Investigating Environmental Factors in Aerosols

Focused on posture & intensity of HHCWs

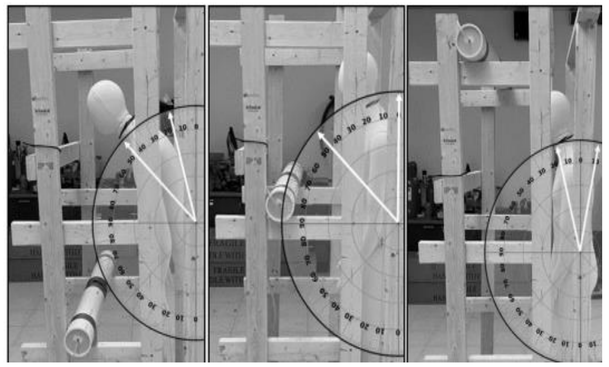
PI: Bellacov, Ryan Mentor: Dr. Kermit Davis

Building off UC prior research

Eturki (2019)

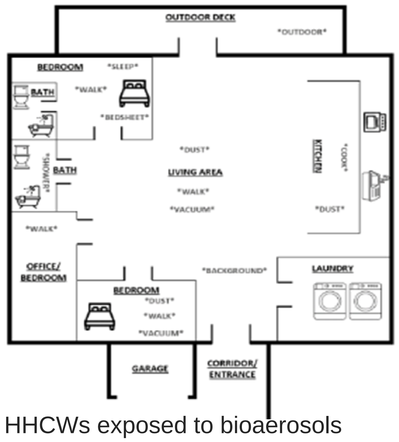
Wind affects exposure

Whitehead 2020



Distance to source of pollutant

Vishal (2022)



HHCWs exposed to bioaerosols

Significance:

What if we are underestimating dose?

Figure 2. Venn diagram of Search Results on Exposure Factors

Lit Review:
-50,0000 publications

7 postures

Intensity of work

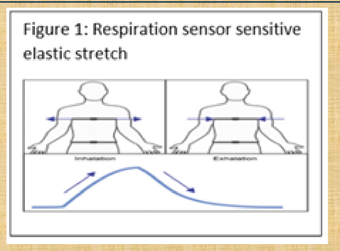
Approach

(30 subjects)

Dependent variables

Independent variables

Lung volume



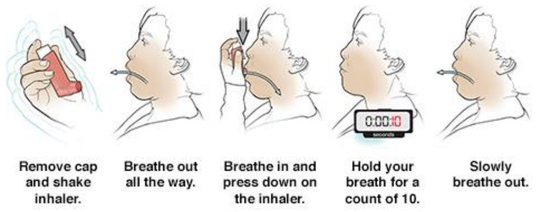
Rib cage expansion

Varies physiological parameters

Expected Results: Intensity of work will have the most significance

Research to Practice (Expanding into Future)

Verify and estimate the dose



Exposure to the HHCW with inhaler?

Acknowledgements

Our team would like to thank the National Institute of Occupational Safety and Health (#T42OH008432) for funding this study.
Finally, thanks to the faculty members which were involved in the creation of this study.

Researcher:

Ryan Bellacov

Ph.D. candidate at University of Cincinnati

References

Mental Health and Suicide Risk Among Veterinarians

Afton Erbe, MPH, PMHNP-BC
University of Cincinnati

Introduction

- 9.7% of veterinarians experience serious psychological distress, which is a key predictor for suicidal thoughts [1,2]
- Women veterinarians experience higher levels of psychological distress and over 60% of the veterinarian workforce is female [3]
- Veterinarians are approximately three to seven times more likely to attempt suicide in comparison to the public [4,5]
- 1 in 6 veterinarians have contemplated suicide [6]

Relevance to NORA

- Individuals working in the veterinary industry are considered a high-risk, understudied population for mental health, suicidal ideation, and suicide attempts [7]

Study Plan

- *Study Design.* Cross-sectional survey with demographic questions and questions on burnout, substance abuse, anxiety, depression, and suicidal ideation
- *Setting and Sample.* Veterinarians licensed in the United States will be recruited via the American Veterinary Medical Association mailing list, state licensing boards, and social media
- *Measurements/Instrumentation.*
  - Copenhagen Burnout Inventory
  - Tobacco, Alcohol, Prescription medication, and other Substance use Questionnaire
  - General Anxiety Disorder Questionnaire
  - Patient Health Questionnaire
  - Columbia Suicide Severity Rating Scale
- *Procedures.* Surveys will be mailed to the address on file with the AVMA or licensing board or a REDCap survey will be distributed via social media. The survey will take approximately 40 minutes. Double data entry will occur to ensure integrity. An insert identifying the Suicide and Crisis Lifeline, Crisis Text Line, and Not One More Vet, which has additional mental health referrals, will be included in the survey packet
- *Data Analysis.* A path analysis will be done to determine if there are causal relationships between the variables

