



2017 Expanding Research Partnerships: State of the Science

Center for Health, Work & Environment
colorado school of public health





DEPARTMENT OF HEALTH & HUMAN SERVICES

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Message from the Director, National Institute for Occupational Safety and Health

It is my pleasure to welcome you to the *2017 Expanding Research Partnerships: State of the Science Conference!* The Conference serves as an opportunity to showcase the best in occupational safety and health research and spotlight the important role of partnerships in the work that we do.

The theme of the **State of Science Conference** is “Expanding research partnerships.” We will do this by bringing together extramural and NIOSH scientists to learn about the leading edge research being conducted across the field of occupational safety and health. The Conference will also foster new relationships, identify areas of mutual interest, and maximize collaborations to address priority worker issues.

In the National Occupational Research Agenda (NORA), science is conducted through partnerships. Now in its third decade, NORA continues to foster partnerships that stimulate innovative research and improved workplace practices. As you will note throughout the Conference, participation in NORA is broad, including stakeholders from universities, large and small businesses, professional societies, government agencies, safety and health practitioners, and worker organizations. I am hopeful that the State of the Science Conference will result in many new partnerships for the betterment of worker safety and health.

I would like to thank our partner, the Center for Health, Work & Environment at the Colorado School of Public Health, whose efforts have helped make the Conference possible. I would also like to thank the many scientific presenters, individuals, and organizations who have made the Conference agenda particularly exciting.

All the best for a successful and productive meeting and enjoy the Conference!

John Howard, MD

Dear Colleagues,

On behalf of the Center for Health, Work & Environment at the Colorado School of Public Health, welcome to the State of the Science Conference. We are pleased to provide the venue for the event. It's a privilege to help convene hundreds of occupational health and safety professionals, advance knowledge, and build partnerships.

As a NIOSH-funded center that serves as a hub for education, research, and public health practice in our region, we understand the power of collaboration. Through r2p, we have learned that partnership is a vital part of achieving our mission to advance worker health, safety, and well-being. Fostering that spirit of collaboration is what this conference is all about.

I'd like to thank NIOSH for inviting us to share our campus for this historic meeting.

On behalf of our entire team, I thank you for joining us and for your commitment to expanding research partnerships. We look forward to learning more about the innovative research happening across the country and finding new ways to work together.

On a personal note, when you are in Colorado, please remember to stay hydrated and use sunblock. We are truly a mile high. Enjoy.

Sincerely,



Lee Newman, MD, MA
Director, Center for Health, Work & Environment
Professor, Colorado School of Public Health and School of Medicine
University of Colorado

Conference Planning Committee

Margaret Kitt, NIOSH, Chair

Sarah Felknor, NIOSH, Co-chair

Max Kiefer, NIOSH, Co-chair

Tricia Boyles, NIOSH, Coordinator

David Christiani, Harvard University

Michelle Haan, Colorado School of Public Health

Emily Novicki, NIOSH

Lee Newman, Colorado School of Public Health

John Piacentino, NIOSH

Christina Spring, NIOSH



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Conference Program

Wednesday, June 21, 2017

8:00am – 10:00am Registration

8:30am – 8:45am Welcome Education 2 South - 1102

John Howard, NIOSH Director

Lee Newman, Director, Center for Health, Work & Environment

**8:45am – 9:45am The Third Decade of NORA Education 2 South - 1102
(Moderator: Margaret Kitt)**

8:45am Review of the 2nd Decade – Sarah Felknor

9:05am Moving forward with the Third Decade – Lore Jackson Lee

9:25am The BNI approach – Paul Schulte

9:45am – 10:00am Break

**10:00am – 11:30am Opening Plenary Education 2 South - 1102
(Moderator: Sarah Felknor)**

10:00am Jennifer Marcum: Leveraging industrial and unemployment insurance data to target at-risk construction firms, Washington State

10:20am Megan Casey: Silicosis prevalence among Medicare beneficiaries, 1999–2014

10:40am Linda McCauley: Dehydration status and heat related symptoms in Florida farmworkers

11:00am Jennifer M. Lincoln: Improving PFD use among commercial fishermen: using partnerships to effect change

11:30am – 1:00pm Lunch/Networking

Food trucks and local venues - on your own

**1:00pm – 2:00pm Ignite Rapid Presentations Education 2 South - 1102
(Moderator: Lee Newman)**

1:00pm Amy Darragh: Virtual simulation training system (VSTS)

1:10pm June Spector: Heat exposure, injury risk, and productivity in agricultural workers

1:20pm Linda Sargent: Dose response of multi-walled carbon nanotube (MWCNT)-induced lung tumors

1:30pm Garrett Burnett: Lean and Broke: What we learned partnering on a national challenge with no money and no time

1:40pm Carisa Harris Adamson: Personal, psychosocial, and biomechanical risk factors for work disability from carpal tunnel syndrome: Findings from the NIOSH Consortium Studies

1:50pm Ellen Duysen: Using trusted research facilitators to assess tribal bison worker hazards

2:00pm – 3:30pm Concurrent Session 1

Session A World Trade Center Education 2 South - 1307
(Moderator: Allen Robison)

2:00pm James E. Cone: Ten-year cancer incidence in rescue and recovery workers and survivors of the World Trade Center disaster

2:25pm James E. Cone: Persistent post-9/11 hearing problems among World Trade Center Health Registry rescue and recovery workers, 2001 – 2007

2:50pm Mayris P. Webber: Maintenance and extension of a cohort of career firefighters as a non-WTC exposed comparison for the FDNY Firefighter Cohort

Session B Transportation, Warehousing, Utilities .. Education 2 South - 2201
(Moderator: Dawn Castillo)

2:00pm Jennifer E Lincoln: A pilot study of healthy living options at 16 truck stops across the United States

2:25pm Guang Chen: Opinions on safety and its influence on driving behaviors: results from NIOSH national survey of U.S. long-haul truck driver health and injury

2:50pm Christopher Drucker: Detecting emergency vehicles: The use of in-vehicle driver support systems to improve transportation safety

Session C Manufacturing Education 2 South - 2305
(Moderator: Stephen Reynolds)

2:00pm Thais C. Morata: Promoting the implementation of evidence-based occupational safety and health practices in the manufacturing industry

2:25pm Christine R. Schuler: Effects of exposure, solubility and genetic factors on sensitization and chronic beryllium disease among short-term beryllium workers

2:50pm Tim Bushnell: The contributions of occupational safety and health to organizational productivity and environmental goals

Session D Total Worker Health Education 2 South - 2306
 (Moderator: Anita Schill)

- 2:00pm Laura Punnett: Building labor-management partnerships for Total Worker Health in public sector healthcare facilities
- 2:25pm Laura Punnett: HearWell: A Total Worker Health™ approach to hearing conservation among transportation workers
- 2:50pm Glorian Sorensen: A Conceptual model to guide Total Worker Health® research and interventions

3:30pm – 3:45pm Break

3:45pm – 5:15pm Concurrent Session 2

Session E Economic Burden Education 2 South - 1307
 (Moderator: John Piacentino)

- 3:45pm Regina Pana-Cryan: The economic burden of occupational illness
- 4:10pm Abay Asfaw: Impact of Nonstandard Work Arrangements on Earnings and Fringe Benefits: Evidence from the 2010 and 2015 National Health Interview Surveys
- 4:35pm Steve Wurzelbacher: Maximizing the use of workers’ compensation systems to improve safety through partnerships

Session F Agriculture, Forestry, Fishing Education 2 South - 2201
 (Moderator: Jeff Levin)

- 3:45pm Chandran Achutan: Attitude Changes in Farmers following a point-source hearing protection intervention
- 4:10pm Carolyn Reeb-Whitaker: Respiratory disease awareness and prevention in the US hop harvest industry
- 4:35pm Stephen Reynolds: Dairy bioaerosol exposures and inflammatory markers in workers: A panel study

Session G Construction Education 2 South - 2305
 (Moderator: Christine Branche)

- 3:45pm Ann Marie Dale: Promoting musculoskeletal disorder prevention efforts within a construction safety management program
- 4:10pm Mary Kathryn (MK) Fletcher: Partnering for hearing loss prevention in construction

4:35pm Emily J. Haas: Use of video exposure monitoring to increase worker proactive dust control practices: Evaluation of five worksite interventions

Session H Healthy Work Design.....Education 2 South - 2306
(Moderator: Paul Schulte)

3:45pm Mojtaba Yazdani: Improvement of human safety in fault-tolerant human and robot collaboration using convex optimization and receding horizon control

4:10pm Chia-Chia Chang: A conceptual and measurement model for worker well-being

4:35pm Glorian Sorensen: Design, construction, and management of a comprehensive employee research database: the PERDS study of the Harvard Center for Work, Health, and Wellbeing

6:30pm Social (Food and beverage available for purchase)

Thursday, June 22, 2017

8:30am – 10:00am Early Career Scientist Plenary.....Education 2 South - 1102
(Moderator: Dave Christiani)

8:30am Sophia Chiu: Respiratory and ocular symptoms among employees at an indoor waterpark resort — Ohio, 2016

8:50am Jaime Butler-Dawson: A longitudinal evaluation of kidney function among sugarcane workers in Guatemala

9:10am Feng-Chiao Su: Mixed exposures to cleaning and disinfecting chemicals among healthcare workers

9:30am Kathleen Attfield: Collaboration between NIOSH and California Department of Public Health to investigate occupational exposures in e-cigarette vape shops

10:10am – 11:40am Concurrent Session 3

Session I State SurveillanceEducation 2 South - 2206
(Moderator: Doug Trout)

10:10am Rebecca Jackson: State-based surveillance and public health practice: Overcoming challenges to using California workers' compensation claims data for public health surveillance

- 10:35am Terry Bunn: State based-surveillance and public health practice: Integration of the Kentucky Occupational Safety and Health Surveillance Program into state drug abuse prevention efforts
- 11:00am Kenneth Rosenman: State-based surveillance and public health practice: Michigan Hospital and emergency department surveillance system

Session J Home Health Care and Hospital Workers Education 2 South - 2201
 (Moderator: Linda McCauley)

- 10:10am Barbara Polivka: Virtual simulation training in home healthcare
- 10:35am Ryan Olson: Total Worker Health intervention for home care workers: Research, translation, and dissemination of the COMPASS program
- 11:00am Steven A. Lavender: Hospital patient room ergonomics: Getting it right for all hospital staff working in these spaces

Session K Personal Protective Equipment Education 2 South - 2305
 (Moderator: Jon Szalajda)

- 10:10am Zhipeng Lei: Development of computational methods for evaluating loose-fitting powered air-purifying respirators
- 10:35am Bingbing Wu: Evaluating a novel respirator seal integrity monitor for controlling inhalation exposure of firefighters
- 11:00am Lee Portnoff: A test for liquid penetration through protective fabric using fluorescent dye under a dynamic hydrostatic pressure regime

Session L Respiratory Health Education 2 South - 2306
 (Moderator: David Weissman)

- 10:10am Kathleen Clark: Implementation of a national spirometry facility network for the Coal Workers’ Health Surveillance Program (CWHSP)
- 10:35am Joshua Schaeffer: Task-based exposures to airborne endotoxins and β-Glucans among dairy workers
- 11:00am Jongeun Rhee: Occupational exposures and the acute respiratory distress syndrome (ARDS)

11:40am – 1:00pm Lunch/Topic Tables Education Bridge

Jason’s Deli Box Lunches (pre-ordered) or local venues
 Topic table information will be available at registration

1:15pm – 2:45pm Poster Session.....Education Bridge

- P1 Hong Kan: Occupational nanoparticle exposure: toxicity beyond the lung
- P2 Mohammad Shoeb: Altered expression of telomere maintenance genes in lung tissue of rats after silica inhalation
- P3 Kari Mendelsohn-Victor: Evaluating oncology nurses’ safety when handling hazardous drugs: Case report analysis from a multi-site study
- P4 Alexander Wu: Airplane pilot mental health and suicidal thoughts: A cross-sectional descriptive study via anonymous web-based survey
- P5 Deborah Reed: Using theater to influence work behaviors of older agricultural workers through community partnerships
- P6 Rafael Y. Lefkowitz: Risk factors for injury and illness in seafarers
- P7 Vy Nguyen: Neurodegenerative mortality among major league baseball players
- P8 Charles B. Hall: Incidence, latency, and survival of cancer following WTC exposure
- P9 T. Renée Anthony: Improving air quality in swine farrowing operations: Results of engineering interventions
- P10 Bethany Lowndes: Surgical assistants at risk of musculoskeletal injury and illness in the operating room: A pilot study to measure exposure
- P11 Judith Graber: Are workplace psychosocial factors associated with work-related injury in the U.S. workforce? National Health Interview Survey, 2010
- P12 Jenna Gibbs: Personal attenuation ratings (PAR) of agricultural workers: How well do earplugs really fit?
- P13 Hali Neves: ATV operation in agriculture: Injury analysis and interventions
- P14 Andrea D. Branch: Higher prevalence of liver steatosis (non-alcoholic fatty liver disease) in members of the World Trade Center Health Program General Responder Cohort than in non-responders
- P15 Andrew Ryan: Work-requirement factors and workplace Injuries among the aging American workforce
- P16 Eloise Zimbelman: Hazards in motion: development of mobile geofences for use in logging safety

- P17 Kang Namkoong: Virtual reality and occupational safety: Exploring the potential of virtual reality technology in agricultural safety education
- P18 Claudia Ma: Actigraphy-based assessment of circadian rhythm: Association with subclinical CVD measures among police officers
- P19 Jamie L. Lancaster: Law enforcement officer motor vehicle crash and struck-by fatality investigations
- P20 Aitor Coca: Critical Wet Bulb Globe Temperature (WBGTcrit) for four protective clothing ensembles made of fabrics with different total heat loss (THL) values
- P21 Laura Kincl: Partnerships in fishing industry safety: The FLIPP engaged research approach
- P22 Murrey E. Loflin: Evaluating and testing fire hose performance during structural firefighting operations
- P23 Emily Hurwitz: World Trade Center Health Program continuing education trainings – expanding partnerships, advancing knowledge, and impacting health professional behavior
- P24 James P. O’Callaghan: Prior exposure to corticosterone markedly enhances and prolongs the response to work-place-related chemical and biological exposures
- P25 Deborah Sammons: The role of the field analysis and sampling group in expanding research partnerships
- P26 Jean M. Cox-Ganser: Spectrum of health outcomes among flavoring-exposed workers: A comparison of the microwave popcorn and flavoring industries
- P27 Matthew Groenewold: Estimating new cases of occupational injuries and illnesses in the United States in 2012
- P28 Jeffrey L. Levin: Commercial fishing safety in the Gulf of Mexico and the Southwest Ag Center: The decade in review
- P29 Brie Hawley: Respiratory symptoms in hospital cleaning staff exposed to a product containing hydrogen peroxide, peracetic acid, and acetic acid
- P30 Andrew Palmiero: Speech intelligibility assessment of protective facemasks and air-purifying respirators

2:45pm – 4:00pm Concurrent Session 4

Session M Exposure Assessment..... Education 2 South - 2206
(Moderator: Max Kiefer)

- 2:45pm Andrew Castano: An evaluation of the collection characteristics and usability factors of three nanoparticle samplers
- 3:10pm Emily H. Sparer: Assessment of ambient exposures firefighters encounter while at the fire station: An exploratory study
- 3:35pm Ninica L. Howard: Comparison of exposures to WMSD risk factors in high and low workers' compensation rate companies in Washington State

Session N Musculoskeletal Disorders Education 2 South - 2201
(Moderator: Jessica Ramsey)

- 2:45pm Jay Kapellusch: The revised strain index - A DUE physical exposure model for complex jobs with job rotation
- 3:10pm Bradley A. Evanoff: Personal and workplace factors for carpal tunnel syndrome: Findings from the NIOSH Consortium Studies
- 3:35pm Ming-Lun Lu: Work-related psychosocial risk factors for low back pain: Evidence from 2015 NHIS data

Session O Extractive Industries Education 2 South - 2305
(Moderator: Jessica Kogel)

- 2:45pm Bon Ki Ku: Lab-on-a-chip device for on-site biomonitoring of workers exposed to respirable silica aerosol
- 3:10pm Ann Backus: FrackMap: Building a geo-spatially based nexus of research publications and perceptions regarding hydraulic fracturing to provide researchers, health professionals and the community access to information about the health risks and impacts of hydraulic fracturing
- 3:35pm Steven Mischler: The personal dust monitor: A partnership success story

Session P OSH In Motion Education 2 South - 2306
(Moderator: John Adgate)

- 2:45pm R. Reid Harvey: Partnership between the National Institute for Occupational Safety and Health (NIOSH) and an indium-tin oxide (ITO) company to prevent indium lung disease

3:10pm Julie Sorensen: Implementation Science: What is it and what do we know about successfully translating OSH solutions into worker practice?

3:35pm Jenny Tsai: Understanding community infrastructure and capacity to engage community agencies in advancing occupational health disparities research

4:00pm – 4:15pm Break

4:15pm – 5:00pm Partnerships Plenary.....Education 2 South - 1102 (Moderator: Margaret Kitt)

4:15pm Barbara M. Alexander: Research partnerships in development of an engineering control for respirable crystalline silica

4:35pm Jessica Bunting: A partner coordinated campaign to prevent falls in construction: Historical review & analysis of reach

5:00pm Closing Remarks

Friday, June 23, 2017

8:30am - 10:00am Extramural research in NORA 3..Education 2 South - 2305 (Open session)

10:00am – 11:30am Center Grantee MeetingEducation 2 South - 2305 (Closed session)

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¹Washington Department of Labor and Industries

Leveraging industrial and unemployment insurance data to target at-risk construction firms, Washington State

Background: Construction is high-hazard work, and continually ranks among the industries with the highest workers' compensation (WC) claim rates in Washington State (WA). WA Labor and Industries (L&I) provides industrial insurance to employers in the state, and maintains uniquely rich administrative data related to WC. We tested the ability to use these administrative data to prospectively identify construction firms at risk.

Methods: Construction firms insured through WA L&I with 10–50 average full time equivalent (FTE) employees during 2011–2013 were included in the sample (n=1,228). Unemployment insurance data from WA's Employment Security Department and time loss (TL) claims information from WA's WC system were linked and modeled using negative binomial regression to test the ability of firm characteristics during a three-year time period, 2011–2013, to predict TL claims rates in the following year, 2014.

Results: Over half (54%) of firms had no TL claims in 2014, 29% had one, and the remaining 17% had two–seven TL claims. Regression modeling identified the following significant predictors with a direct relationship with 2014 claims rates: number of FTE, average WC premium rate, claims history, and firm growth (average quarterly increase in FTE). Average wage per hour and tenure were also significant predictors, but were inversely related to claims rates. The following firm characteristics were analyzed, but not significantly related to claims rates: regulatory activity such as inspections and violations, geographic location, age of firm, and turnover rate.

Conclusions: We demonstrate the ability to leverage administrative data to identify small construction firms predicted to have future WC claims. These results suggest insurers may have a role in risk management by targeted communication and outreach for those at-risk firms, such as those with recent growth. This study should be repeated to determine if these results are applicable to other high-hazard industries.

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¹NIOSH

Silicosis prevalence among Medicare beneficiaries, 1999–2014

Introduction: An estimated 2.3 million workers are exposed to respirable crystalline silica in their workplaces. Because of the long latency period for chronic silicosis, some silicosis cases may not be identified until late in life. As the primary insurance to people aged 65 and older, Medicare claims may be a potential source of nationally representative information to estimate the prevalence for diseases of long latency.

Methods: To assess national silicosis prevalence, Medicare claims for persons aged 65 and older from 1999–2014 were evaluated. The silicosis case definition was modified from Medicare's diagnostic algorithms for other chronic diseases. Prevalent silicosis cases were identified as those with the International Classification of Diseases, Ninth Revision diagnosis code 502 (pneumoconiosis due to other silica or silicates) listed on at least one inpatient, skilled nursing facility, or home health claim or two outpatient or carrier claims within one year. Cumulative annual prevalence per 100,000 beneficiaries was calculated.

Results: Among 74,979,748 beneficiaries aged 65 and older enrolled on Medicare during 1999–2014, 25,684 had at least one claim with a silicosis diagnosis code. Overall, 14,989 beneficiaries met the silicosis case definition. The majority of cases were males (n=13,438, 90%) and whites (n=12,478, 83%). States with the highest prevalence were West Virginia (114 per 100,000), New Mexico (111 per 100,000) and Vermont (65 per 100,000). Cumulative annual prevalence increased until 2006 where it remained constant, averaging 13 per 100,000 per year (5,419 beneficiaries) during 2006–2014.

Conclusions: Medicare claims appear to be a valuable source of surveillance information for diseases of long latency and can be used to evaluate silicosis prevalence among persons aged 65 and older. Future studies may address silicosis-related cost, healthcare utilization and co-morbidities.

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Dehydration Status and Heat Related Symptoms in Florida Farmworkers

Agricultural workers are vulnerable to adverse health effects with rising global temperatures and increased occupational heat exposure. Despite recommended heat exposure criteria being available, heat-related deaths continue to occur in this population. There is evidence that farmworkers experience a high burden of HRI symptoms, but physiological measures of heat related illness (HRI) have not been investigated. We recruited farmworkers from three Florida communities who were monitored over a 3-day work period during hot summer months. Urine specific gravity (USG) was obtained before and after their work shift and an ingested sensor recorded core body temperatures (T_c) and heart rate every 30 seconds during the workday. Farmworkers reported if they experienced excessive sweating, headache, dizziness, muscle cramps, nausea/vomiting, confusion or fainting during their work day. A total of 198 farmworkers were included in this study; the mean age was 38 (±8), and 60% were female. The majority of farmworkers were Hispanic (86%) and spoke Spanish as their primary language (82%). The mean ambient temperature for the hours we monitored workers was 84°F with a relative humidity of 75%. Overall, 52% of workers were dehydrated (USG ≥1.02) before work and 77% after work. Approximately 32% of the workers had a dehydration level after work which indicated high risk of HRI and impaired performance (USG 1.026-1.030) and 21% had reached a recognized level of clinical dehydration (USG > 1.030). Most participants experienced at least one day with T_c exceeding 38°C (100.4°F), the threshold limit value set by the American Congress of Governmental and Industrial Hygienists. Analyses of risk factors for dehydration will be presented along with the extent to which dehydration and elevated core temperature is associated with the likelihood of experiencing heat-related symptoms. Implications for worker safety education will be discussed along with interventions to prevent HRI among farmworkers.

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Improving PFD use among commercial fishermen: using partnerships to effect change

Background: There is no requirement for commercial fishing crews to wear personal flotation devices while they work. Yet the leading cause of death among fishermen is drowning due to the loss of a vessel or a fall overboard. In 2008-2009, NIOSH intramural scientists conducted a study to determine which type of commercially available PFD resulted in the highest satisfaction among commercial fishing crews in Alaska. This study showed that interventions to increase PFD use in the fishing industry should be tailored to each vessel type and focus on addressing the specific barriers to PFD use in each fishery.

