NIOSH-Supported
Education and Research Center (ERC)

15th Annual

2014 Pilot Research Project (PRP) Symposium

October 9-10, 2014
Auditorium, Vontz Center
University of Cincinnati Medical Campus
Thursday, October 9th 1:00 pm—5:00 pm
Friday, October 10th 8:00 am—12:00 pm

Keynote Speakers

Jacqueline Moline, MD, MSc
VP of Population Health and Chair of Population Health of the Hofstra North Shore-LIJ School of Medicine

and

Marvin J. Dainoff, PhD, CPE
Director, Center for Behavioral Sciences
Liberty Mutual Research Institute for Safety

Podium and Poster Presentations by PRP Awardees

Supported by NIOSH grant #T42-OH008432

UNIVERSITY OF Cincinnati

Pilot Research Training Program and Symposium

Welcome to the University of Cincinnati Education and Research Center's (ERC) **15th Annual Pilot Research Project (PRP) Symposium** on October 9-10, 2014**,** held in the Auditorium of Vontz Center, College of Medicine. The purpose of the PRP is to increase the research capacity of research trainees and young investigators in occupational health and safety and to encourage those in related disciplines to pursue occupational health and safety research.

Under the administrative direction of Dr. Amit Bhattacharya, research proposals are solicited and peer-reviewed annually from qualifying faculty and graduate students from the **University of Cincinnati and the following PRP partnering institutions – Air Force Institute of Technology, Bowling Green State University, University of Toledo – Health Science Campus, Central State University, Purdue University, University of Kentucky, Western Kentucky University, Eastern Kentucky University, Murray State University, Ohio University and Kentucky State University.**

At this symposium, the 2013-14 awardees will be presenting the results of their research and the 2014-15 awardees will make poster presentations of their proposed work. The keynote speaker on Thursday, October 9, 2014 is **Jacqueline Moline, MD, MSc, FACP, FACOEM,** Vice President of Population Health and the founding Chair of Population Health of the Hofstra North Shore-LIJ School of Medicine who will deliver the keynote address on **"The World Trade Center Disaster and its Aftermath." Marvin J. Dainoff, PhD, CPE,** Director at the Center for Behavioral Sciences Liberty Mutual Research Institute for Safety will deliver the keynote address on "Safety Climate and the Lone Worker" on Friday, October 10, 2014. There will also be opportunities to speak with all of the presenters individually.

The University of Cincinnati's Education and Research Center is one of 18 such centers funded by the National Institute for Occupational Safety and Health (NIOSH) nationally. Dr. Tiina Reponen serves as the director of the ERC, which is based in the university's Department of Environmental Health within the College of Medicine. The purpose of the ERC is to train professionals in the didactic and research skills necessary to lead the occupational safety and health disciplines. Results of research are translated into action through an outreach program and shared with professionals and practitioners in the region via continuing education.

Since 1999, the PRP program has allocated over 1.1 million dollars to support pilot research projects. These projects have served as a catalyst in bringing over $34 million in additional research support to the region from sources independent of the PRP program, such as, the National Institute for Occupational Safety and Health (NIOSH), National Institutes of Health (NIH), United States Department of Agriculture (USDA), National Science Foundation (NSF), and the Centers for Disease Control and Prevention (CDC). Additionally, the PRP has also brought 33 new investigators from other fields of expertise to the area of occupational safety and health research.

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Symposium attendees are eligible for:

- ◊ **Eligible for ABIH (IH) CM Points; apply online at http://www.abih.org/**
- ◊ **Meets BCSP criteria for continuation of certification credit**
- ◊ **Application has been submitted for continuing education contact hours for nurses. Please contact the ERC office at (513) 558-5710 to obtain information regarding approval status.**

The 15th Annual PRP Symposium is free and open to the public.
For more information about the PRP program, please contact
Dr. Amit Bhattacharya, PRP Program Director,
at (513) 558-0503 or email Amit.Bhattacharya@uc.edu

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Keynote Speaker, Thursday, October 9, 2014

Jacqueline Moline, MD, MSc, FACP, FACOEM

Vice President of Population Health and the founding Chair of Population Health of the Hofstra North Shore-LIJ School of Medicine

Jacqueline M. Moline, M.D., M.Sc., is an Occupational Medicine specialist. Dr. Moline obtained her medical degree from the Pritzker School of Medicine of the University of Chicago in 1988 where she was elected into the Alpha Omega Alpha Honor Society. She completed her first residency in Internal Medicine from Yale University in 1991. In 1993, she completed her second residency in Occupational and Environmental Medicine at Mount Sinai School of Medicine and also obtained her Masters of Science degree. She is board certified for both internal and occupational medicine. In 1993, Dr. Moline was the first recipient of the Fellowship for Occupational Medicine. Dr. Moline was Vice Chair in the Department of Preventive Medicine, Residency Director of the Occupational Medicine Residency Program and Director of the New York/New Jersey Education and Research Center in Occupational Safety and Health.

Dr. Moline's research in the past has focused on the health effects of lead exposure, the health effects of theatrical smoke and fog on actors, and the effect of creosote on exposed workers. In recent years, many of Dr. Moline's endeavors have been centered on the medical evaluation and treatment of World Trade Center (WTC) responders. She began seeing individuals whose health was affected by the WTC disaster in October 2001, and has been instrumental in the development and implementation of the federally-funded medical programs for WTC responders. She has published over 29 articles on the physical and mental health effects of WTC exposure. She has received numerous awards for her service to WTC responders. In July 2011, Dr. Moline was awarded a 5-year, multi-million dollar contract to be the Director of the Queens World Trade Center Clinical Center of Excellence at Long Island Jewish Medical Center/Queens College.

Keynote Speaker, Friday, October 10, 2014

Marvin J. Dainoff, PhD, CPE

Director, Center for Behavioral Sciences
Liberty Mutual Research Institute for Safety

In 2008, the Liberty Mutual Research Institute for Safety appointed Dr. Dainoff as the director of the Center for Behavioral Sciences. In this position, he directs research focused on the behavioral, cognitive, and organizational factors underlying workplace injuries and highway collisions. Dr. Dainoff and his team of research scientists examine topics in risk communication, hazard perception, safety climate, sociotechnical systems analysis, work systems for knowledge workers, and driver performance.

Dr. Dainoff received both his B.A. and Ph.D. in psychology from the University of Rochester. He is a past president of the Human Factors and Ergonomics Society and is director-emeritus on the Board of Certification in Professional Ergonomics from which he received the Distinguished Professional Service Award. He is a Fellow of the Human Factors and Ergonomics Society and serves on the editorial boards of the *International Journal on Human - Computer Interaction* and *Oxford University Press Handbook for Cognitive Engineering*. Dr. Dainoff has been active in the area of technical standards, serving as vice chair of the ANSI/HFES 100 Committee (U.S. National Standard on Human Factors Engineering of Computer Workstations), secretary of HFES 300 Committee (Guidelines for Using Anthropometric Data in Product Design), and secretary, U.S. Technical Advisory Group to ISO Technical Committee 159, Subcommittee 3 - Anthropometry and Biomechanics. He was Program Chair of Ergonomics and Health Aspects of Work with Computers section of Human Computer Interaction International Conference 2007.

