

*21st Annual*

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# UTAH NORA SYMPOSIUM

*April 20–21, 2023*

UTAH  2023  
NORA SYMPOSIUM



# Welcome Address

We are delighted by your attendance this year at our Annual NORA Young and New Investigators Symposium. This year commemorates our 21st Annual NORA Symposium and is attended by students, researchers, and professionals from around the country. We want to thank each of you for attending our symposium and bringing your expertise, knowledge, and vision to our group. We invite you to ask questions of the speakers, network with one another and develop new friendships and collaborations.

We would also like to thank Drs. Ken d'Entremont and Matt Thiese for reviewing abstract submissions, and Jessica Gardner-Yates for her efforts in taking care of everything else. Please contact [jessicagardner4@weber.edu](mailto:jessicagardner4@weber.edu) if you need anything during the symposium. This symposium is made possible in part through the generous support of the Rocky Mountain Center for Occupational and Environmental Health and funding from NIOSH (NIOSH Education and Research Center training grant T42/OH008414-16).

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# **Keynote Address**

## **A Look Back to Move Forward**

Elizabeth H. Maples PhD, CIH

As a Scientific Program Official (SPO) at the Centers for Disease Control and Prevention / National Institute for Occupational Safety and Health (NIOSH), Elizabeth brings her years of experience in safety and health to serve as an advocate for her grantees that in turn promote the field of occupational safety and health through education, research, training and outreach.

Elizabeth earned her PhD in Health Education / Health Promotion from a joint program with the University of Alabama at Birmingham (UAB) and University of Alabama. She served as the Deputy Director for the Deep South Center for Occupational Health and Safety (NIOSH ERC at UAB and Auburn University) for many years. She earned her certification in industrial hygiene through the American Board of Industrial Hygiene in 2018.

In 2022, Elizabeth received an Excellence in Workforce Diversity from NIOSH for contributions promoting the creation and support of a diverse NIOSH workforce.

As an SPO she has the privilege of working with individuals in government, academia, non-profits and other institutions committed to worker health and safety.

## **An Indoor Air Quality Pilot Project: Comparing Pre and Post Intervention Levels of PM<sub>2.5</sub> and Radon in Salt Lake County Homes**

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**Introduction:** Particulate matter can cause environmental effects such as low visibility and haze, but beyond its environmental impact it can also cause long lasting and devastating health impacts on people. Particulate matter, specifically particulate matter having an aerodynamic diameter of 2.5 microns or smaller (PM<sub>2.5</sub>) can lead to health effects such as asthma, decreased lung function, and heart attacks.<sup>1</sup> Radon is another hazard that should be controlled to prevent adverse health outcomes. Radon takes the form of a gaseous discharge that is released as part of the radioactive decay of uranium.<sup>2,3</sup> It is released into buildings from cracks in the building foundation. The presence of radon is dependent on if the ground on which a building was constructed contains uranium and/or uranium decay material. This indoor air pollutant is of major concern in western areas of the United States where geological deposits of uranium are larger compared to other areas in the country.<sup>6</sup> Radon has been cited by the EPA as the leading cause of lung cancer in non-smokers.<sup>1,2</sup> Just as preexisting health conditions and other exposures can compound the effects of PM<sub>2.5</sub> exposure, smoking and poor lung health can have an additive effect on the health outcomes of people with radon exposure.<sup>6</sup> This study was done in partnership with Salt Lake County's Green and Healthy Homes Initiative (GHHI) to test if there is statistically significant difference between average concentrations of both PM<sub>2.5</sub> and radon before and after home renovations. The goal of the County was to reduce PM<sub>2.5</sub> concentrations in the homes through these renovations. Renovations that were done through this initiative included, but were not limited to, removing old flooring (including carpet), installing new flooring, removing swamp coolers, altering walls to install central air conditioning, replacing roofing, updating electrical outlets, installing bathroom fans, and replacing windows.

**Methods:** Participants volunteered for the county's 'Green & Healthy Homes Initiative' at which point the county evaluated if they qualified for the program. The participants of that program then volunteered to be a participant in this study. Three PM<sub>2.5</sub> monitors, and two radon test kits were set up in study participant homes before any renovations were conducted. The PM<sub>2.5</sub> monitors were low cost AirU monitors that were able to collect months' worth of data, storing all data on a microSD card contained in the monitor. Three monitors were placed in each participant's home, one in the most used room, one in the bedroom, and one outside of the home. These monitors remained in the home through renovations and a few weeks afterwards. Dates of when renovations started and ended were used to categorize the collected data into the pre- renovation, during renovation, and post-renovation periods. The pre-renovation period is designated as 'Period 1' and the post-renovation period is designated as 'Period 3'. For this analysis only pre- and post- renovation observations were used. Some monitors had missing values during deployment, which appear as -1; these were excluded from analysis. All PM<sub>2.5</sub> observations were also grouped into Air Quality Index (AQI) ranges to capture what percentage of observed concentrations were in each AQI range. The radon kits were small, activated charcoal test kits that were deployed in the most used room of the home as well as the bedroom. Two kits were deployed before renovations began and two were deployed after renovations were completed. The radon concentrations were attained from radon test kit analysis. One single concentration was given for each kit. As both PM<sub>2.5</sub> and radon concentrations were being compared before and after renovations a Wilcoxon rank sum two-sample statistical test was completed for both variables. A p-value of <0.05 was used as a statistical significance comparison value.

**Results:** Between July 2nd, 2021 and December 5th, 2022 data from 27 AirU monitors, and 34 radon kits were compiled for analysis. Of the 27 monitors deployed in homes for this project, 19 monitors logged data that could be used for further statistical analysis. All other monitors either had monitor malfunctions (e.g., did not log data) or the dates that they were deployed did not line up with when renovations started and ended. Of the 19 monitors that logged data, only six (6) had usable data from both before and after renovations. The Wilcoxon test completed for the PM<sub>2.5</sub> concentrations calculated a p-value of <0.001 for all monitors. The Wilcoxon test completed for the radon concentrations calculated a p-value of 0.58 for all radon results.

**Conclusions:** The data showed a statistically significant reduction in PM<sub>2.5</sub> concentrations between pre- and post-renovation levels. The data also showed no statistically significant reduction in radon concentrations between pre- and post-renovations levels.



## Design and Testing of Obstacle-Detection Systems for Residential Riding Lawn Mowers to Reduce the Frequency of Ride-Over Accidents

Spencer Kirkham<sup>1</sup>, Andrew Youngberg<sup>1</sup>, Saud Alkhaldi<sup>1</sup>, Lowell Dixon<sup>1</sup>, Jincheng Sun<sup>1</sup>, and Kenneth d'Entremont<sup>1</sup>

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**Introduction:** Multi-acre homeowners have long benefited from riding lawn mowers to cut large areas of grass. Those with limited mobility are also assisted by such lawn mowers in maintaining their properties. Not only do motors propel the mowers and the operators, but the motors also spin the blades to cut the grass. Although these mowers are quite useful to their owners, the mowers can pose a danger to bystanders and even pets. The dangers of ride-over accidents involving residential riding lawn mowers have been seen by some citizens in the media. There have been reports of children, pets, and even the mower operators themselves of being driven over while lawns were being mowed. The data regarding such events was recently investigated in detail (d'Entremont et al., 2023). This report and its design project, through a mechanical-engineering Capstone-Design course, built upon the prior reports on lawn mowers by the U.S. Consumer Product Safety Commission (CPSC) (Adler, 1993) and (Adler & Schroeder, 2004). The work of the prior Capstone-Design team working on the same problem was presented last year (Armbruster et al., 2022). This design team continued that work, although a different approach was taken by each design team. This year's team was free to pursue a “clean sheet” design and not be bound any prior work. This is a discussion of the new work.

**Methods:** This design project employs LiDAR (light detection and ranging) as one method to detect people, pets, and other objects in the vicinity of the lawn mower. Additionally, one video camera is located above the operator to provide a 180-degree view of the area behind the mower. The mower operator is alerted to such objects through video and audio. The lawn-mower operator has a display panel with information provided by the sensor systems including a live video feed from the camera. These systems were mounted to and tested on a modern electric zero-turn radius (ZTR) lawn mower.

**Results:** The initial results of prototype testing indicate promise for these technologies to either work independently—or in conjunction with the electronics and control systems of the advanced technology seen in some current riding lawn mowers, especially the electric riding mowers.

This prototype system has not been developed to the extent necessary for mass production and use by the public. Much additional design and testing work would be needed in order to bring it to any such point.