Methods: In order to understand barriers in each high-risk fishing fleet around the country, NIOSH intramural scientists worked with NIOSH funded Ag Center researchers to encourage further studies focusing on improving PFD usage among fishermen. NIOSH data showed that west coast Dungeness crab, Gulf of Mexico shrimp, and New England lobstermen were most at risk for drowning due to falls overboard or rapid vessel capsizings. Using these data to support action, three additional studies were conducted or are being conducted to identify the best available type of PFD.

Results: Each iteration of these PFD studies has identified a unique solution or barrier to PFD use. A new type of PFD for fishermen in the Pacific Northwest has been marketed, fishing associations have established rebate programs for members to purchase PFDs, PFD design considerations have been identified for both cold weather and hot weather found in the Gulf of Mexico, and social marketing campaigns are being evaluated for effectiveness.

Conclusions: NIOSH intramural and extramural scientist have collaborated by sharing data, offering technical support, and advice on best practices to further this type of hands on research with fishermen across the country with a goal to increase the use of PFDs and ultimately prevent drownings.

Ignite Session

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Virtual simulation training system (VSTS)

Background: With healthcare increasingly provided in the home, there is a corresponding increase in need for healthcare worker training in identifying and managing home hazards. Existing training methods using simulated home environments are costly to construct, maintain, and can support only limited data on learning outcomes. In conjunction with the NORA aims to develop new research strategies using technologies such as virtual reality to collect and analyze data, we have developed a virtual simulation training system (VSTS) for training workers to assess and manage hazards that pose a risk to their safety.

Methods: To assure content validity, a mixed-methods participatory strategy (employing focus groups, interviews, and questionnaires) was used to develop a “virtual paradigm”. Gaming technologies were used to create a virtual training system for providing an engaging, active, multi-dimensional learning environment. The environment supports interactive selection and uses dialogue boxes to verify hazards, designate severity, and suggest techniques for management. The system automatically collects information on location, selections, time to decision, and time on task. Embedded tutorials promote usability in relation to three training modules that address: 1) electrical, fire, and burn; 2) slip, trip and lift; and, 3) environmental hazard scenarios. The VSTS was evaluated by our user community during hands-on usability, usefulness, and desirability (UUD) studies and is currently being tested for efficacy in a randomized study.

Discussion: We have developed the VSTS, a realistic virtual environment for training healthcare workers to identify and manage various hazards encountered in the home healthcare environment. The current version uses a standard desktop environment and can be downloaded from the Internet. We are actively translating the system to utilize an untethered interface that is considerably more intuitive, promoting search and investigation. In addition, we will introduce physiological metrics to help establish participant status when making decisions when dealing with hazards.

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Heat exposure, injury risk, and productivity in agricultural workers

Background: Epidemiologic research suggests an association between heat exposure and occupational injuries. Studies also suggest reduced work productivity with increasing heat exposure. These associations and potential mechanisms have not previously been explored in detail in agriculture. The goal of this project was to evaluate the association between heat exposure, injury risk, and productivity in agricultural workers.

Methods: This project consisted of: 1) an epidemiologic case-crossover study among 12,213 outdoor agricultural workers with WA workers' compensation traumatic injury claims between 2000 and 2012. Conditional logistic regression was used to estimate odds ratios of injury for daily maximum Humidex categories; and 2) a cross-sectional field study during August-September 2015 of 46 WA pear and apple harvesters. Mixed effects models were used to estimate the association between maximum measured work-shift Wet Bulb Globe Temperature (WBGTmax) and productivity, psychomotor vigilance (reaction time), and balance performance (total path length of standing center of pressure movement).

Results: The traumatic injury odds ratio in the case-crossover study was 1.14 (95% confidence interval [CI] 1.06, 1.22), 1.15 (95% CI 1.06, 1.25), and 1.10 (95% CI 1.01, 1.20) for daily maximum Humidex of 25–29, 30–33, and ≥34, respectively, compared to < 25. Stronger associations were observed during cherry harvest duties in the June and July time period. There were no statistically significant associations between WBGTmax and post-shift reaction time, total path length, or productivity, after adjustment for relevant confounders, in pear and apple harvesters in the field study.

Conclusions: Agricultural workers laboring in warm conditions are at risk for heat-related traumatic injuries. Further work is needed to elucidate the mechanism of this association in high-risk workers to guide prevention efforts. Projections of the impact of climate change on productivity of workers laboring in the heat should consider individual, work, and economic factors that affect rest and recovery.

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Dose response of multi-walled carbon nanotube (MWCNT)-induced lung tumors

Mitsui-7 MWCNTs (MWCNTs) are strong lung tumor promoters in B6C3F1 mice. B6C3F1 mouse lung tumors have many molecular and morphological similarities to human pulmonary tumors. In previous work, we demonstrated that exposure to inhaled MWCNTs following exposure to a DNA damaging agent caused potent promotion of lung tumors. To investigate a possible threshold for MWCNT-induced carcinogenesis, we exposed B6C3F1 mice to a single dose of either methylcholanthrene (MC, 10 µg/g BW, i.p.) or vehicle (corn oil). One week after i.p. injections, mice were exposed by inhalation to MWCNTs (5 mg/m³, 5 hours/day, 5 days/week) or filtered air (controls) for a total of 2, 5 or 10 days. At 17 months post-exposure, mice were euthanized and examined for lung tumor formation. Thirty six percent of the filtered air controls, 33% of the MWCNT-exposed, and 47% of the MC-exposed, had a mean of 0.33, 0.33 and 0.4 tumors per mouse, respectively. By contrast, 94% of mice receiving MC followed by 10 days MWCNT had an average of 2.9 tumors per mouse while 81% of mice exposed to MWCNTs for 5 days had an average of 1.9 tumors per mouse, and 73% of mice exposed to MWCNTs for 2 days had an average of 1.2 tumors per mouse. Additionally, mice exposed to MWCNTs or MC followed by MWCNTs had larger tumor volumes than their corresponding control groups. Preliminary data indicate a dose response in the percent of animals with tumors as well as the number of tumors per animal following exposure to MC and MWCNTs. In this study, mouse MWCNT lung burden approximates feasible human occupational exposures. Therefore, the results of this ongoing study indicate that caution should be used to limit human exposures to MWCNTs.

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Lean and Broke: What we learned partnering on a national challenge with no money and no time

On October 27, 2016, ten finalists pitched their hearing loss prevention ideas to a panel of judges selected from the academic, business, and investment community. The entrants brought their ideas and products to Washington, DC, to compete in the Hear and Now Noise Safety Challenge. OSHA, NIOSH, and MSHA jointly welcomed these entrepreneurs who had come from all over the country at their own expense for the chance to win... nothing in particular. And they were thrilled for the opportunity. Less than five months earlier I had met with Kelly Schnapp, director of OSHA's Office of Science and Technology Assessment. She suggested that our agencies work together to encourage more people and companies to be involved in workplace safety and health. Thus was born the idea to stage an innovation challenge on an OSH topic that was important to both agencies. We had no money and a very short time frame. Over the next few months we formulated a problem statement, issued a nationwide challenge, coordinated media coverage, engaged partners in the entrepreneurial world, selected finalists, coached the finalists on their business models and pitches, and planned event logistics. Along the way we learned many things: How partnerships within an agency, between agencies, and with the public can affect research-to-practice efforts; where lean start-up principles add value and where they damage the end product; and what incentives are important to each of the actors involved in an event like this.

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Personal, psychosocial, and biomechanical risk factors for work disability from carpal tunnel syndrome: Findings from the NIOSH Consortium Studies

Background: Carpal tunnel syndrome (CTS) leads to more disability than most other upper extremity disorders (Foley 2007). Methods: 4321 workers were followed up to 7 years and prevalent and incident cases of CTS (N=318) were identified. Work disability was derived from SF12 and quickDASH questionnaires, and was defined as symptom driven: (1) change in work pace, (2) lost time, or (3) job change. Workplace psychosocial exposure was assessed using the Karasek Job Content Questionnaire. Job level biomechanical exposures were time weighted averages of peak hand force, HAL, total and forceful repetition rate, and % time all and in forceful hand exertions. Adjusted hazard ratios were estimated using Cox proportional hazards models.

Results: Female gender (HR= 1.75; 95% CI: 1.23-2.5) and rheumatoid arthritis (HR=1.85; 95%CI: 1.04-3.26) as well as high job strain compared to low job strain (HR=2.38; 95%CI:1.03-5.51) were associated with increased work disability. Job change was associated with: (i) HAL (HRmiddle =3.91; 95% CI: 1.82-8.38; HRupper=3.20; 95%CI:1.43-7.19), (ii) total repetition rate (HRmiddle=2.30; 95% CI: 1.15-4.58; HRupper =2.58; 95% CI: 1.23-5.38), (iii) % time in forceful exertions (HRupper =2.03; 95% CI: 1.02-4.05) and (iv) % time in all exertions (HRupper=2.53; 95%CI: 1.17-5.43). Pace change was associated with: (i) HAL (HRmiddle=1.97; 95% CI:1.24-3.12) and (ii) % time in all exertions (HRupper=1.94; 95% CI:1.17-3.24). Lost time was associated with forceful repetition rate (HRmiddle=2.46;95%CI:1.11-5.48; HRupper =1.86;95%CI:0.91-3.83).

Conclusions: Age and BMI were not associated with work disability but being female and having rheumatoid arthritis were. High job strain was strongly associated with work disability due to CTS. Prior analyses found that various measures of force (e.g., peak force, forceful repetition rate) but not repetition, per se, were strongly associated with incident CTS. Conversely, these analyses show that both repetition and forceful repetition are associated with work disability from CTS.

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Using Trusted Research Facilitators to Assess Tribal Bison Worker Hazards

Agriculture is one of the most hazardous industries in the United States. Within agriculture, livestock-handling is particularly dangerous. Injury and fatality rates for bison handlers have not been reported. Bison production is a growing industry and more workers will be exposed to close contact with these animals as the demand for bison meat increases. Workers in many of these newly established tribal bison herds have not received formal training and may have limited animal handling experience, making this a workforce that is vulnerable to injury and fatalities. After working for many years to improve the health of tribal herds, veterinarians recognized the need for improvement in the working environment and safety training for those working with bison. In response to this concern, a partnership was established and a pilot project was developed to characterize risks and hazards associated with bison handling under contemporary reservation field conditions. Research partners included veterinarians, field researchers and a tribal advocacy organization, the Intertribal Buffalo Council (ITBC). This was a mixed-methods study and data were gathered through closed and open-ended questions pertaining to bison worker safety hazards. Data were gathered through observational safety audits at bison herding locations by a veterinarian and a survey completed by a convenience sample of American Indian bison herd managers. Findings indicate that the most common worker safety risks are associated with the use of high-stress handling methods and substandard facilities and equipment. Adverse environmental conditions also contribute to worker health risks. Most common causes of injuries included those caused by equipment and tools, adverse weather and animals. This collaborative study contributes to a better understanding of hazards faced by bison workers. This information will assist bison producers, both tribal and nontribal, in formulating and implementing best management practices to improve the health and safety of workers when handling bison.

Concurrent Session 1

Session A-World Trade Center

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Ten-year cancer incidence in rescue and recovery workers and survivors of the World Trade Center disaster

Background: Follow-up of less than 10 years showed excess cancer rates have been reported in among rescue/recovery workers (RRW) following the World Trade Center (WTC) disaster, but not among non-RRW survivors, but no assessment has extended beyond 2008.

Objective: To evaluate cancer incidence from 2007- 2011 among WTC Health Registry (WTCHR) enrollees.

Methods: We restricted analysis to enrollees at risk for first primary invasive cancer or in-situ bladder cancer at the beginning of 2007. Standardized incidence ratios (SIRs) adjusted for age, race/ethnicity and sex were computed separately for RRW (N=24,863) and non-RRW survivors (N=35,476) with 2007-2011 New York State rates as the reference. Cox proportional hazards models assessed relationships between WTC exposure and selected cancers.

Results: The all cancer SIR was 1.11 (95% confidence interval (CI): 1.03-1.20) in RRW, and 1.08 (95% CI: 1.02-1.15) in non-RRW. SIRs for RRW were elevated for skin melanoma (SIR=1.49, 95%CI: 1.05-2.06), prostate (SIR=1.43, 95%CI: 1.25-1.63), and thyroid cancer (SIR=1.79, 95% CI: 1.26-2.47). SIRs for non-RRW were elevated for skin melanoma (1.54, 95% CI: 1.12-2.07), female breast (1.34, 95%CI: 1.15-1.55), prostate cancer (1.27, 95% CI: 1.10-1.46) and non-Hodgkin's lymphoma (1.49, 95% CI: 1.13-1.93). Both populations had reduced incidence of lung cancer. There was a significant dose-response trend only for bladder cancer in relation to exposure level among RRW, and for skin melanoma among non-RRW.

Conclusions: We observed excesses of specific cancers in one or both populations. The strength of the evidence for the elevated cancers being causally related to WTC exposures is somewhat limited. Continued monitoring of this population is indicated.

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Persistent post-9/11 hearing problems among World Trade Center Health Registry rescue and recovery workers, 2001 – 2007

New onset hearing problems are an emerging post-9/11 concern. Plausible mechanisms for an association between 9/11 exposure and hearing loss include the intense noise and pressure created by collapsing buildings and ototoxic chemicals in the resulting cloud of dust and debris. Chronic sinusitis, a condition prevalent in this population, can also lead to conductive hearing loss. To address these concerns we examined the association between 9/11-related exposure and incident self-reported hearing problems among World Trade Center (WTC) Health Registry rescue and recovery workers (RRW) through 2007. Analyses included RRW with no reported pre-9/11 hearing problems who completed survey Waves 1 – 2. Persistent post-9/11 hearing problems were defined by the combination of report of any hearing problem at Wave 1 and hearing problems in the previous 30 days at Wave 2. We measured WTC-based exposure using a summary scale incorporating five components (location on 9/11, dust cloud, arrival date, work duration, time periods worked) scored by intensity of exposure to environmental toxins. Logistic regression models examined the association between exposure summary scale quartile and hearing problems, adjusted for age, sex, race/ethnicity, education, sinus/headache symptoms, and smoking and chronic disease histories. 459 (2.3%) RRW reported persistent post-9/11 hearing problems. There was a dose-response pattern between exposure quartile and hearing problems. In adjusted models, odds ratios increased from 1.7 (95% CI 1.1 – 2.7) to 2.8 (95% CI 1.8 – 4.3) to 5.0 (95% CI 3.2 – 7.6) comparing quartiles 2 through 4 to the lowest exposure quartile. The association remained when RRW with sinus/headache symptoms were excluded from the model. There was a strong dose-response association between WTC-based exposure and self-reported hearing problems among RRW. The strength of the association increased as intensity of exposure increased and did not appear to be due solely to chronic sinusitis.

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Maintenance and Extension of a Cohort of Career Firefighters as a Non-WTC Exposed Comparison for the FDNY Firefighter Cohort

Hundreds of studies of WTC-exposed rescue/recovery workers have reported the incidence and prevalence of conditions that are thought to occur more commonly as a consequence of exposure to the WTC disaster site. And yet, because a suitable comparison group has not yet been identified, the most critical question remains unanswered: to what extent are apparent disease and symptom excesses associated with WTC-exposures? This project will address the research mandate to answer critical questions about physical and mental health conditions related to the WTC terrorist attacks by enhancing our previous research on the WTC-exposed Fire Department of the City of New York (FDNY) firefighter cohort through the ongoing inclusion of an established comparison cohort of firefighters who did not respond to the WTC attacks. The Firefighter Comparison Cohort is comprised of career firefighters from San Francisco, Chicago, and Philadelphia who are likely to have experienced similar job-related exposures. Continued follow-up of these two cohorts offers the possibility of identifying prevention strategies for workers in the workplace and beyond. Further, we believe that maintaining the FF Comparison Cohort offers a unique opportunity to establish an excellent comparison group for a range of disaster-related research in first responders, which is a stated goal of National Institute of Occupational Safety and Health (NIOSH) leaders, and is the goal that the current proposal addresses. The specific objectives of this 5-year proposal are: Aim 1: Determine whether firefighters in the FDNY FF Cohort have higher cancer incidence rates than firefighters in the FF Comparison Cohort. Aim 2: Establish a well-characterized cohort of firefighters from the FF Comparison Cohort for lifelong follow-up. Aim 3: Compare the post-9/11 prevalence and incidence of physical and mental health symptoms and diagnosed conditions in the FDNY FF Cohort and the FF Comparison Cohort.

Session B-Transportation, Warehousing, and Utilities

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A Pilot Study of Healthy Living Options at 16 Truck Stops Across the United States

There is growing evidence that built environments influence diet and exercise and, as a consequence, community health status. Long-haul truck drivers spend long periods of time at truck stops, it is important to know if this built environment positively contributes to their well-being, emotional, and physical status. Studies found truck drivers are less likely to exercise regularly or make healthy dietary choices than the general population. In a recent survey, 89% of truck drivers had a BMI greater than 25. Availability of healthy food and exercise options at truck stops is critical for improving the health of the nation's roughly 1.5 million truck drivers. To better understand this environment, National Institute for Occupational Safety and Health researchers in collaboration with the Federal Motor Carriers Safety Administration evaluated resources available at truck stops throughout the United States. The built environment included the truck stop itself, grocery stores, and medical clinics near the truck stop that could be accessed by large trucks or safely on foot. Observers used a checklist to record the resource availability within the built environment for personal hygiene and comfort, communication and mental stimulation, health care, safety, physical activity, and nutrition. Data was collected at 16 truck stops along both high- and low-flow traffic routes. Most truck stops evaluated did not provide an overall healthy living environment. None offered exercise facilities, 94% lacked health care access, 81% lacked a walking path, 50% lacked fresh fruit, and 37% lacked fresh vegetables in their restaurant or convenience store. This pilot study underscores the limited access to healthy food and exercise options for this population and raises important questions about the adequacy of the truck stop environment for promoting healthy lifestyles. Widespread efforts to provide healthy food and opportunities for safe physical activity at truck stops are needed for the health of these workers.

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Opinions on safety and its influence on driving behaviors: results from NIOSH National Survey of U.S. Long-Haul Truck Driver Health and Injury

Introduction: In 2014, 657 occupants (90% drivers, 10% passengers) of large trucks died in crashes. Fatal crashes involving large trucks and buses cost the U.S. economy an estimated \$41 billion. When crashes with injuries or property damage are included and the economic impact escalates to \$112 billion.

Methods: NIOSH in collaboration with the Federal Motor Carrier Safety Administration conducted the National Survey of U.S. Long-Haul Truck Driver (LHTD) Health and Injury. This study analyzed the survey data to: (1) provide national estimates on U.S. LHTDs' opinions on their safety needs, and (2) assess the associations between opinions and driving behaviors.

Findings: Among 11 safety-related activities, the top three safety needs identified by LHTDs were building more truck stops/parking areas (95% of LHTDs), followed by strictly enforcing traffic laws for cars and trucks equally (91%), and paying drivers by the hour for loading and unloading time (88%). Drivers who agreed with the statement "increasing speed limit would improve safety" had 2.3 (95%CI, 1.8–3.0) times the odds of being in more frequent categories (often, sometimes, and never) of stating driving ≥ 10 mph over the speed limit than those who did not agree with this statement. Compared to drivers who reported never driving ≥ 10 mph over the speed limit, drivers who reported often driving ≥ 10 mph over the speed limit had 2.1 (95%CI=1.3–3.6) times the odds of receiving more moving violation tickets in the previous 12 months. Drivers who did not agree with the statement "strictly enforcing hours of service (HOS) rules would improve safety" had 3.4 (95%CI=2.7–4.3) times the odds of being in more frequent categories of violation of HOS rules than drivers who agreed with the statement.

Conclusion: Findings highlight attitudes toward safety regulation effect safety-related behaviors and the need for educating drivers on the safety benefits of regulations.

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Detecting Emergency Vehicles: The Use of In-Vehicle Driver Support Systems to Improve Transportation Safety

Background: Public safety occupations (police, fire, emergency medical services) are classified as high-risk for work-related motor vehicle crashes (MVC), in part, due to drivers' inability to detect approaching emergency vehicles. The NIOSH Center for Motor Vehicle Safety's strategic plan identified goals to reduce the incidence and severity of MVC among high-risk occupations through integration of technology-based interventions (*Strategic Goal 2*).

Objectives: To investigate the impact of an in-vehicle driver support system (DSS), which presents concurrent and advanced information about approaching ambulances, on driver performance.

Methods: Eighty-five participants completed a driving simulator experiment where they encountered ambulances crossing four-way intersections in one of three experimental groups: Concurrent DSS, Advanced DSS, and No DSS. All participants were presented with lights and sirens from the ambulances. Concurrent and Advanced DSS groups were presented with additional audio/visual information at the time the ambulances crossed (Concurrent) or before the ambulances crossed (Advanced) the intersections. Driver performance was assessed through: *Safety margin*, the participant's distance, in meters (m), from the intersections when the ambulances entered the intersections; *Collisions*, the number of events in which participants collided with ambulances. Mixed effects and logistic regression models were used to test differences in safety margins and collisions, respectively, among DSS groups, and stratified by the ambulance crossing direction (passenger side (PS)/driver side (DS)).

Results: Safety margin increased, significantly, when participants were presented with a DSS (Concurrent DSS, 11.7m [PS], 11.5m [DS]; Advanced DSS, 28.7m [PS], 29.7m [DS]) compared to No DSS (5.5m [PS], 4.6m [DS]). The risks of collisions with ambulances were lower for participants with a DSS (Concurrent DSS OR=0.4, 95%CI=0.2-0.8; Advanced DSS OR=0.1, 95%CI=0.0-0.2) compared to No DSS.

Conclusion: The presence of a DSS yielded improvements in driver performance. This experiment supports the concept of technologies as a method to advance transportation safety for public safety occupations.

Session C-Manufacturing

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Promoting the implementation of evidence-based occupational safety and health practices in the Manufacturing Industry

The National Institute for Occupational Safety and Health (NIOSH) uses several surveillance systems to guide efforts to improve worker safety and health research and interventions, and to evaluate progress. These surveillance systems indicate that several challenges in occupational safety and health in the manufacturing industry still require attention. Since 2006, NIOSH organized part of its activities into specific programs by industrial sectors. The National Occupational Research Agenda (NORA) Manufacturing Sector was organized to include representatives of different NIOSH units and external organizations (academia, trade/professional organizations, industry, insurers, unions and government). These parties are engaged in the generation and dissemination of safety and health knowledge. Between 2007-2014, 31% of all NIOSH publications applied to manufacturing. Highlights were contributions related to the prevention of traumatic injury, musculoskeletal disorders, respiratory disease, cancer, and hearing loss, outreach to small business and activities related to nanotechnology. Examples include: publication on saw-related injuries; new resources for the control of hazardous energy; adoption of NIOSH-recommended hearing loss prevention practices by several agencies and organizations, and publication of guidance to reduce exposure to nanomaterials at the source. Beyond research, the partnerships established by the Manufacturing Program expanded and expedited the communication of new information and technologies to the public. Using new media and metrics, the Manufacturing Program worked to optimize the dissemination of evidence-based recommendations to inform decision-making in occupational health. New audiences were reached through dedicated sessions in scientific and trade show events, publications and through other platforms that make communication more nimble and accessible, such as co-authorship of NIOSH Science Blogs with external partners on some of the sector's goals. The reaction to these efforts was evaluated, including press presence and other metrics of reach and engagement. This presentation will cover examples of the past decade accomplishments and perspectives on the plans for the current decade.