PODIUM PRESENTATION SCHEDULE

Thursday, October 9, 2014			
	Moderator: Robert Durborow, PhD		
Time	**Title**	**Speaker**	**Affiliation**
1:00—1:05 pm	**Welcome**	**Amit Bhattacharya, PhD, CPE, PRP Program Director**	**Environmental Health University of Cincinnati**
	Welcoming Remarks	**Shuk-mei Ho, PhD, Jacob A. Schmidlapp Chair and Professor**	**Environmental Health University of Cincinnati**
1:05-1:15 pm	**Introduction of Education and Research Center (ERC)**	**Tiina Reponen, PhD, CIAQP, ERC Director**	**Environmental Health University of Cincinnati**
1:15—1:20 pm	**Introduction of Keynote Lecturer: Jacqueline Moline, MD, MSc, FACP, FACOEM**	**Tiina Reponen, PhD, CIAQP, ERC Director**	**Environmental Health University of Cincinnati**
1:20—2:20 pm	**Keynote Address: "The World Trade Center Disaster and its Aftermath"**	**Jacqueline Moline, MD, MSc, FACP, FACOEM**	**North Shore-LIJ Health System and the Hofstra North Shore-LIJ School of Medicine, Great Neck, NY**
2:20—2:30 pm	**Keynote Q & A**		
2:30—2:50 pm	**A Hidden Occupational Health Hazard: ETS Among Child Welfare Workers**	**Jiaqi Zhang for Shauna Acquavita, PhD, LISW-S**	**School of Social Work University of Cincinnati**
2:50—3:10 pm	**Use of Pyrosequencing to Assess Fungal Diversity in Moisture-damaged Buildings**	**Kanistha Chatterjee Coombs for Eric Kettleson, PhD**	**Environmental Health University of Cincinnati**
3:10—4:10 pm	**Break (15 minutes) and Poster Session I**		
4:10—4:30 pm	**Illumina MiSeq as a Tool to Analyze the Mycobiomes in Green-building Materials**	**Kanistha Chatterjee Coombs**	**Environmental Health University of Cincinnati**
4:30—4:50 pm	**An Examination of Emotional Labor among Nursing Supervisor-Subordinate Dyads**	**Yisheng Peng**	**Psychology Bowling Green State University**
5:00 pm	**PRP Networking Picnic**		**French East, Rm 235**

PODIUM PRESENTATION SCHEDULE

Friday, October 10, 2014			
	Moderator: Vijay Golla, PhD		
Time	**Title**	**Speaker**	**Affiliation**
8:00—8:10 am	**Opening Remarks**	**Amit Bhattacharya, PhD, CPE PRP Program Director**	**Environmental Health University of Cincinnati**
8:10—8:15 am	**Introduction of Keynote Lecturer: Marvin J. Dainoff, PhD, CPE**	**Amit Bhattacharya, PhD, CPE, PRP Program Director**	**Environmental Health University of Cincinnati**
8:15—9:15 am	**Keynote Address: "Safety Climate and the Lone Worker: Review of Research"**	**Marvin J. Dainoff, PhD, CPE**	**Liberty Mutual Research Institute for Safety, Hopkinton, MA**
9:15—9:25 am	**Keynote Q & A**		
9:25—9:45 am	**Prediction of Core Body Temperature for Firefighters**	**Anup Paul**	**Mechanical and Materials Engineering University of Cincinnati**
9:45—10:45 am	**Break (15 minutes) and Poster Session II**		
10:45—11:05 am	**Optimized Impingement with Reduced Splatter**	**Sucharitha Rajendran**	**Mechanical and Materials Engineering University of Cincinnati**
11:05—11:25 am	**Give Me a Break: Daily Teacher Recovery**	**Kelsey-Jo Ritter**	**Psychology Bowling Green State University**
11:25—11:45 am	**Flame Retardant Contamination at Fire Scenes**	**Barbara Alexander, PhD, PE**	**Environmental Health University of Cincinnati**
11:45—12:00 pm	**Closing Remarks and Program Evaluation**		

PRP POSTER PRESENTATION LIST

No.	Title	Author	Affiliation
1	Validation of a Neutron Activation Analysis (NAA) System to Quantify Manganese in Bone In Vivo	Linda Huiling Nie, PhD	Health Sciences Purdue University
2	Aligned Carbon Nanotube Sheets for Faster Heat Dissipation in Firefighter Garment	Rachit Malik	Materials Engineering University of Cincinnati
3	Enhanced Cooling of Firefighter Helmets using Phase Change Materials	Marwan Al-Rjoub	Mechanical Engineering University of Cincinnati
4	Exploring Health and Exposures of Cleaning and Building Service Workers in NHANES	Susan Reutman, BSN, MPH, PhD	College of Nursing University of Cincinnati
5	The Impact of Shift Length on Mood and Fatigue	Melanie Kroger-Jarvis, DNP,MSN,CNS	College of Nursing University of Cincinnati
6	Performance of Facepiece Respirators and Masks against Surgical Smoke: SWPF Study	Shuang Gao	Environmental Health University of Cincinnati
7	Investigation of the Efficacy of Recovery Activities in Firefighters	Michael Sliter, PhD	Psychology Indiana University Purdue University Indianapolis
8	Airborne Particle Release and Exposure from Paper Shredding and Biological Response Potentials	Candace (Su-Jung) Tsai, ScD	Health Sciences Purdue University
9	Identification of Immunologic and Genetic Biomarkers for TMA Sensitization	Debajyoti Ghosh, PhD	Internal Medicine University of Cincinnati

NON-PRP INVITED POSTERS

No.	Title	Author	Affiliation
1	The Lurking Element: A Study About the Dangers of Lead and Other Harmful Elements in Northern Kentucky Toy Vending Machines	Brittany Wells	Environmental Health Science Eastern Kentucky University
2	Predictive Models with Pre-cooling Interventions Can Minimize Heat Stress in Firefighters	Ali Alijaroudi	Environmental Health University of Cincinnati
3	Prediction of Core Body Temperature, Sweat Rate, Cardiac Output, and Stroke Volume for Firefighters using a 3D Whole Body Model	Swarup Zachariah	Mechanical and Materials Engineering University of Cincinnati
4	Physical Inactivity, Stress and Injury among Emergency Responders	Jean Schechtman, RN, BSN, COHN-S/CM	College of Nursing University of Cincinnati
5	Evaluating the Effect of Heat Stress on Firefighters	Georganne L. Kincer, RN, BSN, COHN-S	College of Nursing University of Cincinnati

2013-14 PRP Awardees
PODIUM PRESENTATION ABSTRACTS

A Hidden Occupational Health Hazard: ETS among Child Welfare Workers

Shauna P. Acquavita[1] (PI), Jiaqi Zhang[2], Xan Boone[2], Christopher Swoboda[2], Kimberly Yolton[3]

[1] School of Social Work, College of Allied Health, University of Cincinnati
[2] College of Education, Criminal Justice and Human Services, University of Cincinnati
[3] Department of Pediatrics, Cincinnati Children's Hospital Medical Center

Purpose: The specific aims of this project were to define the exposure to Environmental Tobacco Smoke (ETS) experienced by child welfare workers employed in a mid-western child welfare agency. We also assessed how workers address smoking with clients, smoking status of workers, knowledge of the hazards of smoking and ETS, and workers' policies relating to smoking at home, work and in their automobile.

Design: This study utilized two designs: a cross-sectional survey (Survey 1) and an observational-cohort design study (Survey 2). Survey 1 was administered once to JFS child welfare workers. Survey 2 used JFS child welfare workers to log their exposure to ETS over the course of two work weeks.

Methods: Survey Monkey software and encryption service were utilized and links to the surveys were sent out on the JFS list-serv to 248 employees. Survey 1 had a 35% response rate while Survey 2 had a 27% response rate.

Results: An ANOVA conducted ($F = 7.503$, $p = .008$) was significant with a Pearson's correlation analysis indicating employees with an undergraduate degree are more likely to agree that nicotine dependence treatment should be offered or provided to their clients who smoke as compared to employees with graduate degrees ($r = -.328$, $p = .008$). An ANOVA conducted that was significant ($F = 10.710$, $p = 0.001$) with a Pearson's correlation analysis indicating employees who were serious about stopping smoking were more likely to have restrictive policies for smoking in their automobile ($r = -.794$, $p = .0005$). Participants reported nearly half of the children on their caseload lived with someone who smokes and approximately half of those families had at least one person who smokes on their caseloads. Fifty three percent of participants knew of resources available to help clients quit smoking in the community. Overall, eighty-five percent of participants did not feel they had the required skills to help their clients quit smoking. Policies and procedures participants know or followed in regards to ETS were inconsistent. Forty percent of staff reported that JFS staff are not allowed to smoke with clients, 30% ask clients not to smoke around them, and 23% try to have a meeting elsewhere if clients smoke in their home.

