: To address reporting concerns and describe the incidence and prevalence of workplace violence in three large metropolitan fire departments, an existing data system, EMERG, led by the Center for Leadership, Innovation, and Research in EMS – was modified. The EMERG platform was selected because of its patient safety component. It has regulations tied to it that other data do not. We previously heard from first responders that they are hesitant to share their stories for a lot of different reasons including fear of retribution. EMERG is one of the most locked-down data capture systems that we could provide fire departments to ensure that their stories are taken seriously and affirm that they are submitting to a confidential source.

Results: Analysis of free-text and categorical data describing perpetrator characteristics, mental and physical injuries, and risk factors will be described. As an example, in one department, we saw quadruple the number of reports in six months to EMERG compared to previous surveillance we conducted using the first report of injury forms. Over one year of EMERG operation, we received 126 reports from all three departments. Patients were the most frequently reported perpetrator of violence (80%). The majority of violence occurred on scene (82%), with the most frequently reported places of assault as: ambulance (46%), street or highway (27%) and home or residence (25%). Sixty-two (62%) of violence was perceived to be committed intentionally. Additionally, 83% of reports indicate that the EMS provider had no knowledge that the patient or location was potentially violent. The most frequently reported injury was emotional stress (70%). Occurrence of verbal and physical violence simultaneously was reported in 41% of cases,

followed by verbal violence only (40%) and physical violence only (19%). A closer look at the method of verbal violence revealed general verbal violence (68%), verbal violence using slurs and hate speech (45%), and graphic threats (39%) as the top three types.

Conclusion: The results from this reporting system can inform prevalence and incidence estimates of workplace violence in the fire and rescue service. This is one potential solution to the intractable problem of underreporting in occupational safety and health. However, in order to ensure useful surveillance, it remains likely that triangulation of multiple data sources will still be required to approximate the true burden. It would be helpful if other national data sources collecting violence exposure data collaborate to use the same data dictionary.

D1.2

Title: Descriptive Epidemiology of the Fire Service Organizational Culture of Safety (FOCUS) Beta-Test Data: Differences by Safety Climate

Authors: Ashley Geczik, Jin Lee, Andrea L. Davis, Joseph A. Allen, Jennifer Taylor

Background: Safety climate is one of the most pronounced upstream predictors of safety behaviors (e.g. safety compliance), organizational outcomes (e.g. burnout, engagement), and safety outcomes (e.g. injuries). The Fire Service Organizational Culture of Safety (FOCUS) survey measures the industry-specific safety climate of the United States fire and rescue service, which was psychometrically validated. It is expressed by two factors, Management Commitment to Safety and Supervisor Support for Safety. FOCUS is a well-utilized tool for the surveillance of fire service safety climate, having been administered in over 600 fire departments (60,000 firefighters) with many departments administering multiple times.

Methods: The FOCUS beta-test is a random sample of 132 fire departments stratified by Federal Emergency Management Agency region and their organization type (career, combination, volunteer). For our descriptive analysis the baseline sample was that of the beta-test data used in the psychometric validation (8,575 firefighters within 615 stations in 130 fire departments). After exclusionary criteria was applied, our analytic sample resulted in 8,414 individuals nested within 611 stations in 125 fire departments--all of which had emergency medical services (EMS). The average response rate in the sample was 62.3%. We reported descriptive statistics to assess the distribution of all continuous (mean ± standard deviation (SD), range) and categorical variables (counts, percentages) stratified by organization type. These descriptive variables were collected at the individual and department level. Regression analyses were conducted to investigate the associations between safety climate, safety behaviors, and organizational outcomes by organization type.

Results: The mean age was 40.2 years and the mean years of experience was 16.1 years. 1,406 respondents (16.7%) reported that they had experienced an injury in the past 12 months prior to completing the survey. This sample included 53.6% career, 27.2% combination (career and volunteer), and 19.2% volunteer fire departments. The mean Management Commitment score was 71.4 and the mean Supervisor Support score was 81.7. The mean Management Commitment score varied between organizational types, implying a dose response relationship. The mean scores were 67.1 (±8.4), 72.2 (±10.7), and 82.1 (±6.1), respectively for career, combination, and volunteer fire departments. The mean Supervisor Support score was not notably different by organization type. Regression analyses generally supported the beneficial role of safety climate, while suggesting organization type as a potential effect modifier. Specifically, departments with more volunteers tended to have weaker associations between safety climate and its potential outcomes. Overall, we observed that job satisfaction is associated with both Management Commitment and Supervisor Support for all organization types.

Discussion: We investigated the descriptive statistics for 125 of the participating fire departments, which reported data on EMS and fire response. Analysis of the nationally representative data from the fire service indicates that safety climate is indeed positively associated with safety behavior, safety outcomes, and organizational outcomes reflecting employee wellbeing. However, the findings suggest that the association may notably vary depending on organization type. Because FOCUS was designed, and has been used in a longitudinal fashion, it is a strong asset in the surveillance of fire service injuries and well-being outcomes.

D1.3

Title: Firefighter Exposure Tracking: Challenges and Opportunities

Author: David Bernzweig

Background: Firefighting is a dangerous profession with few jobs possessing a higher risk of job-related mortality (Maguire & Smith, 2013). While firefighter fatalities have decreased in the past decade, incidents have remained stable, indicating that current efforts are not enough to

improve health outcomes (Kahn et al., 2020). To that end, it is imperative to improve the consistency of data collection efforts to support policies and procedures that address the health risks of firefighting activities, including efforts to reduce exposures. One way to do this is to utilize pre-existing systems, such as the National Fire Operations Reporting System (NFORS) (Butry et al., 2019). NFORS automates real-time data collection through connection with pre-existing computer aided dispatch (CAD) systems to eliminate touch points, data entry duplication, errors, and the ability to link with the National Cancer Registry. This presentation discusses what the Columbus (OH) Division of Fire has learned by using such data systems as well as how we are trying to further leverage and promote individual firefighter participation in data surveillance activities.

Methods: The sophistication and recent adoption of mobile application (app) technology has presented an opportunity to revolutionize data collection and surveillance efforts in the workplace. Firefighters within the Columbus Division of Fire have been encouraged to download the NFORS Exposures Tracker Mobile App and document experiences encountered during emergency incident responses including possible exposures and types of personal protective equipment (PPE) worn. Although, in busier fire and rescue departments, it is likely not sustainable for firefighters to complete a response after every emergency incident response, there are times officers/managers should encourage participation such as when a possible exposure to SARS-CoV-2 or large fires with known carcinogens occur. This presentation explores trends that have been identified from thousands of incidents documented over the past few years including examples of dashboards that have been developed to guide decisions. We also discuss the difference in data quality, availability, and ease of collection at the department and firefighter levels.

Results: The Columbus Division of Fire has been able to make data driven decisions related to overdose responses, COVID-19, nighttime analytics, high demand EMS transport vehicles, and fire alarm responses. As a result of using data to identify trends, the department has been able to reduce workload, improve response time and communication, predict busier times within certain communities in which we serve, and identify situations using hot spot mapping in which wearing PPE is an especially high priority. Some of these high-level results and dashboards are shared as case examples to support firefighter participation in data surveillance. These results have assisted with ongoing accreditation as well.

Practical Applications: This presentation shows that NFORS is an effective tool to observe worker risks in near real time and demonstrates that individual data [vs. incident level data] collection has a higher level of resolution. However, although mobile technology is convenient for personal tracking and data collection, the challenge of low response rate remains an issue. To this end, we consistently promote the documentation of exposures among our employees by making NFORS part of the narrative on the job and working with the fire chief and local union. Union stewards and officers have spoken about the importance of individual participation at each station. In summary, individual exposure data collection, even with the ease of electronic mobile applications, requires constant outreach and hands-on leadership to motivate firefighters. As lessons learned are shared, we will welcome feedback from others about new and unique ways to engage the workforce in such surveillance efforts.

Session D2
Occupational Stress and Work Organization
Moderator: Douglas Myers

D2.1

Title: Passive Safety Leadership, Stress, Anxiety and Diminished Firefighter Safety Behavior Outcomes

Authors: Todd Smith, Mari-Amanda Dyal, Charmaine Mullins-Jaime, David DeJoy

Introduction: Passive safety leadership has been negatively linked to safety behavior outcomes. However, this relationship is not fully understood. Beyond safety climate, this research has not fully examined mediating factors or variables that may be influenced by passive leadership, which then influence safety behaviors. Research among firefighters in this context is particularly absent. As such, this study aims to examine the relationships between passive safety leadership, stress, anxiety, and safety behavior outcomes.

Methods: This study used cross-sectional data from 742 career firefighters and company officers. A path analysis, using Mplus, was completed to examine the hypothesized model and posited relationships between passive safety leadership, stress, anxiety and three safety behaviors, including compliance, personal protective equipment behaviors and safe work practices. Model fit was examined and paths were assessed for significance.

Results: The hypothesized model fit was good (X2 = 56.056, df = 7, p < 0.001; CFI = .95, RMSEA = .09, SRMR = .04). Posited relationships were confirmed. Passive safety leadership was positively, significantly associated with increased firefighter stress perceptions (β = .14, p<.001). Stress was positively, significantly associated with anxiety (β = .44, p<.001). Anxiety was negatively, significantly associated with all three safety behavior outcomes, including compliance behaviors (β = -.44, p<.001), personal protective equipment behaviors (β = -.44, p<.001) and safe work practices (β = -.24, p<.001).

Conclusions: Passive safety leadership profoundly influences firefighter stress perceptions, which was associated with heightened levels of anxiety. Anxiety had significant negative influences on safety behavior outcomes. This study also underscores the importance of developing active leaders within the fire service to minimize leadership as a stressor and to control anxiety among fire service members as anxiety had detrimental influences on imperative safety behaviors necessary to protect firefighters from injury or fatalities.

D2.2

Title: Safety Climate and Noncombat Injury Events Among United States Air Force Workers

Authors: Christina Socias-Morales, Melody Gwilliam, Emily Haas, Patrick Yorio, Cammie K. Chaumont Menendez, James Collins, Rachael Falcon, Nancy Delaney, Bruce Burnham, Heidi Stallings, David Stuever, Geoffrey Ewing, Stephen Stouder, Richard Soto

Background: Safety climate assessments can identify leading indicators to guide injury prevention efforts; however, few studies have examined the implications of safety climate over time across organizations for both military and civilian workers. The National Institute for Occupational Safety and Health (NIOSH) partnered with the US Air Force (USAF) Safety Center to examine the association between perceptions of safety climate constructs and the occurrence of injury events.

Methods: Survey responses provided by USAF workers in maintenance, support, and operations occupations, as well as injury events (fiscal years (FY)2014-2018) were shared with NIOSH. The USAF administers voluntary, anonymous, occupation-specific safety climate surveys to USAF workers using the internal Air Force Combined Mishap Reduction System (AFCMRS, survey items publicly available: www.afcmrs.org). USAF unit leaders are invited to administer the survey among USAF civilian and military workers according to leadership priority. Exploratory factor analysis (EFA) was used to group individual survey questions into safety climate constructs. Noncombat, work-related injury events involving at least one worker documented within the Air Force Safety Automated System (AFSAS) were aggregated by squadron unit level and matched to squadrons with at least one squadron-wide survey administration. All injury events resulting in medical care beyond first aid are required to be recorded in AFSAS. Injury rates were calculated using the expected number of survey respondents as identified by leadership, for a given squadron. Using SPSS V. 25, researchers calculated bivariate correlations and estimated Rate Ratios (RRs) using negative binomial regression to examine the relationship between injuries and safety climate construct scores.

Results: A total of 1,547 squadrons administered the survey from FY14-18 with an average of each squadron administering the survey an average of 1.6 times during the study period (SD=0.92, minimum=1, maximum=12). On average, there were 144 workers/ squadron (SD=140.1, minimum=5, maximum=1,675) and the average number of injuries during the 5-year period per squadron was 15.8 (SD=29.3, min=0, max=524). The EFA established the measurement of the following safety climate constructs on a 5-point Likert scale: Leadership and Communication (11 items), Overall Safety Climate (9 items), Error Management (2 items), Resource Adequacy (4 items), and Deployment Safety (2 items). Higher safety climate construct scores were consistently correlated with decreasing number of injuries (p<0.001). Specifically, after controlling for the number of workers in squadrons, Rate Ratios (RRs) consistently revealed significant reductions in injury rates with each unit increase in safety climate perception: Leadership and Communication RR=0.40 (95%CI: 0.32–0.48); Overall Safety Climate RR=0.50 (95%CI: 0.40–0.64); Error Management RR=0.37 (95%CI: 0.30–0.47); Deployment Safety RR=0.36 (95%CI: 0.29–0.45). Resource Adequacy revealed a non-significant injury rate reduction RR=0.87 (95%CI: 0.73–1.04).

Conclusions: Squadrons reporting higher safety climate construct scores may be associated with lower injury events. To our knowledge, few studies have quantified safety climate over multiple years and examined the association with injury rates. Although safety climate measurements may be limited by frequent turnover and the self-reported, voluntary, anonymous nature of AFCMRS, the strength of this study lies in the census of injuries. We discuss potential intervention strategies, such as new programs, policies, and practices that could be adopted by the USAF using these results. Future research should include longitudinal analyses that track safety climate perceptions and injuries over a period of years and examine the impact of safety climate on injuries by

occupational groups and detailed injury circumstances, such as injuries related to falls, fatigue or body parts.

D2.3

Title: Psychological Strains as Mediators of the Relationship Between the Work Environment and Work Injuries

Authors: Nathan Bowling, Naomi Swanson, Jeannie Nigam

Introduction: A large body of research has examined how various environmental conditions—including both work demands and resources—relate to psychological strains (Bakker & Demerouti, 2007). Widely studied environmental variables within this literature include role stressors (e.g., ambiguity and conflict; Bowling et al., 2017), organizational constraints (Pindek & Spector, 2016), and interpersonal conflict (Spector & Jex, 1998). Each of these environmental variables is related to various indicators of worker well-being, including psychological and physical symptoms. These indicators of well-being, in turn, may be directly related to work injuries. The current research uses a large archival dataset (N=>7,000) to test whether psychological strains mediate relationships between the work environment and work injuries. Background: The possibility that psychological strains mediate the relationship between the work environment and work injuries is consistent with conservation of resources (COR) theory. In short, COR posits that people are motivated to maintain and grow their existing pool of psychological resources (Hobfoll, 1989). According to COR, the concept of "psychological resources" is inclusive—it comprises anything that a person either inherently values (e.g., healthy interpersonal relationships) or values because it can be used to acquire other resources (e.g., money). COR theory further argues that psychological strains occur whenever a worker either (a) is threatened with a future loss of resources, (b) experiences actual resource loss, or (c) fails to reap a resource gain he or she expected to achieve after a resource investment. Environmental variables may produce psychological strains via one or more of these three mechanisms. We expect psychological strains, in turn, to relate to work injuries. This may happen because managing strains diverts a worker's attention, thus making accidents and injuries more likely. Significance: An understanding of the factors that predict work injuries can inform efforts to make work safer. Knowledge of which environmental factors relate to work injuries, for instance, could be used to guide planned changes to the work environment. Likewise, knowledge of which psychological strains relate to work injuries could provide insights into how organizations could leverage effective coping strategies as a means of reducing work injuries.

Method: The Quality of Work Life (QWL) Survey data were used to conduct the current analyses. The QWL, administered in five separate waves from 2002 to 2018, includes items assessing the nature of the work environment (e.g., "I have too much work to do everything well"), psychological strains (e.g., "How often do you find your work stressful?"), and work injuries (e.g., "In the past 12 months, how many times have you been injured on the job?").

Results: Roughly 10.2% of QWL participants reported at least one work injury during the previous 12 months (mean number of injuries = .20). Contrary to our expectations, initial analyses indicate that the various environmental variables and psychological strains were all modestly correlated ($rs < |.20|$) with number of work injuries. Prior to the May 2022 conference, we will complete additional analyses to examine possible industry differences in the relationships among work environment, psychological strains, and work injuries. Industries that have a high potential for injuries may yield particularly strong predictor-injury relationships.

Discussion: A better understanding of the potential causes of work injuries can help guide organizational effects to improve worker safety and well-being. Although our initial analyses found that the variables assessed within the QWL are only modestly related to injuries, follow-up analyses that separately examine different industries may produce a pattern of results that more closely matches our predictions.

Session D3

Understanding and Visualizing Recent Construction Safety and Health Trends

Moderator: Scott Earnest

The construction industry is one of the most dangerous industries in the United States. In addition to existing safety and health hazards in construction, emerging issues such as mental health, and opioids have had a major impact on the industry and require further examination to improve our understanding. This session will present important construction safety and health statistics on a variety of topics including fatal and severe injuries, mental health, and the impact of opioids. Presentations will highlight multiple publicly available data sources, data dashboards, and findings from an NIH-funded project.

Presentations

1. Visualizing and Disseminating Data on Fatal and Severe Injuries in the U.S. Construction Industry

Presenter: William Harris

This presentation will highlight two publicly available data dashboards on fatal and severe injuries in construction. These dashboards were developed by CPWR and are based on data from OSHA fatality and severe injury reports.

2. Mental Health Among Construction Workers in the United States

Presenter: Samantha Brown

This presentation will examine (1) construction industry trends in psychological distress from 1999-2018 and (2) mental health indicators at the start of the COVID-19 pandemic among U.S. construction workers using data from the National Health Interview Survey.

3. Opioids - Prescription Opioid Use and Stigmatized Attitudes among Apprentice Construction Workers

Presenter: Ann Marie Dale

This presentation focuses on presenting data from an NIH-funded project on opioids in construction and describes the use of prescription opioids and negative attitudes toward workers with opioid misuse and opioid use disorder.

D3.1

Title: Visualizing and Disseminating Data on Fatal and Severe Injuries in the U.S. Construction Industry

Authors: William Harris, Amber Trueblood, Samantha Brown, Xiuwen Sue Dong

Background: Construction is one of the most dangerous industries in the United States. Despite continuous efforts, fatal and severe injuries still occur in construction workplaces at higher rates than most other industries. The objective of this project is to visualize fatal and severe injuries in construction in interactive data dashboards, providing timely and detailed information to all stakeholders. This presentation will introduce two dashboards.

Methods: Data on fatal injuries were mainly from Occupational Safety and Health Administration (OSHA) records of construction fatality investigations, which were requested from OSHA and recoded by the authors. Some fatal injuries were also collected from media and news reports by reviewing daily Google Alerts with the search terms "worker killed" and "construction." Media reports and OSHA records were merged where applicable. Data on severe injuries were extracted from the OSHA Severe Injury Reports, a dataset composed of reports from employers required by OSHA beginning on January 1, 2015. Severe injuries are defined as an amputation, in-patient hospitalization, or loss of an eye. The severe injury dataset does not include incidents under state plan jurisdiction. Both data sources provide detailed data, such as incident location, industry, major cause of injury, individual event narratives, and other relevant information. The information is organized and presented in interactive data dashboards that allow individuals to filter by major criteria such as year, state, and injury type. ArcGIS Dashboard and Tableau were used to create the dashboards for fatal and severe injuries, respectively. These dashboards are updated biannually when new data are available.

Results: The Construction Fatality Map dashboard contains 6,340 construction fatal injuries from 2011 through 2020. The dashboard shows that the leading event type for fatal construction injuries in the United States was falls, slips, trips (34.7%). In addition, the top three states for fatal construction injuries were Texas (823 deaths), California (550 deaths), and Florida (492 deaths). The Severe Injuries dashboard covers 11,000 severe injuries in construction from 2015 to 2020. Falls to a lower level comprised four out of the ten most common severe injury types illustrated by the dashboard. The top three construction subsectors by number of severe injuries were Commercial and Institutional Building Construction (1,165 injuries), Electrical Contractors and Other Wiring Installation Contractors (1,093 injuries), and Highway, Street, and Bridge Construction (912 injuries). The results will be updated when new data are available.

Discussion: These interactive dashboards enable users to explore fatal and severe injuries in a dynamic fashion through filters and interactive chart elements. Users can have custom views of the charts as well as free download data files of the charts. These features provide a useful resource and tool for construction research and training. Since being posted in early May of 2021, the Construction Fatality Map dashboard has received 1,233 unique views over a five-month period. The Severe Injuries dashboard, posted in early August of 2021, has received 234 unique views in a two-month period. (The dashboards are available online: https://www.cpwr.com/research/data-center/data-dashboards/).

D3.2

Title: Mental Health Among Construction Workers in the United States

Authors: Samantha Brown, Amber Trueblood, William Harris, Xiuwen Sue Dong

Background: Historically, mental health has not been considered a safety priority in construction. The high suicide rate among construction workers tells us it is time to pay close attention. The COVID-19 pandemic has likely exacerbated mental health issues in this population. Despite the urgent need, mental health research in the construction industry is scarce. To better understand construction worker mental health and inform life-saving, evidence-based tactics that improve it, this study examines (1) trends in psychological distress from 1999-2018 and (2) mental health indicators at the start of the COVID-19 pandemic among U.S. construction workers.

Methods: This study analyzed nationally representative data from the National Health Interview Survey (NHIS) from 1999-2018 and in 2020. (No industry and occupation measures in 2019 data). NHIS is a cross-sectional household survey monitoring the health of the nation. The sample adult (aged 18 or older) file was downloaded from IPUMS. Construction workers were respondents who reported their main industry was construction regardless of occupation. Survey weights, strata, and clusters were used to account for the complex survey design. Self-reported psychological distress in the past 30 days was defined as Kessler-6 (K6) scores of 5-12 (moderate) or ≥ 13 (serious). The prevalence of psychological distress among construction workers was estimated from 1999 to 2018, and differences between demographic and work-related subgroups from 2014 to 2018 were compared using chi-square tests.

Results: A total of 32,048 construction workers were examined from 1999-2018, representing 13 million (weighted) construction workers annually. The prevalence of serious psychological distress doubled throughout this period, from an annual average of 1.4% from 1999-2003 to 2.8% from 2014-2018. Moderate psychological distress also grew, with a prevalence of 9.6% from 1999-2003 and 17.0% from 2014-2018. Both serious and moderate distress rose during and immediately following the Great Recession, reaching averages of 3.9% and 16.4% from 2008-2011, respectively. Despite fluctuation, the prevalence of serious distress declined along with the economic recovery, while moderate distress somewhat increased from 2011 to 2018. From 2014 to 2018, moderate and severe distress were more prevalent in workers who were female, single, not college-educated, current cigarette smokers, or held a blue-collar occupation ($p < 0.05$). Non-Hispanic racial minorities suffered the highest prevalence of serious (3.2%) and moderate (21.9%) distress, followed by white, non-Hispanic (serious: 3.1%; moderate: 17.5%) and Hispanic (serious: 2.1%; moderate 13.9%) workers ($p < 0.0001$). Distress was also more likely to be reported by workers living below the poverty level (serious: 6.3%; moderate: 24.5%) than those living above it (serious: 2.4%; moderate: 15.9%; $p < 0.0001$). The prevalence of serious distress was nearly three times higher in unemployed than employed workers (5.6% versus 1.9%), and moderate distress was also more common in the unemployed (26.0% versus 15.0%; $p < 0.0001$). Note: Results in 2020 will be added when the 2020 NHIS data are available.

Discussion: Psychological distress among construction workers increased over the past two decades, particularly during and immediately after the Great Recession, a period characterized by unemployment and economic insecurity. Findings also suggested that workers in some construction subgroups, such as females, racial minorities, and those with lower socioeconomic status, are more vulnerable to psychological distress. More research is needed to understand pathways to poor mental health outcomes among construction workers as well as effective workplace and policy interventions to address them, especially in the vulnerable subgroups identified.

D3.3

Title: Prescription Opioid Use and Stigmatized Attitudes Among Apprentice Construction Workers

Authors: Ann Marie Dale, Sam Biver, John Gaal, Bradley Evanoff

Introduction: Construction leads all industries for opioid-related overdose deaths. Construction workers also suffer from high rates of musculoskeletal pain due to physically demanding work. A previous study of construction health claims showed that one-third of workers seeking care for musculoskeletal pain received an opioid prescription, those prescribed opioids for musculoskeletal pain had a higher risk for long-term opioid use, and these long-term users were nearly 10 times as likely to develop opioid use disorder. Training workers on the risks of opioids and development of OUD should reduce the use of using prescription opioids for pain management and reduce the widespread stigma toward workers with OUD. This is important for new workers, as apprentices are generally young and strong, so often expected to perform the most physically demanding tasks on worksites, placing them at greater risk of injuries. The purpose of this study was to describe apprentice construction workers' awareness and attitudes toward workers struggling with substance use,

whether workers with substance misuse behaviors report greater stigmatized attitudes by employers and coworkers than workers without misuse behaviors, and whether workers trained about opioid risks show less stigma and negative attitudes toward workers with opioid use disorder than untrained workers.

Methods: We invited construction apprentices to complete an electronic survey on worker knowledge, attitudes, and behaviors about opioids and the workplace. Workers accessed the survey through a QR code during a training class and were given time to complete the survey. All responses were sent directly to the research team to ensure confidentiality.

Results: 459 apprentices (84% response rate) completed the survey during class (average completion time 7.5 minutes), with each of the 8 training terms represented (9-16% of the workers). More than 90% of workers agreed that their job often required lifting heavy loads and required much physical effort; 72% reported having pain/discomfort in the past 12 months; 35% had seen a physician for pain, 21% had missed days from work due to pain, and 8% had received an opioid prescription for pain (11.4% of those prescribed opioids reported taking more than prescribed, and 21.6% of those with an opioid prescription reported taking pain medications prescribed to someone else). 28% of apprentices reported received training on risks of opioids and substance use, and 7% had training on administering naloxone. Workers with misuse problems (n=34) more often reported feeling negative attitudes and stigma from coworkers including thinking less of those with a substance use problem (p=0.001) and being overlooked for hire if treatment is known (p=0.001). Workers with misuse more often recognized that addiction is not a choice (p=0.03) and acknowledged that substance use is ignored by coworkers (p= 0.02) than other workers. Workers who reported prior training on opioid risks showed no differences in their knowledge and attitudes responses (addiction is a choice, fear of job loss for disclosure, negative opinion of those in recovery, overlooked for hire, and ignore substance use behaviors of coworkers) than untrained workers.

Discussion: These findings mirror past studies and show that many new workers experience pain requiring medical treatment, and some receive or choose to take prescription opioids for pain management. Workers with substance use problems more often feel stigma and negative attitudes from coworkers. There was no difference among workers trained to untrained in their negative attitudes toward addiction, fear of job loss from opioid use, and plan to seek help if needed. These findings suggest that stigma persists in the workplace and that training alone does not appear sufficient to change worker opinions and workplace culture.

Session D4
Robotics in Agriculture
Moderator: Jennifer M. Lincoln

D4.1

Title: Literature Review: Does Improved Agriculture Technologies Mean Improved Safety?

Authors: Darlene Weaver, Menekse Salar Barim, Marie Hayden, KC Elliott, Jennifer Lincoln, Michael A. Flynn

Introduction: Our study sought to evaluate the scientific literature to identify agricultural uses of new technologies, document potential benefits and hazards to workers, and identify knowledge gaps regarding occupational safety and health. The Food and Agriculture Organization (FAO) projects the total global population will increase 25% by the year 2050 to 9.2 billion. To make improvements in the agriculture sector and to meet a growing demand for food, newer and more sophisticated technologies such as artificial intelligence and robotics are being used. It is well known that agricultural work is physically demanding and agriculture workers are at high risk of occupational injury and illness. The agriculture industry is increasing the use of robotics and artificial intelligence (AI) which has the potential to drastically change how food and other agricultural products are produced. Therefore, there is a need to understand the current status of these technologies, and more importantly, the potential occupational safety and health effects associated with their use.

Methods: We conducted a scoping literature review of articles pertaining to robotic and artificial intelligence systems used in agriculture. There were 3248 articles screened by two reviewers, according to the following criteria: (1) relevant to advanced technologies such as robotics and artificial intelligence systems, (2) written in English, and (3) published after 2015. Further analysis was performed, and 80 of the articles were about animal livestock, and 465 related to crop/harvesting. The 465 articles were then separated into two different categories: (1) agricultural technologies used to enhance agricultural production and crop quality, and (2) agricultural technologies used to reduce the occupational safety and health risks of farmers and farm workers.

Findings: The majority of articles focused on increasing production and quality of the crops, and very few were related primarily to reducing occupational and safety risks. There were 53% of the articles related to harvesting technologies to increase food production. These technologies relate to mechanization and manipulation tasks, such as harvesting robots. Another 12% of the articles related to the technologies of harvesting/cropping to increase efficient agricultural production. These technologies relate to Autonomous Driving Control, such as tractors. There were 25% of the articles pertaining to cropping technologies to improve the quality of the crops. These technologies relate to disease detection and monitoring and may use drones. Finally, 10% of articles were on technologies whose primary purpose was to help reduce occupational health and safety risks. These technologies relate to musculoskeletal disorders and repetitive motion tasks, such as exoskeletons. Technology is advancing towards the use of robotics, drones, and autonomous tractors to enhance agriculture production and quality of crops to address serious concerns related to labor shortages and an increasing food demand. Articles that relate to technologies that can reduce the occupational health and safety risk of the worker is very limited which is a concern because the Agriculture sector ranks among the most hazardous industries.

Discussion: These new technologies improve the quantity and quality of crops with the reduction of environmental hazards such as pesticides into the environment along with better detection of crop disease and monitoring of crops. However, there are still extensive knowledge gaps regarding occupational safety and health effects of these emerging technologies. Further investigation is needed to better understand how the adoption of emerging technologies may potentially benefit or compromise agriculture worker safety and health.