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Effects of exposure, solubility and genetic factors on sensitization and chronic beryllium disease among short-term beryllium workers

Historically, exposure-response relations for sensitization (BeS) and chronic beryllium disease (CBD) were inconsistent. Material solubility may play a role, where soluble materials are likely to be strongly associated with BeS, and poorly soluble materials persist and contribute to both outcomes. In collaboration with the US beryllium producer, we evaluated exposure solubility in a worker cohort with ≤6 years’ tenure, surveyed in 1999. BeS prevalence was 9.8% (26/264), with 6 BeS diagnosed with CBD (2.3%, 6/264).

Jobs were classified as *soluble* (salts, e.g. beryllium fluoride, in metal production; beryllium in acid solutions, in leaching and pickling operations) or *poorly soluble* (mostly oxide, metal, or copper-beryllium alloy). Soluble jobs were further divided into *soluble salts* (metal production) and *soluble other*.

Jobs ever worked by solubility				
	Only <i>soluble</i>	Both kinds of jobs	Only <i>poorly soluble</i>	TOTAL
BeS	25.0%(3/12)	12.7%(9/71)	7.7%(14/181)	9.8%** (26/264)
CBD	0.0%(0/12)	2.8%(2/71)	2.2%(4/181)	2.3%(6/264)
BeS	Any <i>soluble</i> 14.5%(12/83)		Only <i>poorly soluble</i> 7.7%(14/181)	9.8%** (26/264)
BeS	<i>Soluble salts</i> 26.5%(9/34)	<i>Soluble other</i> 6.1%(3/49)	Only <i>poorly soluble</i> 7.7%(14/181)	9.8%(26/264)
BeS	<i>Soluble salts</i> 26.5%(9/34)	No <i>soluble salts</i> 7.4%(17/230)		9.8 %** (26/264)

** Cochran-Armitage test for trend, p<0.05

BeS was related to work with soluble materials, comparing having worked in jobs with only soluble, both kinds, and only poorly soluble beryllium, as well as comparing work with any soluble to only poorly soluble beryllium. When work with soluble salts was observed separately, BeS prevalence in other soluble work was similar to work with only poorly soluble beryllium. For CBD, there was no association with only soluble exposure.

The increased BeS prevalence associated with solubility was related to work with soluble salts, although BeS was also observed with other soluble and poorly soluble exposure. These findings suggest that, although relatively uncommon, exposure to soluble beryllium may engender risk of BeS that requires comprehensive exposure control efforts, including dermal protection.

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The contributions of occupational safety and health to organizational productivity and environmental goals

There has been increasing interest in the business case for occupational safety and health. This case has usually focused largely upon expected impacts on injury rates and workers' compensation claims, but not nearly as often on broader impacts on organizational effectiveness. These impacts are not as easy to generalize, since they take such a wide variety of forms. This study brings together, in one conceptual framework, many of the logical and practical connections between efforts to improve worker health and safety, and the goals of organizational productivity and environmental sustainability. It is based on (1) published research that summarizes the modern understanding of the optimal ways of managing production processes (2) publications that detail the ways these modern management ideas can be applied specifically to health and safety management and to environmental management, and (3) case studies of work-related injury and illness prevention and pollution prevention that illustrate their relationship to each other and to productivity and quality. Analysis of productivity and quality case studies has yielded a rich set of occupational safety and health prevention impacts on productivity that includes the following: ergonomics as a means of simplifying processes and increasing efficiency, better control of exposure resulting in better overall process control and fewer defects, training that keeps workers safe while standardizing tasks making them more efficient, and several others. Prevention of work-related injury and illness can also directly support environmental and pollution reduction goals. Furthermore, standard safety and health management practices overlap and integrate with those of environmental and operations management. With this framework, and a large body of examples, managers and workers should be better able to see occupational safety and health as an integral and natural part of improving organizational productivity and environmental sustainability. They may also be better able to make a strong business case for specific safety and health investments.

Session D-Total Worker Health

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Building labor-management partnerships for Total Worker Health in public sector healthcare facilities

The CPH-NEW Healthy Workplace Participatory Program (HWPP) is designed to develop workplace health and safety committees' skills to conduct root cause analysis of health problems, prioritize possible solutions, present a comprehensive business case to leadership, and evaluate implemented interventions. The program has been developed and refined through field-testing, expert and user feedback. We are now undertaking a formal evaluation of HWPP effectiveness, and of whether it moves committees to address a broader scope of worker health and well-being issues. Six public sector, unionized healthcare facilities are enrolled in pairs, matched by agency and type of service. The process is introduced within the existing safety and health infrastructure, adapting it to a joint management-labor committee structure. The "Design Team" in each facility has roughly equal numbers of supervisory and non-supervisory members, with all bargaining units represented. A "stepped wedge" design provides concurrent control data for the first 2.5 years. At mid-point, the coached intervention moves to the second site, and the first site is supported to continue the HWPP process. Data collection elements include absenteeism and workers' compensation claims; all-employee surveys (beginning, middle, end of the study period); targeted pre-post analyses of specific measures relevant to the implemented interventions; and process evaluation data (time spent on the HWPP, satisfaction with meetings, etc.) collected throughout the study. Effectiveness analyses will examine organizational (e.g., management support of safety, health climate) and individual (e.g., musculoskeletal symptoms, self-rated health, sleep quality) outcomes. Process evaluations include proportion of DT effort toward primary prevention, expansion of scope to other worker well-being outcomes, cost-effectiveness of benefits achieved; and program fidelity and sustainability. Initial trainings and baseline data collection are scheduled for early 2017. Results available for presentation will include baseline assessments of organizational readiness for change, and initial responsiveness of labor and management participants to the HWPP process.

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HearWell: A Total Worker Health™ approach to Hearing Conservation among Transportation Workers

Background: Transportation maintenance workers who maintain and repair roadways are regularly exposed to high noise levels. Hearing conservation programs (HCPs) are typically top-down interventions where workers are passive program recipients. The HearWell program aims for active worker participation in development, implementation, and maintenance of an integrated program that protects and promotes hearing health. Using participatory Total Worker Health™ methods and tools from the Center for the Promotion of Health in the New England Workforce (CPH-NEW), we are implementing HearWell among selected maintenance garages at Connecticut Department of Transportation (DOT). The comparison group consists of maintenance garages receiving the conventional HCP.

Methods: A survey was developed and administered to assess hearing health and health and safety climate as a first step. Participants were recruited from 24 DOT maintenance garages with the garage being the essential study unit. Differences between garages were assessed using multi-level models to account for nesting within each garage.

Results: Surveys were completed by 271 (81% participation), the majority were male (97%), white (74%) and were in non-supervisory positions (86%). The mean(sd) age of participants was 44(11) years with seniority of 11(6) years. The majority (n=221, 84%) reported having their hearing tested, but only 94(35%) were tested within the last 2 years. A hearing loss diagnosis was reported by 32(13%); 148(56%) report ringing in ears and/or muffled hearing following loud noise exposure. Mean(sd) safety and health climate scores were 3.79(0.79) and 3.24(0.67) on scales of 1-5 and 1-4, respectively. These characteristics varied little among garages. Twelve garages with high participation were equally randomized into control and HearWell groups.

Conclusion: Frequency of hearing exams is low and hearing health may be poor among transportation maintenance workers. In the next phase of HearWell, working with a management- and union-represented steering committee, workers will design and implement noise and hearing interventions.

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A Conceptual model to guide Total Worker Health® research and interventions

NIOSH's **Total Worker Health® (TWH) Initiative focuses on improving policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being.** Growing evidence indicates the potential benefits of integrated approaches, although there remains an ongoing need for further evidence on the impact of integrated approaches. Such research would benefit from shared conceptual frameworks to structure ongoing inquiry.

This presentation describes a conceptual model to guide research on determinants of worker safety, health and wellbeing, and to inform the design, implementation and evaluation of integrated approaches. This model is rooted in multiple theories and the premise that the conditions of work are important determinants of worker safety and health outcomes, as well as outcomes important to enterprises such as absence and turnover. Integrated policies, programs and practices simultaneously address multiple conditions of work, including the physical work environment and the organization of work (e.g., psychosocial factors, job tasks and demands).

We will present data from hospital patient care workers to demonstrate evidence for the model following three themes: (1) Injury and health behaviors share diverse determinants within the work environment and vary by socioeconomic status of workers. (2) The psychosocial work environment shapes safety and health behaviors and health outcomes. (3) Health behaviors are partially rooted in conditions of work, suggesting that conditions of work need to be addressed if health-related behaviors are to improve.

This presentation will also describe a set of indicators of integration designed to operationalize this model, including: leadership commitment, supportive working conditions, collaboration, comprehensive strategies, participatory processes, compliance, and data-driven change.

In conclusion, this conceptual model provides a structure for research and interventions that underscores the central role of the conditions of work to worker safety, health and wellbeing.

Concurrent Session 2

Session E-Economic Burden

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The economic burden of occupational illness

Assessing the burden of worker injury and illness by condition and sector helps to identify where the burden is highest, when measured by several metrics. In turn, this offers a way to prioritize research and prevention activities that is in part based on addressing the biggest problems first. To demonstrate how this approach can be used, we describe the development and distribution of economic burden estimates of chronic illness across 10 NORA sectors. These estimates are based on NIOSH-sponsored updated national estimates of new cases for 16 chronic conditions with well-established occupational illness causes. We used two methods to derive economic burden estimates for 2013, including medical costs and productivity losses, and reductions in quality of life. Using lung cancer as a case study, first we determined the number of workers age 30 or older, who would die from lung cancer each year following their diagnosis. Future deaths from lung cancer were estimated based on information collected by the Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute. Medical costs were also derived based on SEER information. Productivity losses were estimated based on published information on the relationship between medical costs and productivity losses. We assessed reductions in quality of life using Disability-adjusted Life Years (DALYs). We estimated medical costs and productivity losses at \$3.1 billion, with services ranking highest at \$333.2 million and manufacturing second at \$303.8 million (2015 dollars). The total number of DALYs was 138,310, with services ranking highest at 36,880 and manufacturing second at 33,626 DALYs. These estimates capture different aspects of the burden. There are many ways to combine economic metrics in indexes, as well as use them separately but as a group, i.e., a dashboard. Conditions that consistently rank highest by both individual metric rankings and index rankings indicate the highest priorities for research and prevention, based on burden.

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Impact of Nonstandard Work Arrangements on Earnings and Fringe Benefits: Evidence from the 2010 and 2015 National

Technological improvements, employer efforts to reduce the cost of providing fringe benefits, and worker preferences for flexible work arrangements are some of the factors affecting the increased prevalence of nonstandard work arrangements. We examined the impact of nonstandard work arrangements on personal earnings, family income to poverty ratio, and access to employer sponsored health insurance (ESHI) and paid sick leave (PSL). We analyzed data from the 2010 and 2015 National Health Interview Surveys (NHIS) and accompanying NIOSH-sponsored Occupational Health Supplements. We included worker responses by NHIS work arrangement categories: (1) work as an independent contractor, independent consultant or freelance worker (independent); (2) employment by a temporary agency, or work for a contractor who provides workers and services to others under contract (temporary or contract); (3) regular permanent employee (standard); and, (4) some other work arrangement (other). We examined differences in disparities by arrangement, as well as changes in disparities among workers in different arrangements, 5 years apart. We used four dependent variables to examine the impact of work arrangements: mean annual personal earnings, family income to poverty status, access to ESHI, and access to PSL. The sample consisted of 13,848 (2010) and 17,379 (2015) adults who worked during the survey years and responded to work arrangement questions. We adjusted for covariates and found that compared with workers in standard arrangements, those in nonstandard arrangements were paid less, were less likely to live above the federal poverty level, and were less likely to have access to ESHI and PSL. We identified differences among those in different nonstandard arrangements. Gaps in income and access to employer sponsored fringe benefits among workers in standard and nonstandard arrangements declined slightly in 2015. Future research should examine the implications of these findings for worker safety, health, and overall wellbeing.

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Maximizing the use of workers' compensation systems to improve safety through partnerships

Work-related injuries and illnesses continue to have great personal, financial and societal impact in the United States. Workers' compensation (WC) systems are the largest source of occupational injury information in the US, with millions of claims in some single state databases. WC insurers also offer prevention services and programs and collect information on insured employers including risk/control assessments. This overall WC system information has tremendous potential for prevention purposes, but remains largely underutilized. The mission of the NIOSH Center for Workers' Compensation Studies (CWCS) is to support the use of WC data and systems to improve workplace safety and health through partnerships. CWCS and its partners will be able to support all NIOSH sectors in the future by analyzing existing state-level WC data as a starting point to define the injury burden and need for intervention across multiple industries. As an example, the CWCS and the Ohio Bureau of Workers' Compensation (OHBWC) just partnered to publish data for state-insured private employers in Ohio (<https://www.ncbi.nlm.nih.gov/pubmed/27667651>). NIOSH is also providing extramural funding currently to five states (CA, MA, TN, MI, and OH) to foster collaborations between state departments of health and WC bureaus to use WC data to focus prevention efforts in the state. Another main focus of the CWCS is to work with public and private partners to evaluate the effectiveness of prevention approaches, and to disseminate information on evidence based interventions. As an example, since 1999, the OHBWC has offered a Safety Intervention Grant program where over 2,500 employers have been provided matching funds to implement engineering controls. Recently, an OHBWC and CWCS study (<http://www.ncbi.nlm.nih.gov/pubmed/25223846>) that found that the program significantly reduced affected employee claims and costs. This presentation will give an overview of current CWCS claims and prevention effectiveness studies, highlighting the recent published works in Ohio.

Session F-Agriculture, Forestry, Fishing

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Attitude Changes in Farmers following a Point-source Hearing Protection Intervention

In this randomized control study, we randomized 89 farmers into intervention and control groups. The intervention group received boxes containing hearing protection devices (HPDs) in a weatherproof box that was installed in areas and equipment identified as loud noise sources. We also provided training on HPD use. We administered the same perception questionnaire to both groups over four years. Many of the study participants felt more confident about when and how to properly use hearing protection. Study participants tended to significantly disagree more to the statement “I’m not sure how to tell when earplugs need to be replaced” over the course of the study ($p < 0.0001$). Responses to the statements “I know when I should use hearing protectors” and “I know how to tell when an earmuff needs to be replaced” also changed significantly over the course of the study ($p < 0.05$). We found a high degree of change in study participant’s intent to wear hearing protection. At the beginning of the study, just over 50% of the study participants, in both the control and intervention group, said “I wear hearing protectors whenever I work around loud noise.” By the end of the study, 73% of the intervention group and 67% of the in the control group agreed with the statement; this change over time was significant ($p < 0.0001$). At the beginning of the study 38% of the study participants in the intervention group and 55% of the study participants in the control group said, “On my current job, I seldom wear hearing proctors when I work around loud noises.” At the end of the study, the percentage dropped significantly to 23% and 16% respectively. The point-source hearing device intervention and educational model was effective at changing farmers’ attitudes towards HPDs.

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Respiratory disease awareness and prevention in the US hop harvest industry

Washington's occupational respiratory disease surveillance system identified a cluster of asthma in hop (*Humulus lupulus*) industry workers. An industry partnership was subsequently initiated to raise respiratory health awareness. While grown throughout the US, commercial production is supported by the pacific northwest climate. Using workers' compensation data, 57 cases of respiratory disease associated with hop dust inhalation were identified for the period 1995 to 2011. Workers throughout the industry are at risk during the annual harvest, secondary hops processing, and laboratory research. Workers were diagnosed as having work-related asthma (61%), chronic obstructive pulmonary disease (7%), or with allergic respiratory symptoms. The incidence rate of respiratory disease in hop workers was 15 cases per 10,000 full-time workers; this was 30 times greater than the incidence rate for field vegetable crop workers. The case series was published in the primary literature, followed by fact sheets mailed to all 190 hop growers and 330 regional health care providers. Presentations to the Hop Growers of America led to informational farm tours and industry adoption of bi-lingual training materials. Once engaged, the industry expressed a need for additional safety and health support: they requested an ergonomic evaluation of the hop bale inspection process. The partnership was expanded to include the US Department of Agriculture who perform bale inspections, and resulted in an industry proposal to modify the federal USDA bale-inspection protocol. This story demonstrates the value of nationally supported state-based surveillance, as it was through this mechanism that the sentinel cluster was identified. The agricultural hop industry remains open to different kinds of occupational health promotion. There are many challenges toward effective respiratory disease prevention in this industry, including methods to reduce dust exposure, characterization of the hop dust allergen(s), and an understanding of symptom prevalence in workers.

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Dairy bioaerosol exposures and inflammatory markers in workers: A panel study

Background: Dairy workers experience inflammation from bioaerosol exposure that can manifest in respiratory symptoms and disease (e.g. occupational asthma). There is still a large gap in knowledge regarding the dynamic nature of the inflammatory response. In this study, we conducted repeated nasal lavages on dairy workers over repeated workdays to model the inflammatory response from workplace bioaerosol exposure.

Materials and Methods: Nasal lavages were collected following dairy workers' shifts for a maximum of three days using sterile saline. Cytokines were measured using Luminex, a bead-based multiplexing technology, and a MagPix plate reader. We used linear mixed models to understand the association between inhalable dust and select constituents (endotoxin and β -glucans) and transcripts coding for pro-inflammatory (TNF- α) and anti-inflammatory (IL-10) cytokines.

Results: A total of 36 workers (7 female, 29 male) participated in the study for a median of 3 days (range: 1 – 3). Bivariate analyses indicated a moderate correlation between endotoxin and TNF- α ($r=0.31$), but weak correlations between inhalable dust, β -glucans and cytokines. Controlling for gender, smoking status, and length of employment, results from the repeated measures analysis indicated that a 10 EU increase in endotoxin was associated with a 0.12 pg/mL increase in TNF- α (95% CI: 0.0007, 0.244) and a 0.073 pg/mL decrease in IL-10 (95% CI: -0.142, -0.004). There were no significant associations between inhalable dust and β -glucans and either cytokine. There were no significant differences in TNF- α ($p=0.156$) or IL-10 ($p=0.503$) levels by length of employment (< 6 months v. => 6 months).

Conclusion: This is the first study to conduct repeated measures using sequential nasal lavages to profile the inflammatory state of dairy workers. Findings from this study to date affirm that workplace endotoxin exposures play a meaningful role in subclinical inflammation.

Session G-Construction

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Promoting Musculoskeletal Disorder Prevention Efforts within a Construction Safety Management Program

Background: Musculoskeletal disorders (MSDs) are the leading cause of work-related injuries among construction workers, yet ergonomics programs for MSD prevention are rare, and usually exist as “add-on” programs that are incompletely incorporated into overall safety management programs. We will present an intervention designed to address MSD prevention by systematically incorporating ergonomics within an existing safety management program.

Methods: We collected worker surveys (n=270), researcher observations on the same crews (n=181), worker completed daily pretask assessment forms, written safety documents, and information from training activities, and from construction and safety meetings over a period of six to nine months for each of three construction projects. We identified all activities in the safety programs pertaining to the recognition of ergonomic hazards and to planning for prevention and control of these hazards. Our intervention will address gaps in the existing safety program and conduct ongoing evaluation of intervention effects.

Results: MSD prevention was not systematically incorporated into the existing safety management system, which focused on prevention of traumatic injuries. Other gaps included foremen’s poor recognition of ergonomic hazards and controls (as recorded on daily pretask assessments), few toolbox trainings on ergonomic concepts, few discussions about ergonomically-related issues during worker, foreman, or pre-construction safety meetings, poor communication, and lack of understanding of ergonomic concepts. Workers reported, and researcher observations confirmed that ergonomic hazards were common. Current program changes include training for all safety personnel on ergonomic concepts and methods of communication, addition of ergonomics as a standing topic on meeting agendas, use of worker-preferred language, and development and communication of “best practices” for common activities. Other policy and work process changes will be added in the future.

Conclusion: Active safety management programs must systematically incorporate ergonomics in order to monitor and control ergonomic hazards within the frequently changing work tasks of construction projects.

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Partnering for Hearing Loss Prevention in Construction

Hearing loss is one of the most common work-related illnesses in the U.S., and nearly 22 million workers are exposed to occupational noise. Indeed, almost three-quarters of construction workers are exposed to noise levels above the NIOSH recommended exposure limit (REL), and up to half of all construction workers suffer from some level of hearing loss due to occupational noise exposures. Despite the high risk for construction-related hearing loss, use of evidence-based controls and work practices remains low. A partnership among OSHA, NIOSH, and CPWR (r2p Working Group), which focuses on advancing research to practice, identified hearing loss prevention in construction as a top priority. In 2015 and 2016, the partnership took advantage of CPWR's national training network (TRU-Net) to survey 248 construction trainers and thousands of construction workers to identify gaps in awareness of noise hazards, use of controls and hearing protection, barriers to use, and types of noise-related training that the trainers conducted and the workers received. In this presentation, we will describe the survey results and how the findings are being used by the r2p Working Group and others to translate research findings into effective educational materials for trainers and workers (research to practice – r2p), and to shape future noise-related research questions (practice to research – p2r). We will also discuss the lessons learned and benefits of using partner networks to inform research to practice for construction and perhaps other sectors.

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Use of Video Exposure Monitoring to Increase Worker Proactive Dust Control Practices: Evaluation of Five Worksite Interventions

Relevance: Workers experience periods of elevated exposure to respirable silica dust while performing their jobs, remaining a timely research topic. Personal dust sampling and the evaluation of control technologies provide exposure information; however, social scientific methods are generally absent when understanding how to manage identified risks. Using video exposure monitoring (VEM) technology, these gaps were addressed in cooperative behavioral/engineering interventions in collaboration with several mine companies.

Methodology: This study addressed changes in workers' perceived levels of proactivity; unknown dust sources and controls; and behavior to reduce exposures. Forty-eight workers from five mines participated between April 2015 and September 2016. Each intervention collected repeated-measures data in personal proactivity including risk assessments and responses toward silica while also using VEM technology and software (i.e. Helmet-CAM, EVADE 2.0) that synchronized work tasks and dust exposures.

Conclusions: Results showed quick, economic controls to mitigate dust sources. Management learned solutions such as:

Provide clothes cleaning technology for workers

- Update filtration and pressurization systems in enclosed rooms
- Replace cloth seats in mobile equipment and offices with vinyl or leather options

Workers learned quick fixes to protect their health such as:

- Fold bag flaps the other way while tying product
- Improve housekeeping of beltlines, mill areas, and mobile equipment
- Better store items (i.e. screens) that quickly accumulate dust

A paired sample t-test revealed a statistically significant increase in workers' proactive behaviors from Time 1 (M=4.84, SD=.796) to Time 2 (M=5.10, SD=.683), $t(33) = -2.545$, $p < .016$ (two tailed). The mean increase supports workers' frequency of trying new things to improve their health upon knowing their exposure sources and solutions.

