

Optimization of Phase Change Material for Enhanced Head-Cooling during Firefighting Scenarios



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BACKGROUND

- Prolonged exposure to fire leads to increased brain and core-body temperatures, leading to heat stress.
- Dissipation of heat from the head is necessary.
- Currently available techniques are useful only for cooling body and torso regions.
- A system is developed specifically for head cooling that uses phase change material (PCM) for heat storage (sink).
- Experimental setup (Figure 1) was fabricated in our previous study to demonstrate feasibility of cooling device.

OBJECTIVE

- Validate and optimize safe duration of head cooling system using numerical model, mimicking experimental setup.

RELEVANCE TO NORA

- Absence of cooling systems and extended exposure can lead to increase in firefighter's brain temperature.
- Evaluation of cardiovascular effects show increase in core temperature, high heart rate and mild inflammatory responses.
- Aim is to improve head cooling of firefighters during firefighting activities by optimizing design parameters of a portable head cooling system/device.

EXPERIMENTAL DESIGN

- The data obtained from this experimental setup will be used for the validation of the computational model. (Figure 1. [Al-Rjoub et. al.](#) 2021).

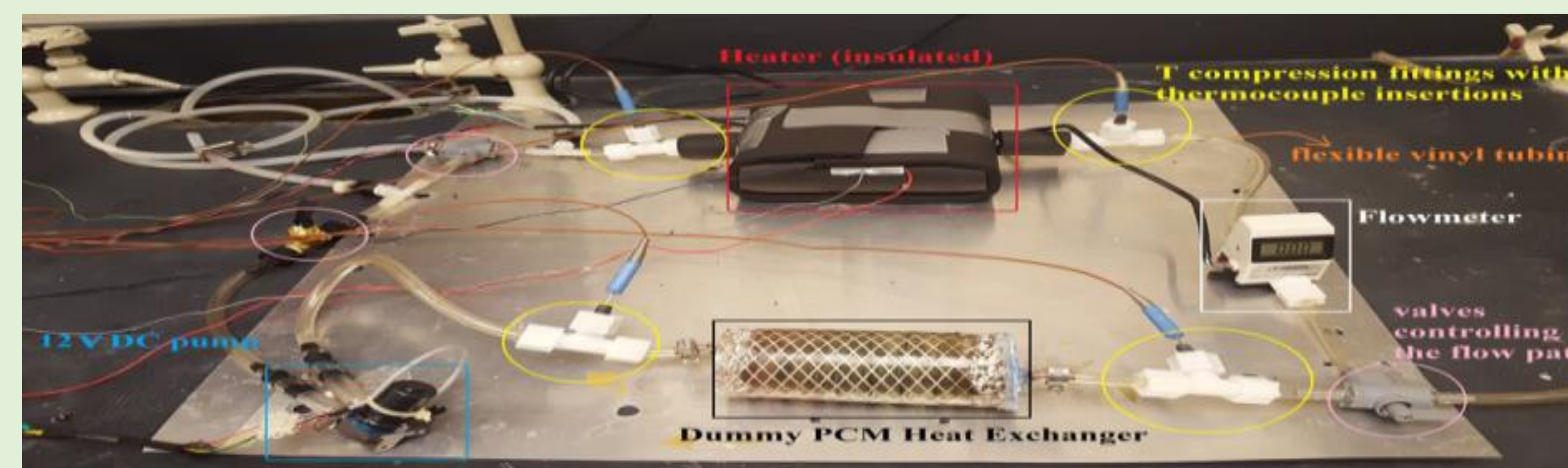


Figure 1 : Experimental model

TASK DESCRIPTION

- Development of computational model to simulate the head cooling system (Figure 2).
- Validation of model using the published experimental data ([Al-Rjoub et. al.](#) 2021).
- Optimization of cooling duration by varying heat load, flowrate, PCM and external temperature as parameters.
- Optimization of safe duration for a) different types of PCM in the heat sink, and b) external temperature as variables using ASPEN HYSYS.