**Conclusions:** The severity of the injuries suffered by those driven over by residential riding lawnmowers, along with the realizable promise of fitting newly developed and affordable technologies to this useful vehicle operated by many homeowners, makes such design, development, and testing projects worthy of pursuit by lawn-mower designers and manufacturers. There is no doubt that larger, better-resourced engineering-design teams will be able to find superior design using such sensors in mowers of the future.

### References:

- Adler, P. (1993). Ride-On Mower Hazard Analysis (1987-1990).
- Adler, P., & Schroeder, T. J. (2004). Hazard Analysis of Power Lawn Mower Studies: Calendar Years 2003 and 1993.
- Armbruster, R., Prescaro, R., Runyon, K., Shull, S., & d'Entremont, K. L. (2022). Design and Testing of Engineering Controls for Residential Riding Lawn Mowers to Reduce the Frequency of Ride-Over Accidents. NORA (National Occupational Research Agenda). <https://nora.mech.utah.edu/files/2022/04/NORA-Hybrid-Booklet.pdf>
- D'Entremont, K. L., Armbruster, R., & Runyon, K. (2023). The Design, Construction, and Testing of Prototype Safeguard Systems to Lower the Frequency of Ride-Over Accidents with Residential Riding Lawn Mowers [Draft].



## **Burnout Associations Using Job Demands and Resources Model Among Lawyers**

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**Introduction:** Law professionals impact many aspects of life for society. They are many aspects that they work in, these include but are not limited to, business, family lives, criminal cases, and copywriting. With so many aspects of our lives affected by lawyers, they make up a large aspect of our society. There are approximately 1.3 million lawyers who are licensed and working in the United States as of 2022 (American Bar Association, 2022). Even as this is the case there have been relatively few studies to identify how different aspects of their jobs effect their mental health. Burnout is a key issue for many occupations and professionals. To date there has been one study which looked into the association between aspects of the job and burnout among lawyers (Bergin, 2014). The Job Demands-Resources theory (JDR) for burnout explains how different demands at a job can cause somebody to lose resources while there are also aspects of life that can increase the amount of resources that a person has at their disposal. This theory can help to understand associations between different aspects of the job or of their life which could influence how much burnout is occurring.

**Methods:** A cross-sectional study of lawyers in New Jersey. A questionnaire went to law professionals in New Jersey which they were asked to fill out. We identified a few different aspects of the job which could tax resources, these being financial stress and expected work outside of normal business hours and two things which could add resources, wellbeing activities and social support at the workplace. Some example questions were” In the past month, how many hours do you work in an average week?” With multiple choice answers to follow and “How many additional hours on average do you work during the week outside of your normal business hours (e.g., 8-5 Monday through Friday, or other if your regular business hours vary from this?” There were also a couple of questions to analyse the level of burnout that a person is feeling. An example of the questions is: “I feel burned out from my work? Never, A few times a year or less, Once a month or less, A few times a month, Once a week, A few times a week, or Every day”. Using the results from these questions we will get odds ratios for these different activities for how these activities affect burnout among lawyers.

**Results:** The anticipated results will look like association measures between the different measures of resource and burnout for the lawyers. A .05 p value has been selected to measure the significance of the different associations. After gathering the results together, the anticipation is that there will be strong associations with different parts of the job and/or of their lives which change the amount of burnout a person is feeling. This will help research in the prevention and treatment of burnout by helping to associate the different factors which really change how a person feels at their job.

**Conclusions:** The conclusions that we anticipate that we will be able to draw off of this data will be first what is the prevalence of high burnout among this cohort of lawyers, and then next that certain parts of a job are associated with higher levels of burnout. We also expect to have a better understanding of what things an employee can do or what a law group can do to help their lawyers to feel less burnt out. Using the results from this study we will be able to develop longitudinal studies to see what can be done to improve the lives of lawyers.

## Using Wearable Devices and Deep Learning Models to Recognize Occupational Physical Activities

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**Introduction:** Accurately quantifying and evaluating occupational physical activities performed by workers is crucial for various purposes, including job descriptions, pre-placement/post-hire employee screening, ergonomic evaluations, and return to work purposes. Manual material handling (MMH) activities such as lifting, pushing, pulling, and carrying are associated with increased risk of work-related musculoskeletal disorders, particularly low back pain. To date, occupational physical activities (OPAs) identification and MMH measurements are often performed manually through observation and direct measurement. Although video-tracking and wearable technologies are being explored as alternatives to direct observation, research on applying these techniques to complicated work tasks is still limited. Therefore, this study utilized kinematic data and machine learning to recognize whole-body activities and upper-body activities separately. The primary objective of this study was to use wearable technology to provide a more reliable and valid approach to recognize occupational physical activities, especially for MMH tasks, so they could be identified and then further analyzed using common risk assessment tools.

**Methods:** Three participants between 18 to 65 years of age were included in this pilot study conducted in a laboratory setting. To measure the kinematics data of the whole body, 17 wireless IMU sensors (MVN Awinda and MVN Analyze, Xsens, Netherlands) were used. The participants were video recorded throughout the experimental process. Fourteen OPAs (7 whole-body activities and 7 upper-body activities) were performed by the participants, first in isolation and then in three simulated work tasks as sub-activities (sorting task, carpet laying task, and drilling task). The kinematic data collected during activities performed in isolation were used to train two deep learning models, one for recognizing whole-body activities and the other for recognizing upper-body activities. The trained models were then applied to recognize activities performed in the three simulated work tasks. Multimedia Video Task Analysis (MVTA, University of Wisconsin, IL) was used to manually label activities in the recorded task videos, which were considered the gold standard for evaluation. The MVTA results were compared with the models' predictions to calculate the models' accuracy in recognizing OPAs performed during the simulated work tasks.

**Results:** The whole-body activities recognition model reached an overall 99.0% accuracy on test data when activities were performed in isolation. When the model was utilized to recognize activities performed in the simulated work tasks, the accuracy decreased to 90.2%. The accuracy varied across activities, with sitting, symmetrical kneeling, asymmetrical kneeling, and stooping having accuracies >95%, whereas crouching had the lowest accuracy of 67%. When recognizing the upper-body activities performed in isolation, the model reached 97.5% overall accuracy. However, when the model was utilized to recognize upper-body activities performed in simulated work tasks, the overall accuracy decreased to 72.0%.

**Conclusions:** For both whole-body activities and upper-body activities, the CNN models reached high accuracy (>97%) when activities were performed in isolation. Although the accuracy decreased when recognizing activities performed in simulated work tasks, the results from this pilot study still indicate that this method has potential to accurately predict and quantify OPAs performed during a task. Most importantly, this study shows potential for using this approach in real-world environments where multiple OPAs are performed, even concurrently, to complete a job task.

**Disclosure:** Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of Liberty Mutual Insurance.

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## **Complacency Causation of Occupational Injuries in the Film and Television Industry**

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**Introduction:** In the history of film and television, accidents have occurred during shooting, such as cast or crew fatalities or serious accidents that plagued production. From 1980 to 1990, there were 37 deaths relating to accidents during stunts; 24 of these deaths involved using helicopters. From 2000 to 2020, there were 76 deaths relating to accidents during production; 132 non-fatal injuries but requiring greater than first aid treatment. Old adages such as “the show must go on” and “break a leg” suggest a cultural viewpoint leaning toward the artistic display over the safety and well-being of the performer. In the last 20 years, movie and television audiences have demanded more prominent and better entertainment leading to production companies using more FX, stunts, and risky activities to bring more bread and circuses to the masses. The idea that there is a credit for safety because it has not happened, and will not happen, swirls within the production environment among many film and television productions’ cast and crew members. However, history reveals this to be untrue.

**Methods:** Examined relevant literature to identify differences between the film industry safety climate and aspirational safety culture. There is a causal relationship between unnecessary filmmaking risks, occupational injuries and fatalities, and prevailing industry complacency. Developing and defining complacency as a bias could set the foundation for a universal tool for the production crew to risk assess and take action to mitigate hazards before filming begins. Very few published peer-reviewed journals and guidelines concerning this topic in the film and television industry, so most of the available data and literature comes from anecdotal experiences, articles, and web sources.

**Results:** This introductory review provided a better understanding of complacency and epidemiological bias through association with new terminology commonly associated with poor aviation safety culture, applied within the entertainment industry circles despite a robust safety climate.

**Conclusions:** A best practice recommendation will be used to develop a risk assessment tool widely by film and television production leaders, and validated by safety professionals, to minimize unnecessary filmmaking risk.