Implications: Six-month follow-ups show how mines prioritize dust mitigation strategies. These results help guide critical and feasible risk responses to respirable silica exposure. Information is being provided in a variety of stakeholder mediums.

Session H-Healthy Work Design

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Improvement of human safety in fault-tolerant human and robot collaboration using convex optimization and receding horizon control

Human-robot teams completing complex tasks together are an exciting prospect for manufacturing and healthcare in the not so distant future. Robots are already integrated into these environments, but truly collaborative human-robot teams are missing. The issue of human safety while working with robots requires careful planning and further development. There is a need for improved control algorithms and guidelines to allow humans and robots to safely work together in a synergistic fashion. The nature of human variability performing job tasks requires a robot worker to be able to learn and adapt to changes while prioritizing human safety. The aim of this research is to present a novel solution to create safe and fault-tolerant motion planning and control of robot workers to enable safe human-robot cooperation. First, human motion in a collaborative task with a robot was recorded using optical motion capture. Then, a novel algorithm was developed for fault-tolerant motion planning and control of an industrial robot to increase the safety of the human worker. This was accomplished by characterizing human motion patterns in real-time while preventing collisions between the human and robot worker. Sudden actuator motions were minimized. The proposed algorithm benefits from the use of convex optimization, disjunctive programming and the concept of receding horizon to work in real-time. Simulation studies were developed in ROS and Gazebo software. The results reveal the performance of the algorithm to solve the simultaneous fault-tolerant and collision-free motion planning problem in industrial robots for use with human workers. Using the proposed algorithm minimizes velocity jumps in the robot due to sudden unexpected events or actuator failure and avoids collisions with the human worker while maintaining acceptable levels of productivity. This approach could enable human and robot workers to focus on the tasks they perform best by enabling closer, safer cooperation.

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A conceptual and measurement model for worker well-being

Increasingly, there is interest in an integrated, systemic approach to worker safety and health. There is recognition of the importance of not only preventing disease and injury, but also enhancing overall well-being. However, there has been no consistent definition of the concept of well-being. NIOSH and RAND Corporation embarked on an effort to develop a conceptual framework and operationalize indicators for worker well-being. This paper presents the first phase of this research. We discuss the multidisciplinary literature review and key conceptual issues that informed the framework development. We present a proposed framework that defines worker well-being as a subjective and objective phenomenon inclusive of experiences both within and beyond work contexts.

We performed a comprehensive literature review of peer-reviewed articles, technical/policy and white papers, and books. Three search engines were used to cover health and medical journals, social science and psychology journals, and the general literature, respectively. Due to the large number of articles, we focused on the following article types: review, meta-analyses, conceptual/theoretical, and methods-focused papers. Our final reference list included 141 articles: empirical (n=32), review/conceptual (n=101), and books (n=8).

Based on the review, we developed a conceptual framework for worker well-being with five proposed domains: (1) Workplace physical environment and safety climate, (2) Workplace policy environment, (3) Health status, (4) Work evaluation and experience, (5) External context. We developed an instrument with the input of an external expert panel and have completed cognitive interviews. The next step is to field a national survey to test the instrument's psychometric properties. These activities will provide tools for partners interested in worker well-being and also inform changes to the evolving well-being framework.

The work presented here represents a first step toward assessing worker well-being. The operationalization of this framework by partners will promote a greater understanding of worker well-being.

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Design, construction, and management of a comprehensive employee research database: the PERDS study of the Harvard Center for Work, Health, and Wellbeing

Since 2007, the Harvard Center for Work, Health, and Wellbeing (a NIOSH TWH Center of Excellence) has worked in partnership with Partners HealthCare, the largest employer in Massachusetts, to establish a research cohort of patient care workers at two of the health system's world-renowned hospitals. This open cohort, called PERDS (Partners Employee Research Database & Study) consists of approximately 13,000 workers to date (growing by about 1,000 people per year) and involves an integrated, longitudinal, administrative database linked with periodic surveys of employees. Types of administrative data, at both individual and workgroup levels, include: occupational injury and workers' compensation; health plan spending and utilization; employee workload and productivity; payroll and scheduling; workplace policies and practices at both unit and hospital levels; and, in the upcoming phase, patient outcomes data. The partnership and database and the research and practice insights that have emerged from them can serve as a model for other occupational health practitioners about methods for harnessing administrative data and translating it into robust scientific data and then into research and practice insights. This session will focus on 1) practical strategies for building the researcher-employer relationships and data management capacities to construct, administer, and maintain a database like PERDS, including lessons learned; 2) presentation of PERDS' structure and function, with a focus on incorporating different types of data into the database and ideas for how such a structure could be replicated in other settings; and 3) a brief synopsis of scientific insights gained from PERDS, future plans for its growth, and opportunities for collaboration between the PERDS team and other occupational health scholars. This project contributes to the NORA Healthcare and Social Assistance sector and the Cross-Sectors of Healthy Work Design and Well-being and Musculoskeletal Health.

Thursday, June 22

Early Career Scientist Plenary

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Respiratory and Ocular Symptoms Among Employees at an Indoor Waterpark Resort — Ohio, 2016

Background: Employees and patrons of the expanding indoor waterpark industry might be exposed to disinfection byproducts that can cause respiratory and ocular symptoms. While investigating patron complaints, a municipal health department requested CDC assistance to evaluate symptoms and etiologies among employees at an indoor waterpark resort.

Methods: We surveyed resort employees about symptoms and work exposures in January 2016. We defined a case as an employee with ≥ 3 symptoms in the past 4 weeks that began at and improved away from work: cough, wheeze, shortness of breath, chest tightness, nose irritation, eye irritation, sore throat. We used log-binomial regression to identify factors independently associated with illness. We measured air temperature and relative humidity and area air concentrations of chlorine and chloroform (a disinfection byproduct). We assessed the waterpark's ventilation system.

Results: Of 112 resort employees, 91 (81%) participated; 45 (49%) worked in the waterpark area; 46 (51%) in other resort areas. Median age was 19 years (range: 15–65). Eye irritation (37%), cough (31%), and nose irritation (29%) were most commonly reported. Twenty-nine (32%) employees met the case definition. Working in the waterpark (vs. other areas) was independently associated with illness (adjusted prevalence ratio: 3.7; 95% confidence interval: 1.4–11.4). Low chlorine and chloroform concentrations were detected. Temperature was below and relative humidity above recommended ranges. Five of six air handling units were not functioning properly.

Conclusions: Employees' symptoms were consistent with disinfection byproduct exposures. Suboptimal ventilation and air quality conditions likely contributed to the higher rate of illness among employees working in the waterpark. A properly functioning ventilation system is important to protecting millions of employees and patrons at 192 indoor waterparks nationwide.

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A longitudinal evaluation of kidney function among sugarcane workers in Guatemala

Introduction: Observed rates of chronic kidney disease (CKD) have been increasing in Central America over the past two decades. Rates have been highest among younger male sugarcane workers. The disease and associated risk factors have not been thoroughly studied. **Objective:** To describe the changes of kidney function across a six-month harvest and to investigate associations between worsening kidney function and occupational and non-occupational risk factors, an evaluation of sugarcane workers in Guatemala was performed.

Methods: Kidney function of 407 sugarcane workers was measured at the beginning and end of the 2015-2016 harvest. In addition, demographic, occupational, and clinical data were collected for the workers. Kidney function was measured by estimated glomerular filtration rate (eGFR, ml/min/1.73 m²). Multivariate regression analyses were used to assess predictors of end of harvest eGFR and change in eGFR. Odds ratios estimating the risk of a >20% decline in eGFR over the harvest were also calculated for risk factors.

Results: An overall increase in median eGFR was observed among participants across the harvest, however 36% of the participants had a decline in eGFR. Both occupational and non-occupational risk factors were found to be associated with a decline in eGFR, including working at a certain work site on the plantation (β -11.93 ml/min/1.73 m²), coastal origin of the worker vs. highland origin (β - 3.67), and current tobacco use (β - 4.90). Multivariate logistic regression analysis showed increasing pre-harvest creatinine (odds ratios (OR) = 21.92) and coastal origin of the workers (OR = 2.94) were associated with a > 20% decline in eGFR, controlling for age.

Conclusion: This evaluation contributes important new evidence suggesting the need for further epidemiological studies on risk factors. Adequate knowledge of risk factors for CKD is the first step towards effective preventive strategies to combat the heavy burden of this disease in Central America.

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Mixed Exposures to Cleaning and Disinfecting Chemicals among Healthcare Workers

Objective: Use of cleaning and disinfecting products is associated with work-related asthma among healthcare workers, but the specific exposures responsible and their levels remain unclear. The objective of this study is to evaluate the association between mixed volatile organic compound (VOC) exposures and occupations in healthcare settings.

Methods: In collaboration with Veterans Affairs Medical Centers, 143 personal air samples were collected from healthcare workers in five hospitals, and analyzed for 14 target VOCs using gas chromatography-mass spectrometry. Hierarchical cluster analysis of the 14 VOC exposures categorized as low, medium, high was conducted to group the measurements into 10 clusters with similar characteristics. For each cluster, distributions of occupations and proportion of high VOCs were calculated to identify the cluster's characteristics. Simple linear regression models of log-transformed exposures were applied to evaluate the association of individual VOCs and occupations.

Results: Ethanol and 2-propanol accounted for $\geq 80\%$ of total VOC concentrations. Highest correlations among VOCs were observed between ethylbenzene and m,p,o-xylenes ($\rho > 0.85$). Cluster analysis showed that floor stripping/waxing workers and housekeepers shared high exposures to chloroform, ethylbenzene, and m,p,o-xylenes. Registered nurses and nursing assistants experienced high exposures to methylene chloride, methyl methacrylate and aromatics. Additionally, floor stripping/waxing workers and registered nurses had high 2-propanol, and housekeepers had high d-limonene. Preliminary results of regression models suggested a 75% increase in m,p-xylene for floor stripping/waxing workers, and a 63% increase in d-limonene for housekeepers compared to all other occupations. Registered nurses had elevated concentrations of ethanol (88% increase), while nursing assistants had higher exposures to ethanol (167%), chloroform (41%), and benzene (47%) compared to other occupations.

Conclusions: Mixed VOC exposure profiles were identified, and high concentrations of some VOCs were significantly associated with specific jobs. Further analyses will evaluate the influence of task and product use on VOC exposures.

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Collaboration between NIOSH and California Department of Public Health to investigate occupational exposures in e-cigarette vape shops

The promise of lower exposures to carcinogenic combustion products from e-cigarettes as compared to conventional cigarettes has resulted in a rapid increase in e-cigarette use in California and across the country. Laboratory tests have detected a variety of compounds in e-liquids and e-cigarette emissions including nicotine, carrier components (propylene glycol and glycerin), formaldehyde, flavorings (including diacetyl), tobacco-specific nitrosamines, metals, and some volatile organic compounds (VOCs). These compounds have known health effects including acute nicotine poisoning, decreased lung function, severe lung disease, and respiratory irritation. In California, use of e-cigarettes in workplaces has only recently been limited by state regulations, and workplace vaping is especially prevalent in stores selling e-liquid and e-cigarette devices (vape shops). In 2016, California Department of Public Health scientists requested NIOSH assistance in characterizing workplace exposures in a number of vape shops in the San Francisco Bay Area. This collaboration addresses NIOSH's current interest in e-liquids and flavoring chemicals using recently developed analytical methods. Sampling included personal and area air monitoring of flavoring chemicals, formaldehyde, particulate matter, and VOCs. The e-liquids themselves were analyzed for flavorings including alpha-diketones. Wipe samples were collected for metals on commonly touched surfaces. Initial findings suggest that employee chemical handling practices need improvement, and detectable levels of formaldehyde and flavoring compounds were found in the air. With data from several sites, the collaboration will be able to develop a better understanding of this emerging industry with summary results and recommendations for workplace health and safety.

Concurrent Session 3

Session I-State Surveillance

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State-based Surveillance and Public Health Practice: Overcoming Challenges to Using California Workers' Compensation Claims Data for Public Health Surveillance

There is a recognized need for improved utilization of administrative datasets for public health surveillance of work-related injuries and diseases. One such dataset is the Workers' Compensation Information System (WCIS), an electronic repository of workers' compensation claims submitted by claims administrators. WCIS contains information on the injury, the employee who was injured, the injured employee's employer, and the medical bills generated from the claim. Several challenges exist that prevent the routine use of WCIS to calculate rates of injury. First, calculating an accurate rate requires using one or more additional data sources to determine the number of full-time equivalents (FTE) as a denominator. Rates by industry involve additional steps to guarantee comparable coding in the claims and denominator sources. In California, several state agencies are collaborating on a NIOSH-funded project to combine multiple datasets that will enhance our capacity to utilize WCIS to calculate reliable injury rates by industry. Of 302,402 WCIS claims with a date of injury between 1/1/2015–6/30/2015, 266,267 (88%) workers were matched to an employer record in the Base Wage File, a database populated with all workers covered by unemployment insurance. Claims with an employer were matched to the Quarterly Census of Employment and Wages (QCEW) to assign a 4-digit NAICS industry code. The number of hours worked in the American Community Survey was used to adjust QCEW employee counts to calculate industry specific rates of WC claims per full time equivalent (FTE). Inter-urban and rural bus transportation, poultry and egg production, cattle ranching and farming, and scheduled air transportation have the highest rates of injury. Current work focuses on methods for classifying multi-establishment firms and addressing difficulties with classifying employers in the public sector.

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State Based-Surveillance and Public Health Practice: Integration of the Kentucky Occupational Safety and Health Surveillance Program into State Drug Abuse Prevention Efforts

The NIOSH-funded Kentucky Occupational Safety and Health Surveillance (KOSHS) Program's Fatality Assessment and Control Evaluation (FACE) program published worker fatality reports in 2006 on fatal occupational motor vehicle crashes that involved drugs. The seminal FACE reports and surveillance data informed 1) drug overdose reports; 2) peer-reviewed publications; and 3) state policy making and public health practice efforts. New collaborations were forged with state and local public health and public safety agencies, organizations, researchers, and federal funding agencies. The reports and publications demonstrated the statewide burden of drug overdoses and the need for drug overdose prevention programs and policies. With collaborators, extramural funding was obtained for Kentucky-specific programs: 1) CDC National Center for Injury Prevention and Control (NCIPC)-funded Drug Overdose Prevention program to enhance use of prescription drug monitoring program (PDMP) data for public health surveillance, inform community interventions, evaluate drug-related laws, and establish a Substance Use Disorder Information and Referral Service containing information for physicians (e.g., prevention of needle sticks when lancing drug abuse-related abscesses), first responders (e.g., handling of fentanyl analogs at drug overdose scenes), law enforcement (e.g., naloxone administration training), and the general public; 2) NCIPC-funded opioid surveillance program to increase timeliness of public health data sources and use of syndromic surveillance data for drug overdose and injury surveillance; 3) Bureau of Justice Assistance funding for multidisciplinary approaches to drug abuse prevention including algorithm development for milligram morphine equivalent calculations in PDMP reports, and death certificate and PDMP data linkage to identify possible drug diversion; and 4) Kentucky Office of Highway Safety funding to improve completeness of drugged driving data. FACE case investigations supported state drug overdose prevention conversations, identified new and emerging risk factors for drug overdoses, raised awareness of the drug overdose problem, enhanced collaborations, and provided evidence of need for multidisciplinary drug overdose prevention efforts.

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State-Based Surveillance and Public Health Practice: Michigan Hospital and Emergency Department Surveillance System

Michigan reviews the physician's history and physical on all patients treated in the 136 Michigan hospitals (including Veteran's Administration hospitals) for amputations, burns, crushing injuries and skull fractures regardless of the payment source. There were 5,686 work-related amputations identified from 2006-2015, 11,810 work-related burns identified from 2009-2015, 3,143 work-related crushing injuries from 2013-2015, and 1,341 work-related skull fractures from 2012-2015.

The Bureau of Labor Statistics (BLS) annual employer survey identifies smaller numbers; 41% of the amputations, 37% of the burns, 43% of the crushing injuries and 47% of the skull fractures identified in Michigan's system. Workers' compensation is identified as the payer for 82% of the work-related amputations, 72% of the work-related burns, 56% of the work-related crushing injuries and 60% of the work-related skull fractures.

Michigan OSHA conducts follow back enforcement inspections on the injuries and the injuries are compiled into annual reports and hazard alerts. Approximately 80% of the companies inspected received a citation directly related to the injury and 60% of the time the hazard that caused the injury was not abated at the time of the inspection, even though the inspection occurred months after the injury.

The Michigan surveillance system has provided a more complete picture of occupational injuries than that provided by the annual BLS employer survey and/or the Michigan Worker Compensation Agency Data. In addition, Michigan's hospital/emergency department surveillance system has allowed for case based enforcement inspections that have proved useful in identifying ongoing hazards and sufficient information on the specific type and causes of injuries to allow for development of educational material to prevent similar injuries in the future.

Session J-Home Health Care and Hospital Workers

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Virtual Simulation Training in Home Healthcare

Home healthcare providers (HHPs) must be equipped with the knowledge and skills to assess home environments to effectively manage hazards that affect their own health and safety. Existing training approaches are limited in scope and emphasize passive over active immersive learning methods. Using gaming simulation, this study developed and evaluated a virtual simulation training system (VSTS) to address the wide range of health and safety hazards faced by home healthcare workers when working in client's homes.

Methods: Our interdisciplinary team used a mixed-methods participatory approach that included focus groups, interviews, questionnaires, and hands-on user usability assessments of the developing simulation. Continuous usability, usefulness, and desirability (UUD) evaluations provided critical input to assure realistic interactive learning experiences. The methods allowed for the iterative development and evaluation of the VSTS.

Results: Home healthcare nurses, aides, therapists, and managers (n=68) described exposures to multiple types of hazards in client homes, including but not limited to animal and human waste, clutter, mold, dim lighting, tobacco smoke, pests, faulty outlets, aggressive pets, lifting/moving patients, tight spaces, trip hazards such as throw rugs, and the lack of safety equipment. A majority of HHPs described hazard management decisions that represented less-than-optimal making do approaches to managing the encountered hazards. These findings were used in developing and UUD testing (N=24) of the innovative VSTS that simulates a client's home environment. The VSTS includes three interactive training modules (fire/electric/burn hazards; slip/lift/trip hazards; environmental hazards) which focus on hazard identification and appropriate course of action.

Discussion: The VSTS currently is undergoing efficacy testing to determine its ability to prepare home healthcare workers to recognize, assess, and respond to hazards in the home using appropriate risk perception and decision-making processes. This training approach should improve HHP risk assessment and decision-making for managing hazards to improve worker health and safety.

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Total Worker Health intervention for home care workers: Research, translation, and dissemination of the COMPASS program

Home care work is physically and emotionally taxing, and home care workers (HCWs) are at high risk for injuries and health issues. These low-wage workers perform dangerous tasks in unregulated private homes and typically have limited access to occupational safety and health support structures. The COMmunity of Practice And Safety Support (COMPASS) program was developed to address this problem, and integrates elements of peer-led social support groups with scripted team-based programs to prevent injuries and promote health among HCWs. COMPASS is a research project of the Oregon Healthy Workforce Center, a NIOSH Center of Excellence in Total Worker Health[®]. This presentation will review effectiveness findings from the COMPASS randomized controlled trial (RCT), but will focus on sharing lessons learned and successes from subsequent translation and dissemination efforts.

The RCT established the efficacy of COMPASS for improving safety and health factors, including hazard correction in homes, use of ergonomic tools, and healthy lifestyle. Subsequently the Oregon Home Care Commission (OHCC) voted to adopt COMPASS into their established training system, which has the potential to reach up to 60% of Oregon's HCWs. Through continued collaboration with the OHCC and the Service Employees International Union Local 503, investigators adapted COMPASS to fit the practical constraints of the training system. The adapted program was evaluated with five groups of HCWs and a sustainable dissemination model was planned. A research technology transfer agreement was negotiated that includes OHCC-University data exchange for long-term evaluation of COMPASS impacts. Over time the dissemination model was adjusted to utilize an emerging resource of trained community health workers as COMPASS facilitators. As the roll out begins for HCWs, further adaptation has been requested to include personal support workers who have more recently joined the union, which may expand the reach of the evidence-based program to thousands of additional caregivers.

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Hospital Patient Room Ergonomics: Getting it right for all hospital staff working in these spaces

The long term goal of this project is to reduce the physical demands, musculoskeletal injuries and discomfort experienced by healthcare workers in institutional settings. In many workplaces the awkward postures and motions exhibited by workers, and the effort required to complete work-related tasks bear a direct relationship to the layout and organization of the workspace. This is particularly true for hospital staff working in patient rooms. Given the boom in healthcare facility construction and remodeling there is an opportunity to address many of the room design parameters that create ergonomics issues for workers who provide direct patient care and other members of the hospital staff. Thus, the primary goal of this project was to create guidelines for hospital designers that address the ergonomics needs of the many different stakeholder groups working in patient rooms through a systems approach, largely driven by a participatory design process. Specifically, this project through a variety of participatory design methodologies: (1) Identified the work tasks that, due to patient room design parameters, ergonomically challenge the identified stakeholders (users); (2) Elicited stakeholder specific recommendations regarding ergonomic aspects of patient room design; (3) Identified patient room design parameters that impact the needs of patients and their visitors and family members, and elicited alterations in patient room design parameters that best support those needs; and (4) Attempted to resolve conflicts between stakeholder groups with regard to patient room design parameters, thereby, allowing for a clear set of design recommendations for patient rooms. In sum, this process has yielded a set of guidelines that should be useable and useful to designers, planners, hospital administrators, and others interested in developing ergonomic, efficient, and effective med/surg patient room designs that meet the needs of all hospital staff while at the same time meeting the needs of the patients and their visitors.

Session K-Personal Protection Technology

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Development of Computational Methods for Evaluating Loose-Fitting Powered Air-Purifying Respirators

Objective: Loose-fitting powered air-purifying respirators (PAPRs) are an important type of respiratory protection for healthcare workers. By understanding the effects of breathing and supplied-air on particle leakage into facepieces, PAPRs can be designed with a smaller blower and battery. This helps to make the respirators quieter and lighter. The aim of this study was to develop computational methods for estimating the performance of loose-fitting PAPRs.

Methods: Computational Fluid Dynamics (CFD) simulations were used to calculate the estimated manikin protection factors (mPFs) of a loose-fitting PAPR. The manikin was a medium-size digital headform operating with cyclic breathing at three workloads (light: 35 L/min, moderate: 55 L/min, and heavy: 85 L/min). For each workload, the PAPR facepiece was supplied with air at five flowrates (85, 115, 145, 175, and 195 L/min). The challenge particles were introduced at the loose-fitting area. The particle concentration of inhalation airflow through the mouth opening was calculated to derive the mPF, the ratio of the challenge particle concentration to the inhalation particle concentration.

Results: At the moderate workload and supplied-air flowrate of 85 L/min, the estimated mPF was 31.8; at the heavy workload and supplied-air flowrates of 85, 115, and 145 L/min, the estimated mPFs were 6.6, 10.6, and 43.1, respectively. For the remaining 11 combinations of workloads and flowrates, the estimated mPFs were > 10,000. The flow patterns and pressure distributions changed instantaneously during breathing cycles. The particle distributions inside the facepiece were not homogeneous; i.e., the majority of the leaking particles appeared in the region between the mouth and the facepiece seal.