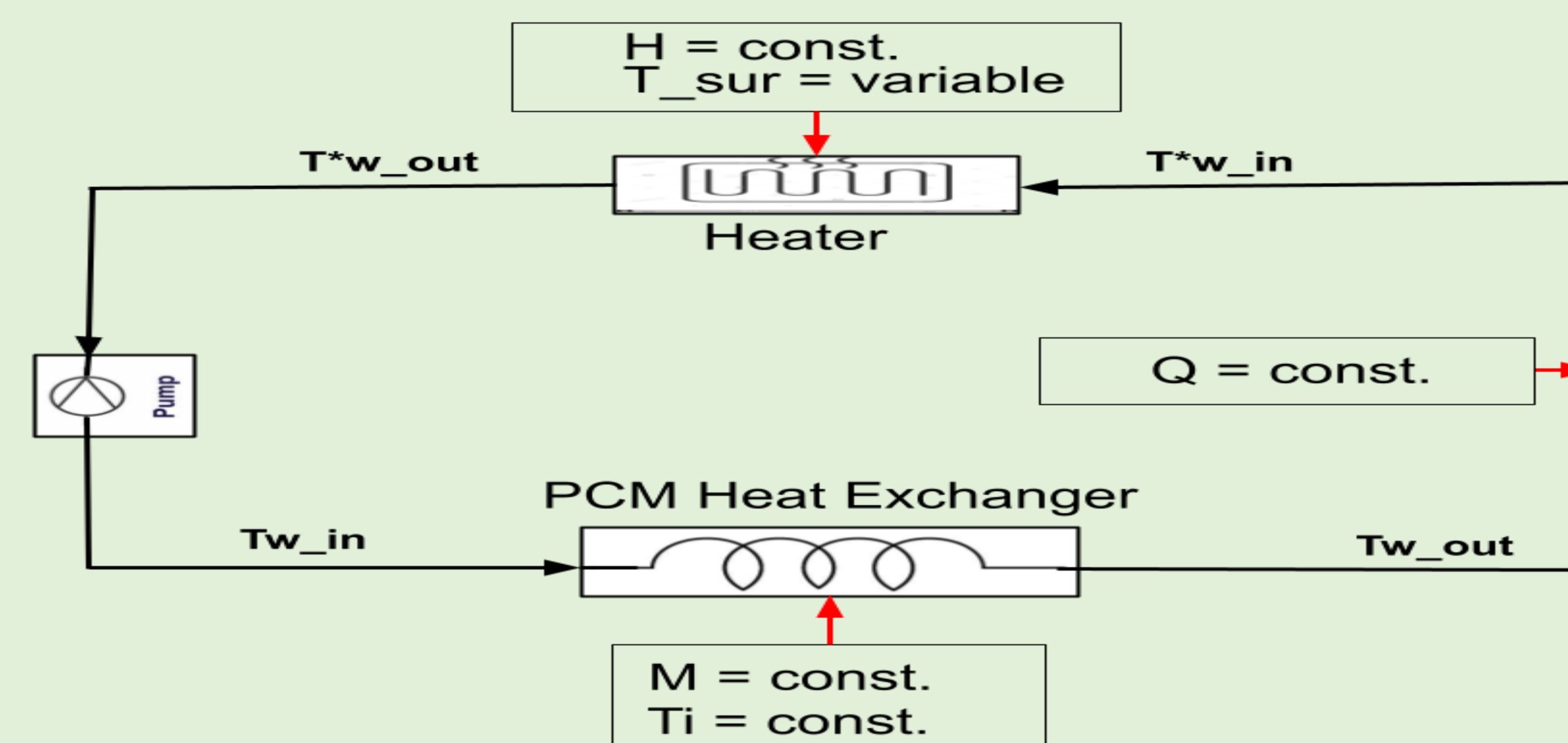


Figure 2: Head cooling system circuit diagram

LIMITATIONS

- Results will be obtained only for the selected parameters and system design.

EXPECTED RESULTS

- Optimized safe duration for firefighting activities using the proposed system.
- Comparison of different PCM based on cooling performance.

FUTURE DIRECTIONS

- Correlate head and core-body temperatures.
- Control heat transfer of the cooling system using feedback controllers.
- Modular design of the heat exchanger to replace heat sink.
- A cap with cooling tubes to absorb the heat from the surface.

REFERENCES

- Al-Rjoub M., Kazmierczak M. J., Bhattacharya A., Rakkimuthu S., Ramadurai S., Stuckey J.P., Banerjee R.K. "Better thermoregulation of brain temperature using phase change material-mediated head cooling system", International J. of Heat and Mass Transfer, Vol. 173, 2021,121204.

ACKNOWLEDGEMENTS

- This research is supported by PRP grant #T42OH008432.

SYNTHESIS AND FABRICATION OF GROUP III-V DOPED CARBON NANOTUBE SHEETS FOR CNT BASED BIOSENSORS APPLICATIONS

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Introduction

- Carbon nanotubes (CNTs) belong to the sp² hybridized family of elemental carbon materials and possess extraordinary electrical, optical, thermal, mechanical, and electromechanical properties thereby making them a promising candidate to form the essential building blocks for biosensor devices[1]–[3].
- CNTs consist of highly stable nanotube shells which have a high specific surface area and a large aspect ratio thereby promoting faster electron transfer[4],[5]. Moreover, these nanotube shells consist of a hollow inner cavity that can be filled and wet, and doped by other semiconducting materials (group III - V) which allow an increased electrical conductivity of the semiconductor transducer nanomaterial in the miniature biosensors[6]–[7].
- The CNT structure, length, density, etc., also have an influence on the performance of CNT-based biosensors [8]. A more denser CNT network promotes a faster transfer of electrons. Doping CNTs also allows for the formation of a denser CNT network [9].
- Filling of the inner cavity of nanotubes also offers a possibility of nanoinjectors, targeted drug delivery, imaging, phototherapy[7], [8].
- At Nanoworld laboratories UC, we built a CVD reactor that can inject nanoparticles in both wet (fuel precursor) or dry (using a particle distributor developed at UC) conditions that can be integrated with CNTs which enables them to enhance their properties.

Objectives

- Synthesis of Carbon hybrid materials (CHMs) via doping and functionalization with NPs.
- Electrical Characterization of CHMs including resistance using 2,4 probe and EIS.
- Other Characterization of CHMs including SEM, EDAX, TEM, XPS, EELS.
- Test moisture sensor on the bench, modify synthesis process, iterate to improve properties.