Conclusion: Child welfare workers are frequently exposed to ETS at work. The dangers of ETS

should be addressed for individuals in this occupation through employer ETS policies, trainings on ETS and how to address smoking in clients, and educating child welfare workers on cessation resources.

Impact: The results of this study contribute to application in the Occupational Safety and Health field by identifying the risk of ETS to child welfare workers and the lack of steps taken by child welfare workers to protect themselves from this hazard.

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Use of Pyrosequencing to Assess Fungal Diversity in Moisture-damaged Buildings

Eric Kettleson[1] (PI), Atin Adhikari[1], Jarek Meller[1], Kanistha Chatterjee[1], Stephen Vesper[2]

[1]Department of Environmental Health, University of Cincinnati
[2]United States Environmental Protection Agency, Cincinnati, OH

Purpose: Exposures to the microbiome of the home have been linked to both development of and protection from asthma. Our goal was to identify household characteristics that create its microbiome.

Methods: Vacuumed settled dust from homes (n=35) in Cincinnati, OH, were analyzed by pyrosequencing to determine the fungal and bacterial relative sequence occurrence. The correlation coefficients between home environmental characteristics, including age of home, Environmental Relative Moldiness Index (ERMI) values, occupant number, relative humidity and temperature, as well as pets (dog and cat) were evaluated for their influence on fungal and bacterial population richness, evenness and diversity.

Results: The fungal richness was found to be positively correlated with age of home ($p= 0.002$), ERMI value ($p=0.003$), and relative humidity ($p=0.015$) in the home. However, fungal evenness and diversity were only correlated with the age of home ($p=0.001$). Diversity and evenness (not richness) of the bacterial microbiome in the homes were associated with dog(s) ownership.
Linear discriminant analysis (LDA) revealed that hydrolytic, lignolytic, and fermentative fungi were common in high ERMI homes. High relative humidity promoted the growth of mesophilic and xerophilic fungi. Older homes contained high concentrations of phylloplane fungi. Dog ownership resulted in homes dominated by soil bacteria compared to homes without a dog which were dominated by human-associated bacteria.

Conclusions: The fungal microbiome of the home is primarily determined by water and age but the bacterial microbiome appears to be significantly influenced by dog ownership.

Impact: Research has shown that moisture damage in buildings is associated with respiratory health problems. This study will serve as a platform for understanding the fungal diversity specifically associated with moisture-damaged buildings and ultimately provide a better understanding of the source of these respiratory ailments. The standardization of pyrosequencing for moisture-damage-associated fungi will be useful for assessing fungal diversity and associated health outcomes among workers in many other workplaces, which are often damp and water damaged (e.g., dairy farms, greenhouses, poultry farms, grain storage buildings, etc.). Results can also for the development of targeted assays kits for indoor microbes.

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Illumina MiSeq as a Tool to Analyze the Mycobiomes in Green-building Materials

Kanistha Chatterjee Coombs (PI), Atin Adhikari

Department of Environmental Health, University of Cincinnati

Purpose: Environmental concerns for improved energy consumption and reduced carbon emissions are driving a green building/remodeling movement resulting in tighter buildings and poor indoor air quality. Recently, more and more office buildings are being constructed using green-building materials to come energy-efficient. Building related symptoms (BRS) amongst office workers have been attributed to poor indoor air quality in modern energy efficient buildings. Furthermore, there has been a causal relationship established between fungal exposures and BRS amongst office workers. Fungi are major colonizers of building material. The potential harmfulness of fungal contamination is dependent on the species content and the building material in which the fungi proliferate. The aim of this pilot study was to investigate the difference in fungal biomass and diversity in green and non-green building materials.

Methods: Four different types of green and respective non-green building materials were selected for this study. Floor dust vacuumed from various office buildings, was sieved and used for the inoculation of the materials. Both inoculated and control building materials were incubated, at 98% humidity, for approximately 2 months. DNA isolated from the incubated samples was analyzed for fungal biomass and diversity using Mold Specific Quantitative Polymerase Chain Reaction (MSQPCR) and next generation Illumina MiSeq sequencing.

Results: Based on initial MSQPCR results, non-green controls had higher trends of mold growth compared to green controls (significant only in wood with $p=0.003$ and green particle board $p=0.002$). Several building materials, including the majority of green materials, inoculated with dust had significantly higher levels of mold compared to controls (Green ceiling tile, $p=0.04$; Green particle board, $p=2.3*10^{-7}$; Non-green particle board, $p=5.59*10^{-12}$; Green wood $p=0.03$). MSQPCR of 36 mold species, forming the basis of Environmental Relative Moldiness Index (ERMI), from these samples revealed several cases of rapid proliferation and outcompetition of certain species with the addition of dust. Future analysis from the Illumina Miseq sequencing data will help further determine differences in mycobiomes between green and non-green building materials.

Conclusion: From initial MSQPCR data, the majority of green building materials used in this pilot study, showed significantly higher levels of mold growth with the addition of dust. Several harmful fungal species (e.g: *Stachybotrys chartarum*) were observed to proliferate notably in building materials inoculated with dust. Additionally, there was no statistical difference in fungal biomass between green and non-green control building materials (without dust).

Impact: Several epidemiological studies have examined the effects of respiratory exposure to indoor fungi, yet there have been few attempt to comprehensively survey the built environment microbiome and determine the interaction between fungal communities and building materials. The results from this study will help predict whether green buildings provide a safer indoor environment, with regards to fungal exposure, as opposed to conventional non-green building materials. Furthermore, this study may also offer valuable insight on determining whether green building materials are suitable for use in humid and flood-prone environments. This pilot study is also relevant to NORA since it will serve as a platform to evaluate if there could a potential cause of adverse health effects among indoor workers from exposures to fungal communities on green-building materials.

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An Examination of Emotional Labor among Nursing Supervisor-Subordinate Dyads

Yisheng Peng (PI), Steve Jex, Robert Kirk
Department of Psychology, Bowling Green State University

Purpose: The purpose of this study was to examine emotional labor in an interpersonal interaction context by 1) examining the crossover of emotional labor process within nurse supervisor-subordinate dyads, as well as the effects on employee well-being, 2) exploring supervisor social support as a mediator between emotional labor and employee well-being, and 3) investigating the relationship between emotional labor and social support within supervisor-subordinate dyads.

Design: A cross-sectional survey design was used. Nurses were used as the target sample for the current study.

Methods: A total of 202 nurses from hospitals, medical centers, and nursing homes participated in this study, with 40 of them having matched supervisor-rated data. Participants were asked to complete separate online surveys containing various measures of emotional labor, social support, and well-being outcome variables. Each participant received a monetary incentive.

Results: Regarding individual crossover, nurse supervisors' faking-emotion was positively related to subordinates' faking-emotion and hiding-emotion. Additionally, nurses' hiding-emotion was significantly related to job distress and emotional exhaustion, with supervisor social support serving as a mediator between them. Furthermore, nurses' hiding-emotion was negatively associated with self-reported receiving support from supervisors; whereas deep-acting was positively related to self-reported giving support to supervisors and receiving support from supervisors. Self-reported giving support fully mediated the relationship between nurses' deep-acting and self-reported receiving support.

Conclusions: Overall, this study not only supported the effects of emotional labor on employee well-being outcomes from an interpersonal perspective but also provided preliminary evidence regarding the crossover of emotional labor among supervisor-subordinate dyads. Moreover, findings suggest the differential impact of deep-acting and hiding-emotion on social support during interpersonal interactions. Future research should further examine the directions of emotional labor crossover and explore the related effects on other important outcome variables.