Impact of Results

- Obtain a baseline understanding of overall mental health among U.S. veterinarians that can be used in future interventional research to mitigate and prevent suicides among this population

Future Funding

- Potential for federal R01 funding to complete a longitudinal study to track mental health changes and outcomes among this population

Acknowledgements

- This research study was supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432

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Cool Coat: An Advanced Wearable Thermal Management Solution for Harsh Environment

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Background

- Workers are often exposed to harsh environments with extreme temperatures, posing **serious risks to their health and safety**[1].
- The Cool Coat project utilizes **carbon veil fabric**, known for its high thermal conductivity, combined with **thermoelectric cooling** sources and fans to create wearable garments for efficient thermal management.
- This innovation aims to enhance comfort and productivity for workers in **harsh environments**, potentially benefiting first responders and military personnel in hot conditions.

Objectives

- Demonstrate the Cool Coat concept integrating carbon veil fabric, fans, and thermoelectric coolers with a focus on user comfort and functionality.
- Compare performance between Cool Coat and a control coat, **analyzing temperature, efficiency, and wearer comfort.**
- Evaluate the effectiveness of the Cool Coat in **cooling distribution.**
- Identify **areas** for improvement for future iterations.

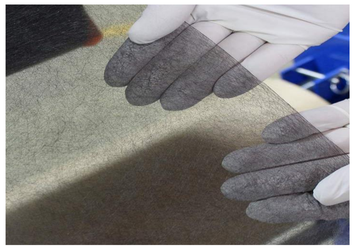
Research Design and Methods

Design & Fabrication: Introducing the Cool Coat with integrated carbon veil fabric, thermoelectric elements, and controlled by an app, alongside a basic control coat for comparison.

Experimental Setup: Using infrared cameras, the performance of both coats is assessed during light, medium, and heavy exercise scenarios.

Data Analysis: Detailed evaluation of the Cool Coat's thermal efficiency and comfort against the control coat with statistical insights.

Preliminary results

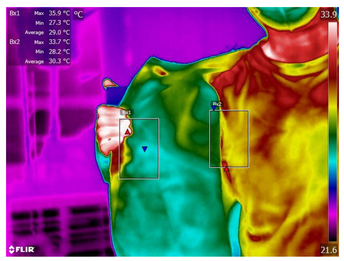


Carbon veil fabric

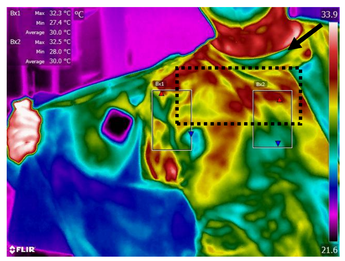
Thermoelectric device

Fans jacket

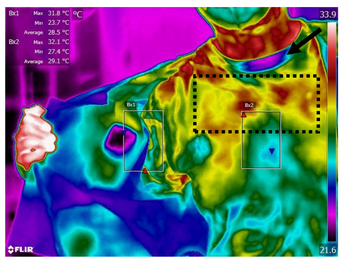
Infrared camera FLIR T640



No cooling



No carbon veil + cooling



Carbon veil + cooling

Expected results

- Cool Coat shows superior thermal management compared to control coat, **regulating temperature and reducing heat risks.**
- Novel approach of **wearable thermal management** utilizing carbon veil, thermoelectric devices, and fans.
- Potential to transform personal thermal management with **a cost-effective, lightweight, and user-friendly design.**
- Prospect of influencing future wearable tech advancements, **boosting safety and health** in demanding conditions.

Future directions

- Scale up production exploration
- Real-time temperature tracking and notifications.

Acknowledgement

This research study is supported by the NIOSH through the PRP Training Program of UC ERC Center Grant G100122.

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2. Chen et al, Aiha Journal 643 (2003): 352-359.

Developing Electromagnetic Shielding Textile for Personal Protection

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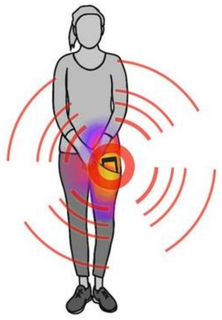
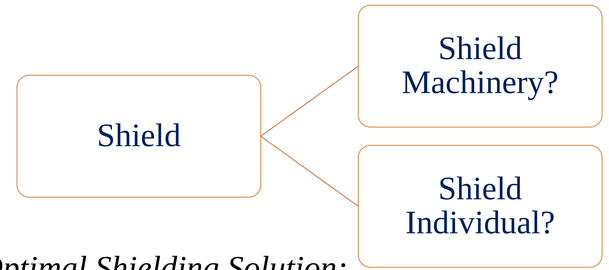
Correspondence: giriph@mail.uc.edu (P.G.); schulzmk@ucmail.uc.edu (M.S.)