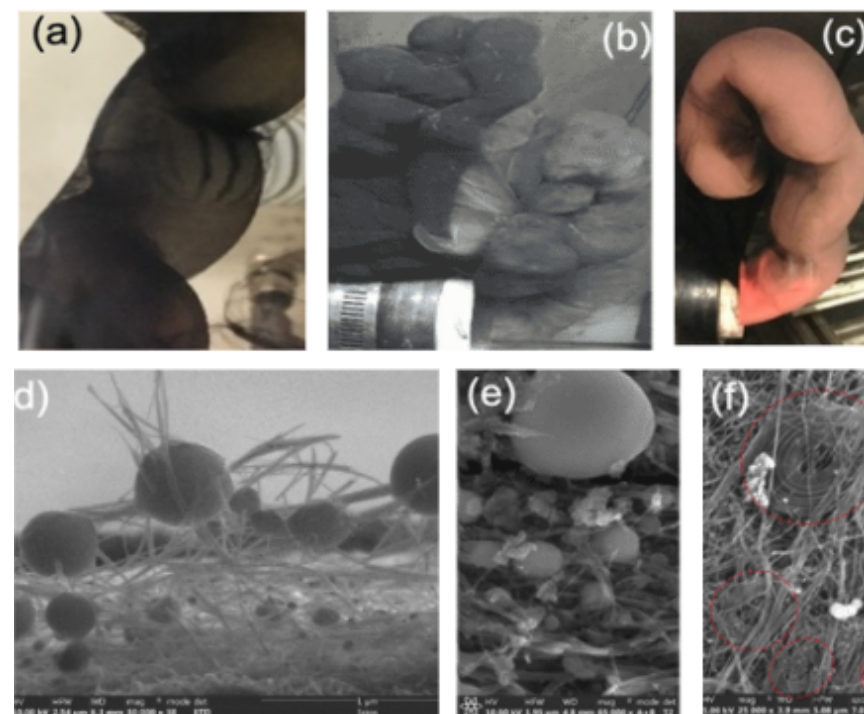


Figure 1: UC CHM design. (a) Pristine CNT (black sock); (b) pristine black sock then particle injection turned on with Ag-Cu (grey sock); (c) CNT-Cu brown sock, floating in the air; (d) Metal particles “glue” bundles of CNTs together which increases thermal and electrical conductivity and strength; (e) CNT-Ag Cu high-density NPs; (f) CNT spiral sheets

Research and Design Methods

- CNTs and CHMs are synthesized using the CVD reactor equipped with a particle injector, developed at Nanoworld laboratories. The nanoparticle injector attached to the CVD reactor can inject dry nanoparticles, as well as nanosized compounds in the fuel to produce high yields of group (III)-(V)doped nanomaterials.
- Initial results with nanoparticles such as copper, cobalt, nickel showed promising results of increased electrical conductivity and produced carbon hybrid materials of high purity, Fig-1. We expect to produce hybrid nanotubes doped with other groups III - V compounds with increased electrical conductivity.
- The CNT sheet produced will be used to form the working electrode of a biosensor. Standard electrodes using pristine CNT sheet and the new sensors using doped/functionalized CNT sheet will be fabricated.
- After synthesis, we will conduct characterization on the samples to measure their electrical conductivity and other properties. X-ray and microscopy analysis will be performed at the Center for Nanoscale Materials (CNM), Argonne National Laboratory using a high-resolution chromatic aberration-corrected transmission electron microscope (ACAT) and advanced in-situ Transmission electron microscopy (TEM).

Future direction

- To obtain external funding to further develop CNTs and prototypes for Biosensors and transition the technology to the medical industry.
- We also plan to combine other nanoparticles specifically focusing on clinical drug delivery applications with our CNTs.

Relevance to NORA

This proposal is related to the National Occupational Research Agenda (NORA) for Cancer, Reproductive, Cardiovascular, and Other Chronic Disease Prevention (CRC) Cross-Sector. The sector includes the 12 objectives in the Agenda which focus on occupational cancer, adverse reproductive outcomes related to occupation, and cardiovascular disease among workers. PRP proposal is to develop a highly sensitive Biosensor to reduce the risk of occupational diseases.

References

- [1] M. J. Schulz, V. N. Shanov, and Z. Yin, Nanotube Super fiber Materials: Changing Engineering Design. 2013.
- [2] R. M. Williams, C. Lee, and D. A. Heller, “A Fluorescent Carbon Nanotube Sensor Detects the Metastatic Prostate Cancer Biomarker uPA,” ACS Sensors, 2018.
- [3] I. V. Zaporotzkova, N. P. Boroznina, Y. N. Parkhomenko, and L. V. Kozhitov, “Carbon nanotubes: Sensor properties. A review,” Mod. Electron. Mater., 2016.
- [4] N. Sinha, J. Ma, and J. T. W. Yeow, “Carbon nanotube-based sensors,” J. Nanosci. Nanotechnol., 2006.
- [5] S. Kruss, A. J. Hilmer, J. Zhang, N. F. Reuel, B. Mu, and M. S. Strano, “Carbon nanotubes as optical biomedical sensors,” Advanced Drug Delivery Reviews. 2013.
- [6] C. Farrera, F. Torres Andón, and N. Feliu, “Carbon Nanotubes as Optical Sensors in Biomedicine,” ACS Nano. 2017.
- [7] J. Pan, F. Li, and J. H. Choi, “Single-walled carbon nanotubes as optical probes for bio-sensing and imaging,” J. Mater. Chem. B, 2017.
- [8] E. Dujardin, T. W. Ebbesen, H. Hiura, and K. Tanigaki, “Capillarity and wetting of carbon nanotubes,” Science (80-.), 1994.
- [9] E. Heydari-Bafrooei, M. Amini and M. H. Ardakani, Biosens. Bioelectron. 85, 828 (2016). DOI:10.1016/j.bios.2016.06.012

Acknowledgements

This research study is supported by the National Institute for Occupational Safety and Health (NIOSH) through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant # T42 OH008432-16

Pressure to Attend Work when Unwell: Health and Safety Consequences among Nurses

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Background

- **Presenteeism:** Attending work despite a health condition that would reasonably excuse absence
 - **Prevalence:** 94% of nurses regularly engage in presenteeism because their jobs are high-stakes and team-based (Rainbow et al., 2019)
 - **Consequences:** Leads to medication errors, patient injuries (Rainbow & Steege, 2017), and poor nurse health (Ruhle & Sub, 2020)
 - This costs hospitals **\$12 billion** annually (Letvak et al., 2012)
- **Presenteeism Pressure:** Social pressures that supervisors and colleagues may enact to push employees to engage in presenteeism
 - Linked to negative worker attitudes, physical health complaints, and turnover intentions (Albert et al., 2020, June) in the general workforce.
 - **May be particularly relevant and damaging among nurses**, given that employers may inadvertently encourage presenteeism to sustain productivity in demanding jobs (Jourdain & Chenevert, 2015)

Aims & Hypotheses

Aim 1: Is presenteeism pressure unhealthy for nurses (i.e., presenteeism behavior, burnout)?

- **Hypothesis 1:** Presenteeism pressure will positively predict a) presenteeism behavior and b) burnout.

Aim 2: Is presenteeism pressure related to nurses' safety behaviors (i.e., nurse safety compliance and safety participation)?