Impact: In alignment with the primary goals of Occupational Health Psychology (OHP), the present research examined how emotional labor and social support affect occupational well-being in nurses. Specifically, this study contributed to literature by supporting the crossover of emotional labor among nurse supervisor-subordinate dyads. This suggests that employees' work behaviors rather than attitudes or feelings can also crossover to each other during the workplace interactions. Moreover, given the emphasis on the social interaction context of emotional labor, the present research further revealed how supervisors' emotional labor affected nurse subordinates' giving and receiving social support. Additionally, nurses represent one occupation with high emotional labor demands. Research on occupational well-being in the nursing population is relatively limited. This study provided evidence that nurse supervisors' emotional labor may affect their subordinates' emotional labor during the interactions, and nurses' emotional labor could affect their well-being through their perceived supervisor support. It was suggested that more healthy emotional management (e.g., deep-acting) and giving social support behavior should be encouraged in nurses' workplace.

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Prediction of Core Body Temperatures for Firefighters

Anup K Paul (PI), Swarup Alex Zachariah, Rupak K Banerjee
Mechanical and Materials Engineering, University of Cincinnati

Purpose: A whole body model for firefighters was used to determine 1) the safe duration of exposure during firefighting activities and 2) the required external cooling rate to regulate the core body temperature between 36.5 ˚C and 37.5 ˚C. The hypothesis of this research is that the heat-induced stress in firefighters can be determined by the computational whole body model. Inability to dissipate bodily heat during physical exertion of firefighting activities causes an increase in heat stress. Elevated heat stress could lead to a number of health related adverse events, including unconsciousness and cardiac arrest. To prevent these adverse effects, early determination and mitigation of heat stress is critical for firefighters.

Design: The proposed research was divided into two parts. First, the time taken for the human body to reach the critical core temperature of 40 ˚C during firefighting activities was determined. Secondly, with the aid of external cooling of 100 W and 150 W, the model tried to restrict the increase in core body temperature of the firefighters between the acceptable limits of 36.5 ˚C and 37.5 ˚C.

Method: The method utilizes two equations simultaneously: a) the Pennes bioheat equation in the whole body, and b) an energy balance equation to determine the change in blood temperature in relation to the body temperature during a sequence of firefighting activity. The inputs for the computational model are the heart rate time series, details of firefighting suit, geometry and physiological details of the individual firefighters. In this study, the firefighting data was assessed for three firefighters and the experimental data included periodic work and rest periods.

Results: The time taken to reach the critical core temperature of 40 ˚C during firefighting activities was calculated to be between 72 – 173 minutes. When external cooling of 100 W and 150 W was applied to the human body torso during rest scenarios, the model for firefighter 2 predicted a core body temperature of 37.05 °C and 36.74 °C at the end of the training session, respectively.

Conclusion: Utilizing the results of this study and with the aid of the computational whole body model, the heat stress and the rate of required external cooling can be quantified for firefighters.

Impact: Assessing heat stress impacts during firefighting activities is one of the NORA's priority re-search areas. This project was designed to aid in determining the appropriate time of exposure to firefighting activity and compute the required cooling rate in cooling jackets for firefighters. This will, in turn, help limit heat-induced stress and avoid thermal shocks. Additionally, it will allow for determination of the performance of newer cooling technologies.

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Optimized Impingement with Reduced Splatter

Sucharitha Rajendran (PI), Raj M Manglik, Milind A. Jog
College of Engineering and Applied Science, University of Cincinnati

Purpose: Occupational workers in industries that involve sprays and jet impingement are in constant danger of contact with splattered droplets. A number of occupational diseases are associated with this. It thus becomes important to find a means to limit this splash of drops while still maintaining the functionality of the chosen spray or jet impingement mechanism.

Design: An experimental setup coupled with a computational algorithm (using OpenFOAM) is used to understand the physical mechanism of drop splash. Water and ethylene glycol are used as working fluids. Heat transfer and temperature measurements are done using an IR Camera.

Methods: Operational conditions such as velocity of impact, drop size, surface temperature, and working liquid properties are varied. A high-speed camera is utilized to capture the splash dynamics. OpenFOAM package is utilized for computational simulations. The algorithm uses finite volume method to approximate the equations of motion. A Poisson-type pressure correction equation is coupled with the continuity and momentum equation. Using the data from experiments, the numerical accuracy is tested and modified.

Results and Conclusion: While effects of inertial and surface tension forces on drop splatter have been previously observed, through these recent experiments, effect of gravitational forces is also noted. It is observed that temperature aggravates the splashing behavior. While comparing present experimental data with suggested correlations in the literature, it is observed that the dimensionless parameters previously proposed to describe the drop splatter, fall short. This can be attributed to the lack of clear defining design parameters in these suggested correlations. Further analysis with more liquids is required to obtain a better, well resolved interpretation of splashing.

Impact: In cooling and spraying industries that handle hot fluids and toxic chemicals, such as pesticides, paper drying, metal annealing and food processing, impingement is most commonly used for heat and mass transfer. In such applications, the impingement results in formation of small droplets. Occupational workers in these industries are in constant danger of contact with splash from these droplets. A number of occupational diseases arise due to skin contact with such splash drops. Since the working temperatures are high, these droplets could easily evaporate to form a toxic mist which, when inhaled, has been proven to cause life-threatening health risks as they contain surfactants, biocides, chelating agents and fatty acids. Thus, a means to control the splatter of drops and thereby minimize the chances of human contact will be of great significance. This study aims to find a means to provide best flow conditions to promote the heat transfer and best spray coverage while prioritizing on the effects on the worker's health.

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Give Me a Break: Daily Teacher Recovery

Kelsey-Jo Ritter (PI), Russell Matthews

Department of Psychology, Bowling Green State University

Purpose: The purpose of the current study was to examine how after-work recovery strategies and at-work break time might increase energy levels and lessen negative effects of stress and work demands due to the nature of the teaching profession. It was expected that daily at-work break time and evening recovery activities would have a positive effect on next-day morning energy. Morning energy was expected to positively predict same-day work and personal well-being outcomes.

Design: This was tested using a daily diary format consisting of six consecutive days of electronic morning and evening surveys. A general survey was given to determine eligibility and key demographic information.

Method: The participants for this study were teachers across the United States who worked at least part time with elementary students. Subjects were recruited via contact with their superintendant as well as through the researcher's professional network using a peer nomination method.

Results: The majority of the hypotheses were supported; evening recovery and morning energy were found to predict several outcomes related to personal and work well-being. Importantly, outcomes of interest such as teaching self-efficacy were found to have significant within-person variance across the 6 days of study collection.

Conclusion: It is possible to conclude that perceived state energy in the morning has important implications throughout the day for teachers. Further, relaxation as a recovery strategy in the evening was a predictor of next day indicators of well-being.

Impact: The current study was one of the first to investigate the effects of work-related breaks on psychological variables, specifically in the field of education. Education is the second largest industry in the nation with over 13.3 million workers (National Services Agenda, 2009), with the largest proportion being employed in secondary and post-secondary institutions. This study helps us to describe the organization of work in the situation of elementary teachers, as well as sheds light on the current problem of teacher burnout and turnover (Kain, 2011). As class size and job demands are likely to continue to increase as state and federal budgets cut funding to education, retaining high quality teachers in the current working environment is difficult as many districts are unable to increase salary or offer additional benefits. This study documents the importance of evening relaxation and morning energy is particularly important outcomes for teachers, teaching self-efficacy and work engagement.

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Flame Retardant Contamination at Fire Scenes

Barbara M. Alexander (PI)
Department of Environmental Health, University of Cincinnati

Purpose: The purpose of this research was to further study potential sources of firefighter exposure to flame retardant chemicals. It is recognized that firefighters suffer high rates of adverse health outcomes such as cancer and coronary heart disease, possibly due to chemical exposures during firefighting activities. Previous research has shown that toxic chemicals accumulate in used firefighter personal protective clothing, possibly leading to adverse health effects.

Design: Samples of unused and used firefighter protective clothing were analyzed for the presence of several flame retardant chemicals, to further quantify potential firefighter exposures to these chemicals.