Conclusions: The larger estimated mPFs were found at lower workloads and higher supplied-air flowrates. Computational methods have potential for assessing PAPR performance and improving PAPR design. Future research is needed to conduct CFD simulations and to validate simulation results with laboratory-based experiments.

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¹University of Cincinnati**Evaluating a Novel Respirator Seal Integrity Monitor for Controlling Inhalation Exposure of Firefighters**

It is widely recognized that the integrity of a respirator seal may be compromised during actual use, especially for firefighters who engage in strenuous activity at work. No method is presently available to fully ensure that the facepiece seal is maintained during actual use. The aim of this study is to develop and validate a novel wearable continuous Respirator Seal Integrity Monitor (ReSIM) that can rapidly detect respirator leakage in real time and alert the wearer.

The ReSIM prototype was developed to detect and enumerate aerosol particles inside an operating respirator. ReSIM units were exposed to known concentration of particulate matter such as monodisperse Polystyrene Latex (PSL) spheres, NaCl particles, and combustion particles. Test aerosols were measured with an optical particle spectrometer as well as with scanning aerosol instruments capable to cover the particle size range of 10 nm to >10 μm . Based on preliminary testing, the aerosol particle sensor Sharp Shinyei PPD 60PV-T2 was selected and utilized in the ReSIM unit. Results show that the ReSIM prototype responds rapidly with sufficient sensitivity and accuracy. This prototype is being tested on a respirator-wearing manikin in an exposure chamber; the aerosol concentrations inside and outside the respirator are measured to determine the protection level. Preliminary data demonstrate that the ReSIM does not interfere with the respirator function and adequately detects various seal failures. As the next step, the ReSIM will be evaluated in the firefighting simulation facility with fire fighters engaged in routine operational activities.

The most significant feature of the ReSIM is real time continuously respirator performance monitoring capability. It is not only ideal for firefighters to alert them a sudden increase in their inhalation exposure, but can be modified and applied to any particulate filter respirator (e.g., used in sandblasting and spray painting).

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A Test for Liquid Penetration through Protective Fabric using Fluorescent Dye under a Dynamic Hydrostatic Pressure Regime

Healthcare and emergency medical personnel wear protective apparel (e.g., gowns and coveralls) to reduce exposure to pathogens. Protective apparel are tested by the manufacturers to assure liquid protection for a range of work related tasks and to assist users with proper selection. Forces generated by an external pressure, such as from a pressing or leaning motion, are likely one of the major routes of liquid penetration through fabrics. These pressures arise when individuals lean or press on a surface that may be wet with blood or other bodily fluids. Hydrostatic tests are used to simulate these events. However, current test methods provide limited ability to compare garments. Some of these tests are also time-consuming and need to be done in biosafety laboratories. We propose a new test method to assess liquid penetration through protective fabric. The present study compared the proposed method with an industry standard liquid penetration test, ASTM F1670. Using both test methods, we evaluated five different garment types. Round swatches (101.6 mm diameter) were randomly selected from the front continuous zones of each garment type. Hydrostatic tests were conducted in an apparatus specified by ASTM F903. For each garment type 24 swatches were analyzed by each test method. Compared to industry standard ASTM F1670 test, the proposed test showed statistically significant differences between all five garments; detected the location of garment imperfections; and found instances where the test apparatus caused premature garment failure. Next, we plan to use this new test method to predict results of the ASTM F1671 test method using a Phi-174 bacteriophage.

Session L-Respiratory Health

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Implementation of a National Spirometry Facility Network for the Coal Workers' Health Surveillance Program (CWHSP)

Rationale: In 1970, the CWHSP was established to help prevent coal worker's pneumoconiosis through early detection and public health surveillance. CWHSP was originally based on chest radiography, which is not a reliable method to detect lung function impairment. Recent changes to Miner Safety and Health Administration (MSHA) regulations require U.S. mine operators to offer spirometry testing for coal miners, and make NIOSH responsible for implementation. Obtaining high-quality spirometry requires attention to detail, and medical literature suggests that many outpatient clinics do not obtain spirometry tests that meet recommended standards. Thus, NIOSH sought to establish a network of facilities able to consistently perform high-quality spirometry. Objective: To report on the development of the NIOSH-approved CWHSP spirometry facility network.

Methods: NIOSH actively recruited facilities, including those already performing CWHSP chest radiographs. For facility approval, we required specific spirometer technical standards, technician training, report format, and electronic data transfer criteria as outlined in the 2005 American Thoracic Society/European Respiratory Society Standardisation of Spirometry guidelines. Facility application forms with step-by-step instructions were posted online. Submitted applications were reviewed for responsiveness to technical requirements. Applying facilities not meeting requirements were offered individual NIOSH staff assistance. NIOSH also reached out to spirometer manufacturers to help facilities using their spirometer models to provide standardized spirometry reports and data transfer formats.

Results: Thirty-four facilities from 13 states applied between September 2014 and September 2016. Multiple deficiencies were identified in each application and resolved with NIOSH staff assistance. As of December 2016, 17 clinics from 10 states are NIOSH-approved, 13 are under review, and 4 withdrawn for consideration.

Conclusion: After initial barriers were overcome, development of the spirometry facility network and expansion of coal worker spirometry surveillance was well received by both facilities and spirometer manufacturers. This network is continually expanding and spirometry tests are being submitted.

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Task-Based Exposures to Airborne Endotoxins and β -Glucans among Dairy Workers

Objectives: Characterize endotoxin and β -glucan exposure among dairy workers across different tasks (birthing, milking, irrigation, medical care, rebedding, mixing feed, truck driving, machine operators, and multi-task work).

Methods: Personal and area air samples were obtained at four Northern Colorado dairies spanning nine weeks from March-September 2015. The goal for each sampling week was to recruit and monitor seven workers performing different tasks during their full-shift. We sampled a total of 38 workers. The SKC Button Sampler was employed for both personal and area samples with a flowrate of 4 L/min. Area samples were completed in triplicate in three locations at each dairy (upwind, downwind, and inside the parlor). Inhalable dust concentrations were calculated based on the gravimetric data. Endotoxin assays have been completed (per Lonza standard protocol). β -glucan assays have been completed (per Cape Cod standard protocol). Preliminary summary statistics were completed in Sigma Plot.

Results: The task with the highest average dust concentration was mixing feed (0.568 mg/m³) followed by working in the dry cow pen (0.459 mg/m³) and the birthing area (0.436 mg/m³). The endotoxin concentrations ranked differently by task in comparison to the dust concentrations. The task with the highest endotoxin concentration was the medical task (22.82 EU/m³) followed by the birthing area (16.23 EU/m³), and those working in the milking parlor (14.85 EU/m³). The area samples (both the dust and endotoxin concentrations) show that across the four dairies sampled the highest concentrations were found inside the parlor.

Conclusions: The next stage in this project is discussions with producers to design and evaluate interventions to reduce exposure to endotoxins, β -glucans, and dust concentrations in the areas with the highest exposure.

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Occupational Exposures and the Acute Respiratory Distress Syndrome (ARDS)

Introduction: The acute respiratory distress syndrome (ARDS) is a rapidly progressive form of acute respiratory failure characterized by severe hypoxemia and non-hydrostatic pulmonary edema. The incidence of ARDS is reported to be from 64.2 to 78.9 cases/100,000 person-years, which totals about 200,000 cases yearly in the United States. In 2016, there are 19 case-reports of either hospital admission for or death from ARDS occurring in the work place. In chemical plants, two case-reports reported that workers were exposed to liquid/gaseous phosgene and high concentrations of ethenone and crotonaldehyde. Also, after welders were exposed to mixed metal fumes and nickel particles, two were admitted to hospital for ARDS and one died. Although ARDS incident cases from work place exposures have been continuously reported since 1988, most published studies are simple case-reports. To have better understanding of association between industrial airborne exposures and ARDS risk, we will conduct an epidemiologic study to investigate the association between high risk industries and hospital admission for ARDS. Our study will highlight the importance of occupational exposures on the risk of ARDS, which has not been widely examined in the US or in other countries.

Methods: Arc GIS Business Analyst data includes Standard Industrial Classification (SIC), number of employees, and FIPs. Our main industries of interest are: mining, construction, and manufacturing defined by SIC codes, and the proportion of employees in those industries in each county. Our main health outcome is county-level annual aggregated hospital discharge counts for ARDS. ARDS occurrences are defined by the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9- CM) discharge diagnosis codes among Medicare enrollees. We will map age-adjusted rates of ARDS incidence and the number of three industries (mining, construction, and manufacturing) by county level from 2006 to 2013 using ArcGIS. Also, we will conduct separate Poisson regressions for each industry, to examine the impact of intensity of industries on ARDS risk, from 2006 to 2013.

Results are forthcoming in 2017.

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An evaluation of the collection characteristics and usability factors of three nanoparticle samplers

Collecting nano-particles (NPs) on transmission electron microscope (TEM) grids allows for the identification of NP morphology, chemical composition, and size. This information can be combined with real time monitoring data to characterize worker exposure. We compared three novel samplers to evaluate the size fractions collected under similar conditions. Data taken from imaging TEM grids were compared to real time sampling data to allow the researchers to evaluate how effective all three devices were at collecting particles in different size ranges. The samplers were the Electrostatic Precipitator (ESP) developed by NIOSH, the Thermophoretic Particle Sampler (TPS) developed by Colorado State University, and the new Tsai Diffusion Sampler (TDS) developed by the Tsai Research Group and utilizes a TEM grid on a polycarbonate 0.2 μ m pore filter. The three aerosols used in this experiment exhibited different size distributions and overall concentrations, allowing the researchers to evaluate a wide range of exposure scenarios. All three samplers excelled at collecting particles below 1 μ m, but the TDS was the only sampler that was also able to collect larger particles because the TEM grid sits on top of a polycarbonate filter which can be analyzed with a scanning electron microscope (SEM) to characterize particles in the micrometer size range. With very short sampling times the ESP is best suited for area sampling of NPs. The TPS has been used to collect small environmental particles in various places, and in this study most particles were found measuring smaller than 2 μ m, indicating the result was consistent with other studies. The TDS uses a commonly available 25mm cassette and can attach to standard sampling pumps making it cost effective.

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Assessment of Ambient Exposures Firefighters Encounter while at the Fire Station: An Exploratory Study

Introduction: Firefighters are at increased risk for many types of cancer due to the hazardous nature of their job. While most studies on firefighters and cancer focus on the exposures encountered while fighting fires, low levels of contaminants encountered at the fire station are also cause for concern. This pilot aimed to describe air quality within a few fire stations in the Boston, MA area, and to investigate factors (physical and organizational) that influenced contaminant levels in the air.

Methods: Air sampling of particulate matter (PM_{2.5}) and particle-bound poly-aromatic hydrocarbons (PAHs) was completed at four fire stations in the spring of 2016 for approximately five days per station. At each station, sampling occurred outside the station, in the truck bay, and in the fire station kitchen. Data were analyzed to assess differences between and within stations. Interviews (n=7) were conducted with officers at each station to explore organizational policies and practices that relate to health and safety at the fire station. Interviews were transcribed and analyzed for thematic content.

Results: Levels of PM_{2.5} and PAHs were generally higher in the truck bays than the outside or kitchen, and varied the most throughout the day. The station with the highest exposures in the truck bay had the lowest level in the kitchen, which was possibly explained by the new building materials in place at the station and the strong separation between building zones. The age and structure of the firehouses appeared to determine the extent to which policies favoring exhaust capture were actually implemented. **Conclusion:**

The levels of PM_{2.5} and PAH observed at these fire stations may contribute to firefighter cancer risk. Through understanding the variability and range of values found, we can begin to design and test interventions that improve firefighter cancer prevention.

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Comparison of Exposures to WMSD Risk Factors in High and Low Workers' Compensation Rate Companies in Washington State

Within industry sectors, workers' compensation (WC) claims rates may vary widely. This research sought to identify differences in exposures to physical risk factors of work-related musculoskeletal disorders (WMSDs) and organizational culture between companies with high and low WMSD claims rates of the back, shoulder, hand/wrist and knee. Six NORA sectors were involved in this research, Agriculture, Healthcare and Social Services, Manufacturing, Wholesale and Retail Trade, Construction and Services (excluding Public Safety). Using WC data between 2000 to 2010, injury rates for each industry sector were calculated for each body area. Employers within sub-industries were ranked by WMSDs injury rates and designated as high rate (highest quartile) or low rate (lowest quartile). High and low WMSD rate companies were then paired based on 1) 4-digit NAICS code, 2) body area, and 3) company size: 20-49 FTEs, 50-99 FTEs, more than 100 FTEs. Using existing exposure assessment tools, comprehensive job evaluations were performed at participating companies. Forty-eight pairs of companies participated (8 pairs per NORA sector, 2 pairs per body area). Following a risk level determination (3- or 4- levels), based on the physical data collected, analyses were performed between paired companies to identify patterns that might result in the disparity in WMSD claims rates. Using the results of the exposure assessments, a physical job evaluation checklist for each of the six NORA sectors was also created. This research quantified the exposures to WMSD risk factors across a large working population (n=2798). The absolute difference in claims rate between company pairs varied between and within group classification for each body area. It was not possible to determine the effect, if any, from these differences. From our job evaluations, risk factors may not be the same between industry groups and as such industry-specific tools may simplify the evaluation process.

Session N-MSD

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The Revised Strain Index - A DUE physical exposure model for complex jobs with job rotation

Background: Modern jobs are often complex - consisting of multiple tasks each of which contain several unique sub-tasks. These jobs can be difficult to quantify with prior physical exposure assessment models, such as the 1995 Strain Index and the ACGIH TLV for HAL, which were designed for simple, mono-task jobs. Methods:

The Revised Strain Index (RSI) is a distal upper extremity (DUE) physical exposure assessment model based on: intensity of exertion, frequency of exertion, duration per exertion, hand/wrist posture and duration of task per day. The RSI improves upon the 1995 Strain Index (SI) by using continuous rather than categorical multipliers, and replacing duty cycle with duration per exertion. Algorithms quantify sub-task-level RSI scores into task level Composite RSI scores (COSI), and further combine COSI scores into cumulative RSI (CUSI), a measure of daily physical exposure from multi-task jobs. Separate simulations of tasks and jobs compared RSI performance to that of the 1995 SI, and to traditional techniques such as peak exposure and time-weighted-average exposure for complex and multi-task jobs.

Results: The RSI and 1995 SI showed good agreement in risk predictions for 1995 SI scores ≤ 3 and > 13.5 . For tasks with 1995 SI scores of >3 and ≤ 13.5 , the two models showed marked disagreement, with the RSI providing much greater discriminations between 'safe' and 'hazardous' tasks for various combinations of force, repetition and duty cycle. Similarly, the COSI and CUSI appear to offer balance between peak-exposure that is biased towards hazardous classifications and TWA-exposure that is biased towards 'safe' classifications of risk.

Conclusions: We believe the RSI is a substantially improved DUE physical exposure assessment model that will be useful for DUE task analysis, intervention and design.

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Personal and workplace factors for Carpal Tunnel Syndrome: Findings from the NIOSH Consortium Studies

Background: The NIOSH Consortium coordinated six independent studies that collected prospective data on personal and workplace risk factors for incident carpal tunnel syndrome (CTS). Analysis of pooled consortium data allowed estimation of associations between workplace biomechanical factors and incidence of CTS, adjusted for personal risk factors.

Methods: All studies collected individual-level workplace exposure information, and followed workers prospectively for the development of symptoms and nerve conduction abnormalities. Individual workplace exposure measures available from all six studies included grip and pinch force, repetition, duty cycle, and wrist posture for different work tasks. Task exposures were combined across the work week using time-weighted averaging to estimate job-level exposures. A common CTS case definition was applied to all pooled study participants. Hazard ratios (HR) were estimated using Cox proportional hazard models.

Results: Workers were enrolled from 54 US workplaces across 10 States. There were 4321 total participants recruited. 2474 participants had complete exposure data and were without CTS or possible polyneuropathy at baseline. Participants were followed up to 6.5 years (5102 total person-years of observation). After adjustment for age, gender, body mass, and other covariates, several biomechanical risk factors were associated with incident CTS, including peak hand force (HR=2.17; 95% CI 1.38-3.43), the rate of forceful hand repetition (HR=1.84; 95% CI 1.19 -2.86) and time spent in forceful hand exertions ("duty cycle" HR=2.05; 95% CI 1.34 to 3.15). Associations were not observed between CTS and total hand repetition rate or wrist posture and incident CTS.

Conclusions: In this prospective study of production and service workers, several measures of exposure to forceful hand exertion were associated with incident CTS, while total hand repetition was not. These findings may influence prevention efforts for CTS.

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Emerging work-related psychosocial risk factors for low back pain: Evidence from 2015 NHIS data

Significance: Musculoskeletal disorders (MSDs), particularly low back pain (LBP), have been the leading cause of disabling injury in the workplace with a workers' compensation cost of \$15 billion annually in the U.S. Prevention of MSDs including LBP has been one of the priority goals in the NORA Musculoskeletal Health cross sector and the Healthy Work Design and Well-being cross-sector, and several sector programs.

Methodology: Data from the 2015 National Health Interview Survey (NHIS), including an Occupational Health Supplement, were used for this study. After applying the inclusion criteria (age \geq 18 and currently employed adult workers who worked at least 20 hours per week), a sample of 14,580 was obtained and weighted according to the NHIS sampling design. Emerging work-related psychosocial factors were defined as work-life interference, exposure to a hostile work environment and job insecurity. Risk of LBP was estimated using multivariable logistic regression, adjusted for personal, physical, traditional psychosocial factors (job strain and supervisory support) and other confounding factors.

Results: The prevalence of self-reported LBP in the past three months in the U.S. working population was 26.7%. Workers who reported work-life interference, exposure to a hostile work environment and job insecurity had a statically significantly ($P<0.05$) increased odds (21%, 67%, 39%, respectively) for LBP. High job demands were associated with an increased likelihood for LBP by 25%, compared with low job demands. Findings from sex and age stratified models suggest that work-life interference was not associated with LBP for older workers (\geq 41).

Conclusions: Although longitudinal research is recommended for confirming the emerging risk factors for LBP, findings from this study may contribute to prevention of workplace LBP through different intervention strategies targeted on the emerging psychosocial risk factors. Sex and age may need to be considered for effective control of LBP risk factors.

Session O-Extractive Industries

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Lab-on-a-Chip Device for On-Site Biomonitoring of Workers Exposed to Respirable Silica Aerosol

Exposure to respirable crystalline silica (RCS) aerosol is a significant occupational health problem. Approximately two million U.S. workers are routinely exposed to airborne RCS. Exposures can be especially high at worksites that involve hydraulic fracturing, construction, and mining. Early detection of pulmonary responses to inhaled silica aerosol, such as lung inflammation and oxidative stress, as well as early identification of silicosis initiation, are of great importance in disease prevention, and from the perspectives of occupational health surveillance and epidemiological research. For screening purposes, field-portable biomonitoring devices that monitor early indicators of potential adverse effects in exposed workers would be highly valuable. In this work, a miniaturized, prototype polymer lab-on-a-chip was designed, fabricated and characterized to perform immunoassays in plasma/serum, with on-chip sampling and biomarker recognition. Using plasma samples from rats exposed to RCS aerosol, the developed lab-on-a-chip was evaluated against commercially available, 96-well plates, enzyme-linked immunosorbent assay (ELISA) kits for tumor necrosis factor- α (TNF- α) and Clara cell protein 16, selected biomarkers of lung inflammation due to RCS exposure. The results indicate that the lab-on-a-chip can detect TNF- α in the concentration range of 0.06 to 4 ng/mL, with a limit of detection (LOD) of 0.5 pg/mL. This LOD is almost 20 times less than that obtained with the commercial assay, and low enough to provide on-site detection of the target biomarker. Preliminary results demonstrate the potential of the lab-on-a-chip device for on-site screening of workers exposed to RCS aerosol.

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FrackMap: Building a geo-spatially based nexus of research publications and perceptions regarding hydraulic fracturing to provide researchers, health professionals and the community access to information about the health risks and impacts of hydraulic fracturing

Relevance: Hydraulic fracturing, a process used to extricate gas and oil from shale plays, while providing us with fuel, can have a negative impact on drinking water, air quality, the quality of the effluent from water treatment facilities, etc. These impacts can translate into occupational and environmental health impacts. The FrackMap was initially a collaborative among Harvard SPH, UPENN and the Harvard Center for Geographic Analysis (CGA). The aim of the project is to develop a geo-spatially based nexus for hydraulic fracturing-related research which researchers, health professionals and the community can use to gain access to peer-reviewed literature relevant to occupational and environmental health risks. Approach: First, the FrackMap was created using data from FrackFocus. Each gas or oil well was geo-spatially located within a specific shale play. Next a key-word-based search of peer-reviewed publications relating to hydraulically fractured oil and gas wells resulted in the identification of 500 articles in 11 research categories (such as waste water, air quality, seismicity, health impacts). Bibliographic map layers, based on the research categories, were created by geo-coding the peer-reviewed articles according to their geo-spatial association with shale plays i.e., regions of unconventional drilling, then applying simple algorithms for locating the geo-coded articles within a shale play and/or state. Additionally, over 60,000 tweets captured by Harvard CGA's Geo-tweet Archive, were analyzed using the Nuance-R platform, geo-coded and mapped. These tweets contain content (benefits/risks) and sentiment (positive/negative attitudes). Impact: Researchers, health professionals, and the community can use the resulting FrackMap to explore a significant slice of current research on hydraulic fracturing created through chemical analysis, fate and transport analysis, exposure assessment, risk analysis, and epidemiology. Using the temporal and spatial information embedded in tweets, we can customize translation of scientific research to improve public understanding of the impacts of hydraulic fracturing. URL: <http://worldmap.harvard.edu/maps/FrackMap>

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The Personal Dust Monitor: A Partnership Success Story

Exposure of underground miners to coal mine dust has resulted in coal workers' pneumoconiosis (CWP) being the direct or contributing cause of almost 75 thousand deaths and the distribution of 44 billion in black lung benefits since promulgation of the Federal Coal Mine Health and Safety Act of 1969. The Act set a respirable coal mine dust exposure concentration limit and mandated the use of a government-approved device to measure miners' exposure concentrations. The subsequently approved coal mine dust personal sampler (CMDPSU) uses gravimetric measurements on its collection filter to determine an average respirable coal mine dust exposure concentration over a working shift. Because of concerns that more protective regulations were needed, in 1996 the Secretary of Labor established the Federal Advisory Committee on the Elimination of Pneumoconiosis among Coal Mine Workers. The Committee recommended that the National Institute for Occupational Safety and Health (NIOSH) research improved sampling instrumentation for use in the mining industry. In response, NIOSH led the development of the personal dust monitor (PDM) in consultation with the PDM partnership, consisting of labor, industry and government. Through regular meetings, the members of the PDM partnership worked together to find a suitable technology for near real-time mass measurements of respirable dust, to refine this technology to handle the difficult conditions found in underground coal mines, to develop a sampling protocol to ensure the new instrument met NIOSH accuracy and precision criteria and finally to complete the testing and data analysis. On February 1, 2016, the underground coal mining industry began using the PDM to collect respirable dust samples in every underground coal mine in the United States and through the first year of PDM implementation MSHA exposure data shows the rate of miners/ overexposure to coal mine dust decreasing by 90%.