- **Hypothesis 2:** Presenteeism pressure will negatively predict nurses' a) safety compliance and b) safety participation.

Aim 3: Nurses work in a wide variety of work environments. How might certain job and supervisor characteristics protect against *or* exacerbate the negative well-being and safety consequences of presenteeism pressure?

- **Hypothesis 3:** a) Scheduling autonomy, b) task significance, c) supervisor support and d) supervisor distrust of absences will moderate the relation between presenteeism pressure and well-being.
- **Hypothesis 4:** a) Scheduling autonomy, b) task significance, c) supervisor support and d) supervisor distrust of absences will moderate the relation between presenteeism pressure and safety behaviors.

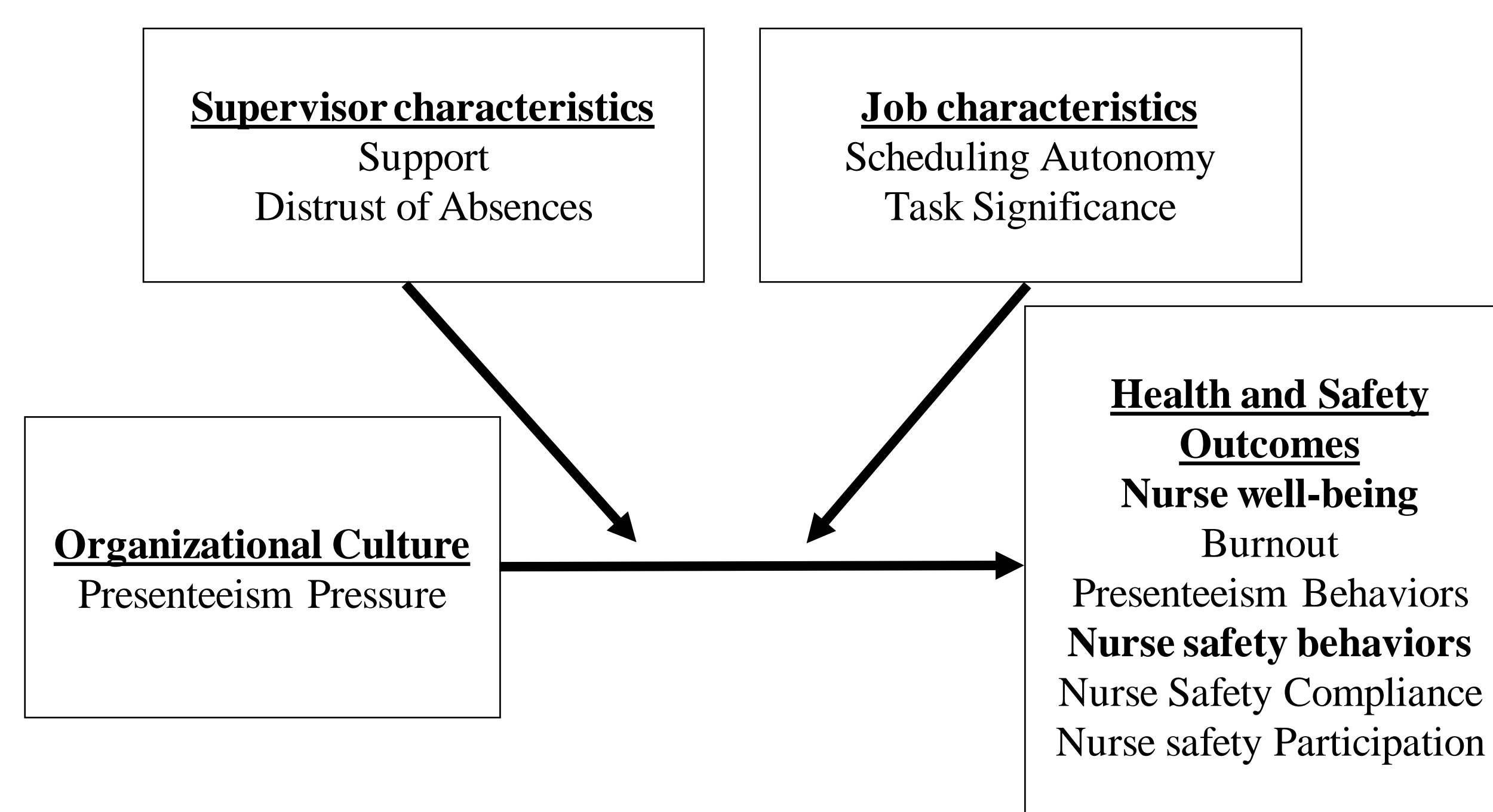


Figure 1. Theoretical model relating presenteeism pressure to nurse health and safety outcomes as moderated by supervisor and job characteristics.

Method

Procedure: Two self-report surveys administered three months apart

- **Baseline survey:** All study variables (i.e., presenteeism pressure, presenteeism behavior, burnout, safety behavior, and job and supervisor characteristics)
- **Follow-up survey (3 months later):** Outcomes (i.e., presenteeism behavior, burnout, and safety behavior)
- The time lag limits biases involved in survey research (e.g., common method bias)

Participants: Registered Nurses working at least 30 hours a week

- 265 nurses will be recruited at Time 1, with 220 as the desired final sample to detect small to moderate effect sizes

Measures:

- Presenteeism Pressure (Huang et al., 2019, April)
 - “I am expected to attend work even if I am not feeling well”
- Presenteeism Behaviors (Aronsson et al., 2000; Hägerbäumer, 2011)
 - “I showed up to work despite illness”
- Burnout: Oldenburg Burnout Inventory (Demerouti et al., 2003)
 - “During my work, I often feel emotionally drained”
- Nurse Safety Compliance (Neal & Griffin, 2006)
 - “I ensure the highest levels of safety when I carry out my job”
- Nurse Safety Participation (Neal & Griffin, 2006)
 - “I put in extra effort to improve the safety of the workplace”
- Scheduling Autonomy: WDQ (Morgeson & Humphry, 2006)
 - “The job allows me to make my own decisions about how to schedule my work”
- Task Significance: WDQ (Morgeson & Humphry, 2006)
 - “The results of my work are likely to significantly affect the lives of other people”
- Supervisor Support: Job Content Questionnaire (Karasek et al., 1998)
 - “My supervisor gives me the resources I need to do my work”
- Supervisor Distrust of Absences: Presenteeism Climate Scale (Ferreira et al., 2015)
 - “I think my supervisor distrusts me if I am absent from work due to a health problem”
- Basic demographic information: age, gender, race and ethnicity, job title, work setting, and job and organizational tenure
- **Data Analysis:**
 - All hypotheses will be tested using multiple regression. Results will be examined both with and without the inclusion of demographic control variables (e.g., gender, type of work environment)

Expected Results & Impact

- **Results:** Presenteeism pressure is expected to be:
 - Positively related to nurse presenteeism behaviors and burnout
 - Negatively related to safety compliance and participation
 - Moderated by scheduling autonomy, task significance, supervisor support and supervisor distrust of absences
- **Impact:**
 - Identify a potentially unsafe, unhealthy type of organizational culture that pushes nurses to attend work when they are not feeling well
 - Delineate the health and safety consequences of this pressure
 - Point to leader actions and job design factors that employers can target to protect nurse health and patient safety

Future Directions

- **Interventions:** Future research could develop and test scientifically grounded interventions in leadership training, policy changes, organizational culture, and job design to reduce presenteeism pressure and, potentially, mitigate presenteeism behaviors in nurses.
- **Long-term Dynamics:** Future longitudinal research may clarify how these relationships play out over time, including potential bidirectional effects between poor health and presenteeism pressure. Such designs could also measure significant events (e.g., diagnosis of a chronic condition, organizational downsizing) that may influence presenteeism and presenteeism pressure among nurses.
- **Non-work Implications:** Future work could test whether presenteeism impacts nurses' lives outside of work, including their work-family conflict and family-work conflict.

Selected References

- Albert, M.A., Huang, S., Smith, C.E., & McAbee, S.T. (2020, April). Testing a model of presenteeism behavior: The role of presenteeism pressure. In S. Huang & S.T. McAbee (Chairs), The many faces of work and well-being: Untangling relations between work and health. Symposium presented at the 35th Annual Conference for the Society for Industrial and Organizational Psychology (SIOP), Austin, TX.
- Huang, S., Smith, C. E., Albert, M. A., & McAbee, S. T. (2019, April). Development of scales for presenteeism and presenteeism pressure. Paper presented at the 34th annual meeting of the Society for Industrial and Organizational Psychology, Washington, DC.
- Jourdain, G., & Chênevert, D. (2015). The moderating influence of perceived organizational values on the burnout-absenteeism relationship. *Journal of Business and Psychology*, 30(1), 177-191.
- Letvak, S. A., Ruhm, C. J., & Gupta, S. N. (2012). Nurses' presenteeism and its effects on self-reported quality of care and costs. *The American Journal of Nursing*, 112(2), 30-38.
- Rainbow, J. G., & Steege, L. M. (2017). Presenteeism in nursing: An evolutionary concept analysis. *Nursing Outlook*, 65(5), 615-623.
- Rainbow, J. G., Gilbreath, B., & Steege, L. M. (2019). How to know if you're really there: An evaluation of measures for presenteeism in nursing. *Journal of Occupational and Environmental Medicine*, 61(2), 25-32.
- Ruhle, S. A., & Süß, S. (2020). Presenteeism and absenteeism at work—an analysis of archetypes of sickness attendance cultures. *Journal of Business and Psychology*, 35(2), 241-255.

Acknowledgement

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 #T420H008432

Please contact Lindsey Freier (lfreier@bgsu.edu) for more information on this and related projects.

Workplace Violence Among Young Black Workers Ages 18-24 in Southcentral Kentucky

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Background

Workplace violence is a significant health problem with as many as 40% of US workers experiencing some form of violence or aggression at work [1]. Workers under the age of 25 have an increased risk of workplace violence compared to all workers combined [2, 3]. In a metropolitan study conducted by Sabri et. al [4] on racial and ethnic differences in factors related to workplace violence, blacks are less likely to use resources to address workplace violence.

Despite these statistics, there is little research on violence among black youths nationally, or in Kentucky. Young workers in general may find themselves in jobs where cash is present, working night shifts, working alone or even interacting with customers/clients in these work settings [8]. Additionally, due to factors such as minority identify, young black workers may be reluctant to speak up when faced with risk or abuse at work. Given their predominant employment in the high-risk retail and service industries [5], the lack of violence prevention programs in these industries [5-7], and the fact that youth may be uniquely affected by workplace violence due to their ongoing cognitive and psychological development, young black workers are a vulnerable group in need of further study.

Workplace Violence Typology

There are four categories of workplace violence which are defined based on the relationship of the perpetrator to the business or employee [9 – 11]. A Type I event is characterized by a perpetrator entering a workplace solely with the intent to commit a criminal act such as a robbery. In a Type II event, the perpetrator has legitimate reasons for using the services of the business. A Type III event is characterized as current or former employee-on-employee violence. A Type IV event is perpetrated by a personal acquaintance of the worker (e.g., intimate partner), with no other relationship to the business. For each violent event discussed, FGD members will be asked to describe the person who perpetrated the violence (Types I-IV discussed above).

Specific Aims

- ❖ Identify risk factors for workplace violence among young black workers
- ❖ Characterize employer-provided workplace violence prevention and response training received by young black workers
- ❖ Describe the employment and educational consequences of workplace violence victimization among young black workers.