## **Do Time-Billing Demands Have an Association with Alcohol and Drug Abuse Among Lawyers?**

Francisco Luna BS<sup>1</sup>, Matthew S. Thiese, PhD, MSPH<sup>1</sup>, Joseph Allen, PhD<sup>1</sup>, Patrick Krill, JD, LL.M., MA<sup>2</sup>

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**Introduction:** Research on lawyer mental health has not reached great depth, but studies have revealed that this population has higher reports of depression, anxiety, stress, and alcohol and drug abuse compared to the general working population of the United States. This study identifies the relationship between time-billing stress and problematic alcohol and substance use among a New Jersey and Utah lawyer population, it also identifies the association between time-billings demands and stress and its association with alcohol and substance use.

Billable hours are defined as the time worked that an attorney could bill to the client. Within the practice of law, billable hours are recorded in six-minute intervals which is one-tenth of an hour (Campbell et al. 2012, Bergin et al. 2014). In contrast, non-billable hours can include meetings, timekeeping, research, administrative tasks, travel, etc.

**Methods:** The data collected focuses on Alcohol Use Disorders Identification Consumption Test (AUDIT-C) scores. Drug Abuse Screening Test (DAST) scores a self-report survey that measures problems related to drug misuse. Logistic Regression analyses will be performed between individual time-billing questions and DAST and AUDIT-C scores.

**Results:** Logistic regression analyses approached statistical significance between problematic drinking (AUDIT C scores =>3) and those participants that reported having a billable hour expectation set by their employer (OR 1.20, 95% CI=0.89-1.62). Analysis between those participants that reported having a billable hour expectation set by their employer and problematic DAST scores (=>4) also approached significance (OR 1.18, 95% CI=0.86 1.61). Participants of this study were asked to rate the impact billable hour requirements have on their mental well-being on a scale from 0 to 10, zero being the most positive impact, and ten being the most negative impact. Those who responded with a rating of four were found to have a statistical significance with problematic AUDIT C scores (OR 2.40, 95% CI=1.20-4.81). Statistical significance was found between the collection of fees/debts stress and AUDIT-C scores greater than or equal to 3.

**Conclusions:** Lawyers within this study who reported having time-billing demands are likely to score an eight or greater when taking the AUDIT-C. A billable hour expectation from their employer between 1850 and 2000 hours per year shows statistically significant relationship with AUDIT-C score of 3 or greater. A deeper dive into stressors related to lawyers' work and alcohol use should be investigated further. Future studies should focus on the association between substance misuse and anxiety, depression, stress, and work culture.

## Unilateral Rhabdomyolysis in a Wildland Firefighter: A Case Report

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**Background:** Rhabdomyolysis is a necrotizing muscular condition which leads to release of intracellular contents. It classically presents with muscular pain and associated swelling, dark colored urine, and elevated serum muscle enzymes.<sup>1</sup> Rhabdomyolysis may be divided into one of three causes including trauma which is the most common cause, nontraumatic exertion, and nontraumatic nonexertional injury.<sup>2,3</sup> Excess heat, from any source, may result in damage to muscle tissue.<sup>4</sup> Firefighters are at increased risk due to their prolonged exposure to increased environmental temperatures in addition to metabolic heat produced through rigorous job requirements. When muscular pain is present it is typically seen in the shoulders, thighs, lower back, and calves.<sup>2</sup>

**Case Presentation:** We described the case of a white male wildland firefighter of 18 years of age who presented for pain and swelling of his right lower extremity following an 11-day period of rigorous physical activity. The patient reported he had been working approximately 12 to 14 hours per day which required extensive physical activity including prolonged episodes of walking on uneven terrain while carrying his protective gear in temperatures often exceeding 100F where he slept outdoors overnight. On his presentation, notable asymmetry of his calves was present in addition to an antalgic gait. X-ray imaging was found to be unremarkable for osseous abnormality, and vascular ultrasound did not reveal deep or superficial venous thrombus. Laboratory analysis was notable for transaminitis, mildly elevated creatinine, in addition to significantly elevated creatinine kinase. The patient was diagnosed with pain and swelling of the right lower leg. He was then placed on work restrictions and his condition improved with rest and oral rehydration over the course of 6 days.

**Discussion:** A comprehensive PubMed search of all articles with unilateral rhabdomyolysis was conducted to assess the validity of a diagnosis of nontraumatic exertional unilateral rhabdomyolysis. The 32 results revealed 16 articles, describing 16 patients, with presentations consistent with unilateral rhabdomyolysis. Although trauma is the most common cause, nontraumatic etiologies were found in 81% of unilateral rhabdomyolysis. Pain was present in all patients who were able to endorse discomfort (15), and exertion was present as the primary cause in 44% of cases. Among the population of 11 males who were identified as having unilateral rhabdomyolysis, 55% of cases were found to be due to nontraumatic exertion.

Rhabdomyolysis classically presents with musculoskeletal pain with accompanying elevation of creatinine kinase levels which begin to rise as early as 2 hours and tend to peak by 1 to 3 days.<sup>4</sup> Acute complications include a vast array of electrolyte abnormalities which may lead to cardiac dysrhythmias and metabolic acidosis. Additional complications include compartment syndrome, acute kidney injury, and rarely disseminated intravascular coagulation. Patients with documented rhabdomyolysis were found to have a mortality rate as high as 8 percent.<sup>5</sup> Additionally, patients with rhabdomyolysis-induced renal failure following crush injury were found to have a mortality approaching 20 percent.<sup>6</sup>

Management includes early recognition with prompt fluid resuscitation in addition to discontinuing any insulting agents that may be contributing to the elevated CK values. In addition to routine laboratory analysis, CK values may be trended and in addition to compartment pressures should be diligently monitored if concern for compartment syndrome arises. Compartment syndrome may ultimately require surgical management via fasciotomy to preserve viable muscle tissue. Exertion

**Conclusion:** Unilateral rhabdomyolysis may arise from a variety of etiologies and appears to be most commonly attributable to nontraumatic rigorous physical exertion. It affects all ages, both sexes, and may lead to dire consequences if unrecognized. It is therefore critical for the clinician to maintain a low threshold of suspicion for rhabdomyolysis in the patient presenting with unilateral musculoskeletal pain.

## The Relationship Between Occupational Tasks and Musculoskeletal Disorders Outcomes

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**Introduction:** When there is an emergency, professionals who are a collective group called first responders (FRs) arrive. First Responders during these emergencies, which include everything from natural disasters to car crashes, first responders First Responders are responsible for the rescue or recovery of various persons as well as saving property (1-4). First responders are made up of firefighters (FFs), and law enforcement officers (LEOs), and emergency medical technicians (EMTs)(5). First Responders people in these occupations are exposed to many different occupational job tasks that could lead to acute or chronic stress. First Responders, similarly, throughout research, they are often categorized as one population because of the physically, mentally, and emotionally demanding nature of their jobs. Despite the similarities, FFs, and LEOs are subjected to different stimuli, stressors, and situations because of their specific roles, like musculoskeletal disorders (i.e. neck, shoulder, low back, knee).

**Purpose:** This study investigates different associations between occupational job tasks and musculoskeletal disease in FFs and LEOs.

**Methods:** This study used an anonymous online survey via Qualtrics. No identifying information was collected for complete anonymity. The first section of the survey collected demographic information, including location of the department, department setting (urban, sub-urban, rural), gender, age, ethnicity/race, height, weight, rank. The remainder of the survey comprised brief screening tools to measure four types of musculoskeletal disease (neck, shoulder, low back, and knee). These measures were selected because of previous literature, as well as for consistency and for the ability to compare musculoskeletal disease outcomes across populations similarly to other research(6). Occupational job task were identified as 1) fitness 2) equipment 3) patient lifting/ working in a car 4) fire attack/ foot pursuit 5) Other. Occupational job tasks were measured on three different scales. 1) were ranked on a scale from 1 (most difficult) to 5 (least difficult). 2) frequency of occupational job task. 3) a composite of frequency plus intensity. Crude and adjusted Odds Ratios (ORs) and 95% Confidence Intervals (95% CI) were calculated using logistic regression. An a priori list of potential confounders was created based on epidemiological data, biological plausibility, and prior research to create a final logistic regression model. An alpha level of 0.05 was used to determine statistical significance, and an alpha of 0.10 was used to determine a trend toward significance.