Session P-OSH In Motion

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Partnership between the National Institute for Occupational Safety and Health (NIOSH) and an indium-tin oxide (ITO) company to prevent indium lung disease

Introduction: In 2009 NIOSH investigators reported two cases of pulmonary alveolar proteinosis (PAP), including one death, at a United States ITO production facility. Along with reported cases of PAP, fibrosis, and emphysema in Chinese and Japanese workers, these cases led to the recognition of indium lung disease as a novel, progressive, and potentially fatal pneumoconiosis. To understand and prevent indium lung disease, NIOSH developed a long-term partnership with the company that owns the US facility.

Methods: Company management requested a health hazard evaluation (HHE) in 2009 to assess preventive measures. The HHE included reviewing company medical surveillance data and collecting air samples. In 2012, NIOSH and the company entered a research partnership, supported by the National Occupational Research Agenda (NORA). To that end, serial evaluations of current worker health and comprehensive air sampling were conducted in 2012 and 2014 to assess exposure-response relationships.

Results: The HHE identified abnormal declines in lung function after hire in 29% of workers and exposure opportunities. In 2012, NORA-supported research showed workers with plasma indium $>1 \mu\text{g/L}$ and those with higher cumulative respirable indium exposures had more dyspnea, lower spirometric parameters, and higher KL-6 and SP-D (biomarkers of lung damage). In 2014, workers whose interval plasma indium increased $>0.4 \mu\text{g/L}$ (the average change) had higher odds of at least one new respiratory symptom, lower % predicted diffusing capacity, and higher KL-6. No additional clinical PAP cases have occurred, likely reflecting the company's investments in exposure controls.

Conclusions: The HHE identified respiratory health effects beyond the two reported cases of PAP and stimulated a valuable research partnership. NIOSH findings from this partnership have been used by the company to improve conditions at the workplace and have also had a global impact by contributing to the scientific knowledge of this novel occupational lung disease.

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Implementation Science: What is it and what do we know about successfully translating OSH solutions into worker practice?

Background: Translating evidence-based research and technology solutions into worksite improvements and worker adoption of safety practices has increasingly been a priority for both extramural and intramural NIOSH researchers. As has been argued, programs, practices or technologies that perform well in the lab or in controlled settings will do little to reduce exposures to hazards in the real world, if industries don't adopt them and workers don't accept them. Although researchers generally agree that occupational health and safety research should lead to substantive improvements for workers, there has been little focus on how to successfully imbed these solutions in the workplace.

Methods: In this presentation NIOSH intramural and extramural implementation science researchers will 1) define and discuss the concept of translational science, 2) review the four phases of translational research, 3) share examples of OSH solutions that have lead to widespread adoption by worker communities or industry, 4) discuss the challenges that researchers typically encounter when moving from the pilot to widespread implementation stage and 4) share initial research on factors that are essential for ensuring successful implementation of worksite solutions.

Results: Lastly, presenters will propose a translational science framework that can be used to further clarify the translation process and which can be used to guide existing NIOSH research through the development and evaluation stage to widespread worker and industry adoption.

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Understanding Community Infrastructure and Capacity to Engage Community Agencies in Advancing Occupational Health Disparities Research

Background/Objective: Globalization, technological innovation, immigration, and decreased unionization have dramatically altered demographics of the U.S. workforce, nature of work, and responsibilities for assuring workplace health and safety. Immigrant workers are disproportionately represented in low-wage, high health risk jobs. Conventional worksite prevention approaches, intended to improve worker health and safety, are relatively ineffective in reaching low-wage immigrant workers. Alternative occupational health (OH) approaches are critically needed to address disparities in OH. Using Chinese immigrant worker health as an exemplar, we examined innovative approaches to increase immigrant worker OH knowledge and skills, and to maximize diffusion of such by tapping into the existing community infrastructure and resources.

Approach: Study 1: Using network analysis we characterized interagency connections (N=42 organizations from service, faith-based, nonprofit, union, and public sectors) and agency roles and assessed organizational capacity specific to Chinese immigrant worker health. Study 2: We assessed factors that influenced the integration of immigrant-targeted Basic Worker Health Education (WHEb) within and by community agencies and evaluated the integration process for WHEb diffusion and sustainability.

Results: Study 1: Central positions in the networks were held by a few service-oriented agencies; strong interconnectedness occurred predominately across the service, public, and nonprofit sectors. The Chinese and Pan-Asian service sectors showed the strongest interconnectedness and highest capacity for Chinese immigrant worker health. Study 2: Agencies were generally responsive to participation in the pilot WHEb implementation trial; additional effort was required to assist agencies identify feasible dissemination strategies. Intra- and extra-organization factors pertinent to organizational decisions for service/program changes were identified.

Conclusion: Community and public agency assets are underutilized in the promotion of immigrant worker health and elimination of OH disparities. Our research provides new knowledge to guide strategic choices to expand OH efforts and facilitate community-based partnership development and dissemination of comprehensive, sustainable prevention programs for immigrant worker health.

Partnerships Plenary

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Research Partnerships in Development of an Engineering Control for Respirable Crystalline Silica

NIOSH researchers were the first to systematically characterize respirable crystalline silica (RCS) exposures to workers involved in hydraulic fracturing. This research could not have been accomplished without the cooperation of industry partners who provided NIOSH with access to worksites and workers. Exposures to RCS for some workers at hydraulic fracturing sites can exceed 10 – 50 times occupational exposure limits. With the new OSHA rule on RCS exposure, engineering controls will be increasingly necessary. NIOSH researchers developed the NIOSH mini-baghouse retrofit assembly (NMBRA) to control inhalation risk for oil and gas workers at the most significant source of RCS emission. The NMBRA is a simple retrofit with no moving parts, which can be installed in the field on existing equipment to control RCS. For each hydraulically-fractured well, hundreds of thousands to millions of pounds of sand are processed through storage and delivery containers called sand movers. The NMBRA mounts on the thief hatches, or inspection hatches, of sand movers, a predominant source of RCS. The NMBRA uses filter bags to capture dust escaping from the thief hatches. This technology was evaluated in the field in 2013 and 2015 in cooperation with an industry partner. Testing demonstrated that the NMBRA effectively captured >98% of respirable dust and RCS at and downwind of the thief hatches. This dust contained freshly fractured quartz, a very hazardous form of RCS. The testing also made it possible to significantly reduce backpressures inside the filter bags. A long-term field evaluation of the NMBRA is currently underway with another industry partner at an active hydraulic fracturing site. This evaluation continues to yield valuable data about performance, durability, and field practices that impact the design and operation of the NMBRA. As a result of this testing, further refinements to the technology will be considered.

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A Partner Coordinated Campaign to Prevent Falls in Construction: Historical Review & Analysis of Reach

Falls are the top cause of construction fatalities and account for 1/3 of on-the-job injuries and deaths in the industry. In 2012, the NORA Construction Sector Council, along with OSHA, NIOSH, and CPWR launched a national construction fall prevention campaign aimed at raising awareness and preventing fall hazards. Through a coordinated effort, many other organizations became invested partners including state health departments, labor organizations, contractor associations, and academia. As the campaign gained momentum, OSHA launched the National Safety Stand-Down to Prevent Falls, a week dedicated to drawing attention to the campaign and its goals. The Stand-Down is a voluntary event for employers to talk directly to employees about hazards, protective methods, and company safety policies. Quantitative and qualitative analysis conducted in 2014, 2015, and 2016 indicate that the Stand-Down has been successful. Between 2014 and 2016, over 10,000 respondents provided information on almost 2,230,000 event participants. These data include only the information provided to OSHA; however, many more companies and individuals participated in campaign activities during this period based on anecdotal reports. This presentation will review the annual breakdown for three years of data on Stand-Down events, including participants reached, activities reported, efforts by state and region, and feedback collected.

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Occupational nanoparticle exposure: toxicity beyond the lung

Background: With potential wide industrial application and increasing production, the potential for nanomaterial exposure is increasing in many industry sectors. Recently identified adverse health effects of nanoparticles have principally focused on the pulmonary system and less on the cardiovascular system. In particular, some multi-walled carbon nanotubes (MWCNTs) cause pulmonary inflammation and fibrosis and promote lung cancer. In contrast, the cardiovascular effects of nanoparticles are less understood. The present study investigates the cardiovascular effects of ultrafine titanium dioxide (UFTiO₂) and MWCNT inhalation.

Methods: Male Sprague-Dawley rats were exposed by inhalation to UFTiO₂ for 4 h at a concentration of 6 mg/m³ or MWCNTs for 5 h at 5 mg/m³. The alterations in phosphorylation level of cardiac proteins were determined by Western blot. The electrocardiogram (EKG) and blood pressure of awake freely moving rats were recorded continuously before, during and after nanoparticle exposure by a telemetry recording system. Left ventricular function in response to dobutamine after exposure to nanoparticles was evaluated by a pressure-volume loop catheter placed in the left ventricle of anesthetized rats.

Results: Inhalation of UFTiO₂ for 4 h increased the phosphorylation levels of p38 mitogen-activated protein kinase and cardiac troponin 1 in the heart, increased systemic blood pressure and reduced cardiac muscle contractility. Pretreatment of the rats ip with the transient receptor potential (TRP) channel blocker ruthenium red inhibited substance P synthesis in nodose ganglia and prevented the biological and functional changes in the cardiovascular system. In a separate set of experiment, inhalation of MWCNTs transiently altered balance of the sympathetic nervous and vagal outflows by interfering with peripheral sensory neurons in the lung, resulting in an increase in systemic blood pressure and a decrease in cardiac output.

Conclusions: Inhalation of UFTiO₂ or MWCNTs can alter cardiovascular function through a pathway regulated by autonomic nervous system.

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Altered expression of telomere maintenance genes in lung tissue of rats after silica inhalation

Exposure to silica causes severe health effects, such as lung fibrosis and cancer. Identification of molecular targets and mechanisms of silica-induced pulmonary toxicity is important for intervention/prevention of lung disease. Telomeres consist of tandem repeats of TTAGGG DNA sequences and are located at the end of chromosomes, preventing chromosomal fusion and degradation. Telomeres shorten with cell division leading to genomic instability and cellular senescence. Shelterin (e.g., POT1) and other proteins (e.g., TTI2, RTEL1) involved in telomere maintenance play an important role in maintaining telomere length and integrity. The goal was to assess the effect of silica exposure on the regulation of genes involved in telomere maintenance. Fischer 344 rats were exposed by inhalation to silica using two regimens: (1) 15 mg/m³ for 6 hr/d x 3, 6, and 12 wk, assessed 1 d post-exposure; (2) 15 mg/m³ for 6 hr/d x 1 wk, assessed 44 wk post-exposure. After exposure, right lungs were homogenized, total RNA was isolated, cDNA was obtained, and expression of telomere maintenance genes was assessed. At all times post-exposure, mRNA expression of POT1, RTEL1, and TTI2 was significantly decreased in lung tissue of silica-exposed animals compared to air controls. Reduced expression of these genes causes disruption of assembly of the telomere and induces DNA damage. Analysis of a focused array for genes associated with telomere function and regulation indicated a reduced expression ($p < 0.01$) of 49 genes after 3 wk post-exposure. However, by 44 wk after a 1 wk exposure, 10 of these genes were overexpressed, whereas 29 genes remained downregulated. Array findings indicated acute and subchronic effects on telomere-associated genes after silica exposure. This study indicates that measurement of genes involved in telomere maintenance may serve as a potential biomarker related to silica exposure and also may offer insight into the mechanism of silica-induced lung diseases.

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Evaluating oncology nurses' safety when handling hazardous drugs: Case report analysis from a multi-site study

Purpose: Oncology nurses handle high volumes of hazardous drugs daily. To date, few studies have examined personal protective equipment (PPE) use when hazardous drug exposures (i.e., spills) occur. As part of a NIOSH-funded RO1, we sought to describe hazardous drug handling practices to inform practice and reduce potential hazardous drug exposures among nurses practicing in ambulatory chemotherapy settings.

Methods: The DEFENS study commenced in March, 2015 after Human Subjects approval. Consented participants (n=378) completed a baseline survey and also completed confidential reports when drug spills occurred. We used descriptive statistics to examine the frequency of PPE use during both routine care and drug spills.

Results: At baseline, 326 (86.5%) nurses reported wearing chemotherapy-approved gloves, 92 (24.4%) wore double gloves (as recommended), and 206 (54.6%) wore disposable gowns at all times when handling hazardous drugs. Across 12 sites, nurses reported 52 unique spills, involving 59 participants. Of these, 25 (42.4%) nurses wore a single pair of gloves, 32 (54.2%) wore double gloves, and 22 (37.3%) did not wear a disposable gown.

Findings: Despite published evidence-based guidelines from professional organizations and institutional policies, a troubling underuse of PPE was reported during routine handling of hazardous drugs and when managing spills. PPE use during routine administration was somewhat worse than during unanticipated spills, especially for double glove use.

Discussion: Nursing practice leaders should emphasize safe practice policies and safety education across health systems and educational institutions. Infusion nurses should comply with relevant professional practice recommendations which include wearing PPE in anticipation of spills.

Implications: Systematic reporting and analysis of hazardous drug spill events provide crucial insights into current gaps in safety practice. Educational interventions are needed to improve awareness and promote PPE use. Occupational health practitioners can lead the educational outreach to and monitoring of this high-risk class of workers.

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Airplane pilot mental health and suicidal thoughts: a cross-sectional descriptive study via anonymous web-based survey

Background: The Germanwings Flight 9525 crash has brought the sensitive subject of airline pilot mental health to the forefront in aviation. Globally, 350 million people suffer from depression—a common mental disorder. This is the first study to describe airline pilot mental health—with a focus on depression and suicidal thoughts—outside of the information derived from aircraft accident investigations, regulated health examinations, or identifiable self-reports, which are records protected by civil aviation authorities and airline companies.

Methods: This is a descriptive cross-sectional study via an anonymous web-based survey administered between April and December 2015. Pilots were recruited from unions, airline companies, and airports via convenience sampling. Data analysis included calculating absolute number and prevalence of health characteristics and depression scores.

Results: 1837 (52.7%) of the 3485 surveyed pilots completed the survey, with 1866 (53.5%) completing at least half of the survey. 233 (12.6%) of 1848 airline pilots responding to the Patient Health Questionnaire 9 (PHQ-9), and 193 (13.5%) of 1430 pilots who reported working as an airline pilot in the last seven days at time of survey, met depression threshold—PHQ-9 total score ≥ 10 . Seventy-five participants (4.1%) reported having suicidal thoughts within the past two weeks. We found a significant trend in proportions of depression at higher levels of use of sleep-aid medication (trend test $z=6.74$, $p<0.001$) and among those experiencing sexual harassment ($z=3.18$, $p=0.001$) or verbal harassment ($z=6.13$, $p<0.001$). Conclusion:

Hundreds of pilots currently flying are managing depressive symptoms perhaps without the possibility of treatment due to the fear of negative career impacts. Although results have limited generalizability, there are a significant number of active pilots suffering from depressive symptoms. We recommend airline organizations increase support for preventative mental health treatment. Future research will evaluate additional risk factors of depression such as sleep and circadian rhythm disturbances.

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Using Theater to Influence Work Behaviors of Older Agricultural Workers through Community Partnerships

Purpose: Senior farmers/farm workers accounted for over half of all farming deaths between 1992 and 2004. This study reports on a promising new intervention to promote health and reduce injury and fatalities.

Method: Didactic readers' theater was piloted in response to the findings of an R21 study to identify possible approaches to senior farmer health. We report on the success of the intervention to date. In collaboration with local community leaders, the intervention is marketed as a dinner theater and is presented at a site well known to the farm families. Couples are recruited to foster family communication and to create a more social atmosphere. Three brief dramas, based on stories from farmers, are performed by local farmers. Following each drama, participants engage in a brief discussion about its content. Evaluation of receptivity and subsequent behavior change is tracked through telephone interviews two weeks and two months post-event.

Results: To date, 369 persons (mean age: 63) have participated across five theaters. Participants rated the event as highly realistic, enjoyable, and they reported that it helped them understand the interactions of aging, health and work injury. More than half (57%) reported making at least one substantial change in their health or work behavior based on the information they received. Examples of changes included focusing on single tasks, fatigue prevention strategies, hydration, improved communication, and skin and hearing protection. Participants like the relaxed environment that supported continued family conversation about health and safety. Community partners liked the uniqueness of the program, the engaging atmosphere, and the ability to tailor the program to their local setting.

Implications: Three theaters are planned for Spring, 2017. Inquiries about hosting a theater are increasing and this technique is being included in two new programs for farmers. An on-line toolkit will be available in 2019.

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Risk Factors for Injury and Illness in Seafarers

Background: The Yale Occupational and Environmental Medicine Program is currently engaged in seafarer occupational epidemiological research using multiple data sources. The overall goal of this research is to describe risk factors for injuries and illness in seafarers, an essential and isolated workforce, to guide preventive interventions in collaboration with the NIOSH Center for Maritime Safety and Health Studies and seafarer welfare agencies.

Methods: Data sources include at-sea injuries and illnesses reported to telemedicine providers, coastal authorities (United States Coast Guard, USCG), and major shipping registries. Descriptive statistics were used to determine distributions of injury and illness. Logistic regression was used to determine risk factors for injury, illness, disability, and fatality at sea and domestic navigable waterways. A seafarer health and exposure survey was developed for ocean-going seafarers at the Port of Newark, New Jersey.

Results: Analysis of telemedicine data identified 1339 total cases, including 870 illnesses (65%) and 469 injuries (35%), with increased risk for disability in non-officers versus officers (OR 1.6; 95%CI 1.17, 2.18). Data from the USCG included 2671 injuries and 259 deaths. The majority of deaths occurred on towing vessels (182; 70.3%). The most frequent causes of death in the towing vessel mariners were pre-existing medical conditions, vessel disasters, and falls overboard. Over 100 seafarer surveys were conducted at Port Newark, New Jersey, finding high prevalence of exposures to noise, heat, vibration, and dust, among others.

Discussion: An important component of the research has been developing a seafarer work exposure and health survey, made possible by unique access to seafarers through collaboration with established global seafarer welfare agencies. Bringing together the multiple sources of data will allow a description of exposures, injury, disability, and death at sea, and reveal potential opportunities for preventive interventions.

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Neurodegenerative Mortality among Major League Baseball Players

Background: Studies suggest a possible link between head injury and neurodegenerative diseases, and findings of chronic traumatic encephalopathy in athletes have called attention to potential neurological consequences of sports. Increased risk of neurodegenerative diseases, including amyotrophic lateral sclerosis (ALS), has been reported among soccer players and American football players. To date, the risk among baseball players—another elite athlete profession but with lower head injury prevalence—has not been evaluated.

Methods: Vital status and causes of death were obtained from the National Death Index for 10,451 players who played at least one professional baseball game between 1906 and 2006. Standardized mortality ratios (SMRs) compared to the US male population were calculated using the NIOSH Life Table Analysis System. Standardized rate ratios (SRRs) were calculated for internal comparisons of whether length of professional playing time or being a catcher was associated with higher risk.

Results: Compared to the US male population, baseball players have lower all-cause mortality with an SMR (95% confidence interval) of 0.76 (0.74-0.79). Mortality was also significantly reduced for cancers, cardiovascular diseases, external injuries, and suicide; however, all neurodegenerative mortality, and dementia/Alzheimer's, Parkinson's, and ALS individually, were not different. The SRRs comparing players with ≥ 5 to < 5 years played, and catchers to other positions, did not indicate any difference for neurodegenerative mortality.

Conclusions: While a lower than expected rate of mortality was observed for many outcomes among professional baseball players, there was no difference for neurodegenerative diseases. Because of the lower frequency and different nature of head injuries in baseball compared to soccer and American football, these results, comparing with prior studies, strengthen the data suggesting that head injuries could underlie increased neurodegenerative outcomes in soccer and American football.

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Incidence, Latency, and Survival of Cancer Following WTC Exposure

The rescue/recovery effort that followed the attacks on the World Trade Center (WTC), led to large numbers of responders being exposed to a wide variety of hazardous material including pulverized cement, glass, asbestos, lead, partially combusted jet fuel, wood, paper, and other flammable material, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides, and polychlorinated furans and dioxins. Three research centers that follow cohorts of rescue and recovery workers since the WTC disaster include the Fire Department of the City of New York (FDNY); the Icahn School of Medicine at Mount Sinai (ISMMS); and the New York City Department of Health and Mental Hygiene (DOHMH). Modest though mostly non-statistically significantly elevated cancer incidence rates following exposure to the WTC site have been reported in all three of the cohorts, despite limited follow-up time since 9/11/2001. In this presentation we will review previous findings from the three cohorts and describe a new NIOSH-funded study that will combine the three cohorts to account for individuals who are in more than one cohort, to increase the sample size (estimated total number of rescue and recovery workers, 58,000), and to make the results more generalizable. In this new study we will update the incidence findings from the prior reports using consistent exposure and outcome definitions, taking advantage of the additional six years of follow-up since those publications. We will also study the time elapsed from exposure to increased incidence of WTC-associated cancer using change point models; the short-term high intensity exposure with long-term follow-up in responder cohorts offers a rare opportunity to investigate cancer latency in humans. Finally, we will examine mortality after diagnosis of cancer; this will assist in assessing the potential impact of surveillance bias on incidence, and will inform on the survival of WTC cancer patients compared to unselected cancer patients.

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Improving Air Quality in Swine Farrowing Operations: Results of Engineering Interventions

A multi-year study has examined engineering controls to reduce concentrations of hazardous wintertime contaminants in indoor swine farrowing buildings. Field interventions incorporated ventilation and equipment replacement in an educational swine farrowing room over three winters. A ventilation system, which included dust removal and recirculation, was installed. Respirable and inhalable dust concentrations were significantly reduced: the system with a pocket-filter (Shaker-Dust Collector SDC-140-3, United Air Specialists) performed better than an equivalently-sized cyclone (Model 16, Donaldson Inc.). Room concentrations of hazardous gases were measured to examine whether increased air movement in the room resulted in drawing these contaminants from the manure pits: hydrogen sulfide (H₂S) and ammonia (NH₃) were *not* increased by using the ventilation system. In year 1, carbon dioxide (CO₂) concentrations exceeded the recommended 1540 ppm limit (mean = 2480 ppm) when common unvented heaters were in use. Mathematical modeling indicated that standard barn heaters (Guardian 60, LB White) heater generated significant contributions of CO₂. Hence, heaters in the study room were replaced with a model that vents combustion gases outside of the building (Effinity 93, Modine Manufacturing), which reduced in-room concentrations (mean = 1420 ppm). The heater itself was associated with 800 ppm CO₂ reduction, while between-winter differences in temperature and pig counts accounted for a 200 ppm CO₂ reduction between study years. Replacing heaters present a low-cost solution to reducing one of the three main air contaminants in this building. We have partnered with producer organization to communicate findings and begun outreach to agricultural extension agents and livestock builders to communicate the low cost solution. Testing the ventilation system in a production barn while tracking human and animal health improvements is under way to demonstrate the cost benefit of ventilation to producers.