D4.2

Title: Livestock Technology Review - Application to Worker Safety & Health

Authors: Marie Hayden, Menekse Salar Barim, Darlene Weaver, KC Elliott, Jennifer Lincoln, Michael A. Flynn

Introduction: Precision livestock farming expands the management capability of farmers to monitor animal health through reliable and affordable technologies due to growing production demands. These technologies range from robotics, and sensors, to artificial intelligence, which continue to change the traditional methods of manual tasks and limitations of humans monitoring multiple animals. The objective of this study was to review emerging technologies to better understand what is available and to determine if health and safety for the workers had been evaluated or considered.

Method: We conducted a scoping literature review and identified 3248 articles. Titles and abstracts were screened according to the following criteria: (1) technology with robotics, sensors or artificial intelligence (AI); (2) Agriculture applicable to United States; (3) written in English; (4) published after 2015; and (5) studies not related to meat production. Five independent reviewers performed the screening using Covidence. Documents required two reviewer agreements. If a conflict occurred a third reviewer provided input to arrive at a final decision. Based on the above criteria, 80 articles were selected for the full review article process specifically to livestock. These articles were classified into the following categories: type of technology (robotic, sensor, AI) and worker safety and health.

Results: Overall, 63% (50/80) of these studies applied technologies for monitoring animal health and welfare. The automated systems accounted for 56% (45/80) articles. Majority of automated systems were automatic milking systems (AMS) and automatic feeding systems. Ten articles focused on the data collected by the built-in AMS sensor to assess the health and milk yield quality of the cattle. Additional automated equipment consisted of automatic milk feeding systems to feed pre-weaned calves, automatic herding systems to direct traffic flow towards the AMS, automatic sprayers to clean cattle hooves, robotic scraper to clean cattle manure on the floor, and mobile robots to collect poultry eggs off the floor. Emerging technologies, 44% (35/80) of articles, included sensors, computer vision, machine learning and platforms devices for processing data. The sensors were used on cattle to detect reproductive health, early disease detection, monitor behavior or stress and lameness, while machine learning included tracking behavior and monitoring growth for pigs. More frequently studies combined technologies such as computer vision and machine learning for breed classification of sheep or tracking sow behavior or monitoring their growth. Additional studies combined sensors and machine learning for monitoring behavior or for early disease detection. When reviewed for worker safety and health evaluations, there were two topics which focused on human-health exposure and human-animal relationship. Two articles focused on human-health exposure by industrial hygiene sampling between a manual system versus an automated robotic system. One article reviewed studies that implemented different sensors and robotic technologies and discussed the concern of the human-animal relationship. There were few articles that acknowledged but had no consistent quantitative

evaluation on the equipment benefits on labor reduction, fewer repetitive tasks, flexibility in time, human animal relationship and mental workload.

Conclusion: Only two of 80 studies evaluated the health and safety of the worker using new technologies. The primary focus for all other articles was to improve animal health and well-being or to improve the quality of production and increase the economic benefits. These primary focuses contributed to the adoption of precision livestock farming; however, much remains unknown about their potential impact on the farmer's health and safety. These findings suggest the potential impact of new technology could have on worker safety is significantly underexplored in the literature.

D4.3

Title: Severe Occupational Injuries from Food Packaging and Movement in the U.S. Supply Chain

Authors: Judd Michael, Serap Gorucu

Background: The modern food supply chain presents unique hazards to employees that result in higher morbidity and mortality rates versus other industries. Employees in food manufacturing, wholesaling and even retailing experience unusually high numbers of occupational injuries and fatalities. One reason for the high hazard rates may be the reliance on a synergistic packaging system designed to load and transport food products within and between manufacturers, wholesalers, and retailers. Packaged food products are often aggregated using automated palletizers before they can be transported by forklifts and pallet jacks. Moving product within facilities is critical to the efficient functioning of all members of the food-related supply chain, but product movement is a common source of occupational injuries. No previous research has examined the cause and result of such hazards. The goal of this presentation is to examine severe injuries and fatalities related to the packaging and movement of food products in segments of the food and beverage supply chain from manufacturing to retailing.

Methods: We used an OSHA database to investigate all severe injuries in the six years from 2015 to 2020 for 12 food and beverage-related industry segments. Our focus was on the food supply chain for the period since OSHA began mandating new reporting procedures for severe injuries in 2015. OSHA's Integrated Management Information System and Severe Injury Database were searched for pallet, skid, crate, carton, palletizer, forklift, pallet jack or powered industrial vehicle related injuries. The methodology provides a specific overview and quantification of the occupational hazards associated with food-related manufacturing, wholesaling/warehousing and retailing firms in the US.

Results: Results show there were 42 fatalities and 1084 severe injuries during the six-year period. Fractures of the lower extremities were most prevalent, with the most frequent event type being transportation-related such as pedestrian-vehicle incidents. Grocery wholesalers and grocery retail stores saw the highest number of injuries, followed closely by the warehousing and storage groups. The frequency of injuries generally trended higher across the years, with 2018 through 2020 being much higher than the first three years. The most prevalent injury event type was transportation incidents, with the "nonroadway incidents involving motorized land vehicles" (e.g., forklifts) category being first. When specifically considering forklift hazards the most dangerous industry sector was wholesaling and warehousing. Results indicate that the three industry segments differ by injured body part and event/exposure types.

Discussion: Significant differences were seen in the three parts of the food supply chain. The number of severe injuries rose significantly in 2020 which may have been a result of pandemic-induced supply chain pressures. Results suggest that the use of palletizers for unitizing and powered industry trucks (PITs) for transporting food products present varied opportunities for employees to suffer severe injuries and fatalities. PITs are critical to the efficient movement of food products and yet are a source of severe injuries and fatalities; the use of forklifts and pallet jacks are therefore a challenge in this industry as with others. The proportion of amputations in the manufacturing segment was significantly higher than the wholesaler, warehousing and storage segment. Narratives provided with each incident report suggest that palletizers are a common cause of amputations. These often occur when an employee reaches into the palletizer to clear a jam or retrieve broken product. The actual transport packaging (i.e., pallets and crates) was also the source of injuries, with a relatively higher number coming from slip, trip and fall injuries in retail locations.

Session E1

Occupational Injury Surveillance in the U.S. Military

Moderator: Melody Gwilliam

E1.1

Title: Beginning to Grasp Finger, Hand and Wrist Injuries in the U.S. Air Force

Authors: Melody Gwilliam, Christina Socias-Morales, Bruce Burnham, Audrey Reichard, Heidi Stallings

Background: Fingers, hands, and wrists (FHW) are anatomically complex and FHW injuries can potentially impair a worker's functional activities at work and home. Impairments from FHW injuries resulting in physical difficulties participating in work, leisure, and self-care activities can have social and emotional impacts and lead to a decreased quality of life. Although FHW are the most frequently injured body parts in work-related injuries, a limited number of studies have examined the characteristics of these occupational injuries. This study describes on-duty (work-related), non-combat FHW injuries among military and civilian U.S. Air Force (USAF) personnel to guide prevention efforts.

Methods: We conducted a retrospective analysis of all work-related, non-combat FHW injuries among military and civilian USAF personnel from fiscal year (FY) 2008 through 2018. Data from the Air Force Safety Automated System (AFSAS) and the USAF Personnel Center's (AFPC) Statistical Analysis and Retrieval System Demographics (STARS DEMOG) was used in this research study. AFSAS captures work-related injuries reported by local military base safety professionals and STARS DEMOG provides demographic data. A non-disclosure agreement was established between the USAF and the National Institute for Occupational Safety and Health (NIOSH) to conduct collaborative research. FHW injuries were grouped together from the injured body part variables "fingers" and "hand/wrist." Occupational groups were created using job series codes for civilian and military personnel. Rates of FHW injuries per 1,000 workers from FY 2008-2018 were calculated using injury numerators and aggregate USAF employment numbers for denominator data. Poisson regression was employed to calculate 95% confidence intervals for injury rates.

Results: There were 14,522 FHW non-combat injuries in the USAF between FY 2008-2018, accounting for 32% of all work-related, non-combat injuries among military and civilian personnel. We observed a statistically significant decrease in all work-related injuries (29%) during the 11-year study period. There was also a statistically significant decrease (21%) in FHW injuries ($p<0.0001$) during the study period. The majority of FHW injuries were open wound injuries (52.8%) and fractures (19.5%). Most (62%) of the FHW injuries involved enlisted personnel. Aircraft maintainers had the highest number of FHW injuries (3,246 injuries, 22% of all FHW injuries), however metal workers had the highest rate of injury (14.5 per 1,000 workers) but accounted for 6% of FHW injuries. USAF personnel aged 16 to 24 years had a higher rate of FHW injuries (4.5 per 1,000 workers) that was almost twice as high as workers 25 and older (2.3 per 1,000 workers).

Conclusions: FHW injuries substantially decreased throughout the USAF from 2008-2018. Efforts made by the USAF to improve worker safety may have contributed to the decline in FHW injuries. Some of the efforts made by the USAF included updates and improvements to safety policies, procedures, and activities. Future safety efforts should focus on implementing prevention strategies among high-risk groups such as young workers (16-24 years), enlisted personnel, metal workers and aircraft maintainers.

E1.2

Title: Estimated Costs of Lower Extremity Fractures Among U.S. Army Soldiers

Authors: Michelle Canham-Chervak, Lana Forrest, Steven Barnes, Veronique Hauschild, Anna Schuh-Renner, Tyson Grier, Ryan Steelman, Esther Dada, Bruce Jones

Introduction: With over 2 million medical encounters annually, injuries represent a leading U.S. Army health issue for which current monetary cost estimates are warranted. As the first step to developing a standard cost estimation approach for all injuries, this investigation focused on estimating expenditures for lower extremity fractures.

Methods: Treatment for a lower extremity fracture was identified in the Military Health System Data Repository (MDR) for active duty soldiers in 2017. Lower extremity fractures were identified from medical encounters with the following International Classification of Diseases, 10th Edition, Clinical Modification (ICD-10-CM) codes in the first or second diagnosis position: S72 (fractures of hip, upper leg), S82 (fractures of knee, lower leg, ankle), or S92 (fractures of feet, toes). Direct medical cost was defined as the total cost paid for a medical encounter by the Military Health System, as noted in the MDR. Indirect medical costs were calculated for lost (hospitalizations) and limited duty time using estimates from the literature, Defense Finance Accounting Services pay charts, and

assuming a 50% productivity estimate for limited duty time.

Results: There were 5,287 soldiers with an initial encounter for a lower extremity fracture in 2017 (99% received outpatient care, n=5,247); most were men (83%) and younger than 30 years of age (56%). The estimated total cost of lower extremity fractures was approximately $116 million (M) based on combined direct medical costs ($24M) and indirect medical costs ($92M; $91M limited duty; $900,000 lost duty). More than 90% of soldiers received care for fractures to the lower leg, ankle, foot, and toes (n=4,842); these fractures accounted for 89% ($103M) of costs. By treatment setting, foot and toe injuries accounted for 53% ($52M) of outpatient costs and lower leg and ankle fractures accounted for 62% ($11M) of hospitalization costs.

Discussion: This analysis provides a foundation for future, broader cost estimation approaches that have been missing from military injury prevention planning and evaluation. The majority of costs were due to lost or limited duty time, indicating the need to include indirect cost estimates as a part of overall military injury cost calculations.

E1.3

Title: The Impacts of the Transition to ICD-10-CM on U.S. Army Injury Surveillance

Authors: Anna Schuh-Renner, Matthew Inscore, Veronique Hauschild, Bruce Jones, Michelle Chervak

Introduction: Injuries are the leading cause of medical encounters and lost work days in the U.S. Army, affecting over half of Active Duty Soldiers annually. This work describes how the transition from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) to the Tenth Revision (ICD-10-CM) impacted U.S. military injury surveillance, by comparing injury rates and distributions under both systems. Historically, Army injury surveillance has captured both acute traumatic and overuse injuries due to cumulative micro-trauma.

Methods: Mapping ICD-9-CM codes to the expanded, more detailed, ICD-10-CM codes is not a straightforward endeavor; therefore, the U.S. Army Public Health Center incorporated ICD-10-CM codes into a comprehensive, systematic approach to taxonomically categorize injury diagnoses. This methodology was applied to Army injuries under ICD-10-CM (Calendar Years 2016-2019) and compared to ICD-9-CM Army injury surveillance definitions (Calendar Years 2012-2015).

Results: Soldier injury rates appeared to increase when surveillance with ICD-10-CM began. Soldiers experienced 1,804 incident injury medical encounters per 1,000 person-years in 2016 (ICD-10-CM), compared to 1,276 injuries per 1,000 person-years in 2015 (ICD-9-CM), a 41% increase. Importantly, the distribution of injuries also shifted, such that the average cumulative micro-traumatic injury rate increased by 42% during 2016-2019 (ICD-10-CM) compared to the 2012-2015 average (ICD-9-CM), while acute traumatic injuries only increased by 17%.

Conclusions: The more detailed descriptions provided by ICD-10-CM codes and the applied taxonomic categorizations have improved Army injury surveillance, and data unequivocally demonstrate that most injuries in this physically active population are cumulative micro-traumatic injuries. An added benefit of the comprehensive taxonomic structure is that it allows for focused analyses on subsets of injury diagnoses if desired. The taxonomy methodology can also be extended to injury surveillance in other populations and may allow for a more efficient transition to surveillance with ICD-11-CM.

Session E2

Fatigue, Sleep and Work Hours

Moderator: Karl Sieber

E2.1

Title: Assessing the Impact of Work Hours on Worker Safety and Health in the Stone, Sand and Gravel Mining Industry

Authors: Todd Smith, Abdulrazak Balogun, Aurora Le, Charmaine Mullins-Jaime

Introduction: Long work hours and overtime can negatively impact worker safety and health. Long work hours and overtime have been linked to increased occupational injury and illness outcomes, including musculoskeletal disorders. Additionally, long work hours and overtime have been associated with stress and burnout, which can be detrimental to overall health. Research exploring these relationships within stone, sand gravel mining (SSGM) operations is limited. The focus of this presentation is to summarize completed studies assessing the impact of long work hours and overtime on worker health and safety outcomes to include musculoskeletal symptoms, stress, burnout, and overall health.

Methods: Survey data were collected from 459 workers employed in the SSGM sector within the U.S. Midwest. Two studies using these data were completed. In the first study, logistic regression analyses were completed to

examine the relationships between work hours and musculoskeletal symptoms (MSS) of the neck, shoulder, lower back and knee. The second study used multiple regression to examine relationships between long work hours and health impairment—particularly stress, burnout and overall health.

Results: Regarding the relationship between hours worked per week and MSS, we found that employees who worked more than 40 hours per week had higher odds of developing musculoskeletal symptoms. It was determined that work greater than 60 hours per week was the greatest concern. Employees who worked more than 60 hours a week had approximately five times the odds of developing low back MSS (OR: 4.7 95% CI: 1.9–11.5), knee MSS (OR: 4.5, 95% CI: 2.0–10.3) and neck MSS (OR: 5.1, 95% CI: 2.2–11.8) compared to those who worked at or below 40 hours per week. Employees who worked 51-60 hours per week also had significantly higher odds of developing neck MSS (OR: 2.7, 95% CI: 1.3–5.3) compared those who worked at or below 40 hours per week. Regarding the relationships between hours worked per week and health impairment, it was determined that work hours were positively significantly associated with stress ($p<.001$) and burnout ($p<.001$) and was significantly negatively associated with perceptions of overall health ($p<.05$).

Conclusions: Long work hours and overtime work are a significant concern within the SSGM sector. Workers working long hours and overtime are more likely to report MSS and report health impairment, including stress, burnout and diminished overall health. As such, work hours and overtime work policies and programs need to be examined by SSGM organizations. Strong evidence suggests that employers should not work employees more than 60 hours per week. Workers working more than 60 hours each week were approximately 5 times more likely to report low back, neck, and knee MSS. Human resource management and management/worker collaboration is needed to maintain pay, so not to burden workers if work hours are reduced. Additionally, job design changes may be necessary to maintain production. In addition, these findings point to the need for Total Worker Health® (TWH) oriented interventions in SSGM aimed at addressing job risk factors and health impairment. TWH strategies provide an opportunity for interdisciplinary and multidisciplinary interventions that can protect workers and improve the overall health and wellness of employees.

E2.2

Title: Findings from a Systematic Review of Fatigue Interventions in Industrial Settings

Authors: Zoe Dugdale, Brianna Eiter, Cammie K. Chaumont Menendez, Imelda Wong, Timothy Bauerle

Introduction: Fatigue and sleep deficiency remain key occupational health and safety concerns in many industries and subsectors, including in mining. Work schedules in the mining industry are often nonstandard, tasks can be physically and mentally demanding, and environments are sometimes hot, poorly lit, and loud. These are all fatigue risk factors and can lead to cognitive impairment and subsequent safety critical events. The purpose of this systematic review was to identify fatigue interventions that have been tested on industrial shiftworkers and explore their effects and the factors that may influence their application in a mine.

Methods: The protocol for this review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist. Relevant studies published between 1980-2020 were identified by carrying out structured, systematic searches in electronic journal databases, consulting external subject matter experts, and manually reviewing the reference lists of a sample of studies. Articles were screened against pre-established inclusion criteria and appraised for methodological strength. Key characteristics such as occupational setting and job task, shift schedule, intervention type, outcome measures, and study findings and limitations were then extracted. Due to considerable heterogeneity in methods, participants, interventions, and findings, a narrative synthesis approach was taken.

Results: Two intervention types – lighting and training – were identified out of several frequently documented in other industries and sectors (e.g., planned naps, rest breaks, strategic caffeine use). Critically, no fatigue interventions were tested in mining. Our review provides strong evidence for bright light interventions at improving subjective sleep quality and reducing sleepiness in industrial shiftworkers. However, there is insufficient evidence to posit the benefits of blue-light blocking glasses and sleep hygiene and alertness management trainings. Notable factors influencing the effectiveness of the lighting interventions included when and how often the interventions were provided and their duration. The training interventions were primarily affected by choices in design and delivery, and the relevance of information to workers.

Discussion: To improve effectiveness, interventions should be customized as much as possible for specific workers and with consideration for contextual factors within the workplace environment. Future studies should investigate whether lighting and sleep hygiene and alertness management trainings are effective fatigue risk management tools in mining-specific environments. Further, so that mines can adopt a more multifaceted approach to managing worker fatigue, a variety of other fatigue-related interventions should be evaluated across similar industrial settings since strategies found to be effective in these comparable environments may be feasibly adapted and implemented in mining contexts. Accompanying this intervention work should be studies that identify best practices for implementing these interventions in industrial workplace settings since intervention use and acceptability can impact adoption and sustained use over time.

E2.3

Title: Survey of Working and Sleeping Time by Industry and Occupation of Fulltime Workers in the U.S.

Author: Guang Chen

Introduction: Long working hours and inadequate sleeping time can lead to increased fatigue and fatigue-related injuries on the job, and decreased wellbeing for workers. This analysis examined working and sleeping time by occupation and industry among fulltime workers in the U.S.

Methods: This study analyzed publicly available microdata from the American Time Use Survey (ATUS) spanning 2015–2017. ATUS is conducted by the U.S. Census Bureau for the Bureau of Labor Statistics (BLS) to assess how individuals spend their time. It is a nationally representative sample of persons aged 15 years or older living in U.S. households. During a 20-minute phone interview, participants were asked about their sequential activities going back 24 hours. Respondents' occupation and industry were coded using Census Industry and Occupation Classification Systems. National estimates of average work and sleep hours were computed by general occupational and industrial groups.

Results: On average U.S. fulltime workers worked 8.1 hours, slept 7.9 hours on a working day, and slept 9.7 hours on a non-working day. Among the general industrial categories, Farming/Fishing/Forestry occupations had the longest working hours (8.7 hours a day) and Education/Training/Library occupations had the shortest working hours (7.3 hours). Utilities had the shortest average sleeping hours (7.3) and traveler accommodation had the longest average sleeping hours on a workday. Among the general occupational categories, Management of Companies and Enterprises had the longest working hours (9.2) and Internet Publishing and Broadcasting had the shortest working hours (5.7 hours). Architecture and engineering had the shortest sleeping hours (7.6) and food preparation and serving related occupations had the longest average sleeping hours (8.3) on a workday. Among certain individual occupations that characteristically worked irregular shifts, Emergency Medical Technicians and Paramedics worked 10.9 hours a day, Taxi Drivers and Chauffeurs worked 9.7 hours a day, Driver/Sales Workers and Truck Drivers worked 8.8 hours a day, and Physicians and Surgeons worked 8.3 hours a day. National estimates of average work and sleep hours were computed by general occupational and industrial groups.

Discussion: BLS recently (July 22, 2021) reported ATUS 2019-2020 data highlighting the change in working at home in 2020 (during the COVID-19 pandemic) compared to 2019 (prior to the COVID-19 pandemic). The amount of time employed persons spent working was about the same in 2019 and 2020--7.7 hours in 2019 and 7.6 hours in 2020. The percent of employed persons working at home on days they worked nearly doubled, rising from 22 percent in 2019 to 42 percent in 2020. Workers with higher levels of education were much more likely to work at home in 2020 than were those who had less education. By industry, from 2019 to 2020, there were large increases in the share of employed persons working at home on days worked for those employed in financial activities (up 40%); professional and business services (up 25%); and education and health services (up 23%). By contrast, there were smaller increases for workers in leisure and hospitality (up 8%); transportation and utilities (up 9%); wholesale and retail trade (up 10%); and manufacturing (up 11%). No change in percentage of working at home among the following general occupational categories: farming, fishing, and forestry; construction and extraction; installation, maintenance, and repair; production; and transportation and material moving. The BLS report suggested that there is a need for comparing how American work before and after the COVID-19 pandemic.

Conclusion: This analysis provided national estimates of working and sleeping hours by industry and occupation for fulltime workers in the United States in 2015-2017, which will be updated by analyzing the ATUS 2019-2020 microdata.

Session E3

Helmet Research on Work-Related Traumatic Brain and Musculoskeletal Injuries

Moderator: Chris Pan

Approximately 7.3% of traumatic brain injury (TBI) cases identified by the Ontario Trauma Registry were work-related (Kim et al., 2016). Work-related traumatic brain injury (WrTBI) accounted for approximately 20% of traumatic occupational injuries and 60% of work-related deaths in the state of Washington (Sears et al., 2013). Some epidemiological studies suggest that WrTBI is thought to be one of the most serious workplace injuries (Konda et al., 2015; Tiesman et al., 2011). The industrial helmet (or hard hat) is the most commonly used and effective personal protective equipment to reduce WrTBIs.

This session will include laboratory-based helmet research studies addressing rear, side, and oblique impacts and fall protection performance for Type I and II industrial helmets. Head and neck musculoskeletal injuries associated with wearing a firefighter helmet will also be presented. These helmets are designed to protect the firefighter's head from thermal and low-velocity (7 m/s or less) direct impact. According to the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS), from 2015 to 2017, injuries to the head and neck accounted for 25% of all reported incidences—out of which, 40% involved overexertion (NFIRS, 2019).

More specifically, this session will present experimental results of three mechanical and biomechanical studies on helmet research to assess and prevent TBIs as well as head and neck musculoskeletal injuries. Using drop tower or manikin drop impacts tests on construction-type helmets, two of the studies will focus on: 1) chin strap and ratchet performance assessment; and 2) biomechanical comparison of Type 1 and II helmet fall protection performance to reduce risk associated with skull fracture and concussion.

The third study will look at biomechanical loading from a typical firefighter helmet equipped, with functional accessories, to the cervical spine. Loading to the cervical spine can possibly result in disc herniation and disc degeneration. Those doing research in these areas will find the session informative with leading edge research results. Practitioners will find the session provides them specific information on developments in the design of "hard hats" what will assist them in selection of more appropriate "hard hats" for their workforce.

Presentation Titles/Lead Authors:

1. Assessment of Fall Protection of Type I Industrial Helmets

Presenter: Chris Pan, Senior researcher and safety engineer, NIOSH/DSR

2. Evaluation of Hard Hats for the Reduction of Head Injuries due to Falls

Presenter: Steve Rowson, Associate Professor and biomedical engineer, Virginia Tech University

3. Lessons Learned While Designing a Next-Generation Firefighting Helmet: Preliminary Data

Presenter: Suman Chowdhury, Assistant Professor and industrial engineer, Texas Tech University

E3.1

Title: Assessment of Fall Protection Performance of Type I Industrial Helmets

Authors: Chris Pan, Clayton Cobb, Andrew Moorehead, Bryan Wimer, Tsui-Ying Kau, John Wu

Background: The performance of Type I industrial helmets is regulated by the Z89.1 ANSI standard for head protection. However, there is no standard requirement for Type I helmets for fall protection, like there is for Type II helmets. Chin straps and suspension system adjustment mechanisms (ratchets) are two important components of a typical industrial helmet, but the effects of proper use of them on the protective performance of Type I helmets have not been evaluated. The current study was designed to analyze the fall protection performance of Type I industrial helmets and to evaluate if the use of a chin strap and tightness of the suspension system have any effect on protection performance.

Methods: Head impact tests were performed using an instrumented manikin that was subjected to a simulated fall to a lower level. The test manikin was custom-built using the body of an off-the-shelf manikin (50th Percentile Rescue Randy, Model #149-1344, GT Simulators, Davie, FL), a 50th percentile crash test dummy headform (Standard 50th Headform ATD-3215, Eyeglass Headform, Humanetics, Farmington Hills, MI), and a 50th percentile Hybrid III neck (Model #78051-90-H, Humanetics, Farmington Hills, MI) with a custom-built reinforced spine. The headform had an aluminum skull. The test manikin was further reinforced with aluminum shoulder elements. The height and body mass of the test manikin with all customarily revised elements were close to a standard 50th percentile male. The

manikin was fitted with a fall protection harness to facilitate lifting. The accelerations of the head during the impacts were measured using a triaxial, piezoelectric accelerometer (Model #66F11, Endevco, Depew, NY). The accelerometer was installed close to the center of gravity of the manikin's head. At the start of the test, the manikin was hoisted, by a lifter, to a height of 5 feet (1.5 m) and was kept at a slightly inclined posture. Head impact tests were performed by letting the instrumented manikin free fall backwards, from a standing posture, so that the manikin would make head-first contact with a solid surface of two different materials (concrete and plywood-covered). Two factors regarding proper wearing of the helmet were considered: (1) with or without chin strap usage, and (2) three levels of suspension system tightness (tight, comfortable, and loose). Four representative Type I helmet models (two basic models and two advanced models) were selected for the study. Each of the impact tests was replicated four times. In addition, impact tests were performed without a helmet under all other applicable test conditions as a control group. There was a total of 192 impact tests with helmets and eight impact tests for the control group.

Results/Discussion: Results show that all four tested helmet models demonstrated excellent performance for fall protection compared to the control group without wearing helmets. The fall protection performance of the advanced helmet models was substantially better than the basic helmet models. However, the effects of using chin straps and suspension system tightness on the helmets' fall protection performance were statistically not significant. By imposing the mean HIC (Head Impact Criteria) values of the impacts without helmets and with different helmet models on the relationships between injury probability and HIC, the probabilities for serious and severe injuries in these scenarios can be estimated. The head injury risk level from a fall could be reduced to an acceptable level by wearing any of the four tested helmet models. The findings of our study provide information to help construction companies and manufacturers better manage the use of Type I helmets for fall protection, thereby reducing work-related traumatic brain injury risks.

E3.2

Title: Evaluation of Hard Hats for the Reduction of Head Injuries Due to Falls

Authors: Steve Rowson, Maura McCartney

The construction industry accounts for more fatal traumatic brain injury events (TBIs) than any other industry, with 57% related to falls. Despite this, hard hat standards do not focus on fall protection, and Type 2 models, which are rated for off-center impacts, are not frequently used. This study's purpose was to compare fall-related injury risks between Type 1 and Type 2 hard hats. An analysis of construction-based accident reports was conducted using the Fatality and Catastrophe Investigation Summaries database provided by the Occupational Safety and Health Administration (OSHA). Low fall heights were commonly reported in construction accidents, and there is a large potential for injury reduction at these heights. A twin-wire drop tower was used with a carriage and size J metal headform that totaled 5 kg. The headform was mounted on a ball joint with a single accelerometer positioned its center of gravity oriented along the z-axis. This allowed the resultant acceleration to be recorded from any orientation. Three impact locations were tested: rear, side, and oblique. Three models of Type 1 hard hats and two models of Type 2 hard hats were each tested one time at each location, with drop heights between 0.3 and 2.4 m. Acceleration and impact velocity were recorded. Models were not tested at heights that would produce accelerations exceeding 400 g. Peak linear acceleration (PLA) and Head Injury Criterion (HIC) 15 ms were calculated. Skull fracture risk was estimated using HIC and concussion risk was estimated from PLA. Type 2 models had lower PLA and HIC values when compared to Type 1. At 5.7 m/s, Type 2 hard hats reduced skull fracture risk by approximately 64% (oblique), 92% (rear), and 34% (side) compared to Type 1. Concussion risk was reduced by 53% (oblique), 78% (rear), and 2% (side). Type 2 hard hats substantially reduce skull fracture and concussion risk when compared to Type 1 hard hats. These findings indicate that the risk of severe head injuries from falls in the construction industry would be substantially reduced if more workers wore Type 2 hard hats.