**Results:** 214 FFs [M = 203, F = 10, NB = 1] and 167 LEOs [M = 141, F = 20, NB = 2] complete this survey. The average age of first responders in this study was  $40.61 \pm 10.23$  (FF =  $39.94 \pm 9.46$ , LEO =  $40.31 \pm 9.89$ ), with 59.36% of the first responder identifying that work in an urban location, followed by sub-urban with 36.90% and rural with 3.73%. For FFs Shoulder showed statistically significant results for both definition 1 (crude:  $p = 0.00$ ; OR = 1.72, 95% CI [1.19 – 2.50] | adjusted:  $p = 0.00$ ; OR = 2.40, 95% CI [1.53 – 3.75] | final:  $p = 0.00$ ; OR = 2.45, 95% CI [1.29 – 4.64]) and definition 2 (crude:  $p = 0.02$ ; OR = 1.27, 95% CI [1.03 – 1.56] | adjusted:  $p = 0.01$ ; OR = 1.32, 95% CI [1.05 – 1.66] | final:  $p = 0.01$ ; OR = 1.53, 95% CI [1.07 – 2.02]) occupational job task, for all regressions models (crude, adjust, and final) for task 1 fitness. For LEOs Shoulder and Low back MSDs showed significance when measured continuously for both definitions. When occupational job task was measured by frequency (definition 1) low back (crude:  $p = 0.03$ ; OR = 1.03, 95% CI [1.00 – 1.06] | adjusted:  $p = 0.01$ ; OR = 1.04, 95% CI [1.01 – 1.08]) showed statistical significance. When occupational job task was measured by frequency + intensity (definition 2) shoulder (crude:  $p = 0.03$ ; OR = 1.01 95% CI [1.00 – 1.03] | adjusted:  $p = 0.02$ ; OR = 1.02, 95% CI [1.00 – 1.04] ) and low back (crude:  $p = 0.00$ ; OR = 1.03, 95% CI [1.01 – 1.05] | adjusted:  $p = 0.00$ ; OR = 1.03, 95% CI [1.01 – 1.05]) showed statistical significance.

**Conclusions:** Based on preliminary data, logistic regression results showed a statistically significant relationship between occupational hazard and mental health outcomes.

## Factors Impacting Symptomatic COVID-19 Infection In Pediatric Participants in the PROTECT Study

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<sup>1</sup> Pediatric Research Observing Trends and Exposures in COVID-19 Timelines (PROTECT) Study

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**Introduction:** Current literature reports that pediatric patients tend to exhibit less signs of infection, and are more likely to become asymptomatic (Nengom et al., 2023). The objective is to assess how factors such as residential air quality, household size, flu vaccination, and demographics are associated with symptomatic, lab-confirmed COVID-19 infection in a cohort of participants ages 6 months to 17 years.

**Methods:** The PROTECT study design is a cross sectional analysis of 293 participants, beginning in October, and using data from then to February 2023 for the following data analysis. Participants were assessed using weekly self-collected nasal swabs, regardless of symptoms, weekly and quarterly surveys, and voluntary quarterly blood draws. Data was pulled from all positive COVID-19 cases from Illness Surveys and PCR Positive tests, with 348 survey events collected. Surveys were administered to participants in the event of a participant tested positive or self-reported and illness. The surveys were used to determine if the child was asymptomatic or not based on the child's feedback. We are using odds ratios to assess the association between the demographic factors and positive COVID-19 tests, to determine symptomatic illness.

**Results:** Of 293 participants, with 148 being female and 145 being male, 214 have had lab-confirmed COVID-19 tests. The median age is For our analyses, we found the median household income, square footage of participants' home, and median household size. We used these medians to create a binary in our calculations, that being above and below the median, to run an odds ratio test. For example, concerning household size, we used the measurement of 1 occupant per bedroom, running odds ratio for one (or less) occupant per room and more than 1 occupant. Our median square footage was 2650 square feet. Our median household income was . Upon assessing occupants per bedroom, square footage and household income, together with receiving two doses of COVID-19 mRNA vaccines, we found that these factors did not have a significant effect on the odd of a child contracting symptomatic COVID. After running the odds ratio of each of the individual variable of interest (VOI) median, we found that odds all VOI where above a 0.05 but less than one, with a 95% confidence interval. This indicates that we are 95% confident that the selected VOI do not have an impact on whether the child will contract symptomatic COVID.

**Conclusions:** After statistical analyses, it appears that household size, number of members in family, and household income do not impact whether a child will contract symptomatic COVID-19. Using the median amount of household size/family members, participants square footage of the home, and annual income, the p-value after running odds ratios were all above a 0.05, indicating that these factors did not significantly increase the chances of a child exhibiting COVID-19 symptoms. Our findings concerning household size and square footage of home correlate with other peer-reviewed research suggesting that children are more likely to present asymptomatically and are less likely to spread it to adult counterparts, therefore lowering household transmission (Sieber, J. et al., 2023). Our cohort was limited by its lack of racial diversity, a factor that could lead to interesting findings concerning the spread of pediatric COVID-19 in minority communities. We also did not have access to many clinical findings, such as in-depth serology reviews of blood samples, which would be useful in assessing immunological factors that could contribute to symptomatic vs. asymptomatic presentation. Future studies could use the model of weekly nasal swabs and regular blood draws in a cohort similar to ours to track fluctuations in infection and contrast it with immunological data to investigate how pediatric patient's immune responses vary, with respect to specific demographic information and vaccination status.



## Noise Exposure Analysis of a Large Print Operation

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**Introduction:** While hazards are present in all workplace environments, few hazards are as prevalent and damaging as loud noise. In 2019, the Bureau of Labor Statistics estimated that 18 million workers were at risk for noise-induced hearing loss (NIHL) as a result of being exposed to damaging noise levels (1). Approximately 5% of all US workers have tinnitus which may be a long-term consequence of occupational noise exposure (2). Excessive noise exposure can lead to a variety of adverse health outcomes including hearing loss, psychological stress, and detrimental cardiovascular effects, such as dyslipidemia and hypertension which have been associated with noise exposure (3,4). We investigated a large print operation which last conducted area noise sampling in 2013. Based on these results, at-risk employees were enrolled in a Hearing Conservation Program (HCP). However, the data from 2013 are incomplete and lack a comprehensive noise map of the facility. Furthermore, several new printing machines have been installed and multiple employees have been cross-trained. The primary focus of this project is to produce an accurate noise map of the facility, develop an understanding of which employees need to be enrolled in the company's HCP, and propose solutions for mitigation of noise-related risks.

While enrollment in an HCP is only required when a worker's noise exposure is at or above 85-decibels (dBA) over an 8-hr time-weighted average (TWA), recommendations will be based on the company's noise exposure criteria of 82 dBA.

**Methods:** A sound level meter (SLM) was used to measure real-time noise levels at seven different locations in each area within the large print operation. These measurements were then used to create comprehensive noise isopleth maps for each of the seven areas requested by the client. Each noise measurement represents the maximum noise level that a worker experienced at the time the measurement was taken. Upon generation of the noise isopleth maps, three work areas were highlighted by the client for personal noise sampling as area noise sampling can underestimate exposure. Personal sampling took place on three separate days with six workers sampled on each of those days. Six workers selected by the client based on the work assignment location were given a Larson Davis Spark 705+ personal noise sampling device at the beginning of their shift. Data analyses were performed using the TWA generated by two different noise doses: OSHA-required threshold level of 80 dBA, an exchange rate of five decibels, and a criterion level of 90 dBA (Dose 1), and the larger print operation Print Shop required dose with a threshold of 76 dBA, an exchange rate of three decibels, and a criterion level of 82 dBA (Dose 2). Both doses were calculated for each personal sample and presented to the client. A noise dose based on ACGIH's noise exposure recommendations, consisting of a threshold of 80 dBA, an exchange rate of 3 dBA, and a criterion level of 85 dBA, was also calculated (Dose 3).

**Results:** Personal sampling is currently ongoing. Based on the preliminary results from the personal noise sampling, at least seven out of nine employees had a noise dose (TWA) equal to or greater than the action level. While only a few workers were exposed to noise legally requiring them to be enrolled in an HCP (85-dBA over an 8-hr TWA), enrollment in the company's HCP is recommended for most workers based on the company's internal standards. The determination of which workers are most exposed will be made once the data are fully collected and analyzed.

**Conclusions:** While the results of the area noise sampling indicated that the majority of the noise levels in the seven work areas were below the action level of 82 dBA, personal noise sampling indicated much higher noise exposure levels. This indicates employees working in the areas of personal noise sampling will likely enter the HCP while those working in other locations of the print operation would likely be removed from the HCP if previously enrolled. After the personal noise sampling and work observations are completed, possible solutions for noise exposure mitigation will be provided and discussed in the final report.