Introduction

- Electromagnetic Fields (EMFs) are classified as possible 2B Group human carcinogens by International Agency for Research on Cancer [1,2].
- Pathological syndrome in humans called electro-hypersensitivity (EHS) or 'microwave syndrome' that causes a headache, anxiety, sleep disorders, fatigue, etc. have increased massively in the last decades which could have been associated with increased EMFs due to the excessive developments in electronic devices [3-5].



Methods



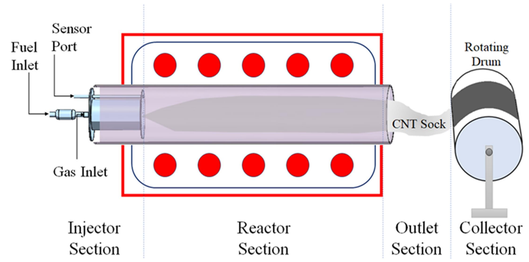
Optimal Shielding Solution:

Manufacture Electronic Devices using Lightweight Shield.

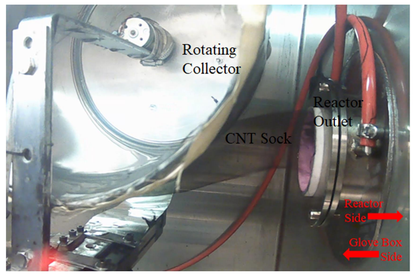
Use flexible shield to prepare PPE for individuals working in radiative environments such as radiology labs and radio towers to ensure occupational safety.

Obtained Results

- FCCVD Reactor system available at Nanoworld Laboratories was used to manufacture thin and lightweight CNT sheet hybrid composites.



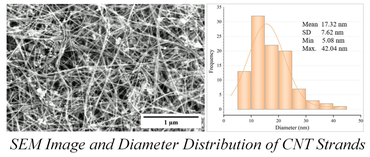
Schematics of FCCVD Reactor



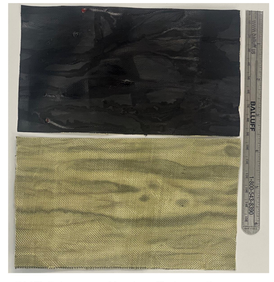
CNT Sheet Synthesis in FCCVD Reactor

- Pristine CNT sheets, CNT-silicone composite sheets, and CNT-silicone/Kevlar composite sheets were manufactured.
- The sheets have a dimension of 90cm × 25cm. The thickness of the pristine sheet was 20µm, CNT-silicone sheet was 22µm, CNT-silicone/ Kevlar Fabric was 116µm, CNT-silicone/ Kevlar Yarn was 435µm, CNT/Kevlar Veil was 90µm, and CNT-silicone/Kevlar veil was 95µm.

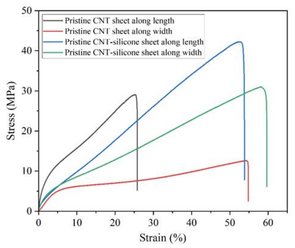
Pristine CNT Sheet



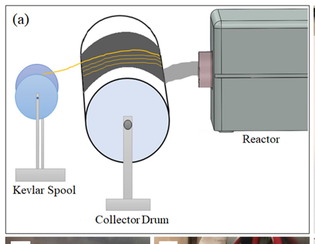
SEM Image and Diameter Distribution of CNT Strands



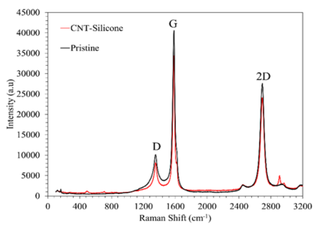
CNT-Silicone/ Kevlar Fabric Composite



Tensile Strength of CNT Sheet and CNT-silicone Sheet



Synthesis of CNT-Silicone/ Kevlar Yarn Composite



Raman Spectra of CNT Sheet and CNT-silicone Sheet

Table. Density, Resistivity, and Conductivity Anisotropy Ratios. The data is for in-plane properties. The results include contact resistance.