E3.3

Title: Designing a Safe Envelope of Weight and Center of Gravity of Firefighting Helmet Through Biomechanical Measurements and Modeling

Author: Suman Chowdhury

Recent injury reports suggest that the heavy-protective firefighter helmet, though designed to protect firefighter's head from thermal and low-velocity direct impact, actually contributes to overexertion/sprain-related head and neck injuries. According to the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS), from 2015 to 2017, injuries to the head and neck accounted for 25% (15,750 cases out of 63,000 cases of fire-related firefighter injuries) of all cases—out of which, 40% involved strains/overexertion, 33% were burns, and

27% were wounds/bleeding (NFIRS, 2019). The modern firefighting helmet also serves as a platform for supporting additional functional accessories, such as communication devices, face shield, visor, thermal imaging, and lighting equipment. The addition of these functional accessories has two major effects: 1) an increase in the total weight, and 2) a potential shift in the center of gravity (CoG) of the helmet system (i.e., helmet plus supporting accessories). These changes can lead to injuries to the cervical spine and fatigue of the neck muscles. In our preliminary investigation, we evaluated biomechanical risks and benefits of three structural firefighting helmets: a traditional-look (with-brim) helmet (58 oz), a jet-style helmet (62.25 oz), and the jet-style helmet with lighting and communication systems (70.85 oz). We measured head-helmet dynamics (i.e., head-neck kinematics, head-helmet relative motions, neck muscle fatigue, and positional instability) of four male (31±3) subjects. We found some legitimate concerns for all helmet types: 1) excessive helmet weight causing neck hyper-flexion (7-10°), reduced neck-extension (20-25°), and reduced neck endurance (for maximum flexion position: 260 ± 9.09s for traditional helmet and 253 ± 3.13s for jet-style helmet; for maximum extension position: 117 ± 35s for traditional helmet and 204.52 ± 46s), and 3) the helmet CoG lies away from the mid-sagittal plane (anteriorly and right lateral)—causing imbalanced lateral bending (5-10° discrepancies to the left (traditional) and right (jet-style), and 4) the helmet was displaced about 10-20° anterior-posteriorly (traditional helmet) both during dynamic movement and roll-off test. The heavyweight and displaced CoG for both firefighting helmet types pose an increased risk of cervical spinal disc loading during prolonged wear. We are currently evaluating the effects of each helmet type on the cervical spinal disc (C1-C7) compression forces in various head-neck full range of movements (flexion-extension, left and right rotations, and left and right lateral bending) in the OpenSim modeling platform. We then analyzed these disc compression forces in our head-neck finite element model (ANSYS/LS-DYNA platform) to calculate the von-Mises stress developed in cervical spinal discs. Our ongoing investigation is believed to reveal a safe envelope of helmet weight and CoG positioning, which could aid practitioners or manufacturers in fabricating a firefighting helmet that lies within the tolerable limit of cervical spinal soft tissues.

Session E4

Interdisciplinary Approaches Along the Translational Research Continuum to Reduce Children's Injuries in Agriculture

Moderator: Florence Becot

In the United States, farm children, both working and non-working, experience significantly more injuries and fatalities than the general population. This high level of risk exposure stems from a complex set of factors ranging from the frequent overlap between the home and work spheres, the dangerosity of the agricultural worksite, dangerous behaviors of parents and children, and the exemption of the agricultural sector from key federal workplace safety and labor regulations.

The National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS) was first funded by CDC-NIOSH in 1996 as the sole Center for Agricultural Safety and Health, out of 11, focused on the children population. Since then, it has developed a portfolio of research and outreach projects to further our understanding of children's exposure to risk and interventions most effective at reducing these risks. The goal of this thematic session is to introduce conference attendees to NCCRAHS' work and to generate interest in potential collaborations through the presentation of current research that highlights its interdisciplinary approach along the translational research continuum.

In the first presentation titled "25 Years of Progress and Persistent Challenges in Childhood Agricultural Safety", NCCRAHS director and nursing scholar, Barbara Lee, will outline the historical evolution of childhood agricultural prevention and intervention research in the United States along with NCCRAHS' approach to this work.

In the second presentation "Surveillance of Medically Attended Agricultural Injuries in Farm Children" epidemiologist, Jeffrey VanWormer, in collaboration with biomedical informatics scholar, Bryan Weichelt, will outline a surveillance research platform (T1) by presenting early findings of 20-year epidemiologic trends in medically attended agricultural injuries in farm children and adolescents using retrospective data from a large rural health care system in north-central Wisconsin.

The last presentation "Agricultural Youth Work Guidelines" led by family studies scholar, Andrea Swenson, provides an example of implementation and adoption research (T4) as she will present the process that guided the updating the Agricultural Youth Working Guidelines and key findings from the research that guided the guidelines' implementation and dissemination.

E4.1

Title: 25 Years of Progress and Persistent Challenges in Childhood Agricultural Safety

Author: Barbara Lee

Background: Since 1996 NIOSH has led the National Initiative for Childhood Agricultural Injury Prevention with a coordinating Center of Excellence through a competitive application process. The National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS) of Marshfield, WI has held that position for twenty-five years. The center's approach is based upon Burden, Need and Impact principles integrated with research that has evolved from epidemiology of injuries (T1) to studies that focus on outcomes and effectiveness in populations (T4).

Methods: All of NIOSH's agricultural centers include several research studies augmented with outreach activities, evaluation, and administrative functions. During the initial center years, a primary focus addressed understanding the scope and etiology of injuries and fatalities. In 2014, the Child Ag Injury Surveillance system was discontinued and NCCRAHS began to systematically gather and code publicly available news reports to fill the gap. Initially, attention was given to development and testing of basic safety guidelines for youth working in agriculture and young children living near worksites. Over time the strategies for knowledge mobilization in the farming community shifted from print media and presentations to social media and interventions based on the socio-ecological model that engaged influencers such as agricultural businesses, insurance providers, farm youth organizations, and the media.

Results: From 1997 to the present there have been notable changes in childhood agricultural injury and fatality rates, as well as variables associated with victims, agents of injury, and environmental/social factors. NCCRAHS' research and outreach initiatives increased their focus on non-working youth, parental behaviors, and effectiveness of educational interventions. Capacity building has witnessed the expansion of child safety advocates (via the Child Ag Safety Network) from a handful of interested individuals and NGOs to more than 75 organization representatives collaborating on position papers, public service announcements, and national-level campaigns on issues such as "Keep Kids Off Tractors." Persistent gaps in a national approach include acceptable strategies for select populations, e.g. Anabaptist, public policy for labor laws and child protective services and, in many situations, the "Farm Kid Paradox" that suggests benefits of youth working and living in agricultural settings outweigh any risk of injury or disease.

Conclusions: Injury and fatality data, combined with intervention evaluations have guided the focus, outputs and impacts of the NIOSH-funded childhood agricultural safety center. The numbers of serious and fatal injuries are declining, involvement of safety advocates has expanded, and public awareness of the preventability of childhood agricultural injury events has increased.

E4.2

Title: Surveillance of Medically Attended Agricultural Injuries in Farm Children

Authors: Jeffrey VanWormer, Bryan Weichelt, Katherine Barnes, Richard Berg

Background: There is no deadlier work for children and adolescents in the United Sates than farming. Despite this, relatively little is known about trends in agricultural injury risk because there is no comprehensive surveillance system for non-fatal, hospitalized, and fatal agricultural injuries. The purpose of this project is to establish a surveillance system of confirmed, medically attended agricultural injuries among children and adolescents who reside on farms in north-central Wisconsin. Multi-year epidemiologic trends in medically attended agricultural injuries, as well as population subgroups at highest risk for agricultural injury, will be estimated.

Methods: A retrospective cohort will be assembled including children and adolescents (age <18 years) who reside within a target 20-county region served by Marshfield Clinic Health System (MCHS). Specific cohort entry criteria will include: (1) residential address on an active farm within the targeted 20-county region, as evidenced by an agricultural production address listed on the state register of licensed dairy producers or a commercial vendor listing of farm residences, and (2) reasonably complete capture of their medical care within MCHS data systems, as evidenced by medically 'homed' status, member of the MCHS-affiliated health insurance plan (Security Health Plan of Wisconsin), or resident of the Marshfield Epidemiologic Study Area. The primary dependent variable will be medically attended agricultural injuries, per MCHS diagnostic codes and vital status from electronic health records, Wisconsin Trauma Care

Registry events, or Wisconsin Ambulance Runs Data System keywords indicative of an agricultural injury.

Results: A pilot demonstration of this system was created for year 2020. Farm status and MCHS patient record linkages identified 3,008 children and adolescents who resided on a known farm operation in the target population. Of these, there were 6 incident medically attended agricultural injuries during the year (estimated injury rate 2 per 1,000 farm children/adolescents). Half of all injuries were related to farm animals (e.g., cows, horses) and two were the result of play in and around farm equipment. There were no in-hospital fatalities.

Conclusions: Children and adolescents who live on farms are susceptible to serious injuries related to their environment. Future analyses will examine trends over time in incident youth farm injuries by person-year of follow-up, as well as more detailed injury, demographic, and circumstantial features to help identify the nature and changes of farm injury risks in the region. Lessons from this study will be applied to future research designed to build a model of childhood agricultural injury surveillance that can be replicated and scaled across other large healthcare systems and linked in a national surveillance network.

E4.3

Title: Agricultural Youth Work Guidelines

Authors: Andrea Swenson, Marsha Salzwedel, Cassandra Peltier, Barbara Lee

Background: The North American Guidelines for Children's Agricultural Tasks (NAGCAT) were developed between 1996–1999 as an occupational injury prevention resource for assigning agricultural work tasks to youth. A consensus-derived approach was used to develop 62 detailed NAGCAT guidelines based on the job hazard analysis framework. NAGCAT became the gold standard for children's work in agriculture and prompted several studies to validate content, dissemination strategies, and guideline efficacy. With more scientific evidence available and changes in technology influencing the types of work tasks youth performed, NAGCAT were updated and renamed Agricultural Youth Work Guidelines (AYWG; released in 2017). Recognizing the changing environment in which youth agricultural occupational injuries and fatalities occur, this presentation will describe the multi-pronged processes used for updating AYWG and the subsequent research guiding dissemination and implementation.

Methods: A 16-person steering committee comprised of representatives from various agricultural industries was formed to provide guidance on topics, practicality, relevancy to diverse audiences, and the overall design of the guidelines. Guideline topics were determined by the steering committee, content consultants created or updated job hazard analysis charts, and a child development specialist addressed developmental concerns. AYWG and associated materials on child supervision, communication, and benefits of farm work were created, translated, and posted online. Dissemination of AYWG included presentations, media kits, press releases, webinars, and trade booths. Following the creation of AYWG, several research studies were completed regarding implementation and dissemination of AYWG. One study included a needs assessment of agricultural health and safety organizations. Ninety-five organizations were asked to complete an online survey related to child agricultural injury prevention needs. A second online survey included a needs assessment of 215 agricultural educators.

Results: Fifty-two organizations completed the organizational needs assessment (55% response rate). AYWG were one of the top three resources identified as being currently used by respondents, with over half (52%) of respondents using guidelines. Organizations identified the largest need for child agricultural health and safety is promotion and dissemination of agricultural safety resources and tools. In the assessment of agricultural educators, a majority of respondents reported they typically teach animal safety (80%) as well as tool and equipment safety (63%). Only 35% of educators reported teaching tractor safety, 22% taught all-terrain vehicle/utility task vehicle safety, and 15% taught rural road safety, despite transportation incidents being a primary source of fatality. When asked where respondents find their agricultural education materials, the most common sources were through their professional network or society, shared by a colleague, and through searches on the internet.

Conclusion: AYWG are an intervention translating research into practice. AYWG were recently updated to keep pace with emerging issues in agricultural work and occupational safety. This presentation will also describe newly launched projects which address (a) youth educators' barriers and motivators for adopting AYWG into their curriculum; and (b) barriers and motivators for adopting AYWG within agricultural organizations, focusing on Latinx serving organizations. The process of updating these guidelines and the subsequent research findings offer insight into how different collaborators inform processes needed to maintain relevancy in an ever-

changing world and reach target demographics to prevent occupational injuries and fatalities.

Session F1

Occupational Injury Surveillance, Part 1

Moderator: Audrey Reichard

F1.1

Title: Time Series, Seasonality and Trend Evaluation of 6-Year (2015-2020) OSHA Severe Injury Data

Authors: Harold Gomes, Vidisha Parasram, Christina Socias-Morales, James Collins

Introduction: New regulatory requirements mandated employers to report severe work-related injuries (e.g., amputation, hospitalization) to the Occupational Safety and Health Administration (OSHA) since January 2015. This study examined the OSHA severe injury reports (SIR) to understand time-related trends and patterns in injuries, such as differences between days of the week, seasonal trends within a year, annual trend over time, and annual trends by industry and injury event.

Methods: OSHA SIR are accessible to the public on OSHA's website, www.osha.gov/severeinjury, and include injury date, latitude, longitude, 2017 North American Industry Classification System (NAICS) industry codes, and Occupational Injury and Illness Classification System (OIICS), v2.01 injury variables. This study included all injury events from Jan 2015 to Dec 2020 (72 months) including 50 states, DC and 5 territories. Time functions were employed to extract the components of date that enabled aggregation by different time units. Data were visualized using Local Polynomial Regression (LOESS) as the trendline to monthly injuries to account for the moving average. Seasonality between 12 months were evaluated. Number of daily injuries were compared by day of the week. Time Series decomposition models (classical additive and multiplicative) were employed to produce a trend of injuries over time while adjusting for seasonal effect. We compared annual trends by 2-digit NAICS and separately by 1-digit OIICS injury event.

Results: There was a total of 61,540 injuries in the 72-month study period. The number of severe injuries reported in a month ranged from 600 to 1,100 and showed seasonal fluctuations. Within an average year, severe injuries gradually decrease from January to April, increase from May to August, and then decrease again from September to December. The trend evaluation (6-year) using LOESS moving average regression suggests a slight overall increase from January 2015 to August 2018, then a decrease up until December 2020. During COVID-19 (March-December 2020), severe injuries were lower than previous years. The Time Series decomposition models indicate that a trend still exists even after adjusting for the seasonal component. The seasonality adjusted trend also indicates a gradual increase of injuries over time up until October 2018, then a substantial decrease. Daily severe injuries ranged from 2-68 per day depending on the day of the week. The mean injury reported on a weekday ranges from 30-36 and weekend 9-14. In a yearly injury trend comparison by NAICS industry, Manufacturing (2,836-3,614 per year) and Construction (1,718-1,969 per year) incurred the highest yearly number of injuries compared to other NAICS industries (< 1,000 per year). Similarly, in a yearly injury trend comparison by OIICS injury event, Contact with Objects and Equipment (4,054-5,105 per year), and Fall, Slips, Trips (2,788-3,366 per year) show substantially higher yearly injuries compared to other OIICS injury types (<1,000 per year).

Discussion: This study describes the feasibility and usefulness of SIR to describe trends in severe, work-related injuries. We found that two industry sectors, manufacturing and construction, shared the largest burden of severe injuries, and the most common injury events were Contact with Objects, and Falls, Slips, and Trips. SIR only include Federal OSHA Jurisdiction and are limited by suspected underreporting. However, the penalty was increased for not reporting a severe injury. Federal OSHA Jurisdiction includes State Plan states for specific activities, USPS nationwide, Military bases, Indian Reservations and certain maritime activities. Given the brief turnaround in SIR dissemination (about 6 months) in comparison to other national injury surveillance datasets that can take a year or more, OSHA should continue to make this underutilized dataset available for analysis to the public to improve work-related injury prevention.

F1.2

Title: Using Multiple Surveillance Systems to Understand Potential SARS-Co-V-2 Exposures Among EMS and Firefighters

Authors: Emily Haas, Alexa Furek, Katherine Yoon, Megan Casey, Susan Moore

Background: Emergency calls in some urban areas, such as New York City, have doubled during the pandemic, increasing firefighters and emergency medical service (EMS) workers' risk of occupational exposure to SARS-CoV-2 (i.e., COVID-19) (Watkins, 2020; Pilgrim et al., 2020). This increased call volume and occupational risk points to the need for examination of EMS response types

to proactively identify scenarios that may need increased resources and risk mitigation strategies. This study explores how data coding within computer-aided dispatch (CAD) systems may influence the assigned likelihood of exposure to SARS-CoV-2, identifying the need for additional data cleaning and verification at the department level to inform accurate surveillance efforts.

Methods: Through a research collaboration with the International Public Safety Data Institute and three fire departments that utilize the National Fire Operations Reporting System, the National Institute for Occupational Safety and Health received monthly, post-call surveillance data generated by department CAD systems. CAD data reports response call characteristics and public health data such as potential exposure to SARS-CoV-2. From March to September 2020, 162,766 incidents were received and labeled as EMS (64.2%), Fire (29.6%), and "other" (6.2%). Just over 8% (n=13,197) of the incidents noted potential SARS-CoV-2 exposures. Within these probable exposures, 86.2% were coded as EMS (M=.11, SD=.311), 9.9% Fire (M=.03, SD=.162), and the remaining 3.9% "other" (M=.05, SD=2.19). Researchers analyzed this data using Generalized Linear Model with binomial logistic regression in R (version 4.0.3) to understand whether SARS-CoV-2 exposure was significantly associated with response type.

Results: The regression results show that those who responded to a fire incident were 78% less likely to experience exposure to SARS-CoV-2 (66% less likely for "other" incidents) in comparison to those who responded to EMS calls, with other variables (population, state, and month) held constant. Although the initial results were not surprising, it prompted a closer examination of EMS call descriptions. Researchers coded original narratives of the 162,766 calls to understand what situations encompassed each response category, particularly EMS. A subsequent analysis added two additional variables (i.e., traffic/motor-vehicle related and hazmat) to account for common, complex situations that could fall into EMS and/or Fire. Researchers also added monthly averages of new COVID-19 cases using public data (The New York Times GitHub, 2021) to control for higher COVID-19 cases within the three cities being studied. Researchers found that having an EMS call versus a fire call increased the odds of having a potential exposure to SARS-CoV-2 by 236.4%, with all other variables (population, COVID-19 new cases, state, and month) held constant. This effect was significant at the 0.001-level for a two-tailed test (z=-44, p<.0001).

Conclusions: EMS calls had the highest predicted probability of responder SARS-CoV-2 exposure, followed by fire, other, hazmat, and auto calls (in order). However, the content analysis informed a new variable with five categories. The statistical difference in these two analyses show the high possibility of measurement error if response data is not standardized. These results show the importance of accurate data tagging including the need to update reporting systems after a response is complete to better identify high-risk scenarios to inform preparedness efforts. For example, results show responses that involve trauma or medical illness in which frontline workers may experience higher risks of occupational exposure, are at a far greater risk than those EMS calls that involve helping patients in auto accidents. The results show scenarios in which EMS workers should pay special attention to the COVID-19 guidelines available for EMS and first responders.

F1.3

Title: SOII vs. MarketScan: What Can Alternative Data Tell Us About the Seasonality of Injuries?

Author: Benjamin Raymond

Background: Previous research shows occupational injuries display a distinct seasonal pattern-- a spike in January and the summer months followed by a significant decline in November and December. It is unclear to what extent these seasonal patterns are caused by employer confusion regarding recordkeeping rules, changes in work exposure, or changes in reporting incentives for workers and firms.

Methods: The seasonality of case records from the Bureau of Labor Statistics' Survey of Occupational Injuries and Illnesses (SOII) was compared to workers' compensation data from the IBM MarketScan Research Databases. Seasonal effects were estimated using an Unobservable Components Model. The seasonal patterns of short-term disabilities claims, long-term disabilities claims, and private insurance claims from the MarketScan Research Databases were also examined for evidence of strategic seasonal substitution away from workers' compensation by workers.

Results: While the workers' compensation data and the SOII display similar qualitative patterns, the year-end decline is much more muted in the MarketScan data (1/3 to 1/2 the decline observed in the SOII). The short-term disability claims and private health insurance claims display seasonal patterns that are inversely related to the seasonality of reported occupational injuries. While these findings suggest workers may strategically substitute from workers' compensation to short-term disability claims or private health insurance claims on a seasonal basis, the

underlying mechanism driving any potential strategic considerations is unclear.

Conclusions: Part of the year-end decline is likely the result of recordkeeping error. However, workers' compensation seasonal estimates suggest some other seasonal factor is significantly contributing to the end-of-year decline in occupational injuries. The seasonality observed in short-term disability claims and private health insurance claims data suggests strategic seasonal substitution away from workers' compensation by workers may be partially driving the end-of-year decline.

Session F2

Crew Resource Management: Critical Decision Making in the Hazard Zone

Workshop Leader/Tutorial Organizer: Murrey Loflin

Crew Resource Management as an Example of a Safety Management System for Firefighting Operations

Purpose Statement: The most dangerous location for fire fighters to operate, in terms of fatalities and serious injury, is on the fireground and in the hazard zone. This session will discuss the importance of critical decision making on the fireground to improve firefighter safety. This session will show the proper use of Crew Resource Management as a practical example of an occupational health and safety management system (OHSMS), and how it can have long term results which improve the safety culture within a fire department.

Crew Resource Management (CRM) requires a commitment to change leadership and operating cultures that have evolved over generations within fire departments. The Unites States military, commercial aviation, health care, and shipping industries have adopted the concept of CRM. The similarities between the flight deck and the cab of an emergency vehicle suggest that CRM has application to the emergency services. CRM goals are to minimize the effect that human error has on operations and maximize human performance. Crews trained in CRM learn skills that enhance communication, maintain situational awareness, strengthen decision making and improve teamwork. Developing, adopting, and implementing CRM for the nation's fire and rescue service is the next logical step. This process works toward a safer, more effective fire service.

Title: Crew Resource Management: Critical Decision Making in The Hazard Zone – Humble Beginnings

Presenter: Dennis L. Rubin, Fire Chief, Upper Merion Fire Department, Upper Merion, PA

Description: Nationwide, the fire fighter's personal protective ensemble, apparatus and equipment technology, available training, safety resources, and safety standards are at the highest, safest levels ever experienced in fire service history. However, United States Fire Administration statistics reveal a ten-year plateau of more than 100 fire fighter line-of-duty deaths and approximately 10,000 serious line-of-duty injuries each year. To worsen matters, fire fighters are being injured and killed on incidents at rates close to those of 20 years ago. Case analyses show that most of these line-of-duty deaths and injuries are preventable. Clearly, the fire and rescue service must change its attitudes, beliefs, and behaviors toward safety, if fire fighter injuries and fatalities are going to be reduced. CRM aims to foster a culture where authority may be respectfully questioned. This process recognizes that a discrepancy between what is happening and what should be happening is often the first indicator that an error is occurring.

Title: Crew Resource Management: Critical Decision Making in The Hazard Zone - The Program Principals

George A. Morgan, Training Specialist, Response Section, National Fire Academy

Description: Culture is generally defined as the behaviors, attitudes, values, and beliefs that are shared within a group or organization. It reflects the collective perception of right and wrong, good, and bad, or desirable and undesirable actions and characteristics.

The safety culture within a fire department is reflected through its members' behaviors, attitudes, and actions in and out of the station as well as on the fire ground. Using CRM provides for:

- Better teamwork
- Newly acquired communication and problem-solving skills
- An operating philosophy that promotes team member input while preserving legal authority
- Proactive accident prevention.

Becoming familiar with the five factors is an essential first component:

- Communication
- Situational Awareness
- Decision Making
- Teamwork
- Barriers

Title: Crew Resource Management: Critical Decision Making in The Hazard Zone – Application in a Case Study

Presenter: Murrey Loflin, Investigator, NIOSH Fire Fighter Fatality Investigation and Prevention Program

Description: Operating in the hazard zone is categorically the most dangerous location in which firefighters operate, in terms of fatalities and serious injury. Statistics provided by the United States Fire Administration reveal a decrease in firefighter line-of-duty deaths in the past ten years, though there is still a need to concentrate on decision making in the hazard zone. Issues related to the lack of scene size-up and risk assessment; poor or inadequate incident management; inadequate communications; and standard operating procedures/standard operating guidelines or not following them have been listed as contributing factors in far too many National Institute for Occupational and Health (NIOSH) fire fighter line of duty death investigation reports. This case study will discuss the use of Crew Resource Management as a practical example of a safety management system that can have long term results which improve the safety culture of the American Fire Service.

Learning Objectives:

1. Review and discuss the principles of the proper application of Crew Resource Management.
2. Discuss how these skills are applied when operating in the hazard zone to prevent harm to firefighters.
3. Describe how the five factors that are used in the Crew Resource Management can likely prevent an injury from occurring.
4. Discuss the effectiveness of crew resource management program while firefighters are operating in the hazard zone on the fireground by using a case study.

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Session F3

Research in the Construction Industry Part 2

Moderator: Scott Earnest

The construction industry employs more than 11 million workers, is very diverse, and has significant health and safety challenges. A consortium of scientists supported by NIOSH, CPWR – The Center for Construction Research and Training (CPWR), and the NORA Construction Sector Council conduct research on existing and emerging hazards facing the industry. They target NIOSH and NORA constructions goals on persistent and emerging hazards faced by workers on the job, identify causes and solutions for safety and health risks, and test the impact of disseminating effective interventions to the industry that result in evidence-based technologies being applied and good work practices to prevent occupational injuries and illnesses. This session highlights selected research projects on a variety of topics funded by NIOSH and CPWR, through the NIOSH-supported National Construction Center.

Presentations

1. Improving Residential Construction Safety through Safety Leadership and Fall Prevention Training

Presenter: Brad Evanoff

Safety training and safety practices in residential construction, particularly by small contractors, lag those in the commercial sector. Improving safety leadership skills of foremen is a critical step to reducing falls and other injuries. We adapted the successful Foundations for Safety Leadership (FSL) program to create the FSL4Res, a

version specific to the unique hazards and organizational challenges of residential construction. This presentation will discuss findings from a needs assessment that informed new trainer guides and three new video scenarios based on fall prevention in residential construction. We plan to disseminate these new training resources and track their reach and uptake.

2. Development of a Mast Climbing Work Platform Visual Inspection Tool

Presenter: Bryan Wimer

Mast Climbing Work Platforms, or mast climbers, are an alternative to traditional tube and coupler scaffolding. They consist of a power-driven working platform affixed to a structure allowing workers to reach multiple heights to complete various construction tasks. Mast climber incidents occur due to several factors including: improper or lack of worker training, anchoring, platform working conditions, guarding, and failure to follow manufacturer's recommended guidelines for assembly/disassembly. A key safety practice that can help prevent safety hazards is to complete a daily inspection of the equipment before use. This presentation highlights an online visual inspection walk through tool that was developed by NIOSH researchers. It allows potential users to do a virtual based daily inspection and presents safety items and hazards they should be aware of during the inspection process.

3. Highlights from the CPWR Small Studies Program and Future Priorities and Opportunities

Presenter: Rick Rinehart

CPWR has funded 30 one-year research projects from 2016 to the present, with several ongoing. This presentation will highlight selected findings and outputs from these projects, discuss current priority areas and opportunities for future funding.

F3.1

Title: Improving Residential Construction Safety Through Safety Leadership and Fall Prevention Training

Authors: Bradley Evanoff, Ann Marie Dale, Barry Stelzer, Anna Kinghorn, Linda Goldenhar

Introduction: Safety training and safety practices in residential construction, particularly in small contractors, lag behind those in the commercial sector. Residential foremen lead both safety and production on their sites and are critical to improving safety practices; improving the safety leadership skills of foremen is a critical step to reducing falls and other injuries. We adapted the existing, successful Foundations for Safety Leadership (FSL) program to create the FSL4Res, a version specific to the unique hazards and organizational challenges of residential construction.

Methods: The existing FSL was created by the Center for Construction Research and Training (CPWR) and uses animated scenarios and interactive discussion to teach six key safety leadership skills (Leading by example, Engages and empowers team members, Actively listens, Practices three-way communication, Develops team members, Recognizes team members for a job well-done). The FSL emphasizes the use of these safety leadership skills to promote safe behaviors, improve safety outcomes, and improve safety climate and culture on the job site. To develop a version of the FSL program that addresses the unique needs of foremen in residential construction, we conducted a systematic needs assessment to identify national and regional training needs, and to understand contractor capabilities and the learning preferences of construction foremen. Following the needs assessment, we convened a Curriculum Development Team of academics and industry experts to make adaptations to the FSL. We used a formal adaptation framework to describe modifications to the original FSL, including content modifications, contextual modifications, and organizational levels at which modifications occurred.

Results: 47 construction stakeholders participated in the needs assessment. Findings showed that the existing FSL was an effective training program and was well regarded by union-based and contractor-based trainers and safety professionals. The FSL was more widely used in commercial construction than in the residential sector. Other findings from the needs assessment suggested specific adaptations to the FSL to increase its reach (Have you heard about it?) and uptake (Have you used it?) into the residential sector. Suggested content modifications included the development of new teaching scenarios that focused on fall prevention and were specific to the residential construction setting, and the development of brief trainer guides for existing FSL scenarios that described situations commonly found in residential construction. Suggested contextual modifications included altering delivery format to allow multiple shorter training sessions instead of a single 2.5-3 hour session. Organizational modifications were suggested to expand the number of trainers who could deliver the FSL4Res, and to ensure that videos and other materials were suitable for shorter trainings at the worksite as well as in classroom or formal course settings.

Discussion: Based on findings from the needs assessment, we have created three new scenarios based on fall prevention in residential construction. We have also developed trainer guides and have begun to work with

CPWR and national contractor associations to publicize and disseminate the FSL4Res. Future work will include surveying and interviewing residential construction contractors to evaluate the reach and uptake of the FSL4Res, and to identify barriers to increasing reach and uptake.