## Impact of Body Composition on Heart Rate Response to Submaximal and Maximal Effort in Firefighters

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**Introduction:** Due to the high physiological demand of firefighting, the National Fire Protection Association (NFPA) recommends a minimum aerobic capacity ( $VO_{2peak}$ ) of  $\geq 42.0$  ml/kg/min to safely perform job tasks. Common methods to assess  $VO_{2peak}$  in firefighters include a maximal treadmill test or submaximal protocols to estimate  $VO_{2peak}$  such as the Wellness-Fitness Initiative (WFI) treadmill protocol and the Forestry Step Test (FST). Recently, interest has grown in determining if  $VO_{2peak}$  is related to workability and job performance potential of a firefighter. Furthermore, prior research has indicated that body fat percentage (BF%) has been linked to poor performance on simulated firefighting tasks, and thus may be a key factor for maximizing and maintaining firefighter workability. The purpose of this study was to evaluate whether the predicted  $VO_{2peak}$  using these submaximal methods yielded different results from the direct measurement of  $VO_{2peak}$  during a maximal treadmill test in active-duty firefighters, as well as explore the relationship between BF% and cardiorespiratory response in each mode of measurement.

**Methods:** 15 (13 male, 2 female) active-duty firefighters ( $35.13 \pm 8.40$  yrs;  $1.79 \pm 0.07$  m;  $89.14 \pm 16.09$  kg) from a Midwestern metropolitan fire department volunteered to participate. Participants completed a 3-site skinfold measurement to estimate BF% followed by the submaximal FST and the WFI treadmill protocol carried out to maximal exertion. Heart rate (HR) was continuously monitored in each test with a chest strap. The post-exercise HR was used to estimate  $VO_{2peak}$  for the FST ( $VO_{2FST}$ ). During the WFI treadmill protocol,  $VO_{2peak}$  was directly measured to determine  $VO_{2peak}$  for the maximal treadmill ( $VO_{2MAXTM}$ ). Time to achieve 85% of predicted maximal HR during the treadmill test was used to estimate  $VO_{2peak}$  according to the WFI submaximal treadmill prediction equation ( $VO_{2SUBMAXTM}$ ). A repeated-measures analysis of variance (RM ANOVA) was used to determine differences between predicted and achieved  $VO_{2peak}$  for the three tests. Pearson-product correlations were used to examine the relationships between BF% and the peak HR achieved in the FST ( $HR_{FST}$ ), submaximal treadmill ( $HR_{SUBMAXTM}$ ), and maximal treadmill ( $HR_{MAXTM}$ ) protocols. An alpha of  $p < 0.05$  determined statistical significance.

**Results:** Anthropometric and aerobic capacity descriptive data (Mean  $\pm$  SD) are presented in Table 1. Results of the RM ANOVA indicated no significant difference ( $F_{1,14} = 0.615$ ,  $p = 0.446$ ) between the three measures of aerobic capacity. The correlation analysis indicated significant relationships between BF% and  $HR_{FST}$  ( $r = 0.821$ ,  $p < 0.001$ ), but no significant relationships between BF% and  $HR_{SUBMAXTM}$  ( $r = 0.110$ ,  $p = 0.695$ ) or  $HR_{MAXTM}$  ( $r = -0.235$ ,  $p = 0.398$ ).

**Conclusions:** The results indicate that  $VO_{2peak}$  measured from a maximal treadmill running protocol can be estimated from submaximal protocols of two different modes. The results also demonstrated that individuals with higher BF% may have increased heart rate during a stepping task. Given that stepping is an action that occurs frequently in the job tasks of a firefighter and that many of the service calls occur at a submaximal intensity, addressing BF% may be important in improving the workability and task efficiency in a firefighter. Further, departments that utilize a submaximal stepping test for assessment of aerobic capacity should take into consideration the potential for the task to be more maximally taxing in those with greater BF%.

Table 1. Anthropometric and aerobic capacity testing measures	
	Mean $\pm$ SD
Body Fat (%)	20.19 $\pm$ 3.49
$VO_{2FST}$ (ml/kg/min)	45.91 $\pm$ 5.84
$VO_{2SUBMAXTM}$ (ml/kg/min)	44.09 $\pm$ 4.61
$VO_{2MAXTM}$ (ml/kg/min)	44.11 $\pm$ 5.12
$HR_{FST}$ (bpm)	136.33 $\pm$ 12.16
$HR_{SUBMAXTM}$ (bpm)	155.82 $\pm$ 4.93
$HR_{MAXTM}$ (bpm)	185.60 $\pm$ 9.95

## Quantifying On-Duty Workload Across Emergency Call Types in Active-Duty Firefighters

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**Introduction:** The work demands of structural firefighting require firefighters (FFs) to respond to emergency calls throughout a 24-hour shift and, according to the National Fire Protection Association (NFPA), the responses to emergencies elicit both physical and mental demands. All emergency calls are designated as either medical emergencies (MED), like chest pain or trauma with a dual-short alert tone, or fire emergencies (FIRE), which may vary from elevator rescues to structure fires with a single, long alert tone. It is known that while both call types elicit heart rate responses following the alert tone, a FIRE alarm elicits a heightened cardiovascular response compared to a MED call. Due to emergency calls requiring higher-intensity work immediately following lower-intensity work around the station, in addition to the unexpected nature of call-timing, FFs are at a heightened risk for over-exertion injuries much like sport-athletes. Training load models have supported injury-prevention in athletic populations and quantify the loads, or demands, of training as either external, or the objective work completed, or internal, which is the intrinsic response elicited by the objective work. Despite the potential for utilizing external and internal load measures to quantify the demands of on-duty emergency responses, or workload, and support strategy-design to mitigate over-exertional injuries, these measures have yet to be applied to an examination across emergency call types. Therefore, the purpose of this study was to quantify the workload of MED and FIRE call tone responses in active-duty FFs.

**Methods:** 33 FFs (4 female;  $36.46 \pm 9.13$  yrs,  $179.92 \pm 7.02$  cm,  $91.43 \pm 12.75$  kg) donned a remote physiological strap that continuously measured acceleration and heart rate (HR) for 4-6 shifts. Time-stamped call logs were utilized to post-hoc quantify the external load of each fire tone call response as impulse load (IMPULSE), the squared sum of triaxial acceleration scaled to gravity ( $N*s$ ). The physiological internal load for each call was quantified as Edward's Training Impulse (ETRIMP), a metric derived from time spent in 5 HR-based intensity zones as a percent of maximal HR (AU). Following call completion, participants provided a rating of perceived exertion from Borg's CR-10 scale, to quantify Foster's Session Rating of Perceived Exertion (SRPE) to reflect perceived internal load (AU), and the NASA Task Load Index (TLX) to reflect an overall internal load from the weighted sum of 6 subscales (AU). Each call was designated as a MED or FIRE call tone response. All calls for each call type were averaged for a single  $IMPULSE_{MED}$ ,  $ETRIMP_{MED}$ ,  $SRPE_{MED}$ , and  $TLX_{MED}$ , and  $IMPULSE_{FIRE}$ ,  $ETRIMP_{FIRE}$ ,  $SRPE_{FIRE}$ , and  $TLX_{FIRE}$ , observation per participant. Separate paired t-tests examined for differences between MED and FIRE for all external and internal load measures. An alpha of  $p < 0.05$  determined statistical significance.

**Results:** For external load,  $IMPULSE_{FIRE}$  was significantly greater than  $IMPULSE_{MED}$  ( $t = -5.305$ ,  $p < 0.001$ ). For internal load, FIRE was significantly greater than MED for all measures, such that  $ETRIMP_{FIRE} > ETRIMP_{MED}$  ( $t = -6.324$ ,  $p < 0.001$ ),  $SRPE_{FIRE} > SRPE_{MED}$  ( $t = -3.929$ ,  $p < 0.001$ ), and  $TLX_{FIRE} > TLX_{MED}$  ( $t = -4.440$ ,  $p < 0.001$ ).

**Conclusion:** The objective work in response to FIRE call tone responses is significantly greater than MED responses. Subsequently, the physiological, perceived, and overall internal load demands to achieve the work required for FIRE call tone responses are heightened compared to MED. It is likely that greater external loads are required for FIRE call tones due to the physical work (i.e., heavy equipment use, hose dragging, etc.), as well as the need to commonly don personal protective equipment in its entirety, including breathing on air. Additionally, particularly in response to FIRE call tones that require fire suppression, the hot environment may elevate the internal responses to work. This information will be helpful in developing strategies that find ways to reduce the workload of a fire call such as examination of the personal protective equipment construction and fitness training strategies that may ultimately reduce preventable load-related injury risk in structural FFs.