CNT Sheet Type	Density (g/cc)	Resistivity (Ω·cm)		Anisotropy Ratio, k∥/k⊥
		Along Length	Along Width	
Pristine CNT	0.25	0.0043	0.0091	2.12
CNT-silicone	0.56	0.0059	0.0163	2.76
CNT-silicone/Kevlar yarn	0.20	0.06	0.11	1.83
CNT-silicone/Kevlar fabric	0.90	0.11	0.26	2.36
CNT-silicone/Kevlar veil	0.30	0.09	0.09	1.89
CNT/Kevlar veil	0.17	0.06	0.06	1.67

- The pristine and composite sheets were lightweight, conductive and they passed Vertical Flame Test ASTM D6413/D6523M-15 and Forced Air Oven Test NFPA 1971.

Conclusion

- Macroscale CNT-silicone/Kevlar composites were manufactured by reinforcing a CNT-silicone matrix with Kevlar yarns, fabrics, and veil materials.
- The hybrid composites are flexible, conductive, and flame resistant.
- The synthesis of CNT-silicone membranes with Kevlar helps us to achieve the pristine strength of Kevlar veil, fabrics, and yarns whilst utilizing the multifunctional properties of CNT and CNT-silicone composites.
- The strength of Kevlar combined with the CNT and silicone properties may be beneficial in EMF shielding applications.
- The composite fabric can be used for manufacturing of electronic devices. On the one hand they will be beneficial for EMF shielding, on the other hand their thermal conductivity can help electronic devices in heat dissipation, i.e. thermal management.
- The fabrics can also be used to prepare personal protective equipment for workers requiring occupational safety in radiative environment such as radiology labs and radio towers.
- Future work: Analysis of EMF shielding efficiency of the various CNT composite materials.

Acknowledgements

This research study was supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432.

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*Some schematic images were obtained through: https://www.pinterest.com.

Impact of workplace design on the health of breastfeeding women in low-wage jobs

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Background

- Women are one of the fastest-growing segments of the U.S. labor force, and the contributions of working women who are also mothers are vital to a strong economy (Kozhimannil, et al., 2016).
- Occupational stress increased in the restaurant industry during the pandemic, and has continued to grow (Lippert et al., 2021). These low-wage food service jobs are dominated by women.
- Since breastfeeding has health benefits for both babies and mothers, the U.S. Surgeon General issued a call to action in 2011 with four recommendations for employers.
  - One recommendation was to establish and maintain comprehensive, high-quality lactation support programs for their employees (Rocheleau et al., 2019).
- In a survey of workplace accommodations for breastfeeding women, only 40% reported having access to break time and private space to express breastmilk (Kozhimannil, et al., 2016).
- Women with adequate break time and private space were 2.3 times as likely to be breastfeeding exclusively at six months (Kozhimannil, et al., 2016).

- One study found workplace support, attitude, and personal strategic planning impacted the psychological distress of the mother returning to work while choosing to express breastmilk (Rojjanasrirat, 2004).
- A more recent study found a consistent relationship between work-related problems with breastfeeding and concurrent low job satisfaction among working women (Whitley et al., 2019).
- Most research, however, has focused on full-time, high-wage Caucasian employees. Over half (64%) of the 1.1 million low-wage workers are women (U.S. Bureau of Labor Statistics, 2022).

Purpose

- This qualitative study will use a descriptive phenomenological approach to increase understanding of the lived experiences of women expressing breastmilk while working in low-wage food service jobs.

Objectives

Aim 1: Identify psychosocial hazards, particularly social factors, perceived by breastfeeding mothers in low-wage jobs in the food service industry.

Aim 2: Examine aspects of work-related design that impact a working mother's experiences while expressing breastmilk at these jobs.

Aim 3: Determine ways to improve the health and well-being of working mothers who are overrepresented in low-wage jobs.

Study Population

- Mothers aged 18 and older who have chosen to express breastmilk while working in a low-wage food industry job.

Methods

Sample:
- Purposive sampling will be used to recruit approximately 20 mothers from Lucas County with an infant between the ages of 0 and 6 months.

Data Collection:
- Potential participants will be recruited by disseminating flyers to mothers in the Lucas County community and utilizing relevant public social media sites.
- Participants will complete a demographic survey and participate in an in-depth interview lasting about an hour to address Aims 1 and 3.
- After the interview, interested participants will participate in the Photovoice portion of the study to address Aim 2.

Measures:
- **In-depth Interviews:** A semi-structured interview guide with open-ended questions was developed based on evidence-based practice (Ahmad et al., 2022).
- **Photovoice:** Participants will take a representative photo of their experience(s) while expressing breastmilk in the workplace. The participants will also provide photo descriptions based on the SHOWeD technique (Santos, Lopes, & Botelgo, 2017).

Data Analysis:
- Descriptive statistics will be applied to the demographic data.
- Recordings from the interviews will be transcribed and rigorous thematic analysis used with the narrative data (Hennink et al, 2020).
- Submitted photos will be categorized and compared to the themes from the narrative data. Exemplary photos and quotes from the descriptions will be selected for each category to enhance understanding from the participants' point-of-view (Tsang, 2020).