Recruitment Area

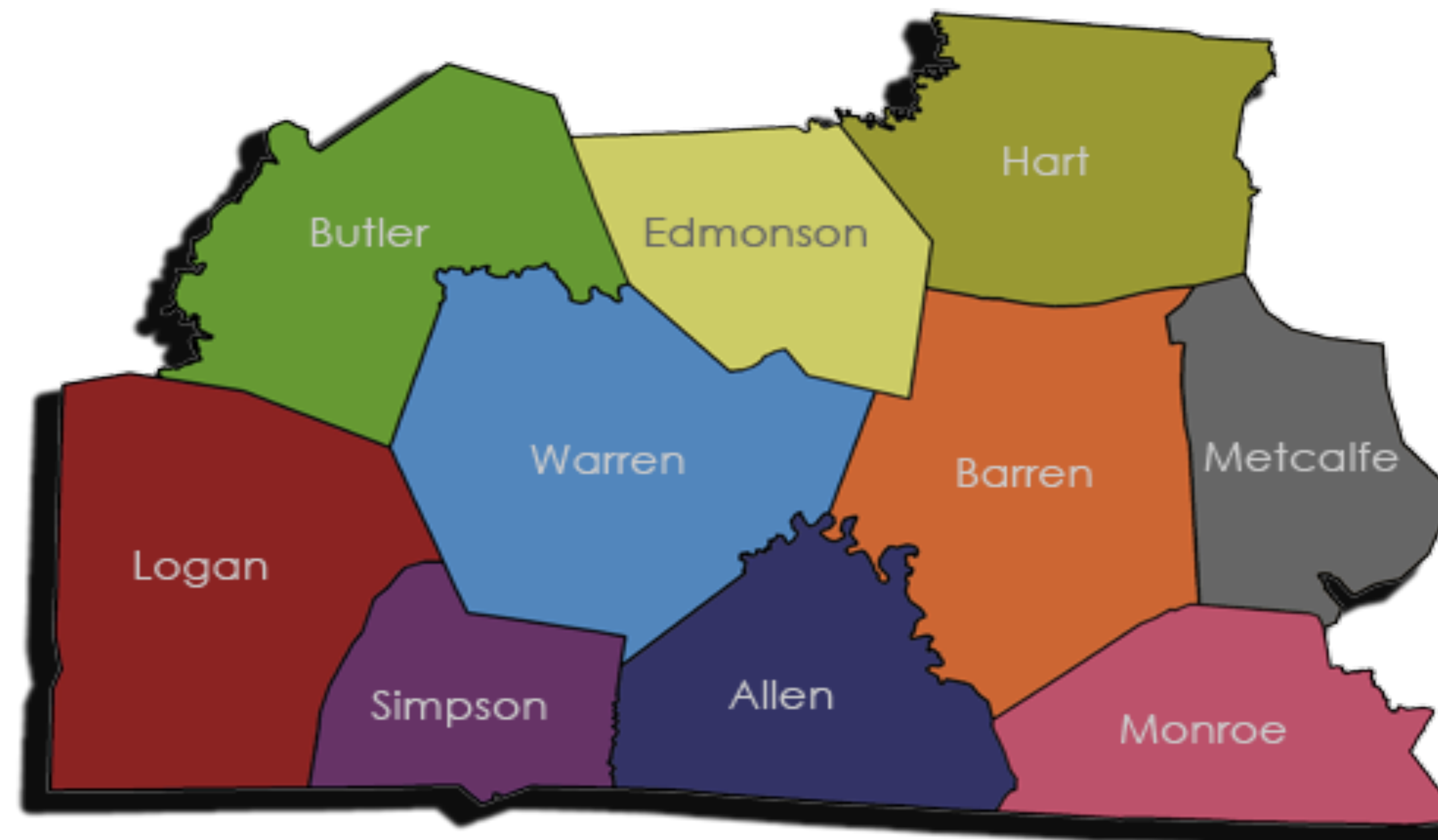


Figure 1: Southcentral Kentucky Counties used for participant recruitment
<https://www.bradd.org/index.php/about-us>

Methods Overview

The proposed study will use open ended questions with additional stems to gather qualitative data via focus group discussions (FGDs) with a team comprising of young black workers living in the ten-county southcentral Kentucky region displayed in Figure 1. Subjects will be recruited into FGDs from multiple sources outlined in Figure 2. To be eligible, subjects must be black and between the ages of 18 and 24. They must also have held a formal job with a company in the past 12 months. Four FGDs will be held: 1) females aged 18 – 21; 2) males aged 18 – 21; 3) females aged 22 – 24; and 4) males aged 22 – 24. Groups are divided by age arbitrarily to support members to interact and relate to each other during FGDs. Groups will also be divided by gender to encourage members to freely discuss and relate their experiences. Between 8 and 10 individuals will participate in each FGD.