Methods: Unused and used samples of firefighter protective clothing, including gloves, hoods and the cuff from a coat, were analyzed for contamination with the flame retardants 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB), bis-(2-ethylhexyl) tetrabromophthalate (TBPH), triphenyl phosphate (TPP), tris (1,3-dichloro-2-propyl) phosphate (TDCPP), and tris (2-chloroisopropyl) phosphate (TCPP). A sample of an unused firefighter hood was analyzed for the presence of polybrominated diphenyl ether (PBDE) flame retardants found previously in used hoods.

Results: Although previous analysis for PBDE flame retardants showed that these chemicals were present in unused and used firefighter personal protective clothing, newer flame retardant chemicals were not found in detectable quantities. This may have been due to the high limits of detection for the current analysis.

Conclusion: Even though no contamination above the limit of detection was found for the 5 flame retardants in this investigation, earlier studies have revealed that firefighter personal protective clothing becomes increasingly contaminated with hazardous substances as it is used. A rapid method for field decontamination of firefighter personal protective gear would be a significant advance.

Impact: Chemical exposures may be partly responsible for firefighters' high rates of adverse health outcomes such as coronary heart disease and cancer. Several studies have demonstrated that firefighter personal protective clothing becomes increasingly contaminated with hazardous substances with use. Regular decontamination of this protective clothing may help to reduce chemical exposures of firefighters.

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2014-15 PRP Awardees
POSTER PRESENTATION ABSTRACTS

Validation of a Neutron Activation Analysis (NAA) System to Quantify Manganese in Bone In Vivo

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Occupational exposure to manganese (Mn) occurs among workers involved in welding, smelting, mining, and battery production. In the US alone, millions of workers, including over 300,000 welders, are at high risk of excessive Mn exposure. Mn exposure is associated with many types of diseases, and the most concerned is neurological disorders. In its final stage, Mn toxicity manifests as a neurological disorder termed manganism, which closely resembles Parkinson's disease. The symptoms of chronic Mn toxicity, once established, become progressive and irreversible. Hence, a biomarker for the assessment of cumulative Mn exposure and early diagnosis of Mn neurotoxicity is crucial. In this project, a potential valuable technology for long term cumulative Mn exposure will be tested and validated in the PI's lab. This technology involves measuring Mn in human bone in vivo. It has been developed in the PI's laboratory and needs to be validated extensively in the lab. In this project, we will validate the system using Mn-doped phantoms, bones from rats fed with Mn, and human cadaver bones. We will also improve the detection limit of the system and minimize the radiation dose to the subject. The validation and application of this technology is critical to millions of workers who have been exposed to Mn for two reasons. First, neurological disorder is one of the main health issues for these workers; second, neurological impairment reduces the workers' productivity and is a major cause for work related injuries.

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Aligned Carbon Nanotube Sheets for Faster Heat Dissipation in Firefighter Garment

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Firefighting in the United States is becoming more of a profession than it once was. Heat injury is a major issue for firefighters as they wear insulated clothing and cannot shed the heat generated from physical exertion. Early onset of heat stress affects cognitive function which combined with operating in dangerous environment makes heat stress and dehydration a critical issue to monitor. More firefighters die in the line of duty from heart attacks than from any other cause. And slips, trips and falls cause a large number of firefighter injuries. While the origins of heart attack and slip, trip and fall may appear unrelated, previous research suggests that heat stress may be a common causal factor in both heart attacks and slips, trips and falls. Research further suggests that one common, critical factor can potentially mitigate both of these injuries and fatalities: modified personal protective equipment (PPE). This project is aimed at the development of a component of the PPE viz. a cooling vest worn under the turnout gear for more efficient heat dissipation from the body of the firefighter. This will be achieved by incorporating carbon nanotube sheet textile material in between layers of

cotton. The carbon nanotube sheet material will also be functionalized by plasma to make it hydrophilic and improve moisture interaction and comfort of the firefighter.

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Enhanced Cooling of Firefighter Helmets using Phase Change Materials

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Successful regulation of heat-induced stress is one of the challenging aspects of firefighting science. During firefighting activities, the firefighters experience increased heat buildup in their bodies as a result of increased metabolism. This increase in metabolism causes a rise in the core body temperature. The rise in core body temperature if unchecked can lead to various ailments such as heat stroke, brain damage, and impaired thermal regulation. Firefighters can also experience unconsciousness or cardiac arrest. The above mentioned reactions or a combination of the same could prove fatal to the lives of the firefighters. The proposed project will strive to determine the safe duration of exposure during firefighting activities and the external cooling rate required for firefighters to regulate their brain temperature. The hypothesis of this research is that with the aid of external cooling, it will be possible to extend the safe working period for firefighters during firefighting activities. The project would involve the use of computational software, using which a predictive Whole Body Model will be used to compute the thermal response of individual firefighters to firefighting activities.

The proposed research is divided into two parts. First, the time taken for the human brain to reach the critical temperature of 40 ˚C during firefighting activities will be ascertained. Secondly, by accurately quantifying the required cooling rate for individual firefighters, it will be possible to regulate the core brain temperature around 37.2 ˚C using heat exchangers and phase change materials to transfer and store the heat generated by the brain. We propose that the accurate estimation of the thermal response of the human body will help in devising better cooling techniques. This will permit in limiting the heat-induced stress and avoid cooling shock to the body. The computational model can also be utilized to analyze new cooling technologies. This will be an attractive economic option over costly and exhaustive field trials. Most importantly, by helping to remove the excess heat generated during firefighting activities from the human body, it will help shield the firefighters from the harmful effects of heat-induced stress and save their lives.

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Exploring Health and Exposures of Cleaning and Building Service Workers in NHANES

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Cleaners and building service (C&BS) workers have the potential for exposure to a number of potential xenobiotic agents, such microbes, dusts, chemicals, and other substances. There is, however, a lack of data on the internal dose of various xenobiotics among this group. National Health and Nutrition Examination Survey (NHANES) databases contain a broad repository of exposure biomarker data, and so present a rare opportunity to examine exposures in a nationally representative sample of US workers. In the upcoming pilot analysis, existing but non-publicly available CDC data from NHANES will be explored for this biomarker repository's potential to fill information gaps with regard to potential exposure risks among C&BS workers. Initially, descriptive statistics (e.g., n's, means, medians, SDs) will be presented for each biomarker of exposure and also for health biomarkers. Next, ANOVAs and cluster analyses will be conducted to compare and contrast exposure biomarkers by work group (C&BS overall and subgroups vs non-C&BS). After selected exposure biomarkers have been identified (narrowed) based on examination of the above ANOVA and cluster analysis results, a literature review of potential health effects of the exposures those selected exposure biomarkers measure will be conducted. If indicated by the strength of evidence, one or two key health outcomes (characterized by one or more health related biomarkers) will be selected for further investigation using regression analysis(es) with adjustment for principle components (of exposure biomarker variables) and other potential key covariates and confounders. Because the risk of bias is greatly reduced in NHANES, and the panel of biomarkers is relevant, this pilot analysis has the potential to generate new hypotheses and suggest insights to inform interventions.

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The Impact of Shift Length on Mood and Fatigue

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Background: Physical work demands, long work hours and persistent thoughts of work lead to disturbed sleep and decreased sleep time. Disturbed sleep and sleep loss contribute to mood changes and fatigue. Fatigue contributes to an increase in work related injuries, car crashes during commutes to and from work, and diminished health and wellbeing for the nurse. Additionally, fatigue has an impact on patient care errors.

Purpose: The purpose of this study is to obtain a baseline measurement of sleep, physical activity, and work hours and to relate these to the fatigue and mood states of Registered Nurses. The results of this study will be used to develop mitigation strategies to decrease nurse fatigue, improve mood, and improve work/life balance.

Methods: Eighty Registered Nurses working 12-hour day shift (n=20), 12-hour night shift (n=20), 8-hour day shift (n=20) and 8-hour evening shift (n=20) will be recruited from randomly selected units in a pediatric inpatient hospital. The Profile of Mood States (POMS) tool will be used to measure the subject's mood based on a fivepoint Likert scale. The tool is based on six subscales to measure mood and will be completed at the start of the study and the beginning and end of each worked shift. The 15-item Occupational Fatigue Exhaustion Recovery (OFER) tool will be used to determine chronic and acute fatigue, and inter-shift recovery of the nurse.