F3.2

Title: Development of a Mast Climbing Work Platform Visual Inspection Tool

Authors: Bryan Wimer, Brianna Eiter, Christopher Pan, Timothy Orr

Background: Mast Climbing Work Platforms, or mast climbers, are an alternative to traditional tube and coupler scaffolding. They consist of a power-driven working platform affixed to a structure allowing workers to reach multiple heights to complete various construction tasks while offering higher productivity and cost savings over traditional equipment. Concerns by manufacturers, construction officials, and construction/safety groups have been raised that an increased exposure to serious or fatal incidents could be present as the use of mast climbers is on the rise. According to CPWR, there were 1,533 fatal falls in construction between 2011 and 2015, with approximately 33% from roofs, 24% from ladders, and 15% from scaffolding. Several mast climber incidents, such as a collapse in March 2015 in Raleigh, North Carolina, resulted in three worker fatalities and one serious injury making up part of the 15% of falls from scaffolding resulting in fatalities. Mast climber incidents occur due to several factors including: improper or lack of worker training, anchoring, platform working conditions, guarding, and failure to follow manufacturer's recommended guidelines for assembly/disassembly. A key safety practice that can help prevent safety hazards is to complete a daily inspection of the equipment before use. During these inspections, many of the hazards present can easily be identified by those familiar and trained to set-up and use the equipment.

Methods: An online visual inspection tool has been developed utilizing both current and previous research where NIOSH addressed engineering and design considerations of mast climbers. Newer online training tools and emergent technology, such as virtual reality simulations, are more limited for mast climbers than for other similar types of equipment such as aerial lifts. This visual inspection tool helps guide potential users through a daily inspection of a mast climber from the ground up. The walkthrough tool is housed on the NIOSH website and includes images of a typical mast climber set up with highlighted areas that the user can click on to complete the daily inspection process. Best practices from manufacturers are included with each highlighted area along with potential hazards that can occur if identified areas are not properly inspected and safety requirements ignored. Relevant OSHA related standards are also presented when applicable.

Discussion: Based on feedback amongst end users, manufacturers, trade groups, and industry standard committees an additional need was also identified. Specifically, end users requested the mast climber tool be made available in Spanish as a significant portion of the construction workforce are Spanish speaking comprise approximately 30% of those who use mast climbers. Of those Hispanic workers, about 40% of reported that they cannot speak English very well, and 21% reported they cannot speak English at all, respectively. Therefore, the walkthrough tool was translated to Spanish to help reduce written/verbal language barriers. Both language versions are readily available and can be toggled between and repeated as needed on the NIOSH Mast Climber website.

F3.3

Title: Highlights from the CPWR Small Studies Program and Future Priorities and Opportunities

Authors: Richard Rinehart, Patricia Quinn

Background/Introduction: Construction is a complex and highly hazardous industry with one of the highest rates of work-related acute traumatic injury in the U.S. Every day, millions of construction workers are employed on worksites in all types of different settings across the country. Each worksite and type of construction (e.g., residential, highway) involves distinct variables, including type of work performed (e.g., electrical, plumbing), number of employers and employees, project designs, materials and products used, and diverse working conditions. CPWR – The Center for Construction Research and Training (CPWR), which serves as the NIOSH-funded National Center for Construction Safety and Health Research and Translation, brings together researchers and industry stakeholders to conduct research on construction health and safety hazards and ways to communicate and mitigate the risks. This presentation will provide an overview of the CPWR Small Studies Program, highlight research findings on topics related to preventing acute traumatic injuries, show where to find study reports on the web, and introduce upcoming research priorities and opportunities for the audience.

Methods: In 1993, CPWR established the Small Study Program to conduct and pilot hypothesis-generating research and attract new investigators into the field of construction health and safety research. This groundbreaking program continues to provide selected researchers with seed money of up to $30,000 and flexibility to initiate short-term studies up to 12 months. The research can investigate and assess the potential risks from emerging hazards and changes taking place in the construction industry, explore new approaches for addressing persistent hazards, target high-risk populations such as small employers, vulnerable workers, residential and light commercial construction firms. Studies often engage stakeholders, through partnerships and other means, to better understand the barriers to and motivators for adoption of best practices, address emerging issues and explore new technologies, evaluate promising research translation products and dissemination strategies, and/or create and test other promising methods and interventions to improve construction worker health and safety. Many major construction research projects began with a CPWR-funded small study.

Results/Findings: To date, approximately $3.75 million has been awarded to fund 127 small studies, 30 of which have been from 2016 to the present. The Small Study Program gives preference to studies that respond to industry-driven priorities, including NIOSH strategic goals, the National Occupational Research Agenda (NORA) for Construction, and more recently the 2018 NIOSH Construction Program Expert Panel Report recommendations. Results are communicated to research scientists and industry stakeholders through published reports posted on CPWR's Small Study Program webpages, peer reviewed journal articles (more than 60% of investigators have published articles on their findings), researchers' dissemination outlets, and products and outreach activities from CPWR's research to practice (r2p) and communications programs. Recent studies have addressed a broad range of hazards and potential solutions, including prevention through design (PtD), workforce sustainability, safety training, ergonomics, the effects of policy on safety, r2p approaches, and other promising interventions to prevent occupational illnesses and injuries.

Discussion/Conclusions: These small studies generate stand-alone findings, innovative approaches, and pilot data which not only contribute to the body of scientific research on construction health and safety, but also provide new insights into emerging hazards, new technologies, potential solutions, and can also identify future research needs.

Session F4

All-Terrain Vehicles Safety in Agriculture

Moderator: Christine Schuler

F4.1

Title: ATV Safety Design Features: Examining Cultural Awareness and Piloting an Educational Program Among U.S. Young Adults in Agriculture

Authors: Jenna Gibbs, Carolyn Sheridan, Aaron Yoder

Previous survey results from >800 Midwestern young adults in agriculture show that 56% have rolled an ATV, yet 76% report allowing extra riders and only 18% report wearing helmets when operating the device. Evaluation results from our previous programs indicated only small changes in behavior with regards to allowance of extra riders and helmet-use following the program. We developed a new ATV safety curriculum focused initially on engineering controls and safety features that can be highlighted at the point of purchase. This included a motion graphic to highlight engineering controls such as crush protection and other safety design features. The new program was delivered to 276 young adult participants in the U.S. in 2020-21. Participants were asked about awareness of specific ATV engineering features in a pre-survey. Higher proportions reported they were aware of windshields (78%), roll cages (69%), and safety flags (55%). Lower proportions were aware of dual wheel systems (35%), 55-inch-wide frames (26%), crush protection devices (21%), stability ratings (19%), GPS rollover alarms (17%), and Original Equipment Manufacturer (OEM) Approved Accessories (16%). Participants were asked if they would consider using any of the engineering controls that were discussed. Although many stated that they were "somewhat likely" to consider more engineering controls, the safety features they mentioned in a feedback section included windshields, roll bars, and OEM approved accessories. Following the program, about a quarter (26%) of participants indicated that they were also "somewhat likely" to consider using a Crush Protection Device in the post-survey. The findings of this study are important for continued development of young adult ATV safety programs in agriculture. Our goal is that young adults to consider some of these safety features when purchasing their first ATV or ATV-related accessories after graduation.

Following this presentation, participants will be able to: 1. Participants will understand how the NIOSH hierarchy of controls can be applied to ATV Safety Training, and how engineering controls are an important component of such a program. 2. Participants will be able to list and describe 8 ATV engineering controls that may be considered at point of purchase. 3. Participants will learn how to consider some of these safety design features when considering purchase of a new ATV for the farm. 4. Participants will gain knowledge with regards to young adult's knowledge and awareness of ATV safety controls and how to engage with young adults about this topic.

F4.2

Title: Protecting Farmworkers in Agricultural All-Terrain Vehicle Rollover Incidents

Author: Farzaneh Khorsandi

Agriculture is one of the most dangerous industries in the United States. The ATV death rate is reportedly 100 times higher in the agriculture industry than in other U.S. industries. Rollover incidents constitute about 85% of ATV incidents in the agricultural industry. There is no practical solution to protect the operator in ATV rollover incidents in the United Sates. A Crush Protection Device (CPD) can potentially protect the operator in low-speed rollover incidents, such as the majority of agricultural ATV incidents. CPD has been designed and commercially produced in Australia. The CPD protects the operator by providing a Crush Protection Zone (CPZ) under the overturned vehicle. In this study, several operational and safety evaluation criteria for ATVs equipped with CPDs were determined based on results of previous studies. In addition, we evaluated some of the safety and operation criteria for three designs of CPD (Quadbar, Lifeguard, and AR-Quad) installed on 13 models of ATVs. Results showed that the installation of a CPD increased the CPZ volume compared to the baseline ATV. Increasing the CPD volume can potentially improve the operator protection in the event of a rollover accident. The AR-Quad, Quadbar, and Lifeguard increase the rear CPZ volume with an average of 0.48 m3 (111% increase), 0.39 m3 (92% increase), and 0.15 m3 (35% increase), respectively, compared to the average CPZ of a baseline ATV which is 0.44 m3. Also, a CPD can potentially protects the operator by increasing the distance between the seat point and the ground surface during a rollover accident.

F4.3

Title: Evaluating Youths' Capability to Ride Agricultural All-Terrain Vehicles Using Computer Simulations

Authors: Guilherme de Moura Araujo, Farzaneh Khorsandi, Fadi Fathallah

All-Terrain Vehicles (ATVs) cause a distressing number of fatalities and injuries among children in rural communities in the U.S. From 2003 to 2010, the number of fatalities involving workers younger than 16 years old was consistently higher in agriculture than in all other industries combined. ATVs are one of the most frequent sources of incidents among youths in agriculture. For instance, since 2020, 20 children have lost their lives, and 23 have been severely injured due to ATV-related incidents on U.S. farms. A number of studies demonstrated that youths are more vulnerable to injuries than adults because of their less developed physical, cognitive, and behavioral characteristics. Thus, it is hypothesized that youths are frequently involved in ATV incidents because of limitations in their physical capabilities, such as their anthropometric measures. There is a need to evaluate potential inconsistencies between youths' anthropometry and the design characteristics of utility ATVs, commonly used to perform tasks in agricultural settings. This study aimed at evaluating potential inconsistencies between the operational requirements of utility ATVs and the anthropometric measures of youths through computer simulations. A numerical computing software (Matlab) was used to evaluate four youth-ATV fit criteria proposed by an ATV safety advocacy organization (National 4-H council). The selected criteria include evaluations about: 1) The distance between the handlebar and rider's knee; 2) Rider's hand size compared to ATV handlebar reach; 3) Relationship between the ATV brake pedal and the placement of the rider's foot on the footrests; and 4) The rider's ability to reach the ATV's footrest. In total, 29 utility ATVs and children of two genders (males and females), three different ages (8, 12, and 16 years old), and three body-size percentiles (5th, 50th, and 95th) were evaluated. Preliminary results demonstrated a physical mismatch between utility ATV operational requirements and anthropometric measures of children. The simulations involving male children under the age of 9 indicated that they could not properly reach the footrests of the evaluated ATVs. The results were even more striking for the simulations with females as a considerable percentage of the ATVs (38%) have a handlebar reach larger than the hand size of females 14-year-old and younger. The incompatibility between the riders' hand size and the handlebar reach compromises riders' ability to properly activate the handbrakes and thus control the vehicle. Such discrepancies compromise youths' capability to operate utility ATVs, increasing their risk of injuries.

Session G1

Occupational Injury Surveillance, Part 2

Moderator: Kitty Hendricks

G1.1

Title: A Time Series Analysis of Nonfatal Occupational Injuries Treated in United States Emergency Departments from 2012 to 2019

Authors: Eric Lundstrom, Scott Hendricks, Suzanne Marsh, Caroline P. Groth, Gordon Smith, Ruchi Bhandari

Background: Occupational injuries represent a significant source of morbidity in the United States. Despite this, time series analyses of nonfatal workplace injuries in the United States have been scarce in recent years. As temporal analyses of public health issues are critical for interpreting the impacts of targeted interventions and identifying emerging issues, this is an obvious gap within current occupational injury literature. Thus, the objective of this study was to analyze rates of nonfatal occupational injuries treated in United States emergency departments (EDs) from 2012 to 2019 using a time series approach.

Methods: Nonfatal occupational injury estimates from 2012 to 2019 were generated using the National Emergency Injury Surveillance System - Occupational Supplement (NEISS-Work) dataset, a nationally stratified probability sample of hospital EDs. Injury rates per 10,000 full-time equivalents (FTE) were calculated using the Bureau of Labor Statistics' Current Population Survey. Autoregressive Integrated Moving Average (ARIMA) modeling was used to analyze trends in monthly nonfatal injury rate estimates throughout the study period. Trends were assessed for the overall estimated injury rate and for injury rates by injury event type.

Results: An estimated 20,519,800 (95% CI = ±3,671,700) nonfatal occupational injuries were treated in United States EDs from 2012 to 2019; the rate of injuries treated during this time was estimated to be 180 (95% CI = ±31) per 10,000 FTE. Injury event types treated at the highest rates during this time included contact with foreign objects and equipment (59; 95% CI = ±11); overexertion and bodily reactions (49; 95% CI = ±11); falls, slips, and trips (28; 95% CI = ±4.9); exposure to harmful substances or environments (18; 95% CI = ±3.9); and violence and other injuries by persons or animals (16; 95% CI = ±3.5). A decreasing linear trend in monthly occupational injury rates from 2017 to 2019 was detected via visual inspection and found to be statistically significant ($p = 0.002$). Significant linear decreases were observed from 2017 to 2019 for the estimated rate of injuries caused by falls, slips, and trips ($p < 0.001$); overexertion and bodily reaction ($p < 0.001$); exposure to harmful substances or environments ($p = 0.010$); transportation incidents ($p = 0.012$); contact with foreign objects and equipment ($p = 0.044$); and violence and other injuries by persons or animals ($p = 0.046$).

Discussion: These results demonstrate a significant, decreasing linear trend in the monthly rate of ED-treated occupational injuries from 2017 through 2019. A decreasing linear trend was also significant for injuries caused by falls, slips, and trips; overexertion and bodily reaction; exposure to harmful substances or environments; transportation incidents; contact with foreign objects and equipment; and violence and other injuries by persons or animals. Injuries caused by contact with foreign objects and equipment, and overexertion and bodily reactions, occurred at the highest rate across all time periods. While rates of injuries have decreased significantly in more recent years, nonfatal occupational injuries continue to be a serious public health problem.

G1.2

Title: Surveillance of Acute Nonfatal Occupational Inhalation Injuries Treated in U.S. Hospital Emergency Departments, 2014-2017

Authors: Kitty Hendricks, Larry Layne, Patricia Schleiff, Angela Javurek

Introduction: Acute nonfatal occupational inhalation injuries are caused by exposures to airborne toxicants and contaminants in the workplace. They can damage the respiratory system and affect other body systems. Currently, there is no nationwide occupational health surveillance system that captures injuries resulting from exposures to airborne toxicants and contaminants. Efforts to identify these injuries have included the use of medical records, including those from poison control centers, physician reports, and hospital emergency departments (EDs). A study conducted in the 1990s found that U.S. ED treated inhalation injury rates, when compared to physician-reported rates in the United Kingdom and Canada, were significantly higher. The current study examines four years of recent hospital ED data nearly two decades later.

Methods: Data from the National Electronic Injury Surveillance System Occupational Supplement (NEISS-Work), a nationally stratified probability sample of hospital EDs, were used to identify nonfatal civilian occupational inhalation injuries treated in U.S. hospital EDs from 2014–2017. A workplace inhalation injury was defined as any worker who sought treatment in a hospital

ED as a result of inhaling a harmful substance from chemical, mineral, or organic sources at work. Due to the lack of a coding structure that would identify all inhalation cases, a three-step process was used to identify cases. First, cases were selected if they were coded with the Occupational Injury and Illness Classification System event/exposure code Inhalation of Harmful Substance '552'; second, all cases with the nature of injury coded as Anoxia '65' were manually reviewed by researchers; and third, a keyword search was performed on the narrative comment field of all remaining cases.

Results: From 2014 through 2017, an estimated 125,600 (95% CI: 92,100–159,000) acute nonfatal occupational inhalation injury cases were treated in EDs, with an overall rate of 2.2 injuries per 10,000 full-time equivalents (FTE) (95% CI: 1.6–2.8). Firefighters comprised 6% (7,800; 95% CI: 5,000–10,600) of the total. Although males incurred 60% (95% CI: 56-64%) of the injuries, the overall injury rates for males and females were similar at 2.3 (95% CI: 1.7–2.9) and 2.1 (95% CI: 1.4–2.7) per 10,000 FTE, respectively. By age group, workers less than 25 years of age were at greater risk of injury at 4.1 injuries per 10,000 FTE (95% CI: 2.8–5.3); this pattern held for both sexes. Thirty-five percent of injuries occurred in the service industry (43,800; 95% CI: 27,300-60,300), with females accounting for 61% (26,800; 95% CI: 16,200-37,500) of service injuries; followed by manufacturing (16,900; 95% CI: 10,500-23,300) and public administration (16,200; 95% CI: 11,600-20,800), each with greater proportions of males (11,300 [95% CI: 6,900-15,700] and 13,600 [95% CI: 9,500-17,700], respectively). Overall, the highest proportion of inhalation injuries (excluding firefighters) was due to chemical exposures (89,000; 95% CI: 65,800-112,200). Injuries related to chlorine and chlorine compounds were more common among females (5,100; 95% CI: 1,900-8,400), while injuries related to carbon monoxide (11,800; 95% CI: 7,600-15,900) exposure were most prevalent for males.

Conclusions: These results illustrate the burden of nonfatal occupational inhalation injuries and provide an understanding of how injuries are distributed based on age and sex. While inhalation injury rates have declined 39% over the last two decades, they continue to be a serious occupational hazard that is likely underreported. The inclusion of industry and occupation coding on electronic health records would allow for a more comprehensive examination of the etiology of inhalation injuries, as well as provide the information necessary to develop targeted prevention efforts.

G1.3

Title: Severe Injuries in the Oil and Gas Industry: An Analysis of OSHA's Severe Injury Reporting System from 2015-2020

Authors: Vidisha Parasram, Harold Gomes, Christina Socias-Morales, James Collins, Audrey Reichard

Introduction: Work-related severe injuries occur across all industries. The Bureau of Labor Statistics (BLS) reports, in 2019, US-private Oil and Gas industry recorded 1,840 lost workday injuries and illnesses. A 2014 study noted the lack of research into non-fatal occupational injuries in this sector. The Occupational Safety and Health Administration's (OSHA) Severe Injury Report (SIR) database allows for in-depth analysis of risk factors to understand the occurrence of severe injuries in this sector. OSHA defines a severe injury as an in-patient hospitalization, amputation or loss of an eye. This study used SIR to describe occupational injuries and guide prevention efforts in the Oil and Gas sector.

Methods: We analyzed the SIR data that are publicly available on OSHA's website. SIR contains incidents reported to OSHA under a 2015 reporting rule (29 CFR 1904.39). Industries were stratified using 2, 5 and 6-digit North American Industry Classification System (NAICS) and analyzed by BLS Occupational Injury and Illness Classification System (OIICS) nature of injury, body part, event, and source codes. A subset database was created of NAICS codes describing the Oil and Gas Industry (NAICS 213112- Support Activities for Oil and Gas Operations and 213111-Drilling Oil and Gas Wells, and 2111-Oil and Gas Extraction) to further access meaningful insights into severe injury occurrence.

Results: The SIR data recorded 61,540 severe injuries from 2015-2020 and the Oil and Gas Industry experienced the largest number of these events, (N=1,701, 3%), closely followed by the General Medical and Surgical Hospitals, NAICS 622110 (N= 1,427, 2%) sector. Within the Oil and Gas Industry, Support Activities (NAICS 213112) accounted for 1,279 (2%) injuries, Drilling (NAICS 213111) 417 (.7%) injuries and Extraction (NAICS 2111) accounted for 1 injury. The number of reports fluctuated from 2015 (N=295, 2016: N=218, 2017: N=350, 2018: N=369, 2019: N=334) to a notable decrease in 2020 (N=135) likely due to the COVID-19 pandemic. The subset oil and gas database show 20% (N=342) of injuries involved oil drilling rigs and machinery but a majority included a variety of other equipment (pipes, ducts, tubing (N=88, 5%), machine and appliance parts, (N=55, 3%), heat-environmental (N=48, 3%), hoses (N=35, 2.06%) and metal pipes, tubing (N=35, 2%)). Approximately 6% of events involved equipment that was

unclassified. Amputations accounted for 29% (N=491) and fractures occurred in 28% (N=481) of severe injuries. Approximately 32% (N=547) involved fingers or fingernails (N=218, 13%), fingertips (N=201, 12%) or fingernails unspecified (N=128, 8%). Severe injuries tended to occur most frequently in January (N=180, 11%), July (N=174, 10%) and September (N=157, 9%) and on Tuesdays (N=313, 18%), Wednesdays (N=292, 17%) and Thursdays (N=279, 16%).

Discussion: The OSHA SIR data are subject to significant underreporting. However, it is useful in that it expands on the understanding of non-fatal occupational injuries in the oil and gas sector and other industries by providing detailed insights into the source of the injury, body part affected and when injuries occur. These results can guide the development of strategic interventions addressing work arrangement issues and injury prevention in the oil and gas sector and can make valuable contributions to measure risk and assess potential gains to reduce such events. These data also provide opportunities to track changes in occupational injury trends moving forward.

Session G2

Ergonomics and Musculoskeletal Disorders

Moderator: Bradley Evanoff

G2.1

Title: Use of a Job Exposure Matrix to Study Both Recent and Past Work Exposures on the Incidence of Carpal Tunnel Release Surgery in the CONSTANCES Cohort

Authors: Bradley Evanoff, Alexis Descatha, Ann Marie Dale, Ryan Colvin

Introduction: Most studies of Carpal Tunnel Syndrome have examined only current workplace exposures as risk factors. We examined the effects of both recent and past work exposures on the incidence of surgery for carpal tunnel release (CTR).

Methods: Participants in a large prospective French general population study (CONSTANCES) were surveyed between 2012 and 2017. The survey included self-reported history of current and past jobs, allowing estimation of past and current workplace physical exposures using an existing job exposure matrix (JEM). CTR cases were ascertained through matching the surveys to national health insurance data for the 8-year period 2009-2016. Analyses were restricted to workers with some period of full-time work in 1999 or later. Poisson regression analyses (controlling for age, Body Mass Index (BMI), and sex) computed the relative risks (RR) of future CTR associated with different work exposures. Eleven exposures including physical force, repetition, posture, and keyboard use were categorized into quartiles, with the top quartile referenced on lower quartiles. Models included different time periods of exposure and/or different exposure lag times.

Results: 777 cases of CTR were observed among the 56,289 person cohort. Those with CTR were more likely to be female, older, and to have a higher BMI. In both men and women, each of the 11 exposures was significantly associated with the incidence of CTR. In the cohort as a whole, RR of CTR per 5 years of exposure in the upper quartile included 1.19[1.13-1.25] for pressing with the base of the hand, 1.17[1.12-1.23] for use of vibrating tools, 1.17 [1.12-1.22] for rotation of the forearm, and 0.88[0.84-0.91] for keyboard use. Women showed larger effect sizes than men for some exposures, including repetition, use of vibrating tools, and pressing with the base of the hand. Higher effect sizes were seen among current workers than among those who had not worked in 5 or more years. Lagging exposures by 3 and 5 years reduced the strengths of association.

Discussion: Use of a JEM in a large general population cohort allowed us to study the effects of work exposures on the incidence of carpal tunnel syndrome. While more recent exposures had stronger associations with CTR, some past exposures were also associated with future risk of CTR. Cumulative exposure to ten of eleven upper extremity physical exposures were associated with increased risk of CTR. Consistent with previous general population studies, duration of keyboard use was protective for CTR (and negatively associated with other exposures). Use of a population specific JEM allowed unbiased estimation of past exposures at the level of the job, and study of past exposures as well as current. The ability to estimate past exposures is even more important in the study of other musculoskeletal disorders such as osteoarthritis and degenerative tendon disorders, which develop over many years.

G2.2

Title: Iterative Design of Novel Aerosol Containment Hood Using Ergonomic Assessment

Authors: Katrina Cernucan, Erik Steenburgh, Andrew Merryweather, Rachael Jones

Introduction: The COVID-19 pandemic has been a dynamic situation resulting in rushed innovation and emergency measures implemented in hospital environments. One such measure is the use of aerosol containment hoods to protect healthcare providers

against COVID-19 exposure. Many of these devices were constructed with little research on their ergonomics. The goal of ergonomics is to provide more efficient and error-free interactions between a human and the environment. A poorly designed device can interfere with physician performance, potentially putting the patient at risk. To maximize patient and provider safety, our aim was to perform an ergonomic assessment of the U-Cover, an aerosol containment hood designed at the University of Utah. We report the results from a 3D motion analysis study during simulated intubation using the U-Cover.

Methods: We recruited seven physicians with experience performing intubations. Each participant signed an informed consent document approved by the University of Utah IRB (#00137408) and performed an intubation procedure. This was selected due to the time-sensitivity and the large space required. The procedure was performed with and without the U-Cover. A 12-camera motion capture system and Motive Body (NaturalPoint, OR) were used to collect subject 3D coordinates with a Conventional Upper Body Biomechanical passive markerset. Biomechanical modeling was performed in Visual3D (C-motion Inc, MD) to calculate procedure time and torso and neck angles. The data were filtered to only contain data points within 10 centimeters of the hood volume. 2D density plots, 95% confidence interval ellipses, and task durations were determined for all data points. To assess ergonomics, torso and neck angles were calculated and averaged for all trials. Statistical analyses were performed in R 4.0.3.

Results: In the hooded trials, the change in the range of 95% of the position data of the endotracheal tube increased along the y-axis and decreased along the z-axis, (y-axis: +43%, z-axis: -15%). The physician is limited in their vertical motion and must use more of the horizontal space to complete the procedure. The mobility of each hand in the frontal plane was reduced in hooded trials compared to non-hooded trials. Changes in the range of 95% of the position data for the wrist showed a reduction in mobility in the frontal plane (Left Wrist: x-axis: -45%, z-axis: -30%. Right Wrist: x-axis: -55%, y-axis: -41%). The average time to complete the procedure was significantly longer in hooded trials than non-hooded trials ($p < 0.001$). No significant differences were seen in mean torso angles and their corresponding standard deviations across hooded and non-hooded trials for flexion-extension ($\bar{x}$: $p = 0.804$, σ: $p = 0.521$) and lateral flexion ($\bar{x}$: $p = 0.279$, σ: $p = 0.861$). No significant differences were found between hooded and non-hooded trials for the mean neck angle and its standard deviations in flexion-extension ($\bar{x}$: $p = 0.812$, σ: $p = 0.491$) and lateral flexion ($\bar{x}$: $p = 0.243$, σ: $p = 0.278$).

Discussion: The use of the U-Cover caused deviations in hand and endotracheal tube movements from the original procedure. Due to the longer duration of the procedure, the physician could be exposed to viral aerosols since the access ports are open during this time, and the patient will endure more time without oxygenation. For the next design iteration, 95% ellipses and density plots were used to modify the hood dimensions to better accommodate intubations. The neck and torso angles indicate there were only minor postural changes during the procedure, suggesting the initial U-Cover design did not significantly alter neck and torso posture. In the original design, the access ports were placed directly next to the aluminum frame, which limited the range of motion of the hands. In the next design phase, the frame will be moved away from the critical access points to enable more efficient patient interactions.

G2.3

Title: Occupational Demands Associated from a Novel Linkage of a Job-Exposure Matrix to the U.K. Biobank

Authors: Elizabeth Yanik, Jay Keener, Martin Stevens, Karen Walker-Bone, Ann Marie Dale, Graham Colditz, Rick Wright, Nancy Saccone, Nitin Jain, Bradley Evanoff

Introduction: Physically demanding occupations, particularly those with great upper extremity demands, may increase risk of rotator cuff disease (RCD) and need for surgical treatment. To investigate this, we linked a job-exposure matrix (JEM) to the UK Biobank to measure physical occupational exposures and estimate associations with incident RCD surgery.

Methods: In the UK Biobank, current job titles and UK Standard Occupational Classification (SOC) codes were recorded during a verbal interview at the baseline visit for UK Biobank participants. Lifetime job histories were captured through a web-based survey. UK SOC codes were linked to US SOC codes enabling use of a JEM based on the US O*NET database. O*NET-based scores for physical demands (static strength, dynamic strength, general physical activities, handling/moving objects (each range=1-7), time spent using hands, whole body vibration, and cramped/awkward positions (each range=1-5)) were assigned to jobs via US SOC codes. Incident RCD surgery cases were identified through linked national hospital episode statistics inpatient records. Cox regression was used to calculate hazard ratios (HRs) as estimates of associations with RCD surgery, accounting for confounders. Among those with lifetime job histories, associations were estimated in relation to duration of time with greatest exposure (above

cut-offs identifying approximately the top quartile of exposure).

Results: We included 277,808 UK Biobank participants providing a current job title and reporting no chronic shoulder/neck pain at baseline. In this population, 1,345 (0.5%) people had a subsequent inpatient RCD surgery. After adjusting for age, sex, race, education, Townsend deprivation index, and body mass index, all O*NET variables considered were associated with risk of RCD surgery, including static strength (HR per point increase=1.13, 95%CI=1.09-1.18), dynamic strength (HR=1.20, 95%CI=1.13-1.28), general physical activities (HR=1.16, 95%CI=1.12-1.21), handling/moving objects (HR=1.12, 95%CI=1.08-1.16), time spent using hands (HR=1.10, 95%CI=1.04-1.17), whole body vibration (HR=1.45, 95%CI=1.30-1.61), and cramped/awkward positions (HR=1.25, 95%CI=1.16-1.33). More frequent exposure to heavy physical work self-reported in the UK Biobank verbal interview was also associated with RCD surgery (HR for 'Always' vs. 'Never/rarely'=2.12; 95%CI=1.79-2.50). Lifetime job histories were available for 100,929 people, in which greater exposures were significantly associated with RCD surgery after more than 10 years of work (Ex. For dynamic strength score≥2 the HR for 11-20 years vs. 0 years=1.91, 95%CI=1.35-2.71, while HR for 1-10 years vs 0 years=1.08, 95%CI=0.83-1.40).