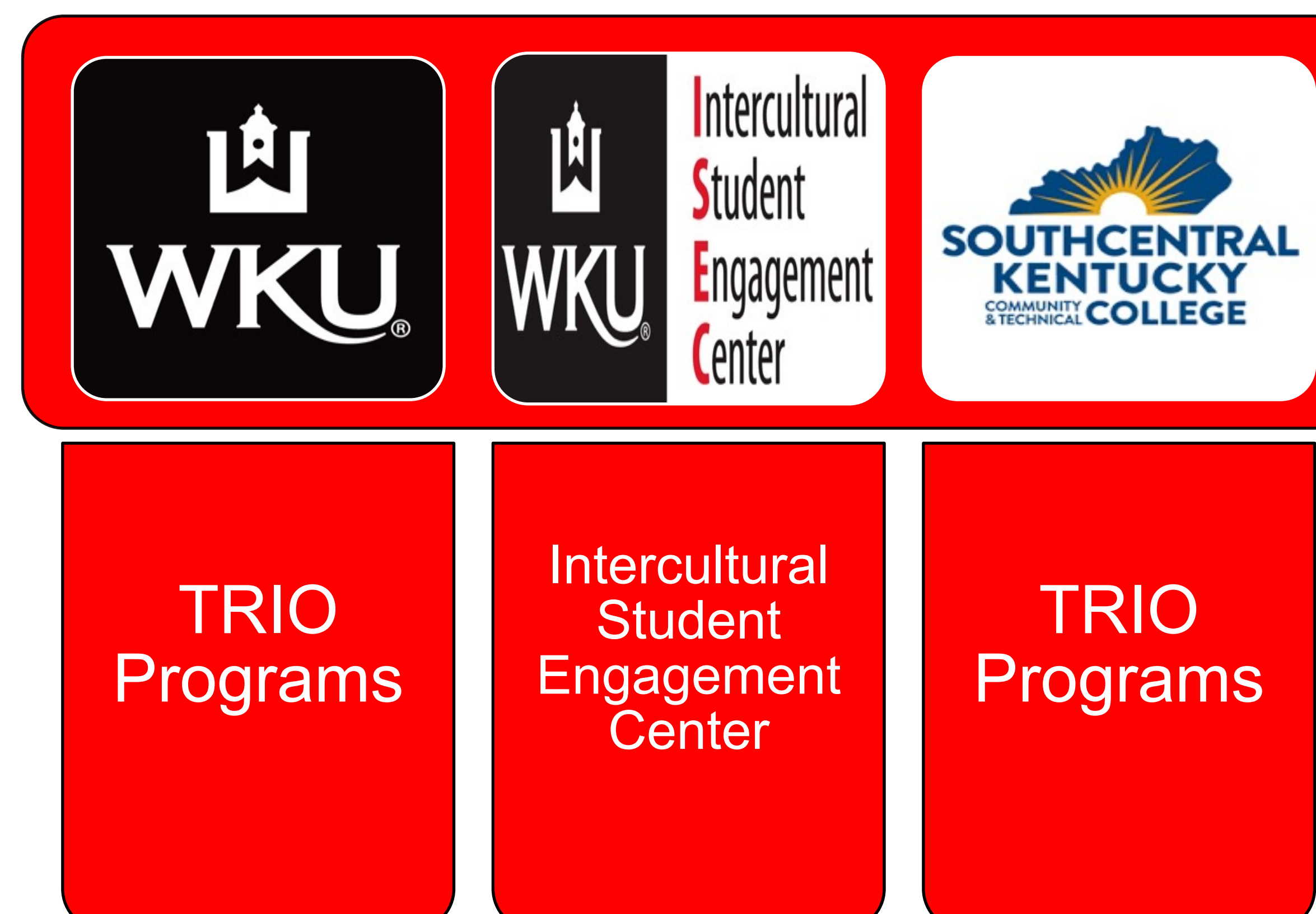


Figure 2: Participant Recruitment Sources

Expected Results

Discussions on violent victimization will solicit information on what young black workers experience related to workplace violence while at on the job. Victimization will be defined as experiencing any of the following four forms of violence: attacks, threats, sexual harassment, and bullying. FGD members will be asked to discuss the following: “while at work, what violent event did you experienced in the past 12 months?”; “what was your experience during the violent event?”; “why did this stand out to you?” We anticipate FGD participants to discuss a range of events which could cause physical or psychological harm. A series of follow-up questions will be asked to collect information on the event characteristics and consequences of these violent experiences. If FGD participants report experiencing more than one form of violence, follow-up questions will focus on all the experiences.

References

- [1] Schat AC, Frone MR, Kelloway EK. Prevalence of Workplace Aggression in the US Workforce: Findings From a National Study. Sage Publications, Inc: Thousand Oaks, CA, US; 2006.
- [2] Statistics UBoL. Age specific incidence rates for fatal occupational injuries and illnesses requiring days away from work by event/exposure. 2019.
- [3] Statistics UBoL. Age specific incidence rates for nonfatal occupational injuries and illnesses requiring days away from work by event/exposure. 2019.
- [4] Sabri B, St Vil NM, Campbell JC, Fitzgerald S, Kub J, Agnew J. Racial and ethnic differences in factors related to workplace violence victimization. West J Nurs Res. 2015;37:180-96.
- [5] Runyan CW, Schulman M, Dal Santo J, Bowling JM, Agans R, Ta M. Work-related hazards and workplace safety of US adolescents employed in the retail and service sectors. Pediatrics. 2007;119:526-34.
- [6] Okun AH, Guerin RJ, Schulte PA. Foundational workplace safety and health competencies for the emerging workforce. J Safety Res. 2016;59:43-51.
- [7] Rauscher KJ, Myers DJ. Occupational health literacy and work-related injury among U.S. adolescents. Int J Inj Contr Saf Promot. 2014;21:81-9.
- [8] Saha A, Sadhu HG. Occupational injury proneness in young workers: a survey in stone quarries. J Occup Health. 2014;55:333-9.
- [9] Nowrouzi-Kia B, Chai E, Usuba K, Casole J. Prevalence of Type II and Type III Workplace Violence against Physicians: A Systematic Review and Meta-analysis. Int J Occup Environ Med. 2019;10:99-110.
- [10] Sanyang E, Peek-Asa C, Young T, Fuortes L. Child Supervision and Burn Outcome among Admitted Patients at Major Trauma Hospitals in the Gambia. Int J Environ Res Public Health. 2017;14.
- [11] Sanyang E, Peek-Asa C, Bass P, Young TL, Jagne A, Njie B. Injury factors associated with discharge status from emergency room at two major trauma hospitals in The Gambia, Africa. Injury. 2017;48:1451-8.

Acknowledgement

This research study was supported by the National Institutes of Occupational Safety and Health through the Pilot Research Project Training Program at the University of Cincinnati Education and Research Center Grant #: T420H008432. Researchers will also like to thank the Western Kentucky University and Southcentral Kentucky Community and Technical College TRIO programs for partnering on this project.