This will be completed at the end of the study. The Fitbit Flex will be used to measure activity, total sleep time and sleep quality for 24 hours a day for seven days. The Fitbit Flex is both a sleep and activity actigraph. Fitbit data are uploaded wirelessly to a Fitbit website and activity data are recorded in one minute epochs. Sleep quality is computed using a standard algorithm based on sleep measurement data. Both activity and summarize data can be downloaded from the website using an API protocol.

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Performance of Facepiece Respirators and Masks against Surgical Smoke: SWPF Study

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Healthcare workers in operating rooms are often exposed to surgical smoke when surgical and invasive procedures are performed by using laser or other devices that interact with tissue. Potentially infectious viruses, bacteria, and hazardous chemicals are found in surgical smoke, which are associated with several respiratory diseases including chronic cough, throat irritation, and asthma. Additionally, surgical smoke is represented mostly by the ultrafine fraction, which is of particular health concern. To control the exposure, the healthcare workers wear surgical masks or filtering facepiece respirators (FFRs). Surgical masks have been demonstrated to be inefficient to protect wearers from airborne particles. FFRs have not been extensively tested against surgical smoke. In this study, we propose to conduct a study to investigate the Simulated Workplace Protection Factor of two N95 FFRs and two surgical masks against surgical smoke. First, a subject will be fit-tested with a facepiece under the test (only N95 FFRs can be fit-tested). If passed, the subject will be studied in the exposure chamber while wearing the tested respiratory protection device and applying an electrocautery unit to the tissue mimicking a conventional surgical procedure. The particle concentration inside (C_{in}) and outside (C_{out}) of the respirator will be measured by a P-Trak condensation particle counter and a Nanocheck particle spectrometer operating in parallel. The SWPF values will be determined as the ratio of C_{out}/C_{in}. The effects of different type of respiratory protection device will be quantified. The particle size will be evaluated as a factor affecting the SWPF. The results will help establish a better understanding of the respirator performance against surgical smoke and will provide scientific data for respirator manufacturers focusing on designing better respirator against surgical smoke.

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Investigation of the Efficacy of Recovery Activities in Firefighters

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First responders are frequently exposed to unique sets of stressors, including chronic stressors (e.g., equipment failures, workload, working with rude individuals) and traumatic stressors (e.g., being in danger; working with the injured/dead/dying). Exposure to these stressors has been shown to have a negative impact on both individual well-being and organizational outcomes, which can subsequently impact victim/patient well-being. As such, it is increasingly important to understand how first responders might use their off-time in order to recover from these stressors. The first goal of the proposed study, therefore, is to determine frequently-used activities that first-responders (specifically firefighters) engage in to recover from work. Secondly, simply because a person uses a particular recovery strategy does not necessarily mean it is an effective strategy. Past research on recovery from work stress has focused on relaxation, pursuit of mastery activities (e.g., hobbies/sports), and psychological detachment as viable strategies in helping employees regain resources. These activities have been shown to be more, or less, effective depending on the chronic stressor investigated, though this research has been limited to white collared jobs. Additionally, no empirical research, to date, has investigated the efficacy of recovery activities in terms of traumatic workplace stressors. That said, the second goal of the proposed study is to determine the efficacy of the currently identified recovery activities in buffering the negative effects of traumatic stressors. Based in past research, it is expected that different strategies will effectively buffer the chronic stressor-outcome relationship than will buffer the traumatic stressor-outcome relationship. In order to meet the goals of the proposed research, two studies will be used. First, a qualitative (interview-based) study will be used to determine the most frequent activities that firefighters engage in to recover from stress. Second, a two-time point longitudinal survey study will be conducted in order to determine whether these strategies are effective for lessening the effects of chronic and traumatic stressors.

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Airborne Particle Release and Exposure from Paper Shredding and Biological Response Potentials

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This project will investigate airborne particle release and exposure to particles released from paper shredding. The focus of this project is the exposure characterization of particles in terms of the particle size distribution, particle number concentration, morphology and the associated biological response to the particles in different size ranges, particularly the nanometer-sized particles and fibers. The paper fiber dust released from paper material manufacturing or manipulating processes has been studied in the past using gravimetric methods, and some health effect symptoms were reported. However, there is lack of information that detailed particle exposure characteristics, and the potential biological responses associated with exposure to printer paper at the disposal stage using such methods as paper shredding. The exposure levels associated with different types of paper and shredder use and the shredding conditions will be studied to analyze the released dust particles. The biological response potential will be tested using human lung cell lines (in vitro) to predict cell uptake, absorption and relocation and a zebrafish model to examine possible alteration of development later in

life after exposure. The exposure to dust particles will be characterized and the associated biological response will be analyzed. The biological response potential will provide information needed to develop an exposure assessment protocol for nanoparticle exposure associated with paper dust and to hypothesize the associated lung tissue response, particle relocation and potential development alteration from inhalation exposure; information from this pilot project will form the basis for a future in vivo study.

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Identification of Immunologic and Genetic Biomarkers for TMA Sensitization

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Workplace exposure to Trimellitic Anhydride (TMA), which is used in producing plastics and paints, can cause occupational health hazards. In the US, an estimated 20,000 factory-workers are exposed to TMA each year in spite of taking aggressive measures to reduce exposure. TMA is a unique chemical capable of causing both non-immunologic (irritation) and antibody-mediated immunologic responses. TMA is rapidly converted to trimellitic acid in ambient humidity causing irritation to exposed epithelial/mucosal surfaces. However, to elicit an IgE mediated response, it must bind to an endogenous protein like human serum albumin (HSA) to form a complete antigen. It is still unclear which TMA exposed workers will remain unsensitized (i.e., no specific antibody) or become sensitized (i.e., develop specific IgE) to TMA which increases their risk for developing occupational asthma. Previous investigations have suggested differential expression of genes with exposure to irritants vs sensitizing agents. There is a paucity of information regarding potential biomarkers for determining risk for TMA sensitization or gene expression signatures that can discriminate irritant from cellular immunologic responses to TMA exposure. To address whether TMA specific IgG4 is a useful biomarker for tolerance vs. sensitization, a Rat Basophil Leukemia (RBL) Cell Mediator Release Assay, will be used. RBL cells expressing human IgE receptor, will be incubated with TMA-exposed factory workers' sera with (a) no TMA-specific antibody (b) specific IgE: specific IgG4 > 1 and (c) specific IgE: specific IgG4 < 1. Cells will then be challenged with TMA-HSA conjugate to measure mediator release. We hypothesize that IgE:IgG4 <1 will inhibit or attenuate mediator release whereas IgE:IgG4 >1 ratios will promote mediator release. To assess differential molecular genetic signatures as markers for TMA sensitization vs. an irritant non-allergic response an in vitro dendritic cells (DCs) model will be used to investigate allergenicity. DCs pre-sensitized using TMA-specific serum IgE will be exposed to a TMA-HSA conjugate to assess TMA specific IgE-medicated reactions, while unsensitized DCs exposed to free TMA will be used to assess the irritant response, with appropriate experimental controls.

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INVITED NON-PRP POSTER PRESENTATION ABSTRACTS

The Lurking Element: A Study About the Dangers of Lead and Other Harmful Elements in Northern Kentucky Toy Vending Machines

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Imagine yourself walking into a dollar store with a young child. As soon as you reach the door, the child is drawn to the vending machines that contain numerous toys. As a parent, you give your child a couple of quarters to get a toy of his or her choice. After the child receives the toy, she marks it by licking and chewing it. As consumers, we tend to believe those toys are safe for use, but sometimes those toys can contain toxic chemicals, such as lead and other metals. Although lead exposure has decreased tremendously over the past three decades, there still concerns about exposure, especially with toys in vending machines and other consumer products for children. An experimental study was conducted by collecting numerous small toys from the Northern Kentucky River Region, and examining them for lead and nine (9) other toxic elements including arsenic, barium, bromine, cadmium, chlorine, chromium, mercury, antimony, and selenium. New global regulations from the Consumer Product Safety Commission related to lead levels in children's toys and other commercial products have increased the need to analyze products for lead and other toxic elements. The research conducted by Eastern Kentucky University's (EKU) Department of Environmental Health Science (EHS) addresses a part of this need. The research also shows a need for technologies that will help businesses and manufacturers monitor their products for the presence of lead and other toxic elements, such as arsenic, mercury and cadmium.