In-depth Interview Guide

Interview Questions

- What were your experiences with feeding your baby when you returned to work?
- Were there breastfeeding supports in place within your workplace?
- How did you combine breastfeeding and your job responsibilities when returning to the workplace?
- How do you think your co-workers or managers feel about women expressing breastmilk in the workplace?
- What support is needed to encourage women to breastfeed after their return to work?

The interview guide will be reviewed by three content experts to ensure content validity and pilot tested for readability and understandability.

Photovoice

The SHOWeD Technique:

- *What do you **See** here?*
- *What is really **Happening** here?*
- *How does this relate to **Our** lives?*
- ***Why** does this situation, concern or strength exist?*
- *What can we **Do** about it?*

*Based on the questions in the **SHOWeD** technique, participants will write a description for each photograph they submit.*

Expected Results

- The investigators will be able to identify psychosocial hazards, particularly social factors, that influence breastfeeding duration and perceptions of women working in low-wage food service jobs.
- Recommendations related to workplace design and policies can subsequently be developed to improve the health and wellbeing of these women.

Future Direction

- Future funding can be used to advance systems, policies, and practices that will create a healthy work environment, and improve well-being by decreasing occupational stress for breastfeeding mothers working in low-wage jobs in the food service industry.
- A proposed NIH submission employing quantitative research methods will be used to statistically test and generalize the findings found from the current qualitative study.

Relevance to NORA

- This study will examine workers in the NORA Services Sector and apply NORA priorities of the Healthy Work Design and Well-Being Cross-Sector Program (NORA, 2018).
- As the number of women in the U.S. labor force continue to grow, it is essential to "improve the design of work, management practices, and the physical and psychosocial work environment" for women returning to work after the delivery of a child (NIOSH, 2022; Rocheleau et al., 2019).
- The Healthy Work Design and Well-Being Program has seven proposed objectives within its research agenda. This study highlights a gap in research that addresses four of these objectives:
  1. identify and examine the impact of worker demographics on employer or organizational practices and work safety, health, and well-being;
  2. improve the safety, health, and well-being of workers with non-standard work arrangements;
  3. improve the safety, health, and well-being of workers through healthier work design and better organizational practices; and
  4. promote a sustainable work-nonwork interface.

Acknowledgements

This research study was supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432

Assessing the Applicability of Methods to Analyze Metals in Toenails

PURDUE UNIVERSITY

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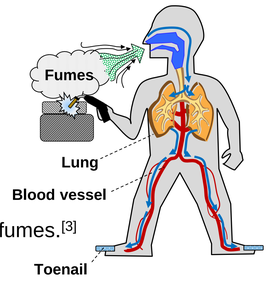
Background

- **Welding fumes**
  - 574,000 employees in welding, soldering, and brazing occupations in US
  - The majority are welders who are exposed to welding fumes.
  - Hazardous metals in welding fumes[1]
    - Manganese (Mn): Parkinson's-like disorder
    - Iron (Fe): pneumoconiosis
    - Zinc (Zn): metal fume fever
    - Chromium (Cr): lung cancer (Cr-VI)
- **Metals in toenail as biomarkers**
  - Inhaled metals deposit in toenails and other body parts.[2]
  - Mn concentration in toenails was proposed as a biomarker of chronic exposure to welding fumes.[3]



- **Toenail metal analysis**
  - No standard methods
  - Inductively coupled plasma (ICP)−mass spectrometry (−MS) is widely used.
  - ICP−optical emission spectrometry (−OES) or X−ray fluorescence (XRF) can be more appropriate for toenail metal analysis.

Methods	Limit of detection	Cost, time, & labor effectiveness	Sample destructiveness
ICP-MS	+++	+	Destructive
ICP-OES	++	++	Destructive
XRF	+	+++	Non-destructive

- **Relevance to National Occupational Research Agenda (NORA)**
  - Sector programs of "Manufacturing" and "Construction"
  - Core and Specialty Program of "Exposure Assessment"
  - Cross-sector program of "Cancer, Reproductive, Cardiovascular and Other Chronic Disease Prevention"

Objectives

- **Explore the applicability of ICP−OES and XRF for analyzing metals in toenails in comparison with ICP−MS.**
- **Hypothesis: ICP−OES and XRF can measure toenail metal concentrations as accurately as ICP−MS.**
  - Specific Aim 1: Measure metal concentrations in toenails using ICP−OES and compare the results to ICP−MS measurements
  - Specific Aim 2: Measure metal concentrations in toenails using XRF and compare the results to ICP−MS measurements