Table 1. External and Internal Loads for Medical and Fire Emergencies (Mean $\pm$ SD)		
	Medical	Fire
IMPULSE (N*s)	1340.09 $\pm$ 253.74	2394.20 $\pm$ 1211.69
ETRIMP (AU)	7.91 $\pm$ 6.59	34.30 $\pm$ 27.64
SRPE (AU)	22.92 $\pm$ 20.93	246.92 $\pm$ 319.52
NASA-TLX (AU)	248.94 $\pm$ 196.99	496.66 $\pm$ 295.78

## Diesel Particulate Matter (DPM) Concentrations in Two Unified Fire Authority (UFA) Fire Stations in Salt Lake City

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**BACKGROUND:** Occupational exposure to diesel particulate matter (DPM) is a significant concern for firefighters<sup>1</sup>. DPM is a primary component of diesel exhaust (DE) generated by the large amount of diesel-powered equipment used in fire stations. DE exposure has been linked to multiple acute and chronic health effects including respiratory, dermatologic, and cardiovascular diseases, as well as an increased risk of certain cancers, such as lung and bladder cancer<sup>2</sup>. The United States has no Occupational Safety and Health Administration (OSHA) (i.e., legally enforceable) DE exposure limit for firefighters<sup>3</sup>. This apparent oversight may, in part, be due to a relative lack of study on DE exposure in fire stations. The objective of this study is to measure DPM levels in two Unified Fire Authority (UFA) fire stations in the Salt Lake Valley. The purpose of these measurements is two-fold: (a) to evaluate whether a newer station design reduces DPM exposure compared with an older station design, and (b) to better characterize fire station DPM exposure in general. Identifying the amount of DPM exposure, as well as differences in exposure between the two stations, has the potential to enable data-driven control and mitigation measures for this hazardous substance, ultimately helping to promote the health of firefighters.

**Methods:** DPM sampling was performed according to the National Institute for Occupational Safety and Health (NIOSH) Method 5040 (Diesel Particulate Matter (as Elemental Carbon)) protocol<sup>3</sup>. Sampling was performed at two UFA fire stations selected by UFA, station 109 (an older station) and station 125 (a newer station). Twenty samples were taken across both UFA stations and were consistently placed in one of five distinct locations at each station: the vehicle bay, outside the station, the living quarters, the sleeping quarters, and the interior of a fire truck. Air samples were sent to ALS Environmental Labs to be analyzed using NIOSH Method 5040<sup>3</sup>.

**RESULTS:** DPM concentrations from sampled air in the two stations will be organized and presented in tables, along with associated analytical errors. Concentrations will be compared to similar studies in the literature<sup>4</sup>.

**Conclusion:** Using DPM as a surrogate for DE, the data generated will be used along with a review of published literature on DE risks and control measures to inform our firefighter clients regarding potential DE-associated health risks at the involved fire stations and, if exposure is significant, to propose short- and long-term control and mitigation strategies.

### REFERENCES:

1. Bott RC, Kirk KM, Logan MB, Reid DA. Diesel particulate matter and polycyclic aromatic hydrocarbons in fire stations. *Environ Sci Process Impacts*. 2017 Oct 18;19(10):1320-1326. doi: 10.1039/c7em00291b. PMID: 28861557.
2. IARC: Diesel Engine Exhaust Carcinogenic. Press Release. 2012. Available at: [https://www.iarc.who.int/wp-content/uploads/2018/07/pr213\\_E.pdf](https://www.iarc.who.int/wp-content/uploads/2018/07/pr213_E.pdf)
3. Andrews, R., & O'Connor, P. F. (2020). NIOSH manual of analytical methods (NMAM). Diesel Particulate Matter (as Elemental Carbon). <https://www.cdc.gov/niosh/docs/2003-154/pdfs/5040.pdf>
4. Payne RL, Alaves VM, Larson RL, Sleeth DK. An evaluation of diesel particulate matter in fire station vehicle garages and living quarters. *Journal of Chemical Health and Safety*. Volume 23, Issue 4, 2016, Pages 26-31, ISSN 1871-5532, <https://doi.org/10.1016/j.jchas.2015.10.020>.

## The Relationship Between Occupational Hazards and Mental Health Outcomes

Uchenna C. Ogonnaya<sup>1,2</sup>, Brian M. Zuleger<sup>3</sup>, Joseph A. Allen<sup>1,2</sup>, Jeremy J. Biggs<sup>1,2</sup>, Matthew S. Thiese<sup>1,2</sup>

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**Introduction:** In times of emergency, any combination of first responders—a collective term for those occupations that respond to and ensure the recovery of people and property from disasters—can potentially respond (1-4). First Responders are typically made up of Firefighters (FFs), and Law Enforcement Officers (LEOs)(5). Firefighters, and LEOs are different occupations but are often called First Responders. This is because they typically all respond to emergencies, natural or manmade. Similarly, throughout research, they are often categorized as one population because of the job's physically, mentally, and emotionally demanding nature. Outside of these collective situations, Firefighters, and LEOs are subjected to different stimuli, stressors, and situations because of their specific job, like negative mental health outcomes (i.e., depression, post-traumatic stress disorder (PTSD), anxiety, and burnout).

**Purpose:** This study looks to investigate different associations between occupational hazards and mental health outcomes in FFs and LEOs.

**Methods:** This study used an anonymous online survey via Qualtrics. No identifying information was collected for complete anonymity. The first section of the survey collected demographic information, including location of department, department setting (urban, sub-urban, rural), gender, age, ethnicity/race, height, weight, rank. The remainder of the survey was comprised of brief screening tools to measure 12 psychosocial constructs (posttraumatic stress disorder, generalized anxiety disorder, drug use, depression, burnout, work engagement, satisfaction with life, alcohol use, job satisfaction, sleep quality). These measures were selected because of previous literature, as well as for consistency and for the ability to compare negative mental health outcomes across populations similarly to other research(6). Occupational hazards measured in this study were 1) traumatic calls 2) losing a child 3) losing a crewmate 4) hypervigilance/dealing with family on scene 5) Other. Occupational hazards were measured on three different scales. 1) were ranked on a scale from 1 (most difficult) to 5 (least difficult). 2) a composite of 2\* frequency plus intensity. 3) a composite of frequency plus 2 \* intensity. Crude and adjusted odds ratios (ORs) and 95% Confidence Intervals (95% CI) were calculated using logistic regression. An a priori list of potential confounders was created based on epidemiological data, biological plausibility, and prior research to create a final logistic regression model. An alpha level of 0.05 was used to determine statistical significance, and an alpha of 0.10 was used to determine a trend toward significance.

**Results and Discussion:** Results: A total of 214 FFs [M = 203, F = 10, NB = 1] and 167 LEOs [M = 141, F = 20, NB = 2] complete this survey. The average age of first responders in this study was  $40.61 \pm 10.23$  (FF =  $39.94 \pm 9.46$ , LEO =  $40.31 \pm 9.89$ ), with 59.36% of the first responder identifying that work in an urban location, followed by sub-urban with 36.90% and rural with 3.73%. Firefighters scored worse than LEOs for DAST2, MWA, SWLS, Job task satisfaction, and supervisor support satisfaction. Law enforcement officers scored worse than firefighters for SPRINT8, PHQ9, BURNOUT, UWES3, Audit3, GAD7, and PROMIS. For FFs, on average occupational hazard 3, losing a life of a crew member or another FFs on a call was ranked as the most difficult occupational hazard with an average rank of  $1.14 \pm 0.64$ , FFs identified that occupational hazard 4, dealing with family or the public at the emergency was the most frequent or common occupational hazard that is experienced with the average frequency score of  $3.62 \pm 0.95$ , and occupational hazard 3, losing a life of a crew member of a another FFs is on average the most intense occupational hazard with an average intensity score of  $9.25 \pm 1.60$ . For LEOs on average occupational hazard 3, losing a life of a crew member or another law enforcement officer on a call was ranked as the most difficult occupational hazard with an average rank of  $1.61 \pm 0.86$ , LEOs identified that occupational hazard 4, extreme hypervigilance was the most frequent or common occupational hazard that is experienced with the average frequency score of  $3.69 \pm 1.15$ , and occupational hazard 3, losing a life of a crew member of a another LEOs is on average the most intense occupational hazard with an average intensity score of  $9.02 \pm 1.88$ .

**Conclusions:** Based on preliminary data, logistic regression results showed a statistically significant relationship between occupational hazard and mental health outcomes.

# **Annual Dr. Paul S. Richards Endowed Distinguished Visiting Lectureship in Occupational Medicine**

**The Future of Occupational Health: How Changing Technology, Work Arrangements,  
and Environments Are Changing Our Practice**

**Carisa Harris-Adamson PhD, CPE**

Carisa Harris, PhD, CPE, is an Associate Professor in the Department of Medicine at the University of California at San Francisco. She is the Director of the Northern California Center of Occupational & Environmental Health in the School of Public Health at the University of California at Berkeley and the Director of the UCSF/UCB Ergonomics Research & Graduate Training Program. She received her PhD in Environmental Health Sciences at the University of California, Berkeley, and teaches a variety of classes including Occupational Biomechanics and Industrial Engineering Human Factors Design.