Conclusion: Many different occupational physical exposures measured through a JEM were associated with incident RCD surgery. Associations were strongest in workers with more than a decade of greater exposure, highlighting the importance of cumulative exposure. Occupation should be recognized as an important contributor to the development of RCD, including atraumatic RCD which likely accounted for the vast majority of our cases.

Session G3

Efforts to Document and Address the Risk of Fatigue in the Agriculture, Forestry and Fishing Sector

Moderator: David Douphrate

Emerging Issue Problem and Session Description: The Agriculture, Forestry, and Fishing (AgFF) industry is often characterized as dangerous work in a dynamic environment that takes focus, good judgement, and often quick reflexes. AgFF workers average longer hours worked per week than those in other industries and may work 16 hours or more per shift during peak harvest periods. AgFF workers consistently have the highest fatality rate of any sector, while also experiencing high rates of non-fatal injury and illness. However, many federal and state OSH regulations have specific exemptions for AgFF work. Extended work hours, shift work, sleep deprivation, and fatigue have been described as a "significant safety issue" and a "cultural norm" within the sector, but little research or interventions have been developed for AgFF work settings.

However, addressing fatigue in AgFF using traditional approaches can be challenging. Several work organizational factors culturally and economically incentivize extended shifts and minimal staffing. Moreover, AgFF workers are older, less likely to have health insurance or paid leave, and live in rural and remote areas. Access to labor is also a factor in extended shifts, and the COVID-19 pandemic may have exacerbated ongoing labor shortages, especially in Agriculture which increasingly relies on H2A Visa workers. However, there is also no universally accepted objective measure of fatigue, and limited research has developed objective strategies to identify fatigue onset, quantified the extent to which fatigue contributes to adverse health outcomes or performance decrement, or developed work organization recommendations to mitigate fatigue in the sector.

This session will begin by exploring the unique socio-ecological contexts of AgFF work, which often makes current sleep hygiene best practices incompatible with the realities of work within the sector. Then the current state of shift work and fatigue research in AgFF will be discussed, highlighting new research projects, followed by a panel discussion of possible approaches for addressing current gaps in AgFF sleep and fatigue research and interventions.

Working Hours, Sleep, and Fatigue Across the Agriculture, Forestry, and Fishing Sector: The Current State of the Science

Presenters: KC Elliott, NIOSH Office of Agriculture Safety and Health, and Jeff Levin, University of Texas Health Science Center at Tyler

Agriculture, forestry, and fishing industry (AgFF) workers often work extremely long hours during peak production seasons, resulting in sleep deprivation and fatigue. We conducted a scoping literature review to examine the extent and nature of research in this area. Article inclusion criteria included peer-reviewed journal articles written in English; published after 1989; covering AgFF workers in high-income countries; with data on working hours/schedules and sleep related to safety and health. Limited research has addressed long hours and sleep deprivation among AgFF workers. We identified 8,350 articles for title and abstract review. Among those, 407

underwent full-text review and 96 met all inclusion criteria (67% agriculture, 25% fishing/seafood processing, 8% forestry). The literature provided some evidence fatigue contributes to fatalities, injuries, and illnesses in AgFF. Older, new, young, foreign born, and female workers, as well as those who work in small organizations and/or work longer hours (40+) are at higher risk for fatigue-related injury and illness. Few studies have developed or evaluated interventions to control risks. Given that fatigue is believed to be a major factor in injury and illness for this sector, future AgFF surveillance and research should increase efforts to capture fatigue and sleep data, directly investigate the role of long hours and non-standard work schedules in these industries, and most importantly, create practical interventions to manage fatigue.

Fatigue and the Need for Recovery among Latino/a Immigrant Cattle Feedyard Workers

Presenter: Athena K. Ramos, University of Nebraska Medical Center, Central States Center for Agricultural Safety and Health (CS-CASH)

Cattle feedyards are animal feeding operations where beef cattle are finished to market weight on grain. Cattle feeding can be dirty, demanding, and dangerous work. This study sought to assess the predictors of fatigue and the need for recovery among Latino/a immigrant cattle feedyard workers in the United States. A path model was examined to explore direct and indirect relations among physical fatigue, mental fatigue, need for recovery, job characteristics, and health and sociodemographic covariates. Lower self-reported health, experiencing physical pain, not handling animals, and decreased decision latitude were directly related to increased physical fatigue. Shorter tenure working on cattle feedyards, lower educational level, experiencing physical pain, and increased job demands were directly related to heightened mental fatigue. Being female, experiencing physical pain, an elevated average of hours worked per day, increased job demands, and less decision latitude were directly related to an increased need for recovery and indirectly related to both physical and mental fatigue. Physical and mental fatigue have specific correlates, but job characteristics, including job demands and decision latitude, can directly and indirectly impact workers' levels of physical and mental fatigue and their need for recovery. Both preventive measures and restructuring work operations may reduce the risk for fatigue and the need for recovery. Implications for cattle feedyard workers, supervisors, and employers are discussed. Finding ways to balance productivity and the well-being of workers should be a high priority for cattle feedyards across the country.

Documenting and Assessing Fatigue in the Northeast Forestry Industry

Presenter: Erika Scott, Northeast Center for Occupational Safety and Health

This presentation will describe recent efforts to document and characterize fatigue and fatigue management strategies in the Northeast Logging industry. Forestry industries are at high risk of injury and fatalities, and fatigue has been shown to be a factor in workplace injuries and near-miss incidents. However, there has been very little research directly examining the role of fatigue in the forestry industry, especially in the United States. Researchers from the Northeast Center in Occupational Health and Safety and Center for the Promotion of Health in the New England Workforce (CPH-NEW), a Total Worker Health Center of Excellence, have joined forces to investigate cardiovascular risk factors, including sleep, among Maine's mechanized logging workforce. This presentation will review a logger field trial conducted in Maine, where a variety of wearable sensors including a custom-designed armband, Empatica E4 wristband and Hexoskin sensor shirt were used to measure a variety of health endpoints. Highlights will include logger comfort assessments, ease of use, data quality, and lessons learned from collecting such data in remote work settings.

Assessments of Sleep Deprivation and Associated Health Impacts in Commercial Fishermen

Presenters: Julie Sorensen, Northeast Center for Occupational Safety and Health, and Laurel Kincl, Oregon State University

Commercial fishing workers often suffer from sleep debt and fluctuating sleep schedules in an environment where the risk of injury or death is constantly present. U.S. Coast Guard reports of vessel sinkings have indicated a potential role of fatigue in vessel disasters, indicating that compromised reaction times or executive decision-making could be a hidden factor contributing to these events. Despite the recognized need to understand the impact of sleep debt, there is an almost complete lack of research on this phenomenon in commercial fishing. In particular, there is little that is known about the direct effects of sleep deprivation in commercial fishing and the risk of injury or the long-term, neuro-cognitive impact of repeated intermittent and limited sleep schedules.

Researchers from the U.S. East and West Coasts are currently collaborating on efforts to advance sleep studies research in commercial fishing, by laying the groundwork for future research in this realm. We will present preliminary data from qualitative interviews conducted with salmon, crab, lobster, and scallop fishing workers on the impact of work on sleep hygiene and the perceived

impacts of sleep debt on their health and well-being, as well as an overview of initial data from health surveys and assessments conducted with the commercial fishing fleet. Information learned in this study will be used to inform future commercial fishing sleep debt studies.

Technology Considerations for Commercial Fishing Sleep Monitoring

Presenters: Leigh McCue, George Mason University, and Julie Sorensen, Northeast Center for Occupational Safety and Health

Actigraphy is commonly viewed as the standard for sleep assessment in non-clinical settings. Commercially available actigraphy devices measure sleep based on accelerometer data and therefore capture motions of a moving platform, such as a commercial fishing vessel, in addition to test subject movements. Inspired by increasing researcher use of multi-sensor devices to measure sleep in various environments, in this presentation we share data collected by test subjects using Actigraph, Fitbit, Dreem, and Oura devices onboard small vessels. The presentation also includes discussion regarding safety and comfort of device wear while commercial fishing, as well as practical limitations on data acquisition and retrieval in the fishing environment. Better understanding the accuracy and wearability of these sleep monitoring devices in a commercial fishing setting will serve as a technology enabler for large-scale study of sleep deprivation within the industry.

NOIRS 2022 POSTER ABSTRACTS

(Presenters Underlined)

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POSTER SESSION

LIST OF FEATURED POSTERS

P1

Title: Response Time Following Local Vibration in Tasks Mimicking Truck Drivers Performance

Authors: Juan Manuel Castellote, Victor Selionov, Irina Solopova

Introduction: Some studies have shown that vibration applied for short periods of time do not show disturbances but others as with a general vibration exposure (common in truck drivers) may result in deleterious effects that may contribute to accidents. It is needed to understand the effects that repeated local vibration have in upper limb fast responses to conform a explanatory framework on truck drivers performance. Repeated exposure to mechanical vibration causes injuries that can be serious (South 2004) (Vartija et al. 2013). Exposure to the extremities contributes to the generation of lesions and local syndromes (e.g. carpal tunnel) (Bensefa-Colas and Choudat 2013) that require rehabilitation. These exposures are observed in works such as driving of freight vehicles by direct transmission through the steering wheel (Sekkay et al. 2018) (Kivekas et al. 1994) (Bovenzi et al. 1987) (Shahbazian et al. 2009) (Barregard 2003) (Rytkönen et al. 2006). The purpose of the present study is to differentiate responses to local vibration in muscles active in driving performance.

Methods: This study includes a pilot data set in subjects (n = 11) exposed to local vibration at biceps brachialis or extensor carpi radialis muscles in movements used for driving performance. Voluntary muscle responses and joint movement are explored after stimulation with different combinations of sustained vibration. For the experimental condition a local mechanical vibration stimulus is used following previous methodologies (Selionov et al. 2009) (Selionov et al. 2013) with low or high frequency. Three vibration durations have been used. Signals are collected by surface electromyography of agonist and antagonist muscles (Castellote and Valls-Solé 2015) (Queralt et al. 2008) as well as by joint mobility electrogoniometry (elbow and wrist). For descriptive and inferential analyses SPSS-27 has been used.

Results: The sustained vibration causes changes in the motor response as well as in joint mobility in the stimulated muscles. Specifically, the voluntary response of joint mobility is seen in some cases slowed down in the face of different combinations of intensity * frequency, while in other cases the phenomenon is not observed. It is noteworthy that after the end of the stimulation and response periods, the final control assessment results in lower response figures than in the initial control, with shorter times ($p < 0.05$). In the slowing down of the response during the evaluation periods, a relationship is observed between the increase in frequency and those cases with motor delayed response ($p < 0.05$).

Discussion and Conclusions: We have explored the effects of sustained local vibration on upper limb motor responses, using different combinations of stimulus intensity * time. 1. Based on the results, a delay in muscle activation and joint movement is observed after local vibration. 2. When the stimulation / response cycles have ended, a reduction is observed in the response times reflected in an anticipated joint mobility. 3. The fact that local vibration deteriorate voluntary responses may affect the performance in occupations such as truck drivers when they have to react fast to avoid an accident.

References: Castellote JM, Valls-Solé J. The StartReact effect in tasks requiring end-point accuracy. Clin Neurophysiol 126: 1879–1885, 2015. Selionov VA, Ivanenko YP, Solopova IA, Gurfinkel VS. Tonic central and sensory stimuli facilitate involuntary air-stepping in humans. J Neurophysiol 101: 2847–2858, 2009.

P2

Title: A Mixed-Methods Approach to Examining Safety Climate among Truck Drivers

Authors: Emily Yueng-Hsiang Huang, Yimin He, Jin Lee, Bailey Lytle, Ashan Senel Asmone, Yang Miang Goh

Presentation Brief Summary: Our project aims to provide safety researchers and practitioners with recommendations to promote organization- and group-safety climate (SC) in the trucking industry. To do this we employ a mixed-methods approach using qualitative and quantitative methodologies with two goals in mind. The first is to understand the needs and concerns of truck drivers from their own perspectives, using trucking industry-specific SC scales as prompts; the second is to analyze and summarize how truck drivers view existing

policies, procedures, and practices to find ways to help promote trucking safety and health. Purpose/Objectives: The purpose of the current study was to use a mixed-methods approach to understanding SC and the strategies to improve SC among truck drivers.

Background: According to the U.S. Bureau of Labor Statistics, transportation incidents remain the leading factor of fatal injuries among truck drivers (Bureau of Labor Statistics, 2020). SC is a key robust predictor of workplace safety. We sought to better understand which psycho-socio-cultural and managerial factors are most important for the designing and implementation of an occupational safety and health intervention programs for truck drivers. To do this we conducted interviews with truck drivers at truck stops to gather critical information for SC enhancement.

Methods: Using both survey (N = 7246) and interview (N=18) responses provided by truck drivers regarding key SC items, we identified a number of positive and negative policies, procedures and practices that truck drivers perceived as the determinants of whether they thought their organizations were committed to promoting safety at work. Item response theory (IRT) analyses were conducted to analyze survey responses with regard to SC measures to identify the most discriminative items indicating which SC items were most sensitive to SC level and had the best potential for improvement.

Findings: Some common themes that emerged from the highest scoring scale items included compliance with regulations, strict speed limits, and autonomy among drivers. Themes from the lowest scoring scale item included discretion to take breaks, flexibility in rescheduling, and communication. Common themes from the scale items with the highest discrimination parameters included safety meetings, tools and equipment, and managers' knowledge and experience. The analyses revealed several effective strategies to promote SC in the trucking industry: (1) Organization-level: prioritization of safety over customer needs, holding regular safety meetings, allowing drivers to take breaks when necessary, and conducting safety workshops, (2) Group-level: allowing drivers to make safety decisions for themselves, leadership acknowledging safe drivers, providing monetary bonuses, and offering positive and negative feedback to improve safety.

Discussion: Our hope is that organizations may use this information to promote safety and, ultimately, reduce occupational accidents and injuries. By using IRT analysis, such that items highest in discrimination parameters were most sensitive to the SC level, we could gauge and differentiate SC levels across trucking organizations; implementing strategies aligned with those items could make improvement in safety climate more substantial. Various themes emerging from interview responses allowed us to expand upon other potential contributing factors that help enhance SC within and across organizations. Conclusions: This study took the initial step of adopting a mixed-methods approach for understanding SC among truck drivers. Based on our results, we offer safety researchers and practitioners some recommendations on how to intervene in unsafe practices and promote organization and group SC in the trucking industry to reduce accidents and injuries in the workplace.

P3

Title: Accidents in the Truck Driver Sector and the Health Paradox of This Demanding Occupation

Authors: Juan Manuel Castellote, Miguel Del Pino

Introduction: It is known that some sectors in industry are more demanding with workers activity with high rates of injuries or illnesses that result in disability conditions. Some well know sectors are fishery and mining industries, and in most instances, societies facilitate either a shift to less demanding work or an early retirement. This is related to the reduction in physical and cognitive capacities that human beings have with age and demonstrates the sensibility of societies to the contribution of these professionals to the society. The case of truck drivers is special. It is an arduous work, with high risk for serious accidents, and additionally with some well-established factors that increase some illnesses. Sedentarism, turns, nutritional habits, and the frequent absence from home -mainly for long-haul drivers-, among other factors, reduce the health state of drivers with age. The increase in accidentability with age should be a result. However, that, it is not so evident unless an analysis is performed with adequate information from databases. Some studies suggest that the rates are increasing with age, but others show a reduction in accidentability, that may constitute a paradox. The present research shows an analysis with data from national databases and wants to clarify the accidentability in this work sector.

Methods: For the present study, National databases from the Government of Spain as well as from the European Union have been used, concerning morbidity, accidentability as well as degree of occupation in different sectors in order to establish rates of accidentability by age groups and analyzing the trend during a period covering consecutive years (2009-2018). Data have been normalized to the general population. For descriptive and inferencial analyses SPSS-27 has been used.

Results: During the period of study (10 years) there is reduction of accidents in the road transport sector although not significant ($p>0.05$). There is a high increase in the accidentability with number of years at work, that is not seen in other high risk occupations such as fishery and mining industries ($p<0.05$). However, there is a reduction in accident rate with increase of the age of the worker in the truck driver sector, and a high significant reduction in those other sectors (fishery and mining industries) without changes in other activities (classif. ILO).

Discussion and Conclusions: The present study supports that workers that stay at work in the truck driving industry have more chance to have accidents. However, the calculated rates support that there is a reduction with age, and this may be due to the healthy worker effect, that means that those workers that follow in the sector are those that still are able to maintain activity in this strenuous activity. The conclusion is supported by data in other hard sectors, where there is also a significant trend for reduction of accidents with age, not easily explained by a learning curve. In these two last sectors, there is a difference from the truck sector because laws support early retirement of workers, as well as may facilitate shift to other less strenuous jobs with age. This explains, as a healthy work effect, the paradoxically reduction of accidents with age, not so evident in the truck drivers sector. It has been documented that the truck driving sector has reduced chances for workers to shift to other activities, aggravated by the advanced age of the worker. There should be some changes in legislation in order to either facilitate easier work for these workers or place a scenario where early retirement is facilitated.

P4

Title: A Hard Day's Night: Shift Work, Fatigue and Cardiovascular Risk Factors Among Maine's Logging Workforce

Authors: Erika Scott, Liane Hirabayashi, Judy Graham

Background: Logging is of the most hazardous industries in the United States (US), despite many workplace safety improvements made in the last decades. Currently, we know little about regional trends in health conditions of logging workers, especially in the Northeast.

Methods: This abstract reports on survey and health assessment data of a longitudinal cohort study involving Maine loggers. Specifically, data on work shift, commute time, sleep quality, and risk factors of obstructive sleep apnea are presented.

Results: Three hundred twenty-five (325) are included in the initial survey analyses, 246 mechanized loggers, and 79 conventional. On average mechanized loggers worked longer days (11.8 hours vs. 9.7 hours) and had longer commutes from home to the woodlot (72.6 minutes. vs. 40.7 minutes) than conventional loggers. Mechanized loggers were more likely than conventional loggers to begin their workday before 6:00 AM. Preliminary analysis of health screening data (sub-cohort of 81 loggers) identified several factors that require addition exploration: average body mass index (BMI) of 30.6, Mallampati scores of class 3 or 4 in 24%, along with average blood pressure of 138/83.

Conclusions: These factors contribute to a need to work with the logging community on cardiovascular risk and factors contributing to sleep quality. The ultimate goal is to make the industry a safer and healthier profession for the current workforce, as well as the workforce of the future.

P5

Title: Investigation of a Fatality That Occurred When a Logging Processor Lost Traction and Rolled Down a Hillside

Authors: Jennifer E. Lincoln, Jeff R. Funke

Background: Between 2010 and 2019, the Bureau of Labor Statistics reported 723 fatalities in the forestry and logging industry. Research has shown that fatalities and injuries have declined due to an increased use of mechanized logging, but work-related hazards persist. These hazards include challenges in terrain, weather, and operating in remote areas. On January 25, 2019, a 32-year-old processor operator was fatally injured when his logging processor rolled down a previously logged (clear-cut) hillside. The processor operator was driving the equipment from a spur road to a main road. As the processor operator approached a narrow inside corner in the road near a log deck (a stack of logs), the tracks on the equipment slipped laterally on the outsloped road. While the processor operator was attempting to exit the cab, the equipment tumbled down the hillside, shearing the operator cab off the equipment and fatally crushing the operator. A logging industry association and the employer requested assistance from the National Institute for Occupational Safety and Health (NIOSH) to conduct an independent investigation of the incident.

Methods: The goal of the NIOSH Fatality Assessment Control and Evaluation (FACE) program is to prevent occupational fatalities across the nation by identifying and investigating work situations at high risk for injury and then formulating and disseminating prevention strategies to those who can intervene in the workplace. This programmatic goal is addressed by conducting surveillance to identify occupational fatalities; performing

investigations of specific types of events to identify injury risks; developing recommendations designed to control or eliminate identified risks; and making injury prevention information available to workers, employers, and safety and health professionals. In January 2020, investigators traveled to the location where the logging processor died to examine the worksite and collect facts from OSHA compliance officers, company officials, witnesses, and workers about what occurred before, during, and after the incident. NIOSH investigators obtained and reviewed training records, health and safety plans, incident scene photographs and drawings, and medical records.

Results: Findings are preliminary, as the investigation report is still in process. The report will be final by the time of the conference. FACE investigators identified the following hazards as key contributing factors: ice and snow had accumulated on the roadway; the roadway design was outsloped; during travel, the boom and processing head were positioned in a way that caused the equipment's center of gravity to shift downhill; the processor head swung while the equipment moved, causing the equipment's center of gravity to shift; the operator cab only had falling object protection design; and the ice bits for the equipment were not engineer designed.

Conclusions: To prevent similar occurrences, NIOSH investigators recommended the following.

- Road designers should limit outsloping on forest roads with potential winter travel;
- Employers should conduct a hazard assessment when working with forestry equipment in areas of steep terrain and provide worker training on hazard recognition as part of a comprehensive and site-specific safety plan;
- Employers should develop, implement, and train operators on strategies for traveling forestry equipment over forest roads;
- Employers should select forestry equipment equipped with falling object protection (FOP) or falling object guard (FOG) and rollover protective structures (ROPS);
- Employers should consider participating in professional safety organizations to strengthen safety and health programs;
- Employers should develop a comprehensive health and safety program for manual and mechanical logging operations;
- Manufacturers should design stowing or sway control features for forestry attachments such as dangle head processors; and
- Manufacturers should provide engineer designed ice bits for forestry equipment operating during winter snow and ice conditions to reduce lateral slipping.

P6

Title: The NIOSH Fatality Assessment and Control Evaluation (FACE) Program – Law Enforcement Officer Motor Vehicle Fatality Investigations

Authors: Melanie Fowler, Nancy Romano

Purpose: Motor vehicle-related incidents are a leading cause of line-of-duty deaths for law enforcement officers (LEO) in the United States – they are also preventable. Data from the National Law Enforcement Officers Memorial Fund indicates that from 2006-2019, 809 officers died due to motor vehicle related incidents (struck-by and crashes) – 43% of all line-of-duty deaths. It is important to promote motor vehicle safety among officers so they can stay safe while working to protect communities. During 2010-2019, on average, one officer per week has been killed on our nation's roads. Most years, motor vehicle-related incidents, including crashes and being struck by moving vehicles while on foot, are the main cause of death for officers. To address these deaths, the National Institute for Occupational Safety and Health's (NIOSH) Fatality Assessment and Control Evaluation (FACE) Program studies LEO motor vehicle-related fatalities and disseminates intervention recommendations to prevent similar deaths.

Methods: The NIOSH FACE Program conducts law enforcement officer (LEO) motor vehicle crash and struck-by fatality investigations. Investigations help us understand risks LEOs face on the job and identify ways to prevent similar LEO deaths. Through field investigations, FACE personnel collect agent, host, and environmental information from the pre-event, event, and post-event phases of the fatal incident. The investigative information is evaluated to identify contributing factors, which are addressed by recommendations aimed at controlling them. Each FACE LEO report includes a description of the incident with personal information removed, factors that contributed to the fatal event, and recommendations for the law enforcement community to prevent similar deaths. The reports do not place blame.

Results: The FACE team have completed 5 NIOSH FACE LEO reports to date, and 8 State FACE LEO reports are also published. In addition to the LEO reports, infographics have been created based on report findings as well as relationships built with stakeholders such as the National Police Foundation and the National Law Enforcement Memorial Fund. Reports and associated products are disseminated to targeted audiences and are available through the FACE webpage, NIOSH LEO motor vehicle safety webpage or the NIOSH internet homepage.

Conclusions: The LEO investigations identify risk factors for fatal motor vehicle-related events that will be used to develop prevention recommendations. The recommendations are shared with law enforcement agencies across the United States with the goal of reducing LEO motor vehicle-related deaths.

P7

Title: Use of the CDC's Social Vulnerability Index to Characterize Firefighters' and Medical First Responders' Potential Exposure to SARS-CoV-2 During Routine Emergency Responses

Authors: Alexa Furek, Katherine Yoon, Susan Moore, Megan Casey, Emily Haas

Background: Populations that are socially and/or economically marginalized face an increased risk for adverse health outcomes during hazardous events. The Centers for Disease Control and Prevention (CDC) created a social vulnerability index (SVI) to identify and map U.S. census tracts that may require additional assistance during hazardous events. Although the SVI has been used to inform resource allocation and community preparedness, it has not yet been used to examine calls in which fire departments and emergency medical service workers respond to emergencies. This research explores the association between potential SARS-CoV-2 exposures during routine emergency response calls in the context of social vulnerability across census tracts in three U.S. cities—Boston, MA; Columbus, OH; and New Rochelle, NY.

Methods: The National Institute for Occupational Safety and Health received monthly, post-call emergency response operations data from the International Public Safety Data Institute's National Fire Operations Reporting System (NFORS). Department computer-aided dispatch (CAD) systems generated these data, including public health data such as potential exposure to SARS-CoV-2. We matched NFORS data by census tract to the CDC's SVI data which ranks census tracts from 0 to 1, where higher percentile rankings indicate greater social vulnerability. We ranked individual census tracts on 15 social factors grouped into four related themes: socioeconomic status (theme1), household composition/disability (theme2), minority status/language (theme3), and housing type/transportation (theme4). Controlling for total population, we examined the association of social vulnerability with SARS-CoV-2 exposure during emergency response calls using a negative binomial regression model in R (version 4.0.3). Using GIS mapping technology (Quantum GIS, version 3.16), we determined social vulnerability percentile rankings and aggregate SARS-CoV-2 exposures at the census tract level in three U.S cities.

Results: From March to September 2020, data from over 160,000 emergency response calls were received, with 13,198 potential SARS-CoV-2 exposures recorded and the highest percentage occurring in May 2020 (22.5%). For calls with potential SARS-CoV-2 exposures, the mean (SD) SVI rankings were overall, 0.611 (0.289); socioeconomic status, 0.610 (0.301); household composition/disability, 0.524 (0.347); minority status/language, 0.619 (0.228); and housing/transportation, 0.583 (0.272). Socioeconomic status and housing/transportation showed a significant association. For every 1-unit increase (1 percentile ranking=0.01) in socioeconomic vulnerability, the expected log count of response calls with potential SARS-CoV-2 exposures increased by 1.8389 (Incidence rate ratio = 6.289, [3.186, 12.455], p-value <0.001). For every 1-unit increase (1 percentile ranking=0.01) in housing/transportation vulnerability, the expected log count of response calls with potential SARS-CoV-2 exposures increased by 0.7338 (IRR=2.083, [1.277, 3.415], p-value <0.01).

Discussion: Our results identified an association between SARS-CoV-2 exposures during routine emergency response calls and higher SVI rankings at the census tract level, with socioeconomic status and housing/transportation both significantly associated with potential exposure to SARS-CoV-2. Although significant individually, household composition/disability and minority status/language were not significantly associated when adding other social vulnerability indices to the model. Our results complement previous findings on the association between SVI and COVID-19 incidence, showing that SVI can be examined at a more granular level to inform risk management decisions. Future efforts could further explore spatial trends in social vulnerability and COVID-19 emergency response call types reported by first responders across the U.S.

P8

Title: Reliability and Validity of a Safety Hazard and Management Assessment Questionnaire

Authors: Libby Moore, Steven Wurzelbacher, I-Chen Chen, Michael Lampl, Steven Naber

Introduction: Managing and improving occupational safety and health requires evaluating performance. Injury rates and costs have been among the most commonly used lagging indicators. Yet these metrics provide inadequate information on injury causes and offer little guidance for

improvement. For this reason, organizations are encouraged to use both lagging indicators and leading indicators (such as questionnaire-assessed safety hazards and management practices). However, the association between types of indicators over time can be complex. Longitudinal data can assist in clarifying these associations and increasing indicator utility.

Method: Employer data were used to evaluate the reliability and predictive validity of a safety management questionnaire. Employers' longitudinal questionnaire responses, including ratings of their safety and claims management system and hazard identifications, and workers' compensation (WC) claims data were analyzed using a marginal model with time-dependent covariates. Multivariable Poisson and linear regression analyses with claim rate and logarithmic cost, respectively, as dependent variables were carried out after adjusting for industry sector and size. Questionnaire data were used to evaluate questionnaire scaling properties and to assess generalizability of results.

Results: Four questionnaire scales were associated with better WC claim outcomes as predicted and two scales were unexpectedly associated with poorer WC claim outcomes. Analyses assisted in interpreting the latter results, suggesting that WC claim rates and costs, rather than being responses, were motivators for employer improvement in some cases. Thirteen hazards on the questionnaire, which were identified by employers as present in their organizations, were associated with poorer WC claim outcomes as predicted. In addition to predictive validity, the internal consistency reliability and convergent and discriminant validity of the questionnaire were supported.

Conclusions: This study extends leading indicator research using longitudinal questionnaire and WC claims data from employers it was designed to assist. It provides information on the potential usefulness of employer safety management scale ratings and hazard identifications for safety self-improvement. Analyses provided insight into associations between leading and lagging indicators, emphasizing the importance of using both for safety improvement. Safety management questionnaire scales were predictive of WC claim outcomes, although support for hazard assessments as leading indicators was stronger. Practical Applications: This study supports the use of employer-completed hazard assessment questionnaires for targeting and prioritizing improvement efforts. Employer-completed safety management scales may be useful for directing improvement efforts, although the conditions under which they are completed, including submission to insurers, require additional consideration.