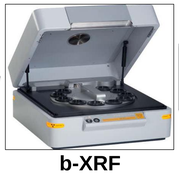
Experimental design

Collection

Cleaning

- **Step 1: Sample collection**
  - Clip toenails of subjects
  - 20 welders and 20 non-welders
- **Step 2: Sample cleaning and weighing**
  - Wash toenails in Triton X−100 (non-ionic surfactant, 1% in deionized water) using ultra-sonication for 1 hour
  - Rinse with deionized water (ASTM II) 3 times
  - Dry in an oven for > 24 hours and weigh using a microscale
- **Step 3: XRF measurement**
  - Measure toenail phantom (95% of polyester resin, 5% of salt) containing known concentrations of metals
  - Create calibration curves of metals
  - Measure toenail samples using both portable−XRF (p−XRF, Niton XL3t 955 Ultra, Fisher Scientific) and benchtop−XRF (b−XRF, Epsilon 4, Malvern Panalytical)
  - Normalize the measurement using Compton Scattering Ag anode peak
  - Calculate metal concentrations in toenails using calibration curves and XRF measurements
- **Step 4: Sample digestion**
  - Pre-digest toenail samples using 70% HNO_3 for 10 minutes
  - Digest in HNO_3 using microwave digestion system (MARS 6, CEM co.) for 15 minutes at 200ºC
  - Dilute 35-fold so that the HNO3 concentration is 2%
- **Step 5: ICP−OES and ICP−MS measurement**
  - Measure the metal concentrations in toenails using ICP−OES and ICP−MS
  - Analyze eight metals (Mn, Fe, Zn, Cr, aluminum (Al), copper (Cu), nickel (Ni), and cadmium (Cd))
- **Data analysis**
  - Calculate toenail metal concentrations by dividing the metal mass obtained using XRFs and ICPs by toenail mass
  - Calculate Pearson's correlation coefficients of ICP−OES, p−XRF, and b−XRF against ICP−MS
  - Regression analysis to compare the results

p-XRF



b-XRF

Digestion

ICP-OES & -MS

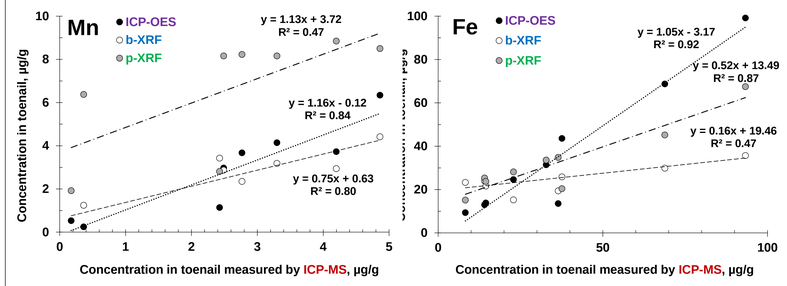
Expected results

- **Comprehensive data**
  - Toenail metal level data of welders and non-welders
  - Correlation factors of ICP-OES and XRFs with ICP-MS
  - Potential correction factors to convert ICP-OES or XRF measurements to match ICP-MS measurements
- **Impact of results**
  - Suggestion of appropriate methods for toenail metal analysis based on exposure levels, budget, and manpower
  - Benefit for welders and other metal workers by providing exposure assessment through toenail metal analysis
  - Potential to improve workplace safety and promote better health outcomes for workers
- **Research to practice**
  - Provide a rapid, easy-to-use, inexpensive, and non-invasive method to analyze toenail as a biomarker
  - Provide direct means to quantitatively evaluate the extent of exposure to metals
  - Guideline to select an appropriate method to analyze toenail metals

Preliminary data

- **Comparison of ICP−OES, b−XRF, and p−XRF against ICP−MS (welders: n = 6, non-welders: n = 4)**

Method	Metal concentration in toenails, μg/g						
	Mn	Fe	Zn	Al	Cr	Cu	Ni
ICP-MS	2.6±1.7	36.5±28.0	94.7±27.9	28.2±37.6	1.0±2.6	5.4±1.8	0.1±0.3
ICP-OES	2.8±2.1	35.3±30.6	81.0±29.3	16.0±32.0	2.2±1.9	6.3±3.0	0.2±0.6
Pearson's r	**1.00**	**0.96**	**0.79**	**0.99**	0.22	-0.15	0.19
b-XRF	2.6±1.4	25.4±6.6	113.2±14.3	0.4±1.9	1.4±0.6	25.8±9.5	0.5±0.5
Pearson's r	**1.00**	**0.68**	0.18	0.3	-0.09	-0.24	-0.10
p-XRF	6.6±2.7	32.6±15.8	72.2±35.5	N/A	1.4±0.5	4.9±1.8	0.1±0.0
Pearson's r	**0.83**	**0.93**	**0.72**	N/A	0.51	0.15	0.52



- **ICP-OES** showed strong correlation with ICP-MS in **Mn, Fe, Zn, and Al** (r = 1.00, 0.96, 0.79, and 0.99, respectively).
- **b-XRF** showed strong correlation with ICP-MS in **Mn, and Fe** (r = 1.00, and 0.68).
- **p-XRF** showed strong correlation with ICP-MS in **Mn, Fe, and Zn** (r = 0.83, 0.93, and 0.72, respectively).