Dr. Harris and her team perform research in a variety of areas focused on understanding and preventing work-related injuries and improving human performance, productivity, and health. Her epidemiological research assesses and adjusts for healthy worker survivor bias in the assessment of physical, personal, and work psychosocial factors associated with musculoskeletal disorders and subsequent work disability.

Additionally, her team is developing a variety of exposure assessment devices (wearables) for primary and secondary prevention purposes and performs various intervention studies on occupational tasks with high risk of musculoskeletal injuries. The implementation of passive exoskeletons in the construction industry is an additional focus. The lab performs various types of research in the construction, computer, medical, hotel, janitorial, and manufacturing sectors. From a global health perspective, Dr. Harris collaborates on research assessing the impact of heavy load carrying among women in developing countries (Nepal, Tanzania, Ethiopia) on associated morbidity.

## Vaccine Protection Against SARS-CoV-2 Illness Duration and Symptom Severity in a Utah Population of Healthcare Workers, First Responders, and Other Frontline Workers

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**Introduction:** Since March 2020 when the first case of COVID-19 was reported in Utah, the evolution of the SARS-CoV-2 virus over the course of the pandemic resulted in the emergence of four variants of concern and five major types of vaccines to this date. After initial vaccine implementation, there were strong data on efficacy to reduce risk of infection, hospitalization and fatalities (Nasreen et al., 2022). However, recent data have increasingly questioned the value of the effects of booster doses. Additionally, there is limited research on the vaccines' protection against illness severity as opposed to the presence or absence of symptoms. The object of our study is to broaden the understanding of how vaccination status impacts illness length and symptom severity through a long-term study involving a large population of healthcare workers, first responders, and other frontline workers.

**Methods:** We analysed survey responses from 551 SARS-CoV-2 PCR-positive illness events at the Utah site of the Research on the Epidemiology of SARS-CoV-2 in Essential Response Personnel (RECOVER) Study. This is a multisite prospective cohort study including healthcare workers, first responders, and other frontline workers. Data were extracted from two surveys sent out to RECOVER participants: (1) the Acute Illness Survey, delivered when participants test positive or report experiencing COVID-19 like symptoms, and (2) the Illness Recovery Survey, delivered when symptoms end or when their reported health percentage is greater than 80/100. We compared vaccination status at the time of infection to survey responses regarding the symptoms experienced, duration of symptoms, and the severity measured on a scale of 0-100 on the worst day of their illness. The four statuses used were; vaccinated with an initial dose, vaccinated with at least one booster dose, unvaccinated, and repeat infection (a 2nd, 3rd, or 4th infection).

**Results:** Of the 551 illness events, 150 (27%) illness events occurred in people vaccinated with an initial dose only, 229 (42%) occurred in people vaccinated with at least one booster dose, 87 (16%) occurred in unvaccinated people and 85 (15%) were a 2nd, 3rd, or 4th infection. Survey responses from people vaccinated with an initial dose reported on average 9.1 symptoms per illness (SPI), a health rating (HR) on the worst day of the illness of 39.6/100, and an average illness duration (ID) of 10.6 days. Survey responses from people vaccinated with at least one booster dose reported on average 8.5 SPI, an HR 43.5/100, and an average ID of 12.5 days. Survey responses for unvaccinated people's illness events reported on average 8.1 SPI, an HR of 45.4/100, and an average ID of 9.5 days. Survey responses for repeat symptomatic infection events reported on average 6.2 SPI, an HR 57.5/100, and an ID of 9.0 days.

**Conclusions:** From the results of these data, repeat symptomatic infection event respondents clearly reported fewer and less severe symptoms and a shorter illness duration than illness events in vaccinated and unvaccinated people. Additionally, survey responses to illness events in unvaccinated people report fewer and less severe symptoms and a shorter illness duration than vaccinated people. These results may suggest there is a hybrid immunity effect in people who have been vaccinated and had SARS-CoV-2 previously. It is important to note that using survey data to draw conclusions on vaccine efficacy is extremely difficult as all survey responses are inherently biased but these results can inform us of how different groups experienced their COVID-19 illness.



## The Relationship of Socio-Economic Status to COVID-19 Vaccination Status, Infection Rate and Long COVID Symptoms Within the Utah RECOVER Study Population

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**Introduction:** Lower Socioeconomic Status (SES) can lead to worse health outcomes for many medical conditions (Dobbs, 2022). Evidence shows individuals in the low SES category experience higher levels of COVID-19 infection (Chen et. al, 2021). A COVID-19 infection may have prolonged symptoms beyond the initial acute symptoms, colloquially termed “Long COVID” (LC). The COVID-19 vaccines appear to provide an effective method of protection from infection (Notarte, 2022). This study aims to examine the relationship between SES and LC among vaccinated participants in the Utah site of the Research on the Epidemiology of the SARS-CoV-2 in Essential Response Personnel (RECOVER) study.

**Methods:** We analyzed data of 811 workers from RECOVER study, a multisite prospective cohort study of Healthcare Workers, First Responders and Essential Workers. Demographic information and LC data were collected from enrollment and follow-up surveys. LC was defined as symptoms that persisted  $\geq 4$  weeks. Vaccination status was confirmed through participant vaccine card submission, electronic medical records and/or the state registry. Infection data was obtained from weekly reverse transcription-polymerase chain reaction (RT-PCR) testing for instances of 1 COVID-19 infection or multiple ( $\geq 2$ ). In this cross-sectional analysis (October 25, 2020 to January 24, 2023), we calculated unadjusted odds ratios (ORs) to examine differences in vaccination status, booster status and LC symptoms between different socioeconomic factors. Participants were grouped into two categories of annual household income: 1) High-Income ( $> \$50,000$ ,  $n = 197$ ) and 2) Low-Income ( $\$0 - \$49,999$ ,  $n = 534$ ). Household income surveys reported 5 different income categories: ( $\$0 - \$24,999$ ), ( $\$25,000 - \$49,999$ ), ( $\$50,000 - \$74,999$ ), ( $\$75,000 - \$99,999$ ), and ( $\$100,000+$ ). The midpoint of each category was assumed as the household income for all participants. This value was then divided by the number of household members, yielding an adjusted household income. Additionally, participants were categorized based on the level of educational attainment: 1) high school education or below ( $n = 44$ ), 2) some college education ( $n = 181$ ), 3) college degree ( $n = 370$ ) and 4) a graduate or professional degree ( $n = 216$ ). For these analyses, the graduate or professional group was used as the comparison group.

**Results:** The low-income group were more likely to be unvaccinated (OR = 2.7, 95% CI 1.6, 4.6) and experience multiple infections (OR = 1.8, 95% CI 1.0, 3.0) when compared to the higher-income group. For educational attainment, those with some college education and those with a college degree were more likely to be unvaccinated (Odds ratio = 3.2, 95% CI 1.8, 5.8; OR = 2.5, 95% CI 1.5, 4.3), less likely to receive a booster shot (OR = 4.2, 95% CI 2.5, 7.0; OR = 2.6, 95% CI 1.7, 4.1) and more likely to report LC symptoms (OR = 4.2, 95% CI 1.9, 9.2; OR = 3.2, 95% CI 1.5, 6.7). Participants with a high school education or below were more likely than the comparison group to be unvaccinated and/or not boosted (OR = 5.9, 95% CI 2.7, 12.8; OR = 3.9, 95% CI 1.7, 8.9). These participants were more likely to report LC symptoms (OR = 2.3, 95% CI 0.7, 7.8), but this relationship was not significant ( $P = 0.1828$ ).

**Conclusions:** Within our study, lower SES may be associated with decreased likelihood of vaccination and increased likelihood of multiple infections. Furthermore, it appears that lower SES may have increased odds in developing LC symptoms. These results indicate a potential association between lower SES and vaccination status, which may be a contributing factor towards increased COVID-19 related illness among this population. More research is needed to understand the drivers leading to this difference in vaccination status, in an effort to reduce this disparity.