P9

Title: Workplace Violence Training among Young Workers 14–24 Years of Age in the US

Authors: Camryn Lopez, Kimberly Rauscher, Carri Casteel, Doug Myers, Corinne Peek-Asa

Background/Introduction: Workplace violence effects all age groups. However, younger workers are at a greater risk due to high-risk employment environments. Because of their increased risk, training in avoiding and responding to workplace violence is essential yet we know little about the workplace violence training provided to young workers. Objectives: To understand more about the extent of workplace violence training received by young workers across the US and specifically, what are the workplace violence topics on which young people are given employer-provided training, the timing of that training, and the training format(s).

Methods: This analysis used data collected on 1,032 US workers ages 14–24 who were surveyed about their work experiences. We used descriptive statistics to analyze the prevalence of training received on each of fourteen training topics related to workplace violence. We also describe when respondents reported they were first trained (e.g. first week on the job) and the format of that training (e.g., watch a video).

Results/Findings: The most common topic with regard to workplace violence prevention was how to properly interact with customers/clients (84%); followed by how to properly work with and communicate with coworkers/supervisors (77%). After these two topics, the prevalence of training on other preventative measures dropped significantly. Less than half were trained on how to recognize warning signs and situations to look for that may lead violence among customers/clients (40%) or coworkers or supervisors (31%), and only 8% were trained in using physical contact to deal with an incident of workplace violence. In terms of workplace violence response training, the most prevalent topic was how to report a violent event to the employer (59%); followed by use of emergency systems to call for assistance (55%). The least prevalent topic in terms of response was in self-defense techniques to use during an attack (11%). Regarding the first instance of training, the majority reported they were trained during their first week on the job (65%); about 10% could not recall when they were first trained. The most common training format was in-person meeting(s) or discussion(s) (74%), then written handouts or other hard-copy materials to read (46%); followed by watching a video (37%) and taking an online course (31%).

Discussion/Conclusions: This investigation shows that young workers lack employer-provided training in important workplace violence prevention and response topics. Most young workers are instructed on how to properly interact with coworkers and customers and receive this training in their first week on the job. While this is positive, knowing the importance of being respectful to others and acting professionally toward both co-workers and customers is only one aspect of preventing workplace violence. Other important information such as how to de-escalate a stressful or tense situation once it has arisen, how to escape a violent situation, or how to defend oneself during an attack were not commonly provided. While all workers should have workplace violence training, young people may need to be targeted for two reasons. One is their overrepresentation in the retail and service industries where workplace violence is more common. The other is their lack of work experience. A young person who is inexperienced may not be as equipped to handle violent or aggressive behavior as an older, more experienced worker. Their lack of experience combined with a lack of training makes young workers a particularly vulnerable population.

P10

Title: Perceptions of Workplace Hazards in a Sample of West Virginia Sawmill Employees

Authors: Wayne Lundstrom, Eric Lundstrom, Patrick Donnelly, Mark Fuller

The forestry industry of West Virginia has a disproportionately high occupational injury rate in comparison to the rest of the country. Despite this, current literature is lacking regarding the state's sawmill industry and how its workforce perceives occupational hazards. Thus, we sought to investigate hazard perceptions within the sawmill industry of West Virginia using a mixed-methods approach. A total of 93 sawmill workers across West Virginia completed paper surveys administered at their workplace; a subset of 9 participants volunteered to complete semi-structured telephone interviews. Of survey participants, the majority (75.2%) considered themselves "workers", with the rest being "lower-level supervisors" (17.2%) or "upper-level supervisors" (7.5%). Survey participants agreed that injuries within the sawmill are often due to worker carelessness (65.6%) and that employees sometimes do not report injuries out of fear for being blamed (69.9%). Additionally, few participants (10.8%) agreed that the money they are paid is worth the risk of occupational injury. After controlling for age using logistic regression, no significant differences were detected between supervisors' and workers' responses. Thematic analysis of telephone interviews revealed that participants feel working with new and inexperienced workers is a barrier to safe work, as well as the idea that working with sawmill machinery is inherently dangerous. These results indicate that sawmill workers in West Virginia broadly agree that the industry is dangerous and present an opportunity to inform future jobsite safety interventions.

P11

Title: Polypropylene Honeycomb in Industrial Safety Helmets

Authors: Shengke Zeng, Jinhua Guan, E.A. McKenzie, Jr., Bryan Wimer, Bradley Newbraugh, Bryan Williamson

Background: Industrial safety helmets protect the construction and other workers from traumatic brain injury (TBI) by attenuating impact acceleration through the helmet. The ANSI standard for industrial head protection (Z89.1-2014) requires that an industrial safety helmet should attenuate the impact acceleration to 150 g (g = 9.81 m/s2) or below as the helmet is impacted on a drop tower with Type II impact setup specified by the standard. A typical Type II industrial safety helmet could attenuate the head impact acceleration to ~110 g, but this acceleration level is still not effective for head protection. A mild TBI usually could already occur at 61~144 g. To further attenuate the head impact acceleration, this study conducted helmet impact comparison tests to determine the feasibility of replacing the conventional expanded polystyrene (EPS) liner inside the industrial safety helmet shell with a polypropylene honeycomb layer, which is considered as an excellent impact energy absorber.

Method: In the comparison impact tests, two brands (Brands A and B) of the Type II safety helmets were modified by cutting a hole of 75 mm in diameter at the front of the EPS liner and inserting a circular polypropylene honeycomb pad with the same diameter and similar thickness of 17 mm (Brand A) or 15 mm (Brand B) into the hole. The hole center was 40 mm above the liner bottom. The individual honeycomb pad was loosely bonded with the EPS liner hole with hot glue dots to observe impact energy attenuation contributed mainly by the honeycomb pad. The density and the cell size of the honeycomb were 80 kg/m3 and 8 mm, respectively. The typical bare compression strength and modulus of the honeycomb were 1.89 MPa and 79.2 MPa, respectively. The helmet impact tests on the original and modified helmets were conducted on a helmet drop tower with Type II test setup. In the first set of the comparison tests, 20 Brand A and 20 Brand B helmets (10 original and 10 modified helmets for each brand) were impacted at the front of the helmets with the standard impact velocity of 3.5 m/s. In the second set of the tests, 50 Brand A helmets

were impacted at the same helmet location as that in the first set of the tests, with the impact velocity variated at 2.5, 3.0, 3.5, 4.0 and 4.5 m/s. At each velocity, 10 helmets (five original and five modified) were impacted.

Results: The results of the first set of the comparison tests showed that the mean impact acceleration through the 20 modified helmets with polypropylene honeycomb pad was 91.8 g which was 20.1% less than the impact acceleration through the 20 original helmets. The results of the second set of the comparison tests showed that the mean impact acceleration through the modified helmets were 53.6, 66.4, 86.6, 112.2 and 231.7 g, which were 9.7%, 13.2%, 20.5%, 45.4% and 30.3% less than those through the original helmets at the impact velocities of 2.5, 3.0, 3.5, 4.0 and 4.5 m/s, respectively. All reductions in impact acceleration were statistically significant except that in the 2.5 m/s condition.

Discussion: With this polypropylene honeycomb material and structure, the plastic bending of the honeycomb cells and the circumferential stretching of the cell wall between the bending hinges attenuated more impact energy than the conventional EPS liner at the impact velocities ranged from 3.0 to 4.5 m/s. Since polypropylene honeycomb reached the boundary between plastic-deformation region and densification region at higher impact velocity than the EPS liner, the polypropylene honeycomb attenuated greater impact energy than the conventional EPS liner at higher impact velocities. Conclusions: The polypropylene honeycomb materials, with the physical properties mentioned above, are an effective substitute for the conventional EPS liner at the front of the industrial safety helmets. They can attenuate greater impact energy at impact velocities ranging from 3.0 to 4.5 m/s.

P12

Title: What's Stopping You? Organizational Constraints as a Multi-Facet Work Stressor

Authors: Nathan Bowling, Jesse Michel, Michael Rotch, Md Rashedul Islam, Stephen Wagner

Introduction: Considerable attention has been given to identifying various forms of work stressors—events or conditions within the workplace that impose adaptive demands on workers (Jex et al., 1992). Such research is important because stressors can undermine workers' psychological and physical health, and thus present a risk for work injuries. The most widely studied stressors include role ambiguity and role conflict (Bowling et al., 2017), workplace aggression (Hershcovis, 2011), and organizational constraints (Pindek & Spector, 2016). The current research focuses on organizational constraints and describes the creation and validation of a self-report organizational constraints scale—the Multi-Facet Organizational Constraints Scale (MOCS).

Background: The organizational constraints construct subsumes the many factors within one's workplace that interfere with effective job performance (Spector & Jex, 1998). Examples include having inadequate equipment or training to do one's work tasks and having to deal with frequent interruptions from coworkers (see Peters & O'Connor, 1980). Organizational constraints may produce work injuries via several mechanisms. First, some constraints (e.g., poor training, inadequate equipment, budget shortages) may create direct risks for work injuries. Second, constraints are related to psychological and physical symptoms—including anxiety, sleep disturbances, fatigue, and dizziness (Nixon et al., 2011; Pindek & Spector, 2016). These symptoms may contribute to engagement in unsafe work behavior. Finally, constraints are linked to engagement in various counterproductive work behaviors (CWBs; Pindek & Spector, 2016), which may include the failure to follow safety procedures.

Significance: Previous research has largely focused on overall organizational constraints rather than on its facets. In fact, one overall measure—Spector and Jex's (1998) Organizational Constraints Scale (OCS)—has been used in most studies (see Pindek & Spector, 2016). Although the OCS yields high levels of reliability and construct validity, it does not provide facet scores. Different facets of constraints presumably have somewhat different sets of causes and effects. A multi-facet scale is needed to provide researchers and practitioners more specificity regarding aspects of work that pose the most risks to worker. Such information can be used as a basis for tailoring interventions to the unique needs of an organization or department. Method: The current research summarizes the MOCS' development. We used standard scale development practices (see Hinkin, 1995, 1998) by first clearly defining the organizational constraints construct. Based on a thorough review of the literature and our own pilot studies, we identified 16 facets for inclusion in the MOCS (example MOCS facets include "poor training," "physical conditions," and "incorrect information"). We conducted three subsequent main studies (Study 1 N = 324; Study 2 N = 400; Study 3 N = 79) to examine the reliability and construct validity of the MOCS.

Results: Collectively our studies provide evidence of the MOCS's reliability and construct validity. Specifically, the MOCS facets consistently produce Cronbach's αs > .85. Furthermore, the MOCS facets consistently predict important work-related criteria, including job dissatisfaction, work-related frustration, and CWB.

Discussion: Given the undesirable effects organizational constraints may have on both individual workers and their employers, more research on this topic is needed. Using a multi-facet scale may aid in the scientific understanding of the conceptual nature of the constraints construct. Furthermore, information about which facets an organization scores high on can be used as a basis for developing tailored interventions to improve the health and well-being of all workers.

Session H1
Work-Related Vehicle Crashes
Moderator: Eva Shipp

H1.1

Title: Driver Injuries in Heavy vs. Light and Medium Truck Local Crashes, 2010 - 2019

Authors: Terry Bunn, Madison Liford, Michael Turner, Ashley Bush

Objective: Multiple research studies on driver injuries in heavy trucks have been conducted but relatively few studies have been performed on light and medium truck injuries. The objectives of this study were to use workers' compensation (WC) first report of injury (FROI) data to 1) compare demographic and injury characteristics between heavy truck drivers, and light and medium truck drivers involved in local crashes; 2) assess WC disposition and lost work time status associated with local heavy, medium, and light truck driver crashes; and 3) describe injury scenarios by specific vehicle type to obtain additional information on the crash circumstances.

Method: A cross-sectional study using WC FROI data for 2010-2019 was performed, and quantitative and free text data were analyzed. Results: There were 800 total local crash FROIs; 451 were heavy truck crashes and 349 were light or medium weight truck crashes. The youngest (<25 years) and oldest age groups (>65 years) were represented at higher proportions of local light and medium truck crash FROIs compared to the heavy truck group. Drivers in the light and medium truck local crash FROIs were employed primarily in the retail trade industry (47%), and wholesale trade industry (21%). The primary vehicle types identified in heavy truck local crashes were semi-trucks (13%), and dump trucks (11%). For light and medium trucks, the specific vehicle types identified were delivery trucks (30%). Heavy truck crashes involved rollovers due to the inability to stop in time when a vehicle was stopped/slowed in front of them, driving off narrow roadways and overcorrecting while bringing the vehicle back onto the pavement, and driving downhill and unable to downshift. Common injury scenarios for light and medium truck crashes involved being rear-ended, running red lights, and turning in front of other vehicles.

Conclusions: The utilization of WC data highlighted common injury scenarios by specific truck types for targeting driver safety training among light, medium, and heavy truck drivers. Future studies using linked WC data and crash data are needed to comprehensively identify specific industries, vehicle types, and circumstances surrounding light and medium vehicle crashes.

H1.2

Title: Trends in Work-Related Fatalities Due to Motor Vehicle Crashes, United States, 2011–2019

Authors: Srinivas Konda, Scott Hendricks, Stephanie Pratt, Rebecca Knuth, Rosa Rodriguez-Acosta, Eric Carbone

Introduction: Motor vehicle crashes (MVCs) are the leading cause of work-related deaths in the United States, yet little is known about how characteristics of MVC fatalities may have changed over time. The purpose of this study was to examine the trends in work-related MVC fatality rates from 2011–2019.

Methods: Data were obtained from the publicly available Census of Fatal Occupational Injuries database. The following Occupational Injury and Illness Classification System event codes were used to define MVCs: 24-Pedestrian vehicular incidents; 26-Roadway incidents involving motorized land vehicle; 27-Nonroadway incidents involving motorized land vehicles. Fatality rates per 100,000 full-time equivalent (FTE) workers were calculated using employment data from the Current Population Survey. Poisson regression models accounting for serial correlation were used to calculate trends in rates, assuming a linear trend across the study period. Average annual percentage changes in work-related MVC fatality rates with 95% confidence intervals (CIs) were calculated. The average annual percentage change in the work-related MVC fatality rate for each subgroup was compared with the average annual percentage change in the overall work-related MVC fatality rate.

Results: During 2011–2019, 15,802 workers died in MVCs in the United States (average: 1,756 per year), accounting for 36% of all work-related deaths (n=44,483). These fatalities were most often due to roadway incidents (n=10,873; 69%). The average annual MVC fatality rate of 1.24 per 100,000 FTEs did not change significantly from 2011–2019 (-0.04%; 95%CI: -0.63%, 0.57%). While the rate of fatalities due to nonroadway incidents significantly decreased by an average of 1.72% per year (95%CI: -3.36%, -0.05%) and the rate of fatalities due to pedestrian

vehicular incidents decreased by an average of 0.35% (95%CI: -1.77%,1.07%), the rate of fatalities due to roadway incidents increased by an average of 0.38% per year (95%CI: -0.35%,1.13%). The MVC fatality rate for Black, non-Hispanics (1.09%; 95%CI: -0.72%,2.88%) and Hispanics (1.31%; 95%CI: -0.19%,2.88%) increased, whereas the average annual MVC fatality rate for whites decreased (-0.50%; 95%CI: -1.24%,0.24%). The average annual MVC fatality rate for workers aged ≥65 years increased significantly (1.61%; 95%CI: 0.03%,3.24%). The MVC fatality rate for driver/sales workers and truck drivers, who accounted for 39% of all work-related MVC deaths for 2011–2019, increased 0.72% per year on average (95%CI: -0.25%,1.76%). The average annual MVC fatality rate for installation, maintenance, and repair occupations showed a significant increase of 3.43% (95%CI: 0.61%,6.20%), which was significantly greater than the percentage change in overall MVC fatality rate (3.46%; 95%CI: 0.58%,6.35%). The average annual MVC fatality rates for construction and extraction occupations (-2.11%; 95%CI: -3.83%, -0.43%) and management occupations (-5.65%; 95%CI: -7.58%, -3.67%) declined significantly, and these declines were significantly greater than the percentage change in overall MVC fatality rate ((-2.07%; 95%CI: -3.90%, -0.28%), (-5.61%; 95%CI: -7.65%, -3.55%), respectively).

Discussion: While the overall work-related MVC fatality rate has not significantly changed over the 9-year study period, trends varied across incident types, demographics, and occupations. MVC fatality rates for those aged ≥65 years and those working in installation, maintenance, and repair occupations increased significantly, while rates for those working in construction and extraction and management occupations and rates of nonroadway incidents across all occupations declined significantly. It is important to identify factors associated with the decline in rates for certain subgroups of the workforce and apply what is learned to other work settings. Research should continue to focus on reducing MVC fatalities across other subgroups where little or no decline occurred.

H1.3

Title: Lessons Learned from Using Crash Records for Injury Surveillance in the AFF Sector

Authors: Eva Shipp, Amber Trueblood, Hye-Chung Kum, Shubhangi Vasudeo, Marcelina Perez, Lingtao Wu

Introduction: Fatal injuries in the agriculture, forestry, and fishing (AFF) sector are grossly overrepresented compared to the rate across all sectors in the U.S., based on the National Census of Fatal Occupational Injury (CFOI). CFOI data indicate that transportation-related injuries are among the top contributors to these fatal events. However, little is known about motor vehicle crashes in AFF, specifically events involving logging trucks and agricultural vehicles in the southwest (SW) region (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas). The overarching goals of this ongoing project are (1) to develop an integrated database of AFF-related motor vehicle crashes that occurred on public roadways in the SW region and (2) use these data to conduct surveillance and research focused on identifying factors associated with higher injury severity events.

Methods: Each state in the U.S. maintains a database of crash records for events occurring on their public roadways. These records include structured fields pertaining to person, vehicle, roadway, and environmental factors related to crash events and resulting injuries. In addition to the structured fields, records include free-text crash narratives where law enforcement officers provide additional details on crash causation. The present project includes the structured fields for crash records from Arkansas, Louisiana, New Mexico, Oklahoma, and Texas for the years from approximately 2010 to 2020. Narratives were obtained for Texas and Louisiana. To the extent feasible, the structured data fields across the five states were mapped to the Minimum Model Uniform Crash Criteria published by the National Highway Traffic Safety Administration to facilitate their integration. Descriptive statistics and geographic information system methods are used to identify the distribution of variables and identify spatial and temporal crash patterns. Multiple logistic regression models were constructed to identify factors associated with higher severity crashes involving logging trucks and farm vehicles. Finally, text mining methods including natural language processing applied to crash narratives are being used to better classify and understand AFF crashes.

Results: At present, the surveillance system contains over 8 million records with nearly 9,000 AFF-related crashes. Analysis of the crash records yielded a protocol for appropriately identifying AFF crashes while also quantifying potential misclassification as an AFF event. Analyses also reflect fields that differ markedly between states and how this impacts the interpretation of findings, including the comparison of crashes and their contributing factors across states. Strengths of crash records include their availability and details that are not included in traditional surveillance systems or clinical records. Key limitations of crash records include a lack of injury-specific information including diagnoses codes and specific fields to reflect industry and occupation.

Discussion: Despite their inherent limitations, crash records can be an important component of injury surveillance involving AFF vehicles in the SW region. They also can be used to identify potential risk factors for higher severity crashes which can inform the selection of countermeasures designed to address these factors.

Session H2

Industrial Mobile Robots: Best Practices for Worker Safety

Moderator: Carole Franklin

Mobile robots are changing the operation of industrial environments, and adjacent economic environments such as warehousing. Industrial robots were typically confined to fixed-in-place cells, to which human entry was prevented or controlled so as to maintain the safety of human workers. When the industrial robot was mounted to the capability of motion (e.g., gantry, hand-pushed cart, etc.), there was a well-defined or easily discernible range of motion. Historically, automated mobile machines in the industrial environment were confined to fixed guidepaths. Now, new technological advances are permitting mobile robots to navigate freely in the same spaces as human workers. However, with this new capability come new hazards and risks that must be evaluated for every deployment of mobile robots. This session will introduce concepts of mobile robotics in the industrial environment and how they are being used in industry, discuss the safety standards related to industrial mobile robots and systems of mobile robots, and how to evaluate and mitigate these new hazards related to industrial mobile robot systems.

The workshop will cover the following topics with respect to mobile robots in industry:

- Paradigm Shift in Industrial Robot Safety
- Introduction to Mobile Robots and Applications
- Safety Standards for Industrial Mobile Robots and Other Mobile Platforms
- Risk Assessment and Hazard Mitigation for Industrial Mobile Robot Systems
- Residual Risks for Industrial Mobile Robot Systems

Session Learning Objectives: Participants will learn what mobile robots are, how they differ from other mobile machines in the industrial environment, how they are being used in industry, what safety standards exist for mobile robots and mobile robot systems, and how to evaluate and mitigate hazards related to industrial mobile robot systems.

Paradigm Shift in Industrial Robot Safety

Presenter: Carole Franklin – Director of Standards Development, Robotics, Association for Advancing Automation (A3)

This presentation will describe how safety practices for mobile robotics requires a paradigm shift from fixed-in-place or defined-motion industrial robotics (whether collaborative or not).

Introduction to Mobile Robots and Applications

Presenter: Mark Lewandowski – Robotics Innovation Leader, Procter & Gamble

This presentation will discuss what industrial mobile robots are, and how mobile robots are being used in industry.

Safety Standards for Industrial Mobile Robots and Other Mobile Platforms

Presenter: Jeremy Marvel – Computer Scientist, National Institute for Standards and Technology (NIST)

This presentation will discuss the industry standards for mobile robot safety and other forms of mobile machinery operating automatically or with degrees of autonomy in the industrial environment.

Risk Assessment and Hazard Mitigation for Industrial Mobile Robot Systems

Presenter: Aaron Prather – Senior Advisor, Technology Planning & Research, FedEx

This presentation will discuss the new hazards related to mobile robot systems and how to evaluate and mitigate these hazards.

Residual Risks for Industrial Mobile Robot Systems

Presenter: Federico Vicentini – Head of Product Safety, Boston Dynamics

This presentation will discuss approaches to a special topic of risk assessment, where some residual risks could be left unresolved due to the nature of the application, the environment, the user requirements, or the mobile robots themselves.

Session H3

Special Considerations for High-Risk Workers

Moderator: Tamara Small

H3.1

Title: Promoting Safety and Well-Being Among Sheet Metal Worker Women Through Mentoring

Authors: Marissa Baker, Lily Monsey, Noah Seixas, Hendrika Meischke, Pranav Srikanth

Background: Women are underrepresented in the construction industry, and research on their experiences reveals exposure to multiple safety hazards including ill-fitting personal protective equipment, less hands-on training with tools during their apprenticeship, physical overcompensation while proving themselves against sexist stereotypes, and sexual harassment. Mentorship has been shown to improve women's experiences and outcomes in the trades and increase their retention.

Methods: Utilizing a randomized control study design, we are longitudinally following apprentice sheet metal workers who were assigned a journey-level mentor and who were not assigned a mentor. To prepare the mentors, we developed an accessible and evidence-based mentorship training program, informed by industry stakeholders. The training included interactive online modules and synchronous Zoom sessions where mentors from across locals are able to build community and practice skills. We surveyed mentors, mentees, and control apprentices to gather baseline data on their experiences in the trades. This survey will be repeated every six months and supplemented with questions assessing the value of different aspects of the mentorship training for mentors.

Results: Twenty-three mentors from across the United States were trained and matched with 42 mentees. Control apprentices were also enrolled. Most mentors indicated they had not received formal mentorship training before, or formal training in skills such as active listening, goal setting, relationship building, problem solving or self-advocacy, all of which are covered in our mentorship training. In post-training evaluations, the majority of mentors reported the training sessions to be valuable and prepared them to meet with their mentees. Amongst enrolled apprentices (both mentees and controls), 38% reported being bullied in the previous six months and 45% reported having experienced discrimination based on their gender. Sixty-five percent of apprentices reported never receiving formal mentorship, indicating this is a needed intervention.

Discussion: Women still face gendered experiences in the construction trades. An appropriate, evidence-based, and accessible mentorship training may help to increase social support, develop leadership skills, and improve retention and experiences for women in construction. This skill development can, in turn, lead to decreased rates of injury amongst female construction workers.

H3.2

Title: Evaluating the Accidents and Levels of Compliance in Construction Sites

Authors: Somendra Pal Rana, Rachna Dawar

Objectives: There has been an unprecedented growth in construction projects in India due to rapid industrialization and favorable environment. However, maximum fatal accidents take place in construction sector making the employment in the sector a risky affair. Employment of untrained migrant workers and constraint in time to complete the projects leads to several accidents at construction sites. Their socio-economic conditions sometimes contribute in unsafe acts at sites also. Ease of doing business has further made the workplace vulnerable to some extent as most of the initial work is done online without physical verification of the site. This results in giving rise to unsafe working conditions from the very beginning of the project.

Methods: The study was carried out to evaluate the accidents and level of compliances with a view to find the credible solutions. Inspections of the construction sites were carried out due to various accidents involving injuries and loss of valuable human lives. Since the construction site is dynamic in nature, it brings with it new challenges with change in worksite, machineries, height, depth and different type of work involved. The study tried to tap all such lacuna that are responsible in increase in accidents. Focus was given to the un-skilled workforce engaged in construction work, which aggravated the already grim situation at the workplace. Such migrated workforce coming from remote areas in a hope of searching livelihood were interviewed. Emphasis was given to know about their working conditions and familiarity with the jobs they were trusted upon at the sites.

Results: It was observed that more than fifty percent accidents took place due to fall from height. Excavated earth that was left without piling and shoring, was another cause of most of the accidents. Strict enforcement and regular training provided fruitful and desired results. It

was observed that proper OSH management and compliance to statutory requirement helped is reducing the accidents drastically. It was also found that legal actions against the managements acted as a deterrent but cannot be considered a viable solution. Lack of awareness and enthusiasm towards statutory compliances prevailed in employers, which can be addressed through proper communication and information.

Conclusions: The sites following the standard operations procedures and work instructions had fewer accidents and the severity of such accidents was also less. Proactive and persuasive approach by enforcement agencies inspired the employers to comply with the OSH laws and make the workplace safe. The top-level commitment for statutory compliances and care for lives, safety and welfare of workers is the key to raise awareness of OSH amongst the stakeholders.

H3.3

Title: Revisiting Formative Research to Identify Gaps in Hazard Recognition Research for High-Risk Workers

Authors: Brianna Eiter, Mahiyar Nasarwanji

Background: To reduce risk of injury or illness, mine workers must be able to identify and mitigate hazards where they work. Hazard recognition is a critically important skill, and one that recent National Institute for Occupational Safety and Health (NIOSH) research indicates a need for improvement (Eiter et al., 2018). A review of the hazard recognition literature suggests previous research has focused primarily on safety-related hazards, e.g., slips and trips and rib and roof falls (Eiter et al. 2018; Kowalski-Trakofler & Barrett, 2003). One potential reason hazard recognition research has focused on these hazards is because of the data sources used to identify and select hazards. However, mine workers are vulnerable to other high-risk hazards such as, dust, noise, and heat but there continues to be limited research focused on mine worker recognition in these areas (Scott & Grayson, 2003). Therefore, the authors sought out to re-evaluate former panoramic scenes and distinguish between safety-related and health-related hazards and then re-examine gaps in research efforts to ascertain hazards that are consistently overlooked and how to address these hazards in future research.

Methods: In 2015, NIOSH conducted formative research to gather information to build an accurate and realistic set of stimuli that would be used as a part of a virtual reality laboratory research study. This formative research was derived from several methodologies including qualitative data collection where mine workers, health and safety professionals, and former Mine Safety and Health Administration (MSHA) inspectors were either interviewed or participated in focus groups, and an assessment of MSHA injury and fatality data and then used to create 32 panoramic scenes of a typical surface stone mine that included over 100 different hazards. The literature supports secondary analyses of qualitative and other formative data when the goal is to apply a new perspective or a new conceptual focus to that data (Heaton, 2000). The goal of this secondary analysis was to re-categorize hazards included in 32 panoramic scenes, re-assess interview and focus group data to identify whether and how health hazards were discussed by mine workers, H&S professionals, and subject matter experts (SMEs), and review data collection materials to determine why health hazards may have been overlooked during initial analyses.

Results: A review of the panoramic scenes indicated that hazards were largely safety-related (e.g., material on the walkway, small vehicles in larger vehicles blind spots, workers performing tasks without having locked and tagged out), though some health-related hazards were included (e.g., noise, welding fumes). This gap in hazard visualization is likely because the selected hazards were based in part on MSHA injury and fatality data. Based on the panoramic scenes developed, it is not surprising that a secondary analysis of the interview and focus group data also indicated that mine workers and H&S professionals primarily discussed safety hazards; however, health-related hazards such as dust and heat exposure were included. Additional analyses will be presented and discussed in the context of re-engaging with previous formative research with a new perspective to identify additional gaps to address with hazard recognition research.

Discussion/Practical Applications: The purpose of this study was to revisit the formative research effort that preceded and informed a hazard recognition study and the creation of a set of panoramic scenes used as stimuli within a virtual reality laboratory environment. These results are being used to inform development and implementation of forthcoming hazard recognition research that will improve mine worker acknowledgement and behavior to reduce hazards that cause chronic outcomes.

Session H4

Participatory Self-Management to Promote Safety Culture/Climate and Sustainability in Hazardous Work Environments

Moderator: Ted Scharf

Abstract: Safety culture/climate continues to be a "hot topic" among safety professionals. But, on its own, the topic "safety culture/climate" is irrelevant, unless and until it is directly connected to the organization's safety management system from which the safety culture/climate derives.

"The U.S. Occupational Safety and Health Administration (OSHA [3409, p.3]) recognizes that new strategies are needed to ensure that all workers return home safe, sound, and healthy from a day on the job. Workplace safety and health standards and their enforcement can have a huge impact on workers' lives—but the OSHA standard setting process is slow and even full compliance with standards will not prevent all work injuries and illnesses. There is much untapped potential to leverage other movements that are big, proactive, diverse in audience and stakeholders, future-thinking, and innovative to advance worker safety and health. Sustainability is one such movement that provides the potential to go beyond the Agency's traditional role and become a transformative force."