Future funding plan

- **Future funding plan**
  - Investigation of the relationship between toenail metal concentrations and health outcomes (target: National Institute for Occupational Safety and Health (NIOSH) R21 or R01 grant)
  - Development of evidence-based policies and regulations for protecting workers and the general population using toenail metal analysis as a tool for exposure monitoring (target: grant from National Institutes of Health (NIH), NIH Health Sciences (NIEHS), or Environmental Protection Agency (EPA)

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Acknowledgements

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Injury Trends in Young Adults from the Manganese Exposed CARES Cohort

INTRODUCTION

The Communities Actively Researching Exposures Study (CARES) is a longitudinal pediatric cohort of children living in Marietta, Ohio near the longest operating ferro-manganese (Mn) refinery in North America.

Inhaled Mn accumulates in the basal ganglia region of the brain which is primarily responsible for motor control. We have previously shown CARES children (7-9 years old) and adolescents (13-18 years old) with higher concentrations of blood and hair Mn demonstrated postural instability.

No study has examined the impact of pediatric Mn exposure on injury.

CARES STUDY DESIGN

Recruitment 2008-2013	Child and Adolescent Exposure Biomarkers	Child and Adolescent Neuromotor Measures	Young Adulthood Measure
Child age 7 to 9 years; Lived in the community for entire life	Blood Mn, Pb; Serum Cotinine; Hair Mn; Toenail Mn	Postural Balance	Injury Survey

RESEARCH QUESTION

Is early life Mn exposure associated with injury?

We hypothesize child and adolescent biomarkers of Mn exposure will be associated with injury variables.

METHODS

Disseminate survey to characterize injury trends in the CARES cohort now that they aged into young adulthood

Conduct multivariable linear regression models to examine the association between childhood (ages 7-9 years) and adolescent (ages 13-18 years) biomarkers of Mn exposure, measured in blood, hair and toenails, and self-reported injury data (e.g. event, work-related, body part, limited activity)

NORA RELEVANCE

This study will contribute to the Manufacturing sector and Musculoskeletal Health cross-sector research agendas to reduce the burden of occupational illness, enhance knowledge of occupational safety, and develop effective interventions to reduce exposure.

RESEARCH 2 PRACTICE

- Partner with young adult community members as they enter the labor force
- Identify occupational safety and health needs for young adults exposed to Mn
- Contribute to the development of interventions to prevent injury

FUTURE FUNDING

- Follow CARES into adulthood
- Implement intervention study to prevent injury

ACKNOWLEDGEMENTS

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Assessing the Impact of Respirator Design and Demographics on the Performance of N95 Respirators

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BACKGROUND

- N95 Facepiece Filtering Respirators (FFRs) approved by the National Institute for Occupational Safety and Health (NIOSH) are often used to protect wearers from exposure to hazardous airborne particles.
- Ill-fitted respirators may compromise the protection offered to wearers. The US Occupational Safety and Health Administration (OSHA) mandates that all employees wearing respirators be subject to OSHA's fit testing (OSHA 29 CFR. 1910.134) to ensure that the wearer is effectively protected.
- There are some specific design elements on the N95 FFRs, including nose-clip/shaped designs, respirator shape styles, etc., to ensure that respirators provide effective protection for the wearers.
- Sex/gender and race/ethnicity may affect respirator fit because of differences in facial structure variations, nose and cheekbone proportions, soft tissue characteristics, etc.

SIGNIFICANCE

- N95 FFRs are widely used to mitigate particle inhalation and offer significantly high level of protection in many occupational and non-occupational environments.
- Understanding the influence of potential factors on the performance of N95 FFRs is crucial; it is vital for advising workers and the general public on selecting the most suitable respirator style, thereby ensuring their effectiveness and safety.

SPECIFIC AIMS

- Quantitatively characterize how the ***nose-clip shape*** of a respirator affects the respirator performance by using both manikin-based and human subject-based evaluation approaches.
- Quantitatively characterize how the ***respirator shape style*** affects the performance of NIOSH-approved N95 FFRs through manikin-based and human subject-based study designs.
- Determine the impact of ***subject characteristics*** on the fitness of respirators.