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Surgical Assistants at Risk of Musculoskeletal Injury and Illness in the Operating Room: A Pilot Study to Measure Exposure

The operating room (OR) is a physically demanding environment for the surgical worker. Up to 50% of allied health staff experience musculoskeletal pain, illness, or injuries during their work in the OR, however, most current research is focused on the surgeon. This study aimed to complete an exposure assessment of risk factors for work-related musculoskeletal injuries for allied health staff in the OR. Six allied health staff, all surgical assistants, were recruited for participation. Work postures and self-reported fatigue and musculoskeletal pain were collected for two full workdays. Wireless inertia measurement units (IMUs) were instrumented on allied health staff before the start of the workday to collect neck, shoulder, and back postures in surgery. Despite reports of pain from half of the participants, overall they did not experience a significant increase in pain and fatigue from before their surgical day until after their surgical day regardless of spending 15-19% of their full workday assuming postures with moderate to severe musculoskeletal health risk. Additionally, surgical assistants elevated their shoulders beyond 45 degrees an average of 1.3-1.7 (\pm 1.3-1.6) times each minute during the operations, for the left and right shoulder, respectively. Both self-reported pain and posture assessment data provides evidence that surgical assistants are at risk of musculoskeletal illness and injury. Further research is needed to study all allied health staff and to determine an appropriate intervention. As one of the first studies to quantify biomechanics in the operating room for surgical allied health staff, this is pilot work that will lead to a more thorough investigation of exposure in the OR, interventions to prevent and mitigate musculoskeletal injuries and illness through healthy work design, and improve worker health and well-being for surgical allied health workers.

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Are Workplace Psychosocial Factors Associated with Work-Related Injury in the U.S. Workforce? National Health Interview Survey, 2010

Introduction: Psychosocial hazards in the workplace may adversely impact worker health. This cross-sectional study investigates whether workplace psychosocial hazards may be associated with work-related injuries in the US.

Methods: Using data from 16,417 adult workers enrolled in the 2010 National Health Interview Survey (NHIS) Occupational Health Supplement, we calculated weighted prevalence estimates for: work-related injuries (WRI), all injuries, sociodemographic and work characteristics, and occupational psychosocial factors (job insecurity, work-family imbalance, hostile work environment). Logistic regression was used to assess associations between psychosocial work factors and WRI or all injuries controlling for demographic and work-related covariates.

Results: A work-related injury in the past 3 months was reported by 99 (0.65%) of respondents while 427 (2.46%) reported any injury. The prevalence of WRI was higher among men (0.77%) vs. women (0.51%), moderate/heavy vs. light/no alcohol users (0.88% vs. 0.57%), current vs. non-smokers (0.82 vs. 0.55%) and those who worked 41-48 hours weekly (1.19%) vs. a 40 hours week (0.59%). In the multivariate analysis, job insecurity, work-family imbalance and hostile work environment were each positively associated with having a work-related injury (OR: 1.67, 95% CI: 1.02-2.79; OR=1.74, 95% CI 1.00-3.02; and 2.01, 95% CI 0.93-4.36, respectively), and a worker with one or more occupational psychosocial factors was twice as likely to report a work-related injury (OR= 2.07, 95% CI 1.25-3.43) compared to those with none. Hostile work environment and reporting at least 1 work-related psychosocial factor compared to none were also positively and significantly associated with any injury (OR: 2.06, 95% CI 1.42-2.99 and OR=1.42, 95% CI 1.11-1.81, respectively).

Conclusions: Occupational psychosocial factors, particularly job insecurity and work-family imbalance, appear to be significant predictors of work-related injuries. These findings suggest that workers' health may be improved by addressing psychosocial hazards in the work environment, but should be confirmed in prospective studies.

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Personal Attenuation Ratings (PAR) of Agricultural Workers: How Well Do Earplugs Really Fit?

In a recent Great Plains Center survey, agricultural workers reported exposure to loud noises (e.g. grain augers, tractors, livestock) an average of 5 days per week. In the same survey, >70% of these workers reported having a least one symptom of noise-induced hearing loss. Many outreach/educational efforts have focused on increasing agricultural worker's awareness and use of hearing protection devices (HPD). In comparison to manufacturing/construction workers, agricultural workers receive less formal training on how to use HPD, thus it is important to learn if they are adequately inserting differently types of earplugs for noise protection. The goal of this project was to evaluate the effectiveness of HPDs used by agricultural workers by comparing their individual personal attenuation ratings (PAR) to the manufacturer reported noise reduction rating (NRR). The effectiveness of the inserted HPDs were quantified via the 3M E-A-Rfit™ Dual Ear Validation System at several regional farm shows, and the results were compared to the manufacturer reported NRR. Sixty agricultural workers (255 plug pairs) were tested, using four common earplug models available at farm supply stores. Many agricultural workers reported personal preferences for plug types like the 3M 'Ultrafit' triflange plug (36%) and the 'EARsoft' formable plug (36%). However, personal attenuation test data show that even though formable ear plugs like the 3M 'Classic' and 'EARsoft' brands have higher reported NRRs, they did not necessarily fit agricultural workers the best. In fact, less than 6% of the agricultural workers achieved attenuation levels near the manufacturer's NRR for formable plugs. Older agricultural workers (≥ 60 years) had lower PARs across all plug types. Overall, more agricultural workers achieved higher PAR using non-formable, push-in type plugs (they received PARs of 12 and 13 dB for 'Pushin' and triflange plugs). These were both significantly below the manufacturer NRR ratings, adjusted for dB scale.

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ATV Operation in Agriculture: Injury Analysis and Interventions

All-terrain vehicles (ATVs) have been implicated in over 14,000 deaths since 1982 and continue to be a major public health transportation related hazard. An estimated 80% of riders use ATVs for recreational purposes and the remaining 20% use the vehicles for various occupational applications. Recent data analysis reveals a 300% increase in work related ATV deaths. The agricultural community bears the greatest burden experiencing 65% of all occupational related fatalities occurring on the farm or ranch. An examination of 1230 cases revealed that patterns existed between agent, host and environmental factors. This poster presentation will include some of the historical background on the expanding popularity of ATVs, epidemiology of injury and illness related to loss of control events, case studies that demonstrate a range of interventions and application. A comprehensive literature review regarding injury epidemiology, interventions and training has not occurred previously. This study looks at the compilation of 85 research articles to understand the current scope of ATV use and interventions directed toward the farming and ranching field.

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Higher Prevalence of Liver Steatosis (Non-alcoholic Fatty Liver Disease) in Members of the World Trade Center Health Program General Responder Cohort than in Non-Responders

Background: World Trade Center (WTC) responders are not routinely screened for liver disease, even though a previous study of WTC-exposed firefighters found fatty liver disease in 22%. Many WTC responders were heavily exposed to dust, airborne particulate matter, and chemicals known to cause liver toxicity. Proven hepatotoxic exposures and hepatotoxins include particulate matter, air pollution, close proximity to major roadways and to toxic waste sites, exposure to active and passive smoking, and to volatile chemicals. Studies in animals confirm the hepatotoxic effects of airborne particulate matter (PM2.5) and chemicals.

Methods: Low-dose noncontrast chest CT scans of 60 WTC responders and 170 control patients participating in the Mount Sinai Early Lung and Cardiac Action Program (MS-ELCAP), were analyzed to identify individuals with moderate-to-severe liver steatosis, defined as liver attenuation <40 Hounsfield units (HU). Univariable and multivariable linear regression was used to analyze WTC exposure as a risk factor.

Results: Liver attenuation <40 HU was present in 10 (16.7%) in the WTC group and in 9 (5.3%) in the non-responder group. The mean and (SD) of the WTC group was 52.8 HU (11.6) and the mean in the control group was 57.6 HU (9.3), a statistically significant difference ($p < 0.01$). The WTC group had a higher percentage of males, current smokers and participants with higher pack years of smoking. By univariable linear regression analysis, being in the WTC cohort was significantly associated with higher fat content; a non-significant trend remained after controlling for gender, age and pack-years of smoking in multivariable analysis ($p=0.09$).

Conclusions: The WTC attack exposed responders to known liver toxins. Our findings support further investigation of progressive fatty liver disease in a larger group of WTC responders. Proactive screening is important because liver disease is often a silent killer that remains undiagnosed until irreversible organ damage has occurred.

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Work-Requirement Factors and Workplace Injuries among the Aging American Workforce

With the overall American population aging, by the year 2020 a quarter of the workforce will be aged 55 years and above. Although, workers in this age group experience lower rates of non-fatal occupational injuries, compared to their younger counterparts, the impact of such injuries is greater. Limited research studies have used longitudinal analyses to assess the potential risk factors for occupational injuries in the aging workforce. The current research uses data from the Health and Retirement Study (HRS), which is an ongoing- nationally-representative- panel study, active since 1992. The current studies began from 2004 with 7,212 working persons, aged 50 years and above, were followed retrospectively until 2012. Based on Directed Acyclic Graphs, negative binomial regression accounting for correlation, due to the repeated nature of the data, and Cox regression models, with the counting process approach, were used to examine relations between work-requirement factors and occupational injuries, while controlling for potential confounders. Over the study period, 3.6 occupational injury events per 100 full-time equivalent (FTE) workers occurred. The rate of injury events per 100 FTE was highest among those in the age group, 50-60 years (4.2), and lowest for those 70 years and above (2.9). Rates were higher among Hispanics, compared to non-Hispanics. Rates decreased with increasing education levels and were highest among those employed in farming/forestry/fishing (9.6), followed by protection services (7.5); they were lowest for those employed in managerial positions (2.2) and sales (1.8). Multivariable regression models identified that high physical work requirements were associated with higher risk for experiencing occupational injuries. Marginal structural models were also employed to account for the joint effects of time-varying confounding. Findings from this study serve as a potential basis for development of interventions that can inform policies, and safer work practices among aging workers.

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Hazards in motion: development of mobile geofences for use in logging safety

Geofences are user-defined virtual boundaries with a wide range of applications. As tracked objects move across geofences, alarms are signaled. Until recently, most geofences have been used as static boundaries. The objective of this study is to characterize geofences as mobile safety zones around people and equipment in forest operations by evaluating geofence radius, intersection angle, pace, and transmission interval. We collected GNSS-RF data using a replicated field experiment in which a ground worker surrounded by seven geofence radii walked along a designated route past six stationary personal location devices (PLDs) placed at varying distances perpendicular to the route, representing 23 unique radius-angle combinations. The ground worker walked at three paces combined with three PLD transmission intervals. Geofence alert delay was calculated by comparing the predicted intersection times based on recorded GNSS-RF coordinates to the intersection times observed in the field. Simulation was also used to evaluate geofence alert delay as a mobile geofence intersected a stationary geofence. Eight mobile geofence radii were combined with 91 stationary PLD locations perpendicular to the midpoint. Each stationary PLD was surrounded by a geofence with a 50m radius. All fixed PLD locations and the center point of the mobile geofence were assumed to have bivariate Gaussian probability density and the simulation was performed using five standard deviations, representing varying levels of GNSS accuracy. Radius-angle combinations in the field trial affected the geofence alert delay, with more negative (earlier) alerts occurring at the larger angles. Simulation results indicated more accurate alert generation associated with lower standard deviations and supported field results of earlier alerts at larger angles. These results suggest that alerts associated with hand fallers and other ground workers passing alongside or working near safety geofences on active logging operations will have low accuracy and are likely to be triggered more frequently.

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Virtual Reality and Occupational Safety: Exploring the Potential of Virtual Reality Technology in Agricultural Safety Education

This study examines the potential of virtual reality technology in occupational safety education. Specifically, this study develops a virtual reality tractor safety content and tests its impact on behavioral intention to install Cost-effective Roll Over Protective Structure (CROPS) designed by NIOSH. Virtual reality (VR) refers to a “real or simulated environment in which the perceiver experience telepresence” (Steuer, 1992, p 7). With advance in thin computing technology, such as smartphones and tablets, and affordability of head-mounted VR devices (Hoberman et al., 2012), VR has become a popular approach to study human behaviors in the context of safety education, especially when it provides the opportunity to have immersive experience of a risky situation that cannot be experienced within a classroom or laboratory environment (Kinatader et al., 2014). In addition, VR contents are often designed to be more interesting and enjoyable than traditional education materials (Laver et al., 2102). Therefore, VR contents are expected to enhance the effectiveness of tractor safety education, as it provides an immersive experience of tractor related activities in diverse situations without actual risk of injuries. To test a VR tractor safety content, this study will recruit 60 university students. They will be assigned to either a control or an experimental group. The participants in the experiential group will be exposed to a VR tractor safety content with head-mounted VR gears and those in the control group will be exposed the same content with a traditional television screen. This study expects that the immersive VR experience will enhance: (1) risk perception (severity and susceptibility) about tractor-related accidents, (2) self-efficacy on tractor safety behaviors, and (3) behavioral intention to install CROPS. The experiment will be conducted in March, 2017. This is current NIOSH-funded research through the Southeast Center for Agricultural Health and Injury Prevention.

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Actigraphy-based Assessment of Circadian Rhythm: Association with Subclinical CVD Measures among Police Officers

Objective: Associations between actigraphy based estimates of circadian rhythm and cardiovascular disease have not been investigated among police officers. Literature describing the methodology for estimating circadian rhythm parameters from wrist activity data are scarce. This study provides the method for estimating parameters of circadian rhythm from wrist movement data and examine the association of these parameters with subclinical CVD measures: carotid intima media thickness (IMT), brachial artery flow-mediated dilation (FMD), and ankle brachial index (ABI).

Methods: Participants were 281 officers from the first follow-up examination of the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study. Wrist movement data were collected using an actigraph. A cosine curve with a 24-hour period was fit to estimate the three parameters of a circadian rhythm: Mesor, Amplitude, and Acrophase. The common carotid artery (CCA) intima media thickness (IMT), and FMD were assessed using ultrasound. Correlation analyses were used to assess associations between circadian rhythm parameters and the subclinical CVD measures. We utilized data from officers who wore the actigraph for at least 7 days and had non-missing values for CVD measures (n =210).

Results: The cohort was relatively young with mean age of 49 years and a majority were white (80%). Following adjustment for demographic and life style variables, the mean IMT was negatively associated with both mesor ($r=-0.15$, $p=0.037$) and amplitude ($r=-0.15$, $p=0.047$). Similarly the maximum IMT was negatively associated with both mesor ($r=-0.19$, $p=0.009$) and amplitude ($r=-0.16$, $p=0.030$). FMD was negatively associated with mesor ($r=-0.18$, $p=0.012$) while ABI was not significantly associated with either mesor or amplitude.

Conclusion: Reduced levels of circadian rhythm parameters (mesor and amplitude) were associated with increased carotid arterial wall thickness and impaired brachial reactivity, early indicators of atherosclerosis progression. Future prospective studies that elucidate the underlying mechanisms of this relationship are warranted.

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Law Enforcement Officer Motor Vehicle Crash and Struck-By Fatality Investigations

Introduction: In 2014, the Bureau of Labor Statistics reported the fatality rate for the more than 900,000 U.S law enforcement officers is nearly four times more than the average worker. In 2015, 123 officers died as a result of a traumatic injury on the job; 36% of those line of duty deaths (LODD) were motor vehicle-related incidents. Although officer's motor vehicle-related fatality rates are significant, information pertaining to these incidents is not routinely used for prevention purposes. NIOSH has partnered with the National Institute of Justice (NIJ) to learn about officer's motor vehicle related risks and work towards law enforcement supported interventions.

Methods: Following the public health model, the NIOSH/NIJ team cooperates with the fallen officer's department and other agencies at the municipal, state, and federal level to investigate motor-vehicle LODDs. 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 for access by police departments and agencies, officer organizations, manufacturers, and safety and health researchers.

Findings: Initial observations from 5 case investigations indicate law enforcement agencies investigate officer-involved fatal crashes following procedures used to investigate crashes among the general public. These investigations focus on policy violations rather than evaluating incident circumstances with a preventive focus.

Conclusion: NIOSH/NIJ investigations have identified multiple contributing factors that could influence policy, training, and intervention development. This approach addresses all facets of the injury control hierarchy leading to policy and behavioral changes, thus having a positive impact on the safety of law enforcement officers.

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Critical Wet Bulb Globe Temperature (WBGT_{crit}) for four Protective Clothing Ensembles made of fabrics with Different Total Heat Loss (THL) Values

Introduction: Managing heat stress while wearing protective clothing (PC) in the workplace is critical for worker safety and health. There is a variety of PC, such as firefighting ensembles, emergency medical clothing, chemical, biological, radiological and nuclear suits, etc., designed to protect the wearer's body from specific hazards. Each type of PC has a different level of protection, and thus different clothing thermal characteristics (thermal and vapor resistances). This study evaluated the WBGT_{crit} of PC ensembles with four different THL values determined by a sweating hotplate (SHP) test.

Methods: Seven healthy male adults participated in this study. Subjects were acclimatized for 5 days prior to the testing in random order of four PC ensembles with and identical design but different THL values, and a control test wearing working clothes. Control is the cotton regular working clothes; PC- A was a prototype with a THL value of 904 W/m²; PC-B had a THL value of 700 W/m²; PC-C was another prototype with a THL value of 500 W/m²; and PC-D was a commercially available chemical PC ensemble with a THL value of 191 W/m². Subjects walked on a treadmill at a metabolic work rate of 160 W/m² in a climatic chamber, while slowly increasing the level of heat stress when their core temperature reached a steady-state. The WBGT was set at 25.5 (50 %rh) at the start of the session and the ambient temperature was increased by one degree every five minutes after reaching a steady-state. The point at which the core temperature began to increase was defined as the inflection point. The WBGT recorded five minutes before the inflection point was determined as the WBGT_{crit} for each PC ensemble.

Results: For control working clothes, the WBGT_{crit} is significantly different from any of the PC tested. The PC built with the lowest THL value also has a significantly lower WBGT_{crit} than the other PC tested. However, there are no significant differences in WBGT_{crit} between PC built from fabrics that are above 500 W/m². The materials used to manufacture these PC ensembles were rated in a range from a very low (PC-D, 191 W/m²) and a very high THL value (PC-A, 904 W/m²). Three of the PC ensembles did not show any differences on WBGT_{crit} even with THL differences of about 400 W/m².

Conclusion: In summary, the results of this research supports that the SHP-THL value may be effective in distinguishing basic thermal characteristics of the fabrics used for PC; however, the overall effect of fabric THL ratings on PC WBGT_{crit} was not linearly related in our study. Moreover, this preliminary data suggests that heat stress caused by PC with different THL values, between 500 and 900 W/m², may not be physiologically different in terms of WBGT_{crit}.

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Partnerships in Fishing Industry Safety: The FLIPP Engaged Research Approach

Commercial fishing is a dangerous occupation. The Fishermen Led Injury Prevention Program (FLIPP) engages fishermen and fishing community members. This project is led by public health researchers, Oregon Sea Grant Extension and FLIPP community researchers (CRs) in partnership with NIOSH and the US Coast Guard. FLIPP is engaging fishermen in research to understand high risk tasks, safety perceptions, and injury prevention opportunities in the Dungeness crab fleet. CRs were selected based on their existing knowledge and connection to the fishing industry. Many are fishermen's wives/girlfriends. They complete ongoing training on human subjects' protocols, outreach methods, and the project. CRs organized focus groups with Dungeness crab fishermen in 7 ports along the West Coast. Fishermen shared their insights on injuries and safety, which influenced the creation of an injury survey. CRs administered surveys in person along the West Coast just before the 2015-16 crab season. Just before the 2016-17 crab season, CRs are engaging fishermen in safety conversations with the survey results. Using an engaged research approach has been crucial for the success of all aspects of FLIPP. Informative focus groups, survey work, and ongoing interactions with the fleet are directly connected to our CRs having existing relationships and credibility with the fishing industry. Focus group results revealed a concern for safety, but reluctance for anything that would create additional safety regulations. With community researchers, we successfully surveyed 436 fishermen. The majority of limiting injuries (88%) occur with deckhands. The most common are sprains and strains (36%) and most are associated with handling, hauling, and setting gear (72%). Conducting outreach and engagement with the survey results is providing an opportunity for fishermen to develop targeted and appropriate solutions. Participation by fishermen in safety-related research is challenging due to concerns of potential regulations. This engaged research approach can foster injury prevention efforts.

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Evaluating and Testing Fire Hose Performance during Structural Firefighting Operations

Introduction: The National Institute for Occupational Safety and Health Fire Fighter Fatality Investigation and Prevention Program (FFFIPP), identified incidents of thermal degradation of attack hose during structural firefighting operations. During Investigation F2014-09 MA, FFFIPP investigators learned that an attack hose involved in the incident had burned through. The investigators reviewed previous cases and identified several instances where hoselines had burned through during structural firefighting operations. The current edition of the National Fire Protection Association (NFPA) 1961, *Standard on Fire Hose* does not address the thermal performance of attack hoselines, and manufacturer's published information does not include thermal performance data.

Methods: To better understand the thermal performance of attack hose, FFFIPP investigators contacted the Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) for assistance. The ATF Fire Research Laboratory began a series of tests to explore the impact of radiant heat on attack hose. ATF established heat flux values and developed full-scale tests to replicate fireground conditions.

Results: Preliminary ATF test data was presented to the NFPA 1961 technical committee along with an ATF memo supporting adoption of thermal test procedures. As a result, the technical committee decided to develop thermal performance test standards for adoption in the 2017 edition of NFPA 1961. Final testing results, including documented test methods, were provided to NFPA and the fire service community. Underwriters Laboratory (UL) is currently working with NFPA to finalize the thermal performance additions to NFPA 1961.

Conclusions: The National Institute for Occupational Safety and Health Fire Fighter Fatality Investigation and Prevention Program investigation results continue to be used to develop standards addressing risks for fire fighters. With the final adoption of a revised NFPA 1961, *Standard on Fire Hose*, fire fighter safety and health continues to improve.

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World Trade Center Health Program continuing education trainings – expanding partnerships, advancing knowledge, and impacting health professional behavior

The World Trade Center (WTC) Health Program provides compassionate monitoring and healthcare for responders who worked at the WTC, the Pentagon, and the site near Shanksville, PA, as well as survivors who lived, worked, or were in school in the New York City disaster area. As of September 30 2016, a total of 75,742 individuals were enrolled in the WTC Health Program and it is estimated that an additional 50,000 individuals may still be eligible for care. NIOSH recognized that primary care providers could benefit from training focused on consistent approaches to screening and treatment for these patients and that an expanded outreach program was necessary as members were distributed nationally. To address this need NIOSH developed a training initiative with a CME/CE provider and established a gateway for researchers to share findings such as recognition of symptoms, approaches to treatment, and conditions covered by the Program with providers across the country. The partnership addressed a national continuity of care approach by teaching health professionals about the resources available in the Program. CME/CE activities are an effective but often overlooked mechanism to identify key partnerships and expand partnership involvement, as many health professional disciplines are required to update training for their specialties. The innovative WTC Health Program CME/CE collaboration provided access to over 43,000 learners from 46 states, D.C., 3 territories, and abroad on desktops, tablets, and mobile devices. The trainings provide solutions to help achieve public health level impact and improve health outcomes for 9/11 responders and survivors. The WTC Health Program was successful in disseminating research to health care professionals to improve safety and health outcomes. CME/CE training is available through CDC and should be considered as a research dissemination strategy.