Organizational sustainability extends far beyond the safety and health management system in a hazardous work environment. And there are many strategies and approaches that promote organizational sustainability (OSHA, 3409). With respect to a sustainable safety and health management system, one critical strategy is active, participatory engagement by every member of the workforce in that environment. This session will explore theoretical and practical approaches to developing and maintaining such engagement for a sustainable safety and health management system. Further, this session will connect these strategies to the creation of a strong safety culture/climate for the organization.

Presentation #1: A brief history of worker engagement in safety initiatives

Presenter: Lisa M. Kath, San Diego State University

The first presentation will provide the theoretical background and support from industrial/organizational psychology. Leading management theories will be briefly compared.

Presentation #2: "Non-compliance," "complacency," and other explanations for unsafe work practices that blame workers for systemic failures: one psychologist's perspective

Presenter: Ted Scharf, NIOSH, Cincinnati

The second presentation will examine a few of the – often untested, and incorrect – perspectives that are attributed to workers who appear to ignore or to short-cut safety guidelines.

Presentation #3: The promise of, and problems with, worker participation

Presenter: Scott Schneider, Laborers' Health and Safety Fund
of North America (retired)

The third presentation will address some of the available approaches to improve safety and safety culture/climate in hazardous work environments, with an emphasis on worker participation at all levels of management.

Presentation #4: Using close call reports to empower worker-led interventions

Presenter: Emily J. Haas, NIOSH, Pittsburgh

The final presentation will illustrate some of these approaches with results of interventions from the industrial construction and aggregates industries.

Discussion: David LeGrande, Communications Workers of America (retired)

The session will conclude with a discussion of the directions for future development of the ideas presented in this session.

Learning Objectives: Session participants will be able to:

1. Describe key components of the academic literature on organizational management related to worker participation.
2. Describe and assess this literature compared to popular descriptions that promote safety culture in the workplace.
3. Evaluate possible methodological errors in the misinterpretation of this literature.
4. Suggest both theoretical and practical examples of worker self-management in hazardous work environments.

Industries: Relevant to all industries with hazardous work environments. The presenters and discussant have research and intervention experience in agriculture, communications, construction, emergency response, and mining.

Reference:

Occupational Safety and Health Administration (OSHA). U.S. Department of Labor. (2016, December). Sustainability in the Workplace: A New Approach for Advancing Worker Safety and Health. Washington, DC: OSHA 3409. 37p. Sustainability in the Workplace - Overview | Occupational Safety and Health Administration (osha.gov)

H4.1

Title: A Brief History of Worker Engagement in Safety Initiatives

Author: Lisa Kath

Industrial-organizational psychology has a rich history of studying management theories and approaches that include worker engagement. This presentation (which needs to be virtual) reviews this history as a backdrop for the symposium that follows. This presentation will start off with a discussion of McGregor's Theory X and Theory Y management (McGregor & Cutcher-Gershenfeld, 1960; Sorensen & Minahan, 2011). In this approach, Theory X managers hold the assumption that workers are inherently lazy and need to be supervised closely and motivated through external rewards or punishments to accomplish performance goals. Theory Y managers hold the assumption that workers are largely self-motivated to perform well, and that they need to be empowered to achieve performance goals. Only Theory Y managers are going to be inclined to include worker engagement (most notably, their participation in decision making).

There are other movements and approaches that inherently incorporate worker engagement. One such movement is what is commonly called kaizen, or "continuous improvement" (Kato & Smalley, 2010). In this approach, factory workers are empowered to make small changes necessary to improve the manufacturing process. This approach was a radical departure from historic time-and-motion studies, where workers were studied to determine the precise movements required, and they were not permitted to deviate from their standardized protocols. Another such approach is participatory ergonomics, which is the "involvement of people in planning and controlling a significant amount of their own work activities" (Burgess-Limerick, 2018). The "ergonomics" part indicates a certain level of focus on the physical aspects of the job (tools, human-machine interaction), but it also emphasizes participation in decision making as a key element. More recently, particularly in the nursing field, there has been study of structural and psychological empowerment. (Laschinger & Havens, 1997; McDermott et al., 1996). This approach indicates that the structure of the organization needs to empower workers to have control over their own work to ensure quality and well-being.

There are several terms associated with teams who are empowered to be engaged in decision-making about work processes: quality circles (Lawler & Mohrman, 1987), Total Quality Management (Dahlgaard et al., 2008) and self-managed teams (Solansky, 2008). In these approaches, individual team members and the team as a whole are trained to identify areas where improvements can be made, and they are empowered to bring issues/concerns to the team for discussion about what needs to be changed. In all these approaches, there is strong evidence that including worker engagement in the improvement of processes is a powerful way to make significant strides toward better quality and safety. Understanding the long history of worker engagement and the notable empirical support worker engagement has enjoyed can be helpful in designing safety initiatives that are likely to be most effective.

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H4.2

Title: "Non-compliance," "Complacency," and Other Explanations for Unsafe Work Practices That Blame Workers for Systemic Failures: One Psychologist's Perspective

Author: Ted Scharf

Safety professionals often express their frustration regarding a failure in safety compliance by workers. Another common term is the "complacency" of workers with respect to workplace safety and health policies, procedures, and practices. This presentation will start

with the organization of work issues that may exert a profound impact on day-to-day workplace safety. For example, the provision of the number of workers, and/or the availability of the appropriate equipment to complete a task safely, are both key criteria with respect to safe work practices in an organization. But what happens when the number of staff are inadequate, and/or when safety equipment is unavailable? In short, safety and productivity often appear to be in conflict. Continuing, "non-compliance" and "complacency" are most often attributed to workers, and rarely, if ever, to the organization and management of the work processes. Examples that may be perceived as "non-compliance" or "complacency" will be offered from workers' experiences on job-sites, and that derive from focus group interviews with Ironworkers. 1. These examples will be shown to be appropriate adaptations by workers to function effectively in hazardous work environments, and to accommodate to management rules. From a psychological perspective, adaption by each worker to a specific hazardous work environment is a key requirement to be able to function effectively. As one NIOSH colleague summarized the problem: miners are not working 300 feet underground because that is a safe place to be, they are working there to extract coal. 2. The challenge for safety professionals is to distinguish effective adaptation from dysfunctional adaptation and from habituation. Finally, it is incumbent on researchers and other safety professionals to examine, very closely, the actual physical and work organization conditions on a particular job-site, before they conclude that a worker is complacent or non-compliant. In many cases (Ironworker interviews), the worker has no control over staffing and other safety-related concerns on the job-site. Yet, in the broader safety literature, we often see "non-compliance," and "complacency" described as a relatively stable personality trait applied to individual workers. The purpose of this presentation is to challenge this judgment and description. This presentation will conclude with a practical example (again from the Ironworkers) regarding how unions and other organizations of workers might re-assert control over staffing and other organization of work issues that directly impact safety in hazardous work environments.

References: 1. Scharf, T., Hunt, J., III, McCann, M., Pierson, K., Repmann, R., Migliaccio, F., Limanowski, J., Creegan, J., Bowers, D., Happe, J., and Jones, A. (2011). Hazard Recognition for Ironworkers: Preventing Falls and Close Calls – Updated Findings. In, Hsaio, H., Keane, P. (Eds.). Research and Practice for Fall Injury Control in the Workplace: Proceedings of International Conference on Fall Prevention and Protection. Morgantown, WV., NIOSH. May 18-20, 2010. pp. 196-201. https://www.cdc.gov/niosh/docs/2012-103/pdfs/2012-103.pdf 2. Wiehagen, Bill, (NIOSH, retired). Personal communication, 1997.

H4.3

Title: The Promise of, and Problems With, Worker Participation

Author: Scott Schneider

Worker participation is key to an effective safety program and prevention. Workers are on the front lines and know where the problems are and how to fix them. But power imbalances in the workplace inhibit effective worker participation. This presentation will discuss ways to elicit effective participation and address these power imbalances through competent persons, rights to refuse unsafe work, joint safety committees and health and safety reps.

H4.4

Title: Using Close Call Reports to Empower Worker-Led Interventions

Authors: Emily Haas, Joseph McGuire, Brendan Demich, Cassandra Hoebbel

Problem Statement: The National Safety Council (2013) discusses close calls as unplanned events that could have resulted in injury or damage but did not. Following a close call, workers complete reports to document these upstream risk indicators and initiate organizational and individual responses to mitigate hazards. However, it is unclear how these reports influence actions or controls to reduce risk. Some practitioners have argued that close call incidents should undergo risk assessments using the probability and consequences of occurrence. Based on the probability of a negative event occurring, risk assessments can help organizations determine whether the level of risk is acceptable, assess trends, and prioritize risk reduction strategies (McKinnon, 2012; Pinto et al., 2011; Ristic, 2013). To that end, National Institute for Occupational Safety and Health (NIOSH) researchers took two activities often implemented separately (close call reports and risk assessments), to inform gaps in worksite interventions.

Methods: A collaboration with industrial construction and aggregate entities occurred in which 249 close call reports were content analyzed over a three-month period in 2018. Of these 249 reports, 167 were valid, work-related close calls. Researchers coded the reports using ANSI/ASSE's (2011) qualitative 5×5 risk matrix in which close calls were analyzed for probability of occurrence (i.e., rare, unlikely, moderate, likely, almost certain) and consequence if the event happened (i.e., first aid, minor injuries, lost time, disability/fatality, multiple fatalities) to

calculate a risk rank (i.e., low, moderate, high, and critical). Additionally, NIOSH's hierarchy of controls (2015) was used, if applicable, to categorize corrective actions taken in response to the close call. Researchers used these results to determine relationships among the risk type and the corrective action implemented.

Results: The risk matrix analyses suggested that 19% of the close calls were low risk, 25% moderate, 30% high, and 26% critical risk. To determine a relationship between the risk type and the corrective action implemented by the organization or its employees, a nonparametric median test compared the proportion of scores within each category of corrective action that fell above the median risk type across all categories; risk types were ranked from 1 (low risk) to 4 (critical risk). The results of the test were significant (chi-square=13.64, df = 4, $p < .005$), indicating that the relative frequency of levels of risk varied across types of corrective actions. For example, the action "Implement safe work procedures" was associated with a higher level of risk than the action "Not yet fixed" or "issue PPE."

Practical applications: This study provides insight into ways that close calls can be used as a metric of safety management and improve worker engagement in risk management interventions. Notably, the results showed that the dominant corrective action in response to the close calls reported was an increased adherence to safe work practices on the job. Consequently, this presentation also discusses how one company, Cessford Construction, used results of their close call analyses to engage employees during onsite trainings to create tailored intervention materials including four leading indicator checklists – or scorecards – for use by the workforce during their shift (McGuire et al., 2019; Haas et al., 2019). The checklists provide workers with reminders about common causes that contribute to incidents and processes that could be utilized to prevent their occurrence. Because this program was developed by Cessford frontline employees it has been readily adopted, empowering them to take the lead in "fixing" identified hazards. These results provoke thoughts on organizational and communication gaps that might exist about safe work procedures as well as underlying reasons why certain work procedures are not always implemented as intended.

Session I1

Use of Workers' Compensation Claims to Advance Safety

Moderator: Steven Naber

I1.1

Title: The Impact of a State-Based Workers' Compensation Insurer's Risk Control Services on Employer Claim Frequency and Cost Rates

Authors: Steven Wurzelbacher, Stephen Bertke, Michael Lampl, P. Timothy Bushnell, David Robins, Steven Naber, Libby Moore

Objective: This study evaluated the impact of a state workers' compensation (WC) insurer's onsite risk control (RC) services on insured employers' WC claim frequency and cost.

Methods: We used regression analyses to model 2004-2017 claims data from 4,606 employer policies that received RC visits over time and compare this claims experience to matching policies that did not receive RC services.

Results: Relative total WC claim rates increased slightly after RC services, while relative lost-time claims rates and cost rates decreased. The impact of RC services was cumulative up to the fourth visit but diminished thereafter.

Conclusions: The insurer RC consultation program was effective in reducing WC LT claim frequency and WC cost rate for serviced employers. This is consistent with the limited research conducted on insurer RC services and related regulatory visits.

I1.2

Title: Surveillance of Agricultural Injuries: Comparison of State Trauma and Workers' Compensation Data Sources

Authors: Marizen Ramirez, Carri Casteel, Daniel Boonstra, Fred Gerr, Joseph Cavanaugh, Christina Rosebush

Background: Although it is well-established that Agriculture is among the most dangerous industries in the US, surveillance of agricultural injuries is hampered by methodological challenges. The objectives of this study are to identify the types of agricultural injury data available from two administrative databases (trauma registry and workers' compensation) and characterize the cases most likely captured in one database versus another.

Methods: Data were accessed from the Iowa Trauma Registry (ITR) and Iowa's statewide workers' compensation data from 2005-2014. The ITR collects data from injury cases that led to trauma response in all Level I, II, III and IV hospitals across the state. Data from the Iowa Division of Workers' Compensation Data (WC) are submitted by agricultural operations across the state. Data were matched across these two state-level databases using deterministic and probabilistic linking procedures. Logistic regression models were then developed to identify predictors of capture in one or both of these databases. Predictors were identified using step-wise model selection procedures. The entry into the model and exit from the model criteria was a Wald p-value limit of 0.2.

Results: A total of 2,508 agricultural injuries were reported in the ITR. Of these, 26% were caused by machinery, 18% from falls and 12% from being struck by or against objects. More than 90% of trauma cases were male; 32% were fractures; 16% were open wounds; and 8% were head injuries. The WC dataset contained a total of 3,529 agricultural injury claims. A lower percentage of males were injured (83.2% out of 3,529 claims) in the WC dataset than in the ITR. For WC, the top causes of injury were falls (27.3%), overexertion (26.9%), and natural environments (including animal-related incidents) (10.4%). Sprains and strains were most prevalent at 36.7% followed by fractures at 17.2%. WC cases were just slightly younger (average age= 41) than ITR cases (average age=49). A total of 110 cases linked across both the trauma registry and workers' compensation databases, representing only about 4.4% of the trauma registry and 3.1% of the workers' compensation cases. Age, sex, cause of injury and nature of injury were identified as predictors of capture in either the ITR or WC data sources. Profiles of the cases with the highest probabilities of capture in the ITR and WC data sources will be generated.

Conclusion: From this study, we concluded that the trauma data and workers' compensation data represent two unique surveillance sources for targeting different types of agricultural injuries.

I1.3

Title: Workers' Compensation Claim Counts and Rates by Injury Event/Exposure Among State-Insured Private Employers in Ohio, 2007-2017

Authors: Steven Wurzelbacher, Alysha R. Meyers, Michael Lampl, P. Timothy Bushnell, Stephen Bertke, David Robins, Chih-Yu Tseng, Steven Naber

Background: This study analyzed workers' compensation (WC) claims among private employers insured by the Ohio state-based WC carrier to identity high-risk industries by detailed cause of injury.

Methods: A machine-learning algorithm was used to code each claim by US Bureau of Labor Statistics (BLS) event/exposure. The codes assigned to lost-time (LT) claims with lower algorithm probabilities of accurate classification or those LT claims with high costs were manually reviewed. WC data were linked with the state's unemployment insurance (UI) data to identify the employer's industry and number of employees. BLS data on hours worked per employee were used to estimate full-time equivalents (FTE) and calculate rates of WC claims per 100 FTE.

Results: 140,780 LT claims and 633,373 medical-only claims were analyzed. Although counts and rates of LT WC claims declined from 2007-2017, the shares of leading LT injury event/exposures remained largely unchanged. LT claims due to Overexertion and Bodily Reaction (33.0%) were most common, followed by Falls, Slips, and Trips (31.4%), Contact with Objects and Equipment (22.5%), Transportation Incidents (7.0%), Exposure to Harmful Substances or Environments (2.8%), Violence and Other Injuries by Persons or Animals (2.5%), and Fires and Explosions (0.4%). These findings are consistent with other reported data. The proportions of injury event/exposures varied by industry, and high-risk industries were identified.

Conclusions: Injuries have been reduced, but prevention challenges remain in certain industries. Available evidence on intervention effectiveness was summarized and mapped to the analysis results to demonstrate how the results can guide prevention efforts. Practical Applications: Employers, safety/health practitioners, and researchers can use these data to understand industry differences in the level and mix of risks, as well as industry trends, and to tailor safety, health, and disability prevention services and research.

Session I2

Measuring and Predicting Footwear Slip Risk

Moderator: Jennifer Bell

I2.1

Title: A Portable Device for Measuring Shoe-Floor Coefficient of Friction in Situ

Authors: Kurt Beschorner, Arnab Chanda, Brian Moyer, Alexander Reasinger, Sarah Griffin, Isaiah Johnston

Introduction: Friction performance of footwear is widely recognized to influence on the wearer's risk of slipping [1]. Most modern devices for quantifying this friction are laboratory-based devices that cannot be easily used in environments where slips naturally occur (i.e., in situ) [2]. Portable measurements would enable end-users to identify high performance footwear for a particular work environment and could enable testing on walking surfaces that are difficult to simulate in a lab (ice, grass, etc.). Thus, a need exists for such technology.

Methods: A portable device (NextSTEPS, XRDS Systems) was developed that weighs 18 kg, is capable of testing whole shoes, and is battery powered. The device applies dynamic conditions (normal force of 250 N, sliding speed of 0.5 m/s, and shoe-floor angle of 17°) that are predictive of human slips [1]. The device is operated via a laptop-based user interface. The device has motors that generate horizontal and vertical motion, while force sensors measure friction and normal forces. A lockable hinge joint enables the user to set the shoe at the prescribed angle. The device determines coefficient of friction (COF) as a ratio of friction to normal force. The device was validated against the slip outcomes of 67 human exposures to liquid-contaminated flooring. Liquid contaminants included diluted glycerol and canola oil liquids and flooring materials included laminate and porcelain tile. Each participant was given a different pair of shoes for the tests. These shoes included a combination of shoes labeled as slip-resistant and shoes without this designation. Participants were categorized as slipping or not slipping based on whether their shoe slipping distance exceeded 3 cm [1]. The COF for each shoe was measured under the same flooring and contaminant conditions as were present during the human exposure to the slipping. A logistic regression curve determined whether the observed COF values measured from the device were associated with slip outcome. Slip predictions were made using a training and validation set. To develop these predictions, a training data set was used that involved 9 shoe-floor-contaminant conditions and 124 human slip exposures (human slipping data set previously described in [1]). A receiver operating characteristic curve was developed to determine the COF cutoff that yielded the best sensitivity and specificity based on Youdin's J parameter. This cutoff was then applied to the current data set to predict slips (COF values below the cutoff) and no slip outcomes (COF values above the cutoff). The odds ratio, sensitivity and specificity of these predictions were quantified.

Results: The COF values measured by the device were found to predict human slipping ($p = 0.006$) with fewer slips associated with higher COF values. The training data set yielded a cutoff of 0.122. The slip outcome predictions based on the training data set were sensitive (91%) and specific (62%) to the observed outcomes. An odds ratio of 16.5 (95% confidence interval: 3.4-79.4) was observed for conditions where a slip was predicted relative to cases where a slip was not predicted.

Discussion: This study represents a significant step forward for developing portable technology to deliver footwear testing into natural working environments. Further research is needed to determine the capacity of the device to provide accurate and repeatable readings, particularly across different walking surfaces and on sloped surfaces.

Acknowledgements: Funding for this research was provided by the National Institute on Aging (R44 AG059258). The authors thank David Williams for his assistance with collecting COF data. References 1. Iraqi, et al., Coefficient of friction testing parameters influence the prediction of human slips. Appl Ergo, 2018. 70: p. 118-126. 2. Chang, et al., The role of friction in the measurement of slipperiness, Part 2: survey of friction measurement devices. Ergo, 2001. 44(13): p. 12.

I2.2

Title: Predicting Footwear Slip Risk Using a Low-Cost, Portable, Shoe Tread Scanner

Authors: Sarah Hemler, Kurt Beschorner

Occupational slips and falls are a major cause of injury in the U.S. Forty to 50 percent of all falls are due to slipping which is often caused by low friction at the shoe-floor interface [1]. Footwear is an important, modifiable risk factor for improving shoe-floor friction. Specifically, good practices in shoe outsole tread can improve shoe-floor friction and tread channels can drain fluid away from shoe-floor interface. When the tread on shoes becomes too worn, the fluid cannot be adequately dispersed, leading to under-shoe fluid pressurization and increased slip risk. Previous work in our group has shown that the size of the continuous worn region (WRS) on the shoe outsole is indicative of under-shoe traction performance and thus, shoe safety [2,3]. However, there is a need to

develop a low-cost, automated tool for assessing shoe wear and slip risk. The aim of this study was to develop and use a low-cost, portable, shoe tread scanner to predict slip risk based on the shoe outsole geometry. The scanner utilizes frustrated total internal reflection (FTIR) technology to image the heel of the shoe outsole. FTIR describes the process of shining light into a transparent plate (waveguide) such that the light is internally reflected. When an object with a larger refractive index than air touches the waveguide, the boundary condition changes and the light is transmitted out of the waveguide and can be detected by a camera. Slip outcome and the heel contact scans of 34 slip-resistant shoes used in a human-slipping study were determined. During the human-slipping study, participants unexpectedly walked over a contaminated surface in their own shoes. The peak slip speed (PSS) was calculated as the local maximum speed at least 50 ms after heel contact. A step was classified as a slip if the PSS exceeded 0.2 m/s [4]. On the scanner, the shoes were loaded (335 N) and the contact between the shoe and the waveguide was captured with a camera. An image processing procedure identified and quantified the size of the largest continuous worn region on the heel (WRS). The WRS across the shoes ranged from 1 to 1006 mm2 with an average (standard deviation) WRS of 325 (624) mm2. A univariate logistic regression was used to test the effect of WRS (identified from the scanner) on slip outcome (human slipping study). A larger WRS was significantly associated with an increase in slip outcome. This study showed that a low-cost, portable, shoe tread scanner was able to predict slip outcome based on shoe outsole geometry. The results are consistent with previous studies that have shown that using the size of the worn region on a shoe can be useful in predicting under-shoe traction performance [5]. Furthermore, this low-cost tool could be used to recommend replacement for shoes that reach a certain threshold on the logistic regressions. As such, the scanner shows promise as a practical tool for reducing occupational slip and fall risk.

Acknowledgments: This study was funded by the National Institute for Occupational Safety and Health (NIOSH R01 OH 010940) and the National Science Foundation (NSF GRFP 174752). References: 1. Courtney, et al., Occupational slip, trip, and fall-related injuries–can the contribution of slipperiness be isolated? Ergonomics, 2001. 44(13): p. 1118-1137. 2. Hemler, et al., Changes in under-shoe traction and fluid drainage for progressively worn shoe tread. Applied Ergonomics, 2019. 80: p. 35-42. 3. Hemler, et al., Traction performance across the life of slip-resistant footwear: preliminary results from a longitudinal study. Journal of Safety Research, 2020. 4. Beschorner, et al., Fluid pressures at the shoe–floor–contaminant interface during slips: Effects of tread & implications on slip severity. Journal of biomechanics, 2014. 47(2): p. 458-463. 5. Beschorner, et al., An observational ergonomic tool for assessing the worn condition of slip-resistant shoes. Applied Ergonomics, 2020. 88: p. 103140.

I2.3

Title: Predicting the Friction Performance of Footwear Based on Outsole Features

Authors: Kurt Beschorner, Arian Iraqi, Emily Meehan, Mahiyar Nasarwanji, Chris Deschler, Sarah Hemler, Claire Tushak, Natasa Vidic

Footwear with good frictional performance is widely recognized to prevent slips in fluid-contaminated conditions [1]. Friction performance of footwear is typically measured using expensive and specialized equipment [2]. This approach is inaccessible to many individuals. The purpose of this study was to predict friction performance of shoes based on inexpensively and simply measured outsole parameters. Footwear in the study was assessed through mechanical friction testing and through human-centered testing. Mechanical friction testing was conducted on fifty-eight shoes designated as slip-resistant (SR) [3] and fifteen shoes without this designation (NSR). An additional 36 SR shoes were assessed using human-centered methods. The key shoe features for predicting friction performance were the tread surface area, the presence of a bevel at the posterior region of the shoe, and the tread hardness. Friction performance was tested using biofidelic testing methods [4] with a canola oil contaminant. Flooring conditions included laminate flooring and ceramic tile. COF was measured as the average ratio of friction to normal force over a 200 ms period. For the NSR shoes, fluid pressures were also measured to determine the contribution of fluid drainage to these shoe designs. A statistical model was developed to predict COF for these shoes based on the tread surface area, bevel, hardness, flooring, and whether shoes were designated as slip-resistant by the manufacturer. Higher tread surface area, the presence of heel beveling, and lower hardness predicted an increase in shoe-floor COF for SR shoes, but not for NSR shoes. For NSR shoes, fluid pressure was negatively correlated with COF. NSR shoes with worse drainage (higher fluid pressure) had about a 50% reduction in friction performance than shoes with better drainage (lower fluid pressure). Thus, NSR shoes can improve friction performance by improving tread drainage whereas SR shoes can improve friction performance by targeting surface area, heel shape, and material hardness. The statistical model developed for SR shoes was validated using human exposures to an oily surface. Slip outcome

was determined based on slipping distance. Logistic regression methods were used to determine whether slip outcome was dependent on the predicted COF (calculated using the previously developed statistical model based on tread surface area, heel beveling, and hardness). A higher COF predicted by the statistical model was associated with a significant reduction in risk of slipping. This study demonstrates that the friction performance of slip-resistant shoes can be predicted using tread features and that the friction performance of shoes that are not slip-resistant can be predicted based on fluid drainage capacity. These results provide insight for designing and selecting shoes even when friction testing equipment is unavailable.

Acknowledgments: This study was funded by the National Institute for Occupational Safety and Health (R03OH011069). References: 1. Bell, J.L., J.W. Collins, and S. Chiou, Effectiveness of a no-cost-to-workers, slip-resistant footwear program for reducing slipping-related injuries in food service workers: a cluster randomized trial. Scandinavian journal of work, environment & health, 2019. 45(2). 2. Chang, W.R., R. Gronqvist, S. Leclercq, R.J. Brungraber, U. Mattke, L. Strandberg, S.C. Thorpe, R. Myung, L. Makkonen, and T.K. Courtney, The role of friction in the measurement of slipperiness, Part 2: survey of friction measurement devices. Ergonomics, 2001. 44(13): p. 1233-61. 3. Iraqi, A., N.S. Vidic, M.S. Redfern, and K.E. Beschorner, Prediction of coefficient of friction based on footwear outsole features. Applied ergonomics, 2020. 82: p. 102963. 4. Iraqi, A., R. Cham, M.S. Redfern, and K.E. Beschorner, Coefficient of friction testing parameters influence the prediction of human slips. Applied Ergonomics, 2018. 70: p. 118-126.

Session I3

The Role of Worker Age in Occupational Injuries

Moderator: James Collins

I3.1

Title: Risk of Work-Related Reinjury Among Older Workers With and Without a Work-Related Permanent Impairment: Are Work-Related Injury Rates Differentially Underestimated for Workers Aged 65 and Older?

Authors: Jeanne Sears, Deborah Fulton-Kehoe, Sheilah Hogg-Johnson

Background: The workforce is aging; nearly 20% of Americans aged 65+ are employed. Work injuries among older workers are more severe, more costly, and more apt to result in permanent disability, early retirement, or death. Reports of lower injury rates for older workers are less than compelling, and evidence is scant for workers aged 65+. Work injury rates are often based on population size and calendar time, rather than on individual work-time at risk—differentially underestimating rates for older workers due to more part-time/intermittent work and retirement. Workers 65+ are also more likely to have health insurance or retirement alternatives to workers' compensation (WC) and have markedly higher WC underfiling rates than those <65; work injuries are often billed to Medicare. To mitigate the impact of underfiling WC claims, we focused on reinjury among workers who previously filed WC claims. We assessed: (1) reinjury risk for workers aged 65+ vs. <65; (2) interaction between age and permanent impairment; (3) reinjury rates based on WC claims vs. self-report; (4) effect of denominator choice on age comparisons; and (5) age distribution of job strain, physical demands, and other injury risk factors.

Methods: Washington State WC claims for a retrospective cohort of 43,114 injured workers were linked to state wage files containing quarterly hours worked from injury date (2003-2017) through 2018. Reinjury was defined as reopened (aggravation/recurrence) or new injury claims. Two denominators were used: calendar quarters, and full-time equivalent (FTE) quarters (cumulative work hours ÷ 520). Reinjury risk by age was assessed using Cox proportional hazards regression, controlling for worker, injury, and job characteristics. Survey data were used to assess associations between age and self-reported reinjury, health, and workplace factors. Workers with a work-related permanent impairment were interviewed in 2019 (N=599), about a year after claim closure. Reinjury rates per 100 worker-years were calculated using both calendar time and FTE time.

Results: Cohort: Using calendar time, the WC-based reinjury rate for workers aged 65+ (N=855) was 2.9 (2.4-3.4) per 100 worker-years vs. 6.0 (95% CI: 5.8-6.1) for <65. Using FTE time, the reinjury rate was 11.2 (9.4-13.3) for 65+ vs. 12.5 (95% CI: 12.3-12.7) for <65. In adjusted Cox models using calendar time, workers 65+ (vs. <65) had half the reinjury risk (HR: 0.50; 95% CI: 0.42-0.59); this gap narrowed substantially when using FTE time (HR: 0.85; 95% CI: 0.72-1.01). Workers with (vs. without) permanent impairment had higher reinjury risk (HR: 1.14; 95% CI: 1.09-1.19); there was no detected interaction with age. Survey: Using calendar time, the self-reported reinjury rate for workers 65+ (N=34) was 22.7 per 100 worker-years (11.4-45.5) vs. 12.0 (95% CI: 9.5-15.1) for <65. Using self-reported FTE time, the reinjury rate was 35.7 (17.8-71.3) for 65+ vs. 14.8 (95% CI: 11.7-18.6) for <65. Workers 65+ (vs. <65) were more likely to work

<100% FTE, be unemployed or retired, and have chronic conditions; they were similar regarding job strain, ability to handle physical job demands, comfort reporting an unsafe work situation or work injury, and comfort filing a WC claim.