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Predictive Models with Pre-cooling Interventions Can Minimize Heat Stress in Firefighters

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Objectives: The objectives of this pilot study were: i) develop a data driven model that can be used to predict if a firefighter would cross the threshold of industrial hyperthermia (core body temperature – CBT > 100.4 ^{O}F) during live-fire training, and ii) pilot test the utility of this model by implementing a proactive intervention: pre -cooling to keep firefighters' CBT within "safe" limit.

Design: A *cross-sectional* design was used in this study in order to test the utility of this model by implementing a proactive intervention: active pre-cooling to keep firefighters' CBT within "safe" limit. The independent variables are the amount of heat/cold exposure and physical activities. The dependent variables are the physiological responses (CBT,HR).

Methods: Twenty-eight full time firefighters' CBT and heart rate (HR) were measured real time while undergoing a live-fire training consisting of three scenarios (Sc1, Sc2 and Sc3).
Classification trees (CT) were used to predict the outcome variable (firefighter crossed the upper threshold of

hyperthermia – Y/N). The predictor variables were: age, body mass index, baseline CBT, baseline HR and duration of each scenario. Three CT models were developed, one for predicting CBT response after each scenario. Twenty-eight CTs were developed by randomly leaving out one firefighters' data in each CT to assess the model's efficacy using "leave-one-out" method. Success rate was calculated as: 100*(number of correct classifications)/28. As a proactive intervention application, we first identified a firefighter who would reach hyperthermia as per the model and his CBT was predicted with a regression tree (RT). The firefighter was cooled (using a cooling vest) before the scenario for 14 minutes.

Results: The success rate of CT models for Sc1, Sc2 and Sc3 were 43%, 61% and 89%, respectively. The CBT predicted using RT (101.35 ^{O}F) was higher than that observed after cooling (100.49 ^{O}F).

Conclusions: The predictive model was successful for Sc3, moderately successful for Sc2 and unsuccessful for Sc1. We piloted the utility of predicting CBT response of firefighters through early identification of a firefighter with high risk of entering hyperthermia and implementing proactive cooling to reduce the CBT. Predictive models with pre-cooling interventions can minimize heat stress in firefighters.

Acknowledgement: *This study was funded by the NIOSH grant # T42OH00843206. Special thanks to Fire Chief, Dr. William Jetter, Captain Russell L. Kammer and all participating firefighters from all fire stations for their participation and co-operation in this research study.*

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Prediction of Core Body Temperature, Sweat Rate, Cardiac Output, and Stroke Volume for Firefighters Using a 3D Whole Body Model

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Purpose: This study determines the core body temperature (T_c), sweat rate, cardiac output, and stroke volume for individual firefighters using a computational whole body model. The *hypothesis* of this research is that the heat-induced stress in the firefighters can be determined by the computational model. Inability of the firefighters to dissipate bodily heat during physical exertion caused by firefighting results in an increase of their heat stress levels. Elevated heat stress could lead to a number of health related adverse events, including unconsciousness and cardiac arrest. To prevent these adverse effects, early determination and mitigation of heat stress is critical for firefighters.

Design: The objectives for the project are defined by the following four aims: 1) revise the existing human body model to incorporate the firefighting suit, 2) adapt the existing model to recreate the results of the experimental data, which was collected during the live-burn studies, 3) determine the variations in T_c, sweat rate, cardiac output, and stroke volume during live-burn activities in real time, and 4) inform fire departments of the warning signs that may lead to adverse events when exposed to working in a hot environment.

Methods: The method utilizes two equations simultaneously: a) the Pennes bioheat equation in the whole

body, and b) an energy balance equation to determine the change in the blood temperature in relation to the body temperature during a sequence of the firefighting activity. The inputs for the model are the heart rate time series, details of the firefighting suit, the geometry and the physiological details of the individual firefighters. The firefighting data assessed in this study included periodic work and rest periods. T_c obtained from the model (T_{c_comp}) was verified with the experimental variation of T_c ($T_{c\_experimental}$) over time. Various sweat rates were tested to evaluate the experimental data. These sweat rates were expressed as a percentage value of the maximum sweating rate (E_{max}). Additionally, the model also computed the predictive lower and upper T_c bounds ($T_{c\_comp\_lower}$ and $T_{c\_comp\_upper}$), which were obtained by varying each temporal value of the input heart rate time series by -10% and +10%.

Results: The results obtained are: 1) using available data and realistic assumptions, the error between $T_{c\_experimental}$ and T_{c_comp} was computed to be less than 1%, 2) cardiac output varied between 5.6 lit/min – 33.9 lit/min during the combination of firefighting and resting activities, and 3) stroke volume was computed to be between 0.05 lit/beat - 0.31 lit/beat. The reported range of stroke volume is moderately higher when compared with the literature reported values and is currently under investigation. Additionally, the variation in $T_{c\_experimental}$ was within the predictive bounds of $T_{c\_comp\_lower}$ and $T_{c\_comp\_upper}$.

Conclusion: Utilizing the results of the whole body model, the heat stress and the physical exertion levels can be quantified for firefighters.

Acknowledgement: *This research study was supported by the National Institute for Occupational Safety and Health Targeted Research Training Program of the University of Cincinnati Education and Research Center Grant #T42-OH008432.*

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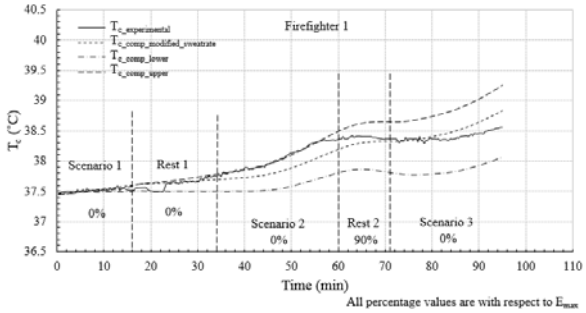

Figure 1: Comparison of $T_{c\_experimental}$ with T_{c_comp}, $T_{c\_comp\_lower}$, and $T_{c\_comp\_upper}$ during a firefighting training drill

Physical Inactivity, Stress and Injury among Emergency Responders

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Purpose: The purpose of this research study is to identify the relationship between physical stress, physical inactivity, and injury among emergency responders (firefighters and emergency medical technicians).

Design: In order to decrease stress and increase cardiovascular wellbeing a simple exercise regimen using stress bands was developed. This regimen includes split squat exercises, including the quadriceps, gluteus maximus, and hamstring muscles. Data collection will include, vital signs collected at baseline and post intervention, wall squat timing, as well as self-reported physical, psychological stress, sleep pattern and physical activity. Convenience sample of approximately forty firefighters will be included. This study will help to determine whether a simple activity will decrease stress and increase cardiovascular well-being in the firefighter population. This study will begin immediately after IRB approval and culminate by the end of Fall semester 2014.

Acknowledgement: *Resource funding from National Institute for Occupational Safety and Health, University of Cincinnati Educational and Research Center Grant # T 42/OH 008432.*

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Evaluating the Effect of Heat Stress on Firefighters

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Purpose: This interdisciplinary study was designed to test emerging monitoring technology to detect adverse effects of heat stress on firefighters cardiovascular, neuromuscular, and cognitive systems during live burn events.

Background: Sudden cardiac death is a primary cause of on-duty firefighter deaths. Heat stress and over exertion impact cardiovascular, neuromuscular, and cognitive systems. Real-time feedback of physiological responses has the potential to allow incident commanders to remove firefighters from heat exposure and over exertion situations as they approach physiological limits, thus preventing on-duty injuries or fatalities.