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Prior exposure to corticosterone markedly enhances and prolongs the response to work-place-related chemical and biological exposures

Systemic exposure to a variety of inflammagens and toxicants has been used to evaluate the pathogenesis of inflammation, sickness behavior, and inflammatory disorders. While many inflammatory conditions occur in the periphery, it has been well established that peripheral inflammation exerts effects on the brain. Neuroinflammation, the elaboration of proinflammatory molecules in brain, is associated with symptoms (e.g., lethargy, anhedonia, anorexia, depression, etc.) collectively termed sickness behavior. Furthermore, stressors have been shown to alter the response to neuroinflammatory conditions. Here, we used a single systemic injection of the bacterial mimic lipopolysaccharide (LPS), nerve agent surrogate diisopropyl fluorophosphate (DFP), and pesticide chlorpyrifos oxon (CPO) to induce neuroinflammation in adult male C57BL/6J mice. Exposure to corticosterone (CORT) in the drinking water for 1 week, or biweekly for several weeks, was used to mimic high physiological stress prior to agent exposure. Inflammatory cytokines and the activation of STAT3, the downstream signaling module for neuroinflammation, were measured by qPCR and immunoblot, respectively. Acute exposure to these agents is neuroinflammatory without producing evidence of brain damage. Exposure to high levels of CORT causes the anti-inflammatory nature of the glucocorticoid to be lost and instead, neuroinflammation is markedly exacerbated. This neuroinflammatory “priming” by CORT is so pronounced that previously sub-neuroinflammatory exposures to LPS by inhalation instigate neuroinflammation. Furthermore, intermittent exposure to CORT for 30+ days has a markedly synergistic effect on the neuroinflammatory responses. These findings highlight the possibility for an isolated chemical or biological exposure event to be exacerbated by a stressful stimuli. These findings are relevant to exposures experienced by farm workers and pesticide sprayers, as well as to the construction sector where physiological stressors may be combined with inflammagen exposures. Further, this research demonstrates the potential for recurrent physiological stress to exacerbate not only chronic inflammatory disorders, but also health outcomes for workplace exposures.

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The Role of the Field Analysis and Sampling Group in Expanding Research Partnerships

The Field Analysis and Sampling Group (FASG), within the Biomonitoring and Health Assessment Branch (BHAB) in the Division of Applied Research and Technology, works in partnership with industry, government, academic and professional communities, both nationally and internationally, to serve a unique and critical role within NIOSH. The FASG is the only group within NIOSH with a mission to conduct research to develop and evaluate biomarkers of exposure in the laboratory and the field. In the last 5 years, the FASG has conducted a total of 98 field site visits in the Construction, Healthcare, Manufacturing, Oil and Gas Extraction, and Public Safety Sectors. Fifty-one of the field site visits were for BHAB studies. FASG collaborated with the Division of Surveillance, Hazard Evaluation and Field Studies: Hazard Evaluations and Technical Assistance Branch and Industry Wide Studies Branch, Health Effects Laboratory Division, and the Western States Division, to conduct 47 site visits for Health Hazard Evaluations (HHEs), the National Occupational Research Agenda projects, and other field studies. In the last 5 years, FASG has also collaborated with researchers on 2 internal and 2 external projects where BHAB conducted analysis of samples. Methods that have been developed in our laboratory, as well as those commercially available, are utilized to evaluate biomarkers of exposure and effect. FASG collects numerous sample types including blood, urine, sputum, dermal, semen, breath, personal air, area air, and surface wipes. Point of care and direct read instruments, such as spirometers, the Piccolo[®], and the NIOX[®], are also utilized in the field to enhance biomonitoring and exposure assessments in near real-time. In the last 5 years, FASG has collected >10,000 urine samples and >1,500 blood samples from study participants. The samples are then usually aliquoted into 2-10 aliquots per sample. This has resulted in FASG handling over 100,000 samples.

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Spectrum of health outcomes among flavoring-exposed workers: A comparison of the microwave popcorn and flavoring industries

Obliterative bronchiolitis has been documented in both popcorn and flavoring workers. However, comparisons of symptoms and spirometric abnormalities within and between these groups have not been investigated.

Methods: We used data from 1,644 flavoring and 967 popcorn workers with acceptable spirometry quality from ten Health Hazard Evaluations and a state medical surveillance program collected from 2000-2012. We compared symptoms and spirometry outcomes to the U.S. population by using the Third National Health and Nutrition Examination Survey (NHANES III). We examined differences by industry and job classification using generalized linear models. We considered the jobs of flavoring compounding and popcorn flavoring mixing to have similar potential for direct exposure to flavoring chemicals. Analyses were adjusted for potential confounders.

Results: Flavoring workers were more likely to be non-white, male, former or never smokers, and have longer tenure. Twenty-one percent of flavoring workers had ever worked in compounding, while six percent of popcorn workers had ever worked in mixing. When compared to NHANES III, workers in both industries had elevated rates of respiratory abnormalities; popcorn workers had significantly more asthma, respiratory symptoms, and obstructive/mixed spirometric patterns (standardized morbidity ratios (SMRs): 1.4-2.8); and flavoring workers had significantly elevated asthma, wheezing, and spirometric restriction (SMRs: 1.3-1.5). In comparing industries, asthma, lower respiratory symptoms, and obstructive/mixed patterns were more prevalent among popcorn workers than flavoring workers (prevalence ratios (PR): 1.3-2.9, $p < 0.05$). Within-industry models showed flavoring workers who had ever worked in compounding were more likely to have restrictive patterns (PR: 1.7, $p < 0.05$), whereas ever-mixers in popcorn had higher prevalence of obstructive/mixed patterns (PR: 2.4, $p < 0.05$).

Conclusion: There are indications that spirometric abnormalities were work-related in both industry groups. However, it is unknown whether the spirometric abnormality differences reflect similar physiologic responses in the lung. Further research should be undertaken to explore these issues.

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Estimating New Cases of Occupational Injuries and Illnesses in the United States in 2012

In the third decade of the National Occupational Research Agenda (NORA), National Institute for Occupational Safety and Health (NIOSH) research priorities will be guided by the morbidity and mortality burden associated with particular occupational hazards, the need for specific investments to address these hazards, and the potential impact of related proposed projects to reduce the burden of occupational injury and illness. Because no single surveillance system can provide them directly, efforts must be periodically undertaken to calculate comprehensive national estimates of overall occupational mortality and morbidity, using a variety of data sources. This presentation describes the development of updated national estimates of the incidence of occupational injury and illness.

We estimated the new cases of 16 chronic conditions with well-established occupational causes by applying attributable fraction estimates to population-based incidence data from 2012. Attributable fractions were calculated using relative risk estimates identified in a comprehensive review of the recent literature and population exposure data from a variety of sources. To these numbers, we added estimates of new cases of occupational injuries and musculoskeletal disorders (MSDs) from national surveillance systems, after adjustment for underreporting, and direct estimates of new pneumoconiosis cases, all of which we assumed to be occupational.

Using a combination of surveillance, exposure, and epidemiologic data from various sources, we estimated that there were 6.1-6.3 million new cases of occupational injury and illness in the U.S. in 2012, including 1.0-1.3 million illnesses and 5.1 million injuries. Non-cancer respiratory diseases including occupational asthma, chronic obstructive pulmonary disease and pneumoconioses (0.4-0.6 million) and MSDs (0.5 million) comprised the most numerous occupational illnesses.

These estimates reflect the broad public health consequences of occupational injury and illness. They also form the basis for estimates of economic and quality of life consequences and inform decisions regarding which occupational health interventions will be most impactful.

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Commercial Fishing Safety in the Gulf of Mexico and the Southwest Ag Center: The Decade in Review

Background: The commercial fishing work sector continues to experience one of the highest occupational fatality rates in the U.S. There are regional differences in distribution of these events relative to fishery type, geography, and other variables such as cultural factors.

Methods: Over the last decade, the Southwest Ag Center has been exploring these factors and developing interventions through engagement of a vulnerable population of commercial fishermen in the Gulf of Mexico and forming strategic partnerships with numerous stakeholders, most notably the U.S. Coast Guard. This has involved a variety of quantitative/qualitative methods including focus groups, surveys, a community trial with quasi-experimental pretest/posttest intervention design, and development of a social media campaign to enhance adoption of personal flotation devices (PFDs).

Results: Shrimp is a major fishery in the Gulf and earlier studies showed more than 80% of these fishermen are Asian, mostly Vietnamese. Culture plays a significant role in attitudes/beliefs among Vietnamese shrimp fishermen of the Gulf, and may influence behaviors that are risk factors for fatal and non-fatal injuries. In particular, commercial fishing industry leaders are able to influence behaviors and practices among fishermen. Over the last decade, safety tip cards, interactive CD instructional tools for vessel sound signaling and Mayday calls, and signage for a variety of safety concerns have been developed and disseminated. Statistically significant changes in attitudes/beliefs have been noted. Presently, identifying barriers to use of lifesaving PFDs, preferences of commercial fishermen for various PFD designs, and development of a social media campaign to promote use on deck are underway. Conclusions:

Culturally appropriate training and awareness measures combined with recognizing normative influences can favorably alter attitudes, beliefs, and behavioral intent related to workplace safety in this population.

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Respiratory Symptoms in Hospital Cleaning Staff Exposed to a Product Containing Hydrogen Peroxide, Peracetic Acid, and Acetic Acid

Disinfecting products consisting of a mixture of hydrogen peroxide (HP), peracetic acid (PAA), and acetic acid (AA) are widely used as sporicidal agents in healthcare, childcare, agricultural, and food production industries. HP and PAA are strong oxidants and possible asthmagens, however, exposure measurements for HP, PAA, and AA in healthcare settings are largely lacking. We conducted a health and exposure assessment of 50 cleaning staff at a hospital where a new sporicidal product consisting of HP, PAA, and AA was introduced 16 months prior. Full-shift time-weighted average air samples were collected and analyzed for HP, AA, and PAA content (n=49). Acute eye, and upper and lower airway symptoms were assessed in a post-shift survey. A subset of 35 participants also completed an extended questionnaire that assessed chronic symptoms. Associations between exposure and symptom prevalence were evaluated using log-binomial regression. Air samples for HP (range: 5.5 to 511.4 ppb) and AA (range: 6.7 to 530.3 ppb) were all below established US occupational exposure limits (OEL). PAA ranged from 1.1 to 48.0 ppb. Hospital cleaning staff using a sporicidal product containing HP, PAA, and AA reported work-shift eye (44%), upper airway (58%), and lower airway (34%) symptoms. Acute nasal and eye irritation, as well as chronic shortness of breath on level ground, were significantly positively associated with increased exposure to the mixture of the two oxidants: HP and PAA, as well as the total mixture of HP, PAA, and AA. Acute and chronic symptoms reported by hospital cleaning staff were positively associated with combined exposures to the strong oxidants HP and PAA at relatively low levels. These results indicate a need to monitor respiratory, and/or eye symptoms in hospital cleaning staff using products containing HP and PAA, and if necessary, to use a combination of engineering and administrative controls to reduce exposures.

Andrew Palmiero, MS¹

Daniel Symons

Judge Morgan III

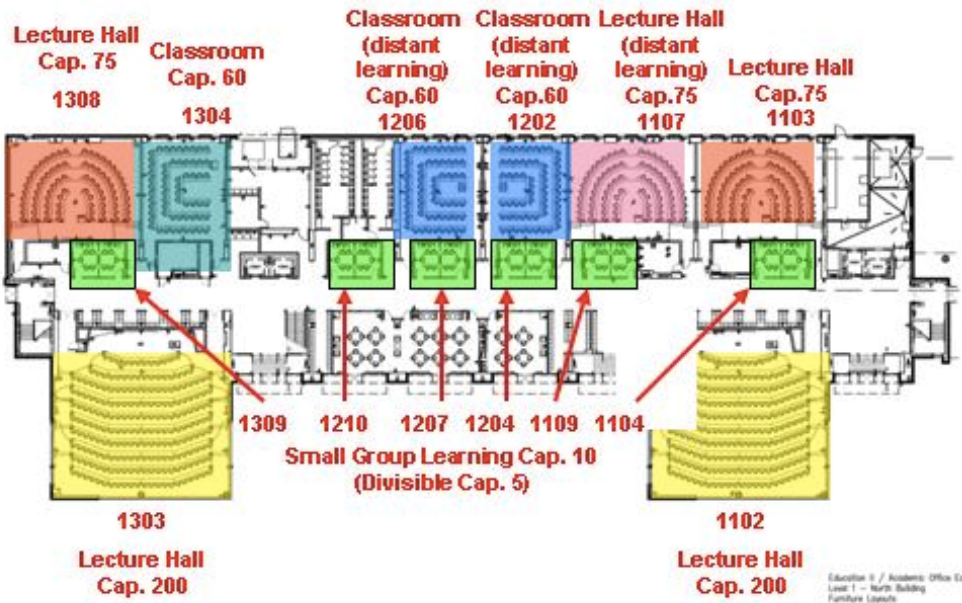
Ronald E. Shaffer

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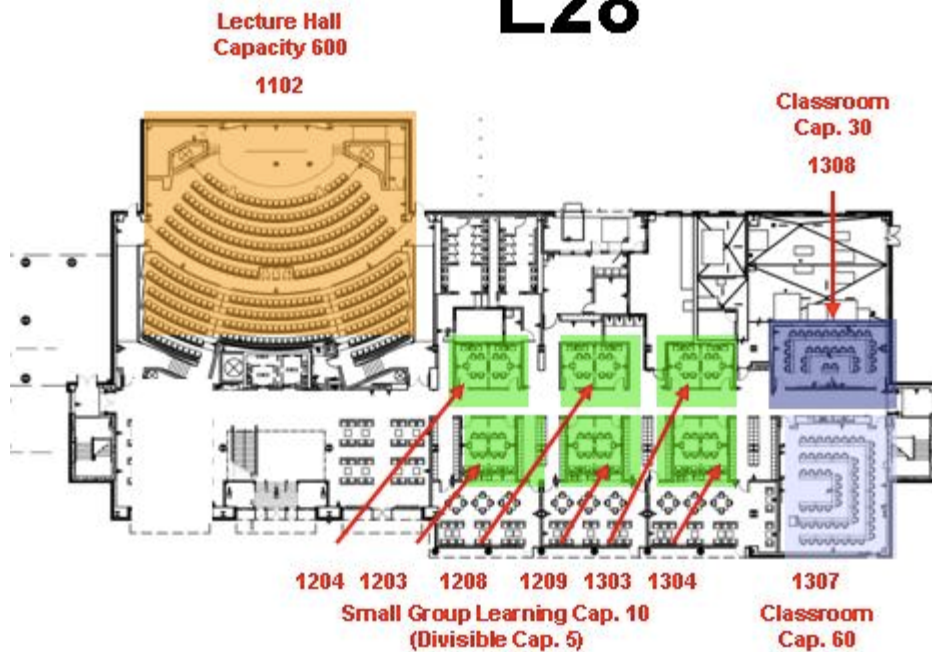
Speech Intelligibility Assessment of Protective Facemasks and Air-Purifying Respirators

Speech Intelligibility (SI) is the perceived quality of sound transmission. In healthcare settings, the ability to communicate clearly with coworkers, patients, etc., is crucial to quality patient care and safety. The objectives of this study were to: (1) assess the suitability of the Speech Transmission Index (STI) methods for testing reusable and disposable facial and respiratory personal protective equipment (protective facemasks [PF], N95 filtering facepiece respirators [N95 FFR], and elastomeric half-mask air-purifying respirators [EAPR]) commonly worn by healthcare workers; (2) quantify STI levels of these devices; and (3) contribute to the scientific body of knowledge in the area of SI. SI was assessed using the STI under two experimental conditions: (1) a modified version of the National Fire Protection Association 1981 Supplementary Voice Communications System Performance Test at a Signal to Noise Ratio (SNR) of -15 (66 dBA) and (2) STI measurements utilizing a range of modified pink noise levels (52.5 dBA (-2 SNR) - 72.5 dBA (+7 SNR)) in 5.0 dBA increments. The PF models (Kimberly Clark 49214 and 3 M 1818) had the least effect on SI interference, typically deviating from the STI baseline (no-mask condition) by 3% and 4% STI, respectively. The N95FFR (3M 1870, 3M 1860) had more effect on SI interference, typically differing from baseline by 13% and 17%, respectively, for models tested. The EAPR models (Scott Xcel and North 5500) had the most significant impact on SI, differing from baseline by 42% for models tested. This data offers insight into the performance of these apparatus with respect to STI and may serve as a reference point for future respirator design considerations, standards development, testing and certification activities.

North Tower P28

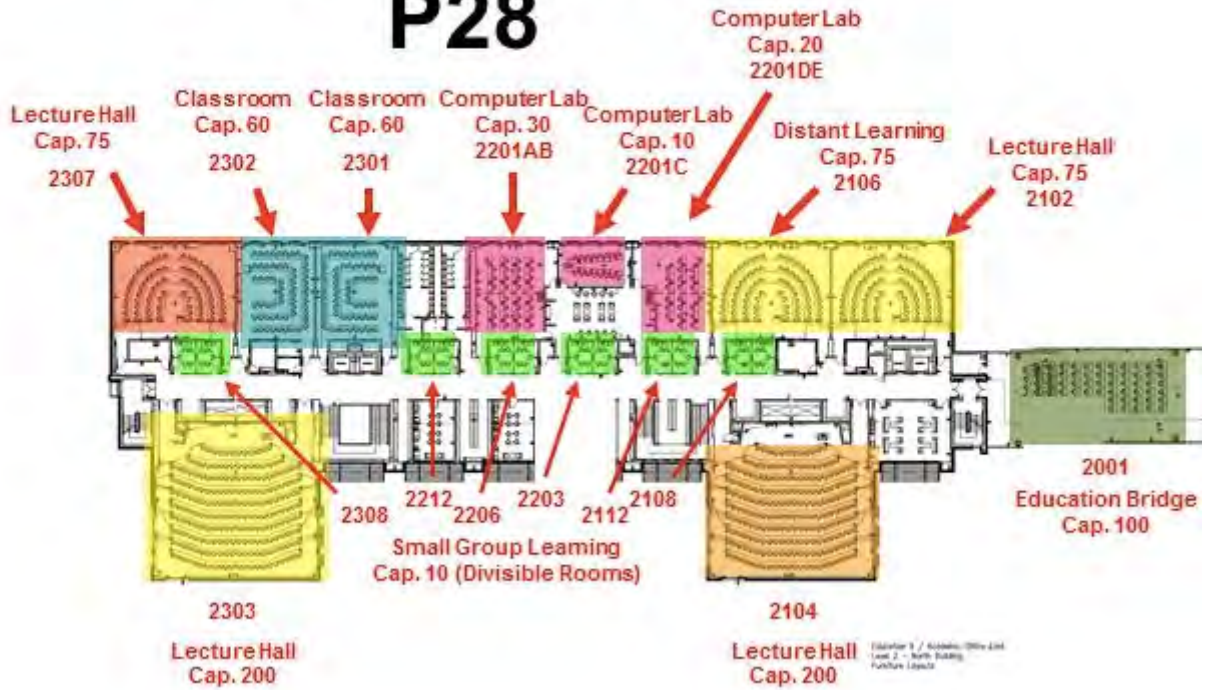


South Tower L28

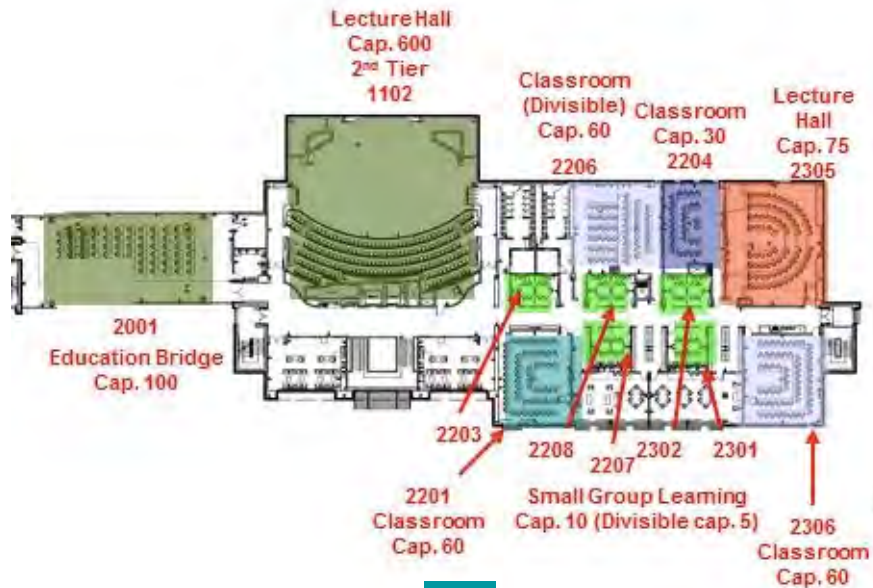


Second Floor

North Tower P28



South Tower L28



Conference at a Glance

Wednesday, June 21		Thursday, June 22		Friday, June 23	
8:00am–10:00am	Registration	8:30am–10:00am	Early Career Scientist Plenary Room 1102	8:30am–10:00am	Extramural Research in NORA 3 Room 2305
8:30am–8:45am	Welcome Room 1102			10:00am–11:30am	Center Grantee Meeting Closed Session Room 2305
8:45am–9:45am	Third Decade of NORA Room 1102				
9:45am–10:00am	Break				
10:00am–11:30am	Opening Plenary Room 1102	10:10am–11:30am	Concurrent Session 3 Session I–Room 2206 Session J–Room 2201 Session K–Room 2305 Session L–Room 2306		
11:30am–1:00pm	Lunch/Networking	11:40am–1:00pm	Lunch and Topic Tables Education Bridge		
1:00pm–2:00pm	Ignite Rapid Presentations Room 1102	1:15pm–2:45pm	Poster Session Education Bridge		
2:00pm–3:30pm	Concurrent Session 1 Session A–Room 1307 Session B–Room 2201 Session C–Room 2305 Session D–Room 2306	2:45pm–4:00pm	Concurrent Session 4 Session M–Room 2206 Session N–Room 2201 Session O–Room 2305 Session P–Room 2306		
3:30pm–3:45pm	Break	4:00pm–4:15pm	Break		
3:45pm–5:15pm	Concurrent Session 2 Session E–Room 1307 Session F–Room 2201 Session G–Room 2305 Session H–Room 2306	4:15pm–5:00pm	Partnerships Plenary 1102		
6:30pm	Social	5:00pm	Closing Remarks		