Conclusions: Choice of denominator substantially affects reinjury comparisons by age, due to differential employment patterns. Workers aged 65+ appeared half as likely to be reinjured as workers <65 when using calendar time but did not significantly differ once rates were adjusted for work-time at risk. Survey data suggested that permanently impaired workers aged 65+ may have well over twice the reinjury risk of those <65—risk not explained by differences in physical demands, job strain, or various other work factors. Work injury incidence among workers aged 65+ is likely higher than previously appreciated. Continued aging of the workforce necessitates increased attention to injury surveillance and prevention for older workers.

I3.2

Title: Environmental Factors of Ladder Overreaching in Older Adults

Authors: David Williams, Kurt Beschorner, Stephen Lord, Daina Sturnieks, Erika Pliner

Introduction: Ladder falls are the second most common cause of all falls [1], with people over 65 years having the highest hospital and intensive care admission rates due to falls from ladders [2]. In people presenting to an emergency department due to a ladder fall, 37% identified overreaching as a factor in their fall [3]. To better understand ladder fall risks for an aging working population, this study examined the role of environmental factors on reaching during ladder use in older adults.

Methods: A total of 104 healthy older participants were asked to complete a laboratory-based roof gutter clearing task on a straight ladder. The task required the participants to climb to the third step of a straight ladder and remove tennis balls from a gutter (5.8 m in length and 2.1 m above the ground) until all the tennis balls were removed. Participants were allowed to move the ladder as many times as necessary to complete the task in a safe and quick manner. The maximum center of pressure (COP) location relative to the ladder center was used to quantify reach as this measure is highly correlated with maximum hand displacement during the gutter clearing task. The maximum COP was quantified for each reaching attempt on the ladder. A COP value that travelled outside the ladder base of support (199 mm from the ladder center) was classified as an overreach as the ladder would have likely tipped and resulted in a ladder fall if the ladder was not secured in this experiment. Extracted environmental factors were the percent of time into the ladder task (% time), ladder position (categories based on ladder location: left, middle left, middle, middle right, right), and whether the tennis balls extended so far from the ladder that they could not be removed without moving the ladder (remaining debris). The environmental factors were entered into a multivariate linear regression. Reach was the dependent variable as measured by the maximum COP of each reach.

Results: Environmental factors had a significant impact on reach ($F_{6,827}=6.40$; $p<0.001$). Ladder position ($F_{4,827}=3.68$; $p=0.006$) and remaining debris ($F_{1,827}=4.65$; $p=0.031$) were both significant predictors of reach. The % time into the climb was not found to be a significant predictor of reach ($F_{1,827}=0.55$; $p=0.460$). Maximum COP values were significantly farther from the ladder's center when the ladder was positioned in the right middle of the gutter, compared to the right and left ends (Tukey HSD; $p<0.05$), and when there was remaining debris (i.e., tennis balls) after the reach. The right middle position (15%) and remaining debris (11%) conditions had the most reaches classified as overreaches.

Discussion/Conclusion: Our analysis found reach to be explained by environmental factors, that is, ladder position and remaining debris (tennis balls). Motivation can increase lateral reaching while on a ladder [4]. Remaining debris may act as a motivator to overreach. Ladder position may also prompt overreaching since the highest reach was observed at a position where many participants were on their last climb or second to last climb to complete the gutter clearing task. The results of this analysis draw important conclusions regarding the effects of environment on overreaching. These models help illustrate how the environment is associated with more dangerous decision making in terms of overreaching. These findings can help guide interventions to lower overreaching risk during ladder tasks.

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I3.3

Title: Traumatic Injuries and Fatalities Among Young Workers in Alaska: 2014-2018

Authors: Richard Evoy, Devin Lucas, Samantha Case, Laura Syron

Background: Young workers (aged 15-24 years) experience higher rates of job-related injury compared with adult workers (aged 25-44 years) in the United States. Young workers may have limited or no prior work experience, as well as lack safety training, which can contribute to their risks of sustaining injuries. In 2018, Alaska had the second highest work-related fatality rate and 14th highest injury rate in the United States but there is a lack of literature on young worker injuries in Alaska. The study's objective was to characterize occupational injuries and fatalities experienced by young workers in Alaska.

Methods: To describe patterns of traumatic injuries and fatalities among young workers, we used data from four datasets: Alaska Workers' Compensation, Alaska Occupational Injury Surveillance System (AOISS), Alaska Trauma Registry, and Alaska Fishermen's Fund. Cases were manually coded using the Occupational Injury and Illness Classification System (OIICS). Duplicates were manually identified between the datasets using the injury date, narrative, and location and the workers' sex and age. Industry and occupation were coded using the North American Industry Classification System (NAICS) and Standard Occupational Classification System (SOC) codes based on workers' job descriptions. The employee mailing address or their listed state of residence were used to identify Alaska residents. Descriptive analyses were performed.

Results: Young workers represented ~14% of the nonfatal injuries and ~12% of the fatalities across the four datasets during 2014-2018. Young workers experienced twenty fatalities and 12,904 nonfatal injuries. Nonresidents of Alaska comprised 14.7% of nonfatal injuries and 30% of fatalities. Young workers in the Seafood Product Preparation and Packaging industry (NAICS 311710) had the most injuries (n=828, 6.42%) followed by the General Medical and Surgical Hospital industry (NAICS 622110) (n=651, 5.04%). Based on occupation, Laborers and Freight, Stock and Material Movers (SOC 53-7062) had the highest number of traumatic injuries (n=719, 5.57%) while Food Processing Workers, All Other (SOC 51-3099) had the second most injuries (n=611, 4.73%). The three most common events leading to injuries were injured by handheld object or equipment (n=904, 7.01%), overexertion in lifting/lowering (n=798, 6.18%), and struck against stationary object or equipment (n=657, 5.09%). The three most common nature of injury codes were sprains/strains/tears (n=3,062, 23.73%), cuts/lacerations (n=2,479, 19.21%), and bruises/contusions (n=1,981, 15.35%).

Conclusion: Although progress has been made in reducing injuries among workers, Alaskan young workers still experience injuries and fatalities frequently. Based on findings, there is a clear need for researchers, public health professionals, parents, employers, and young workers to prioritize young worker safety through an integrated approach, from education and training to adequate workplace supervision and support.

Session I4

Connecting Safety Climate/Culture to Safety Management: A Brief Summary

Moderator: Ted Scharf

Presenters: Ted Scharf, Lisa M. Kath, Emily J. Haas

Workshop Description

Major goals:

1. Describe the complicated literature in safety climate & safety culture.
2. Summarize the current state of the art, including future directions for this research.
3. Connect this literature to OSH management systems in hazardous work environments.

This workshop will also consider:

a. The work organization context in which safety policies, procedures, & practices are implemented in a hazardous work environment.

b. Interventions to improve safety climate & culture in organizations.

Learning Objectives: Session participants will be able to:

1. Describe key components of the academic literature in safety climate and safety culture.
2. Assess the current state of the research and discuss promising future directions for research in this area.
3. Apply this literature to examples of occupational safety and health management systems.

4. Compare potential interventions that address safety culture and safety climate by improving policies, procedures, and practices in hazardous work environments.

Industries: Relevant to all industries with hazardous work environments. The presenters have research and intervention experience in agriculture, construction, emergency response, and mining. Examples from these industries will be discussed.

Who should attend: Safety professionals, other practitioners, researchers, and students who would like to learn more about the burgeoning discipline of safety climate and safety culture are invited to attend this tutorial. Researchers who are considering teaching a class in safety climate and safety culture may also find it useful. Principal investigators with active research in this discipline are likely to find the material to be somewhat basic. No prerequisites are required. All those interested in this topic are invited to attend.

Please note: There is a great deal of material to cover to provide this overview and introduction. Consequently, there will not be extensive hands-on activities, as in a true workshop. We will provide a mental scaffold to help keep the information organized, and we will provide learning aids for you to refer to after the workshop is over.

Session Outline:

Organizing questions/issues for the session:

A. Why should anyone care about safety culture / climate in an organization?

SC & C have been shown to be valid, leading indicators of safety in hazardous work environments (e.g., Casey, Griffin, Harrison, and Neal, 2017; Schonfeld and Chang, 2017; Zohar, 2010, 2014). But so what? How does this connect to the organization?

1. Organizational (foundational) culture and climate
2. Safety culture and climate as a subset within organizations
3. Culture vs. climate
    a. Underlying attitudes & beliefs, compared to a "snapshot in time"
    b. Similarities across both domains
    c. References for further study
4. Utility of safety climate assessments
    a. Dx, early indicator:
        1. Focused problem
        2. Overall assessment of safety
    b. Prioritizing or targeting interventions/improvements in safe work practices
    c. Continuous improvement
    d. Organizational sustainability
    e. Connections to OSHMS's
    f. Business case

B. The overall context of safety in a hazardous work environment: National and International standards of sustainability and improved safety climate / culture in an organization: safety with productivity.

1. A few popular myths about safety climate/culture:
    a. Safety culture/climate is just management talking to make themselves feel good. It doesn't really matter.
    b. Safety and productivity are at natural odds with one another
    c. Safety C/C is too esoteric or ephemeral to be measured
    d. Nothing can be done to change safety C/C.
2. The broader context within which safety climate/culture operates
    a. Simplified models (Scharf, et al., in preparation)
    b. Safety and health management systems
        1. Hierarchy of controls in hazardous work environments
        2. Process safety
        3. High reliability organizations
    c. Socio-technical systems
    d. The complete organizational context: safety with productivity
3. Practical concerns in the workplace
    a. Injury and illness outcomes
    b. Reporting safety problems; psychological safety
    c. Incentives for safety
    d. Managing the transition period from coerced reporting to voluntary and proactive reporting

C. What is safety climate/culture, and how does it function in a hazardous work environment?

1. Crew/group based aggregation of culture/climate
    a. Level of aggregation is flexible, depending on organizational structure and function
    b. A group-level phenomenon
    c. Lone-worker is still part of a work group or team (Huang, et al.)
    d. Zohar comparison between espousal and enactment (2010); "walking the talk," and behavioral integrity (Simons, 2002)
2. Measurement of safety climate
    a. Moss, Kath, McGonagle, and Bauerle, (2015, May); measurement decomposed into espousal and enactment
    b. Individual level measurement of the interaction term, that is aggregated at the selected group level
    c. Neal and Griffin (2006) individual "perceived safety climate" and "group safety climate."
    d. Safety climate "level" (mean) and "strength" (degree of coherence/variability)
3. Common first-order factors within the construct of safety climate (e.g. Hahn & Murphy, 2008)
    a. Management commitment to safety
    b. Supervisory performance/safety feedback
    c. Worker involvement in safety
    d. Coworker behavior norms
    e. Guldenmund and many other references
4. Relevant empirical methods
    a. Brief digression on exploratory factor analysis and confirmatory factor analysis, i.e. determining factor structure
    b. Measurement equivalence across different demographic groups
    c. Brief digression on HLM, contextual analysis, and ICC(1) and ICC(2), i.e. empirical analysis of group-level phenomena
5. Parallel or related constructs
    a. Health climate
    b. Psychosocial safety climate
    c. Work-ownership climate
    d. Psychological health and safety at work (Canada)
6. Antecedents, mediators, moderators, and other closely related phenomena to SC
    a. Safety leadership
    b. Supervisors – pretty much everything – a long list of potential elements here
    c. Co-worker and crew-level attitudes and orientation
    d. Safety attitudes
    e. Safety knowledge
    f. Safety motivation and lack of same
    g. Safety performance:
        1. Safety compliance and lack of same
        2. Safety participation and lack of same

D. Interventions to improve safety climate and culture:

1. Interventions and other examples of strong, positive safety climate training
    a. CPWR
        1. Safety Climate Assessment Tool (S-CAT), 2016, 2018;
        2. Foundations for Safety Leadership (FSL), 2017;
        3. Safety Climate and Safety Management Information System, 2014.
    b. AIHA "How To" Guides (Schneider, 2017)
    c. IAFC: National Safety Culture Change Initiative
    d. NRC: nine traits of a positive safety culture
    e. Zohar and Polachek (2014)

National Institute for Occupational Safety and Health (NIOSH). (2006). Information Circular 9490: Job training analysis: a process for quickly developing a roadmap for teaching and evaluating job skills. By Wiehagen, W.J., Conrad, D.W., Baugher, J.M. Pittsburgh, PA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2006–139. (http://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2006-139.pdf).

Session J1

New Bureau of Labor Statistics Office of Safety and Health Program Methods and Approaches

Moderator: Elizabeth Rogers

Organizer: U.S. Bureau of Labor Statistics (BLS) Office of Safety and Health Statistics (OSHS)

BLS proposes an emerging issues session on new OSHS program methods and approaches with three detailed presentations on: 1) improvements to the secondary disclosure methodology and effects on data for the Census of Fatal Occupational Injuries and Illnesses, 2) changes in the next version of the Occupational Injury and Illness Classification System, and 3) results from the 2020 Survey of Occupational Injuries and Illnesses.

Improvements to Secondary Disclosure Methods in the Census of Fatal Occupational Injuries

Presenters: Daniel Friel and Julie Krautter, Bureau of Labor Statistics, Office of Safety and Health Statistics

The Census of Fatal Occupational Injuries (CFOI) at the Bureau of Labor Statistics (BLS) collects a complete census of all fatalities that occur during a calendar year as the result of workplace injuries. CFOI data present unique disclosure challenges because there are a small number of fatalities per year (5,333 in 2019) and many fatalities are reported publicly. For any information that BLS collects from confidential sources, it is required to protect the collected data. With the recognition that CFOI was not adequately protecting its confidential data, we set out to update the methodology. In this presentation, BLS will outline the options that we considered for disclosure limitation and the benefits and drawbacks of each, including reduction of publishable CFOI cells.

Occupational Injury and Illness Classification System (OIICS 3) for Data Users

Presenter: Christen Byler, MSPH, Bureau of Labor Statistics, Office of Safety and Health Statistics

The Occupational Injury and Illness Classification System (OIICS) was developed by the Bureau of Labor Statistics (BLS) and has been used to classify occupational safety and health surveillance data by nature, part of body, source, and event or exposure since 1992. Its second major revision, OIICS 3, is set for release in 2022. This presentation would orient OIICS stakeholders and data users to the changes they can expect and tips for how their organization can plan for a smooth transition in light of the series break. Some highlights of OIICS 3 include redesigning codes to anticipate technological changes in the workplace (e.g., robotics and autonomous vehicles), new codes to capture use and/or failure of safety interventions, and the addition of two classification structures to capture worker activity and location of incident. OIICS 3 also incorporates coding rules and examples into the new manual format for ease and consistency of coding.

Results from the 2020 Survey of Occupational Injuries and Illnesses (SOII)

Presenter: Imani Drayton-Hill, Bureau of Labor Statistics, Office of Safety and Health Statistics

Annually, the SOII collects occupational injuries and illnesses from approximately 230,000 US employers and publishes estimates of incidence rates and counts as well as detailed case and demographic data for cases that involve one or more days away from work. BLS will publish results of the 2020 SOII in November 2021. (These estimates are embargoed prior to the publication of results.) COVID-19 can be a recordable illness if a worker is infected as a result of performing their work-related duties and meets OSHA criteria. The SOII relies on OSHA recordkeeping requirements, which mandate employers record certain work-related injuries and illnesses on their OSHA 300 log (29 CFR Part 1904). While the OIICS classification system used by SOII does not include a code specifically for COVID-19, these cases were included on the Nature code 3299 – "Other diseases due to viruses, not elsewhere classified." This presentation will explore SOII collection challenges related to COVID-19 cases, injury and illness estimates from the 2020 SOII, and the strengths and limitations in using SOII data to analyze COVID-19 in the workplace.

Session J2

Laboratory Studies to Reduce Work-Related Injuries

Moderator: Jennifer Bell

J2.1

Title: Developing a Test for When Worn Shoes Should Be Replaced – Research to Practice

Authors: Kurt Beschorner, Sarah Hemler, Johanna Siegel, Vani Sundaram, Joel Haight, Mark Redfern

Occupational slips can be prevented through selecting slip-resistant footwear and replacing worn shoes [1]. We have conducted a series of experiments to understand shoe wear and determine when worn shoes should be replaced. This research was motivated by a gap in

knowledge around the surface mechanics of worn shoes and lack of guidance for when worn shoes should be replaced. The research involved three main components: friction testing of shoes that were exposed to accelerated wear under mechanically controlled conditions; friction testing of shoes that were worn by workers in occupational settings; and human slipping responses while wearing shoes with various levels of wear. The shoes were evaluated under liquid-contaminated conditions. A finding that was consistently observed was that shoe friction performance declined when a worn region formed on the outsole and the size of this worn region increased slip risk [2-4]. This resulted in an important paradigm shift from prior methods of characterizing shoe wear based on tread depth [5] or shoe age [1]. Thus, measuring the size of the worn region represents a promising new means of evaluating the worn condition of shoes and assessing whether these shoes should be replaced. Identifying the size of the worn region as a key metric formed the basis for new tests that empowered workers to assess the worn condition of their shoes. One test that emerged assessed the worn condition of the shoe using the base of an AA battery [6]. This test was validated across the accelerated wear, natural wear, and human slipping data sets. Shoes that failed this test had poorer fluid drainage, a 30% loss in friction performance, and an increase in slip risk. Therefore, this test was determined to be a valid method for assessing when worn shoes should be replaced. The "battery test" for shoes was disseminated through informational posters, dedicated websites, and a video. This research was incorporated into informational posters developed by the National Occupational Research Agenda (NORA) cross-sector on Traumatic Injuries. These posters were targeted at two sectors of interest: food service workers and hospital workers. Websites hosted by NORA and by the Human Movement and Balance Lab at the University of Pittsburgh were created to provide supplemental information on worn shoes. A video was produced that communicated this information and provided a tutorial for applying the test. Future research should aim to monitor the efficacy of the battery test in altering worker footwear replacement behavior and the resulting impact on their slip and fall risk. Furthermore, additional work may be needed to assess the human factors of utilizing the test and whether adaptations are desired by end users.

Acknowledgements: This research was funded by the United States National Institute for Occupational Safety and Health (R01OH010940).

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J2.2

Title: The Relationship Between Weight Shifts, Discomfort and Seated Breaks During Standing

Authors: Julie Rekant, Zachary Wiilson, April Chambers

Background: Sit-stand desks are increasingly a part of the office workplace. Their ability to improve physical activity and energy expenditure, as well as reduce discomfort is promising but unproven [1-3]. The potential for sit-stand desks to address discomfort likely depends on identifying correct usage: how much time sitting versus how much time standing is needed to prevent discomfort in both positions. Proposed ratios vary from 1:1 to 3:1. However, field research that has tried to impose set time limits have found workers indicating they prefer self-choice [4,5]. Weight shifting has been shown to be a powerful indicator of discomfort [6,7]. The long term goal of this research is to use technology to develop general dosage guidelines for sit-stand desks. As a first step towards this, the objective of this pilot study was to identify which aspects of weight shifting best predict discomfort and fatigue.

Methods: Healthy adults between the ages of 35-55 years old with no current orthopedic or muscular disorders were recruited to participate in this study. All research procedures were approved by the University of Pittsburgh Institutional Review Board. Subjects were asked to perform a computer task using a sit-stand desk in the standing position. Subjects stood on a force plate for 90 minutes while center of pressure movements and ground

reaction forces were collected continuously. Subjective discomfort of body regions and overall fatigue surveys were measured on a visual analog scale at five-minute intervals. Each survey concluded by asking if the subject would like to take a seated break; after two consecutive "yes" answers the subject was given a short seated break.

Results: Participants demonstrated different weight distribution change patterns during standing. Participants who did not request seated breaks until later (after 60 minutes of standing) or at all during the 90-minute visit demonstrated more sustained, alternating weight shifting. Those who requested seated rest breaks during the first hour demonstrated very little changes in medial-lateral center of pressure until right before they requested a seated break. Preliminary results show an increase in medial-lateral center of pressure excursions during the five-minute window prior to the participants receiving a seated break. Subjective ratings of discomfort in the lower body also increased in the ten-minute window prior to participants requesting seated breaks.

Discussion: This work reinforces previous prolonged standing research demonstrating increased weight shifting behavior with increased discomfort [6, 7]. Two different styles of standers were identified – those who move very little then demonstrate a specific pattern of quicker then slower large-amplitude movements and prefer to stand for less than an hour, and those who shift their weight consistently over time and prefer standing for longer periods of time. Finally, this pilot study shows the ability to use center of pressure changes during standing as a marker of discomfort, standing style, and sitting vs. standing preference when using a sit-stand desk.

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Session J3

Special Topics in Work-Related Injuries

Moderator: James Collins

J3.1

Title: Work Schedules, Commutes, and Risky Driving Behaviors from a Cross-Sectional Survey of U.S. Oil and Gas Extraction Workers

Authors: Kait Wingate, Alejandra Ramirez-Cardenas

Background: Consisting of over 470,000 workers in 2019, the U.S. oil and gas extraction (OGE) workforce faces fatality rates higher than for all U.S. workers. The leading cause of death among OGE workers is transportation incidents, primarily due to motor vehicle crashes, and these fatalities are trending upwards. While the Occupational Safety and Health Administration (OSHA) regulates safety on oil and gas well sites, off-site motor vehicle crashes are outside of OSHA's jurisdiction and motor vehicle safety (MVS) policies are the responsibility of each company. OGE workers often have long commutes and workdays; however, information about their driving behaviors, work schedules, and work environment is limited. This presentation will review the findings of a survey administered to U.S. OGE workers to characterize worker demographics and employment characteristics and examine the relationships between those characteristics and employer policies on risky driving behaviors and poor driving outcomes.

Methods: Researchers from the National Institute for Occupational Safety and Health administered a questionnaire and short interview to a sample of 500 OGE workers at worksites in Colorado, North Dakota, and Texas between 2017 and 2019. Questions included worker demographics, employer characteristics, work and commute schedules, worker health and exposures, safety culture, training, and driving behaviors. Statistical analysis and data management was performed using R and Microsoft Excel. Descriptive analyses, t-tests, and chi-square tests were performed as well as multivariable logistic regression to assess risky driving behaviors. Adjusted odds ratios were calculated for the final regression models.

Results: 498 workers completed the survey. The majority of respondents were male (96.8%) and white (70.7%), and over one-third were Hispanic (35.3%). Over half of respondents reported working for well servicing companies (54.4%), followed by drilling contractors (21.3%) and oil and gas operators (19.1%). Almost three-quarters of respondents (72.9%) reported driving for

work. The mean total hours worked per day was 11.87, and the mean total daily commuting time was 1.82 hours. Company MVS policies that were almost universally reported included seat belt use and mandatory crash reporting. Less commonly reported MVS policies included journey management and fatigue management. The most frequently reported risky driving behavior was talking on a hands-free cell phone (always, often, or sometimes; 59.8%). About a quarter of respondents reported other behaviors such as ever having fallen asleep while driving a work vehicle (27.2%), feeling drowsy while driving a work vehicle (once per week or more, 26.1%), and driving 10 mph or more above the speed limit (always, often, or sometimes; 24.9%). Regression results identified the following variables to be significantly associated with poor driving outcomes: less sleep, longer daily commutes, longer work hours, alternative work schedules, working in North Dakota, no employer maximum work hours policy, in-vehicle monitoring systems, no ban on hands-free cell phones, and no employer fatigue management policy.

Discussion: While a large proportion of respondents reported driving as a part of their job, motor vehicle safety is often overlooked, as driving on the job is largely unregulated. OGE workers reported long daily commutes, long work hours, and limited sleep, all of which were significantly associated with risky driving behaviors and poor driving outcomes. Interventions such as alternative accommodations and modes of transportation are needed to help shorten commutes and allow sufficient sleep hours. Further research on commutes, work hours, and work schedules, and their impact on fatigue may help explain transportation injuries and fatalities among OGE workers. Additional evaluation on employer MVS policies and programs could help to identify gaps in risk management for work-related crashes.

J3.2

Title: Demonstrating the Impact of Interventions to Prevent Work-Related Injuries

Authors: James Collins, Jennifer Bell, Cammie K. Chaumont Menendez, Hope Tiesman, Christina Socias-Morales, Guang Chen, Melody Gwilliam, Scott Hendricks, Harold Gomes, Srinivas Konda, Vidisha Parasram

Background: The public health approach to reducing work-related injuries is an iterative process that utilizes surveillance data to characterize the injury burden, assesses risk factors to understand the underlying causes of injuries, and develops, implements, and evaluates interventions to address the problem. Researchers in the National Institute for Occupational Safety and Health's (NIOSH), Division of Safety Research (DSR), Analysis and Field Evaluations Branch (AFEB) have collaborated with industry partners, employers, stakeholders, and other federal research agencies over the past 25 years to conduct intervention evaluation research. The purpose of our research is to demonstrate the impact of workplace interventions in populations of workers and communicate the findings regarding the effectiveness of successful interventions to stakeholders, industry partners and decision makers who can take action to create broad impact to benefit the overall workforce.

Methods: This presentation will examine a series of research studies that highlight the evolution of the NIOSH research branch to evaluate the efficacy of interventions to prevent work-related injuries. The values and skills of rigorous inquiry, and methodological and practical considerations for conducting high quality intervention evaluation research will be discussed. The presentation will review the process of engaging industry partners and stakeholders, developing relevant research questions and specific methodological issues. More specifically, this presentation will examine the selection of the most appropriate study design, the development and implementation of interventions, establishment of study populations, length of follow-up, outcomes to measure, and economic assessments.

Results: Key findings from a range of intervention evaluation studies will be presented that have demonstrated statistically significant impacts on reducing motor vehicle crashes, falls from heights, falls on the same level, low back injuries, and violence in the workplace. These studies evaluated the efficacy of "best practices" interventions that addressed hazards across a range of occupations and industries including retail trade, healthcare, law enforcement, transportation, taxi drivers, food service workers, truck drivers and military personnel (Air Force and Navy). They also examined a range of interventions from multi-faceted programs to single interventions to prevent high priority injuries resulting from slips, trips, and falls, patient lifting, violence, and motor vehicle crashes.

Conclusions: The importance of demonstrating the impact of safety promoting ordinances and "best practices" injury prevention programs cannot be overstated. After demonstrating the effectiveness of successful municipal ordinances and workplace injury prevention programs, findings are disseminated widely to the research community, safety professionals, employers, unions, workers, and decision makers who can act on translating research to practice, reducing the risk of injury for the worker populations beyond the study population. The

future of workplace intervention evaluation will have to be adaptable to focus on the changing demographics of the US workforce, health inequities, underserved worker populations, changes in work organization and the rapid influx of technology to ensure that all workers have equal access to safe and healthy work environments to accomplish the NIOSH mission of preventing work-related injuries.

J3.3

Title: Occupational Injury in Group Homes

Author: Adam Moskowitz

Background and Objective: Residential care communities, commonly referred to as group homes, are a patchwork system of care and services for individuals who cannot live alone or with their families because of physical, emotional, and/or intellectual special needs. Residents live in small groups with 24-hour support from on-site staff, who also engage in cooking, cleaning, facilitating group activities, and driving for the residents. Group home employees are often young or part-time students, due to the flexibility of work hours and applicability of the experience to medical or care-focused careers. These workers face many of the same hazards as other clinical or medical workers, including patient-handling injuries, workplace violence, and biological exposures. However, little is known about injury trends or risks among group home employees. This project aims to describe occupational injury trends in group homes and identify risk factors for severe injury, patient-handling injury, and violence-related injury in the group home setting.

Methods: A dataset of workers' compensation claims from group homes operating in the Upper Midwest from 2006-2017 was analyzed. Incident descriptions were read by investigators and coded for violence and patient handling-related incidents. Log binomial regression was used to model risk factors for experiencing workplace violence, a patient-handling related injury, and lost-time injury.

Results: Of 4,365 injury claims, 13% resulted in lost time and 87% were medical only. Roughly 51% of all claims involved some form of violent incident or contact with a resident, 33% of all claims were specifically associated with violence, and 15% of all claims were related to patient-handling injuries. Claims involving violence were significantly associated with younger and male workers, while patient-handling related injuries were significantly associated with female workers. Common injury causes were lifting, falls, and absorption of noxious materials. Strains, contusions, and punctures were the most common injuries, with the lower back, finger, knee, and shoulder being the most commonly affected body parts. Patient handling-related injuries were a significant risk factor for having a lost-time claim.

Discussion and Conclusion: Group home employees are at high risk for injury, especially in younger age groups. A significant portion of injuries to group home employees involve contact with residents or incidents of violence. While workplace violence can have lasting psychological impacts on the victim, claims involving safe-patient handling injuries are generally more severe and carry higher risk for losing days of work. Safe Patient Handling policies from the medical field can be applied to group homes as an intervention to reduce injury risk from contact with residents. Verbal de-escalation should be prioritized over physical restraints when dealing with aggressive behavior. Because group homes operate out of residential houses and not regulated spaces like hospitals or medical facilities, extreme care should be taken to clear areas of debris and ice to prevent falls.

NOIRS 2022 ABSTRACT AND SESSION PROPOSAL REVIEWERS

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