Design: All subjects signed informed consents as per the approved IRB protocol. Data collection process was designed around the firefighters' Live Burn firefighting and ladder traversing trainings. The trainings included 3 scenarios lasting approximately 10 to 20 minutes each followed by a rest period. Objective and subjective measures were gathered prior to the trainings (baseline) and at pre-scenario and post-scenario events throughout the trainings. Core Body Temperature and Polar Heart Rate and/or Bioharness data were gathered continuously throughout the trainings.

Methods: Core body temperature (CBT) and heart rate (HR) were monitored continuously during three training scenarios using an FDA approved ingestible radio pill, Polar HR chest strap or Zephyr Bioharness, and a CBT data recorder. The three scenarios included search and rescue, hose advancement, and backup or three scenarios of ladder climbing. Rest measurements of blood pressure (BP), pulse, SpO2, tympanic temperature,

height and weight were obtained. Pre- and post-scenario measurements of BP, pulse, SpO2, tympanic temperature, reaction times (RT), perceived exertion (RPE), perceived respiratory distress (RD), perceived thermal comfort (TC), postural sway, and height and weight were obtained.

Results: Real-time continuous CBT and Polar HR data increased as the firefighters progressed through each scenario. Past results support the validity of using real-time monitoring of firefighters physiological responses during live burn events and the potential for systems to identify and remove firefighters from harmful situations.

Conclusion: We have examined the objectives of quantifying objective and subjective measures and of determining the association between these measures of heat stress and overexertion associated with Live Burn activities and other trainings carried out by firefighters. Further data collection will be performed to determine if the results obtained so far will be sustained.

Acknowledgement: *The work presented in this poster was supported by NIOSH grant #T42OH00843207.*

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Selected PRP Awardee Publications, Conference Presentations, and New Grants Based on PRP Results for 2013-14

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Conference/Poster Presentations:

Britton, AR, **Sprung, JM**. Safety motivation, behavior, and life satisfaction among farm couples. Poster presented at the 29th Annual Conference of the Society for Industrial-Organizational Psychology, Honolulu, Hawaii, 2014.

Borchers, AB, Lee, RL, Martsolf, DS, Maler, J. Employment Maintenance Among Women Who Have Experienced Intimate Partner Violence. Poster presented at the Midwest Nursing Research Symposium, St. Louis, Missouri, March 29, 2014.

Frank, E (presenting), Vinicius Carreira, Eileen Birch, and Jagjit Yadav. Carbon nanotube and asbestos exposures induce overlapping but distinct profiles of lung pathology in mouse models of repeated, low-dose exposure. Podium presentation at the Ohio Valley Society of Toxicology 2014 Annual Meeting, Wright State University, Dayton, OH, September 26, 2014**. (**Won "Best PhD Student Platform Presentation")

Mani, A, Dunning, K, Larsh, T, Cox, C, Shukla, A, Bhattacharya, A, Revilla, FJ. Dynamic fall-risk predictors in Parkinson's disease. Poster presentation at the 66th Annual Meeting of the American Academy of Neurology, Philadelphia, PA, April 26 to May 3, 2014.

Paul, AK. Predicting thermophysiological response and safe duration of exposure during firefighting activities: Validation and Application of the Whole Body Model. Invited session talk for session Human Whole Body Modelling at the the 7th World Congress of Biomechanics, Boston, MA, July 6-11, 2014.

Poole Wilson T, Davis, KG, Dareiseh, N, Kotowski, SE, Documenting the Amount of Manual Handling Performed by Nurses in a Hospital Setting. Poster presented at the Human Factors and Ergonomics Society Healthcare Symposium, Chicago, Illinois Human Factors and Ergonomics Society, March 16-19, 2014.

Sergeev AV. Coronary intervention procedures in CAD patients with diabetes: Racial disparities are associated with post-procedure mortality. Presented at the American Heart Association (AHA) Epidemiology and Prevention Scientific Sessions, San Francisco, CA, March 18-21, 2014.

Sergeev AV. Drug-eluting stent utilization and post-coronary revascularization procedure mortality: Do racial disparities matter? Presented at the American Heart Association (AHA) Epidemiology and Prevention Scientific Sessions, San Francisco, CA, March 18-21, 2014.

Singh, U. Endotoxin In Size-Specific Airborne Particles Induces Differential Nitrative Stress In Human Bronchoepithelial Cells. Oral presentation at the Annual Meeting of the American Academy of Allergy, Asthma & Immunology (AAAAI), San Diego, CA, February 28, 2014 - March 4, 2014.

Sliter, MT. But we're here to help! Buffers of the relationship between victim incivility and its outcomes. Paper presented at the 10th Annual Work, Stress, and Health Conference, Los Angelos, CA, 2013.

Sliter, MT, Kale, A, Yuan, Z. Humor as a coping mechanism for traumatic events in firefighters. Poster presented at the 28th Annual Conference of the Society for Industrial-Organizational Psychology, Houston, TX, 2013.

Sliter, MT. The relationship between victim incivility and employee outcomes in firefighters. Poster presented at the 28th Annual Conference of the Society for Industrial-Organizational Psychology, Houston, TX, 2013.

Smith, CR, **Gillespie, GL**, Beery, TA. Do adolescent employees perceive the risks of workplace violence? A mixed methods study. Paper presentation at the 2014 Annual Midwest Nursing Research Society Research Conference, St. Louis, MO, March 27-30, 2014.

Sprung, JM, Jex, SM. An examination of the work-family interface among farm couples. Paper presented at the 29th Annual Conference of the Society for Industrial-Organizational Psychology: Honolulu, Hawaii, 2014.

Zachariah. SA, **Paul, AK**, Bhattacharya, A, **Banerjee, RK**. Prediction of core body temperature, sweat rate, cardiac output and stroke volume for firefighters using a 3D whole body model. Paper presented at the 7th World Congress of Biomechanics, Boston, MA, July 6-11, 2014 (received 3rd prize in the MS student paper competition).

New Grants Funded Based on PRP Results:

Frank, E (PI). (Jagjit Yadav, faculty mentor). Genetic susceptibility to pulmonary toxicity following exposure to carbon nanoparticles. NIEHS Center for Environmental Genetics- Career Development Program: New Investigator Scholar Award, 02/2014-02/2015, $4000.

He, X (PI). How Sample location affects the Measurements for FFR Inward Leakage? NIOSH/NPPTL FY14 Innovation Grant #9277457, 01/2014–12/2014, $25,000.

Salyers, MP (PI), **Sliter, MT (Co-I)**. BREATHE-OUT Burnout Reduction: Enhanced Awareness, Tools, Handouts, and Education-Organizational Understanding and Training. NIMH R34 Research Grant, 2014-2017, $666,159.

Salyers, MP (PI), **Sliter, MT (Co-I)**. The impact of burnout on patient-centered care: A comparative effectiveness trial in mental health. PCORI, IH-1304-6597, 2013-2016, $1,506,292.

Yokota, H (PI). Mechanical loading and bone. NIH R01 AR52144, 09/01/14 – 08/31/19, $1,900,000.

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Financial support from PRP Steering Committee donors for the PRP Networking Picnic is gratefully acknowledged.

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Conflict of Interest Disclosures

Dr. Amit Bhattacharya has identified a conflict of interest as follows:

- Co-Founder, OsteoDynamics, Inc.; has equity shares. Serves on the Board of Directors and technical and Technical advisor. Does not receive monetary compensation.

Dr. Marvin Dainoff has identified a conflict of interest as follows:

- Research results were conducted as non-proprietary research by the Liberty Mutual Research Institute for Safety. All of the results have been published in the peer review literature. However, once published, this research has been utilized by the Risk Control Services group of Liberty Mutual Commercial Insurance in developing consulting services for customers.

Discussion of commercial products or services of the commercial entities will not take place in either of these presentations.

NOTES:

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Supported by: National Institute for Occupational Safety and Health (NIOSH)
Grant #: T42/OH008432-09

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