## Demographic Factors and Symptoms Associated Long-COVID in Children and Youth in the Utah PROTECT Cohort.

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**Introduction:** While Long-COVID has been observed in adult populations, there is limited literature on observing the prolonged illness in pediatric populations. Existing literature almost exclusively focuses on children hospitalized for COVID-19, but not all COVID-19 diagnoses in children lead to hospitalization. Our The Utah Pediatric Research Observing Trends and Exposures in COVID-19 Timelines [PROTECT] cohort consists of unhospitalized children and youth between the ages of 6 months and 19 years. Furthermore, none received medical treatment for COVID-19, despite a majority testing positive for COVID-19 since October 2021. The objective of this study is to observe COVID-19 trends and assess vaccine effectiveness in a pediatric population.

**Methods:** The study design is cross sectional, beginning in October 2021 and continuing until the present. Long COVID symptoms data were gathered from a study-specific pediatric Long COVID survey which was distributed to all participants who had tested positive for COVID-19 via PCR nasal-swab test. Parents/guardians responded to the survey per IRB guidance. Long COVID was defined as symptoms [refer to Table 1 - list out symptoms in table] persisting greater than or equal to 4 weeks since onset of initial infection. Odds Ratios (OR), confidence intervals, and p-values were calculated using Python software according to guidelines set in reference 1.

**Results:** Of the 293 active participants between the ages of 6 months and 19 years, 214 tested positive for COVID-19 (confirmed by Reverse-Transcriptase Polymerase Chain Reaction [RT-PCR] test) from October 21, 2021 to February 28, 2023. Of those that tested positive, none reported hospitalization or receipt of medical treatment for the infection. 195 responded to the Long COVID survey and 10 indicated that their child had experienced symptoms related to COVID-19 for at least one month following their positive COVID-19 test. Among these 10, the median age was 5 years and 3 months, (compared to 8 years and 7 months in the study population), 5 were female (50.5%). We assessed association of demographic factors with the odds of developing Long COVID-19. Sex, age, race, ethnicity, and household income were not found to be statistically significant on whether a child developed Long COVID symptoms. Those who did not attend in-person school or day-care had an OR of 5.031 (95% confidence interval of 1.38 - 18.37) relative to those who did. Those who did not have two or more doses of a COVID-19 mRNA vaccine at the time of their initial infection had an OR of 6.107 (CI: 1.27 - 29.29) relative to those who were vaccinated. For those 10 participants reporting Long COVID-19 symptoms, the most common symptom was a cough (70%) (See figure 1).

**Conclusions:** Demographic factors did not demonstrate association to the development of Long COVID. Interestingly, in-person school or day-care attendance and receipt of at least 2 doses of COVID-19 mRNA vaccine decreased the odds that a child would develop Long-COVID-19 after initial infection. Strength of our study is [RT-PCR infection confirmed, one of the early studies reporting long covid in kids, etc]. Limitations to this analysis includes small sample size (n=10) with majority of children <1 years of age which impacts in- person school/day-care attendance and vaccination status. Future studies will need to take into consideration a child's age as their exposure, immune profile, and vaccine access may be different across age groups.

## Validation of an Accelerometer-Based Inclinometer for Measuring Shoulder Elevation Angle during a Simulated Industrial Working Task

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**Introduction:** Work-related musculoskeletal disorders (WRMSD), and in particular those involving the upper extremity (UE) are widespread and their highest prevalence is reported in occupational sectors characterized by highly repetitive tasks and prolonged time spent in non-neutral postures such as metalworkers, assemblers and welders which reports respectively 40.8%, 38.7% and 29.3% of the total UE injuries. Due to the relevant impact of such conditions in terms of socioeconomic burden, there is an increasing interest in the research community in systems/devices able to provide quantitative data on the main factors involved in the biomechanical risk. In this context, the use of wearable inertial sensors (IS) appears of particular interest due to their small size, low cost, and possibility to record data on-board. Thus, the aim of this study was to evaluate the accuracy of arm elevation angle measured with a single tri-axial accelerometer fixed on the humerus, through comparison with an optoelectronic motion capture system, during a simulated industrial working task, and to validate the method for future analysis in the field.

**Methods:** Twelve healthy young adults (mean age 26 years), recruited among the students of the University of Cagliari, were asked to manually tighten and untighten 6 nuts on bolt in a straight-line pattern, using a wrench, at a self-selected speed, in a laboratory environment. A single tri-axial accelerometer (ActiGraph wGT3X-BT LLC, Pensacola, Florida, USA), located on the dorsal side of the distal humerus, was used as inclinometer to estimate upper arm elevation angle with respect to the gravity vector. An optoelectronic motion capture system (OPTO) was used to evaluate the accuracy of IS data, through a cluster-based upper body module. Four small reflective spherical markers were attached at each vertex of the square shape cluster; the IS was located at the center of the cluster having its vertical axis (y-axis) aligned with the longitudinal axis of the humerus (Figure 1a). From accelerometer raw data, IS shoulder elevation angle was calculated as:

$$\text{IS angle} = \cos^{-1} \frac{a_y}{\sqrt{a_x^2 + a_y^2 + a_z^2}}$$

Marker coordinates were used to create a reference system integral with the cluster and then calculate OPTO shoulder elevation angle as the angle between the vertical vector of the initial reference system and the one from the cluster reference system, at any given time. To evaluate the accelerometer accuracy in quantitatively assess exposure to biomechanical risk factors, IMU and OPTO signals were processed to calculate the duration of the task spent with a shoulder elevation angle between 20° and 60° and up to 60°.

**Results:** The results showed a good accuracy of the accelerometer in the estimation of shoulder elevation angle, during the working task; between subjects, the maximum angular variance observed was less than 10° (Figure 1b). The analysis on the duration of the task spent with a shoulder elevation angle up to 60° revealed a maximum percent variance between IS and OPTO measures of 6.36%; the computed maximum and minimum accelerometer error was 12.89 and 2.03 seconds respectively.

**Conclusions:** The main purpose of this study was to evaluate the accuracy of arm elevation angle measured with a single tri-axial accelerometer, through comparison with an optoelectronic motion capture system. This approach was hypothesized suitable to provide a set of time parameter useful to better define the exposure to physical factors associated to the development of UE-WRMSD. The results obtained demonstrated the potential use of accelerometer-based inclinometers to evaluate the exposure to biomechanical risk factors in a real working environment.

## **Worst-Case Noise Isopleth Mapping and Risk Assessment of Engineering Composites Manufacturing Company Assembly Area**

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**Introduction:** Noise, unwanted sound, is emitted during pressure changes in the air from a vibrating source. Noise exposure is measured using A-weighted decibels (dBA), a noise range subjective toward sounds at higher frequencies, to which the human ear is more sensitive. At a Utah engineering composite manufacturing company, the assembly of aircraft composites generates a potentially hazardous noise. As a rule of thumb, when conversing with someone at arm's length, if people must raise their voices to be heard, the noise is understood to be at or above 85 dBA. Noise greater than a time-weighted average (TWA) of 85 dBA over an 8-hour period is considered hazardous by the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA). Workers exposed to noise exceeding the 85 dBA threshold, are required to participate in OSHA's Hearing Conservation Program (HCP) mandates. However, small decibel reductions cause a logarithmic decrease in the intensity of noise exposure. Any reduction can cause substantial prevention of hearing loss and other noise-related health effects. Worst-case noise exposure was measured to characterize the hazard and risk to workers' hearing and exposure controls will be suggested in line with the unique requirements of their manufacturing environment.

**Methods:** Three isopleth maps will be constructed at the beginning, middle, and end of the 10-hour shift. Ten-by-ten-foot grids were drawn onto a map of the 190 ft by 90 ft assembly area, creating 152 boxes. The team used a Larson Davis SLM LxT1 Sound Level Meter (SLM) to take three noise measurements in the middle of each box and averaged for a single value. Heat maps were created through computer software and analyzed for high decibel "hot spots" and differences across each map.

**Results:** Preliminary data analysis suggests that the assembly area is largely under the OSHA 85 dBA action level, meaning the exposed workers would not qualify for Hearing Conservation Program enrollment. However, there are highly populated work areas where assembly tasks and tools produce more noise. These noise exposure hot spots are the areas of greatest concern moving forward with the analysis. In some of these areas, not only production noise contributes to the worker exposure, but also workers' loud music and machines such as forklifts.

**Conclusions:** Further analysis must be done to determine if the three maps represent actual and expected noise levels during worst-case noise exposure. After making this determination, the research team will offer recommendations to the engineering composites company.

### **References:**

- [1] NIOSH. 2021. Occupational Hearing Loss (OHL) Surveillance. National Institution for Occupational Safety and Health. Retrieved at: <https://www.cdc.gov/niosh/topics/ohl/default.html>
- [2] OSHA (1983) 'Occupational Noise Exposure: Hearing Conservation Amendment; Final Rule', Fed Reg. Washington, D.C.: US Department of Labor, pp. 9738–9785.