Table 1. The N95 Respirators will be tested in this study.

Respirator model		Nose-clip
3M 8210		No nose-clip (Control)
		Conventional nose-clip
		M-shaped nose-clip
Moldex 2200		No nose-clip (Control)
		Conventional nose-clip
		M-shaped nose-clip

Respirators	Name	Model	Manufacture	Styles	Size
	3M™ particulate matter respirator	8210	3M (Saint Paul, MN)	Cup-shaped	Regular
	3M™ AURA™ health care particulate respirator and surgical mask	1870+	3M	3-Panel flat-fold	Regular
	3M™ particulate respirator	9502+	3M	Vertical flat-fold	Regular
	3M™ VFlex particulate respirator	9105	3M	V-shaped pleats	Regular
	Kimberly-Clark N95 particulate filter respirator mask	46767	Kimberly-Clark (Irving, TX)	Duckbill	Regular
	AOSafety pleats plus N95 particulate respirator	1050	AOSafety (Indianapolis, IN)	Large flexible pleats	"Small/Medium"; "Medium/Large"

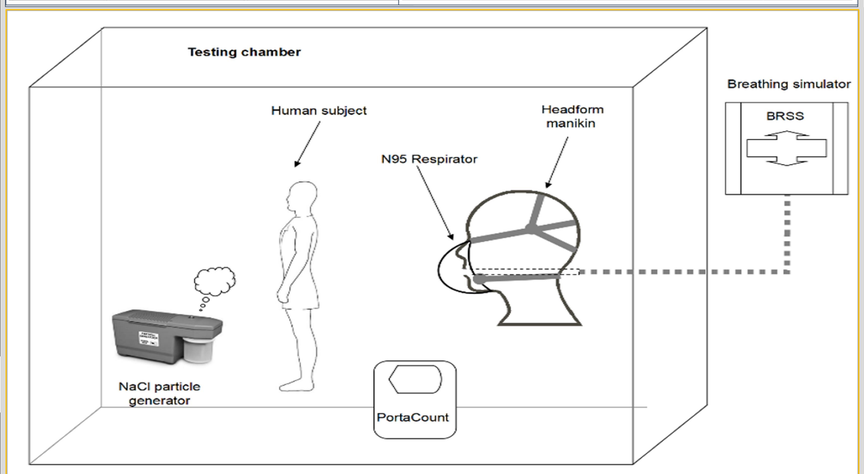


Figure 1. Experimental setup for respirator testing.

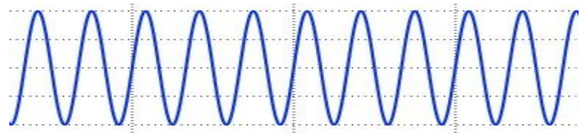
ACKNOWLEDGEMENTS

This research study was supported by the National Institute for Occupational Safety and Health through Pilot Research Project Training Program of the University of Cincinnati, Education and Research Center Grant #T42OH008432.

RESEARCH DESIGN AND METHODS

- This study will be designed as a two-fold study: *Manikin-based testing* & *Human subject testing*. The testing will be conducted in a 24-m^3 aerosol chamber. The experimental set up that will be used for testing the respirator performance is presented in Fig.1. N95 FFRs as shown in Table 1 will be tested.
- ***Manikin-based testing.*** An advanced static headform will be connected to the breathing simulation system to simulate a sinusoidal breathing pattern of a human. Protection factor (PF) is an estimate of the performance of a respirator.

$$PF = \frac{C_{out}}{C_{in}}.$$



- ***Human subject testing.*** 20 human subjects will be recruited. The face width and length of subjects will be measured with spreading calipers. Subjects will randomly choose N95 to perform the quantitative fit testing (QNFT). Fit Factor (FF) will be used to evaluate the fit of N95 FFRs, and determined as

$$FF = \frac{C_{out}}{C_{in}}.$$

DATA ANALYSIS

- The geometric mean (GM) and geometric standard deviation (GSD) of PF and FF values will be calculated. Comparisons will be performed among log-transformed PF-values and logged FF-vales.
- Analysis of variance (ANOVA) will be performed to determine how the respirator designs (nose-shaped & respirator-shaped styles) impact the performance of N95 FFRs.
- Multiple regression analysis will be used to analyze the relationship between face dimensions influenced by gender/sex and race/ethnicity to the respirator fit.
- A p-value below 0.05 represents a significant difference.

EXPECTED RESULTS

- The FFR nose-clip design and shape styles will be significant factors in affecting the performance of respirator as quantified by the outcomes such as the PF and FF values.
- The facial dimension will impact the fit of FFR, and this relationship is influenced by the respirator design.