INTRODUCTION

- Air pollution has become the biggest environmental health risk..
- EPA research on health effects from air pollution showed that air pollutants have detrimental effects on lungs, heart disease, and other health problems¹.
- According to Fortune Business Insights, the global market for air filters stood at USD 12.10 billion in 2019 and is projected to reach up to USD 20.63 billion by 2027 ².
- Carbon nanotube (CNT) hybrid fabric is a multifunctional material with light weight, good strength, and it also has antimicrobial property and can improve personal protective equipment (PPE)^{3,4}.
- The goal of this project is to use CNT-based filter to capture toxic pollutants and particulate matter.

OBJECTIVES

Specific Aims (SA) in the research.

SA 1: Synthesis of Filter membrane.

SA 2: Characterization of Filter membrane.

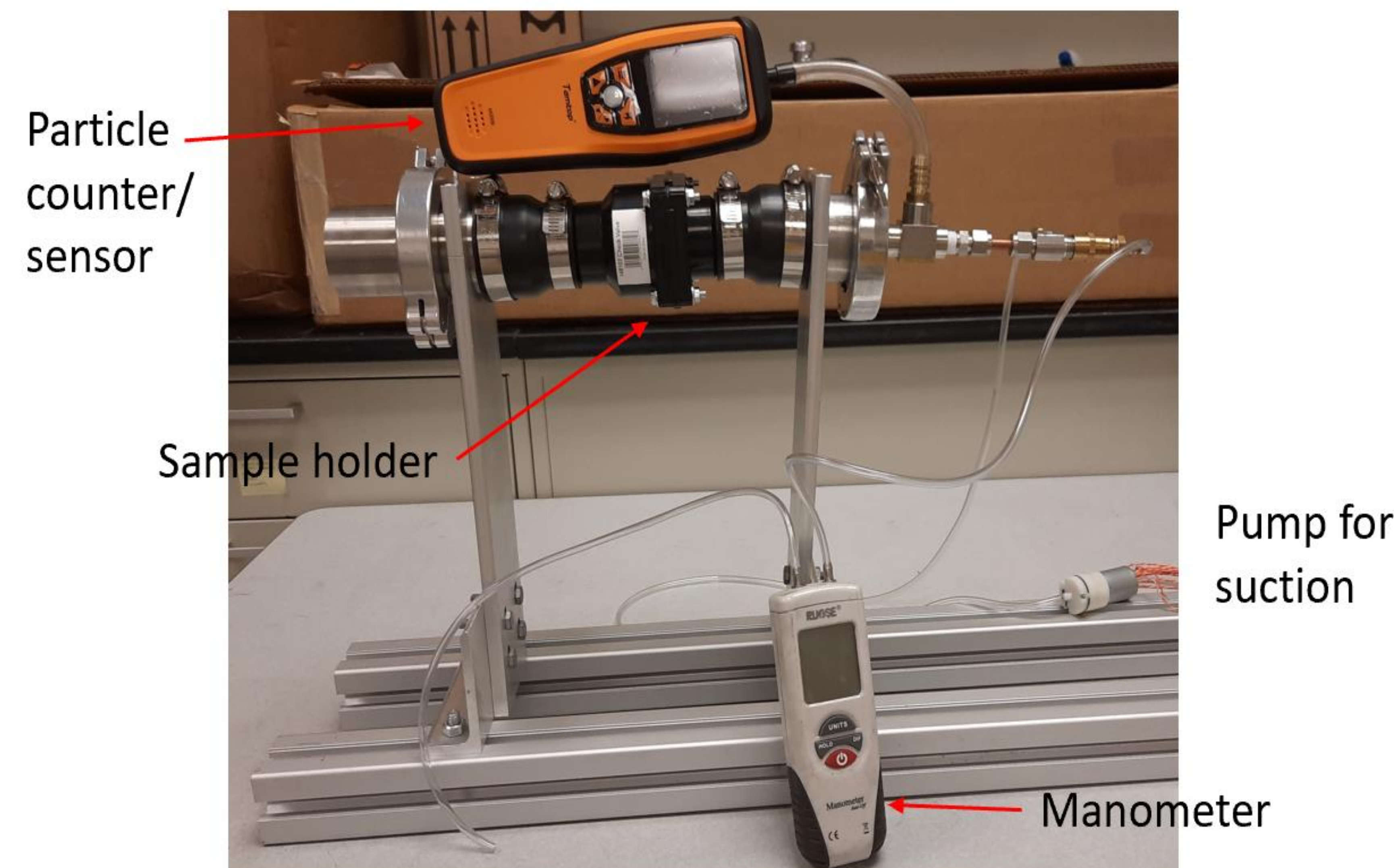
SA 3: Check the longevity of membrane.

SA 4: Modify membrane according to results, iterate from SA 1.

RELEVANCE To NORA

- Daily, public safety workers work in uncontrolled environments that places them in contact with biological, chemical, physical and psychosocial hazards.
- This PRP proposal is to develop a filter that can reduce the risk of the particulate exposure for all NORA personnel.

EXPERIMENTAL DESIGN



Experiment Setup

Step 1. Use CNT hybrid material as a filtering layer to remove particles using filtration mechanisms.

Step 2. Then heating will be used to clean the filtering layers.

Step 3. The CNT filter layer will also be investigated to adsorb gases and then decompose them using heat with help from the catalytic NPs.

Step 4. This research will focus on the applications such as use of the hybrid CCM material in textiles. The hybrid material will not be used directly in contact with wearer. Inner and outer layers of fabric will be used to make a sandwich structure with CNT CCM hybrid material in the middle.

Step 5. Particle release from CNT hybrid material will also be investigated for safety.

Step 6. Contaminant release from smoke(plastic burn/incense/cigarette) will be tested first and then the other target gas/particles will be selected based on the results from the previous experiment.

PERFORMANCE EVALUATION

- Experiment will be conducted without nanotubes layers and input and output particle concentrations will be recorded for 20-30 minute while burning Plastics/incense/Cigarettes.
- Input and output particle concentrations will be recorded with carbon nanotube layers for 20-30 minute.
- Particle counter data along with SEM/TEM/EDX other post analysis techniques will be performed on the tested carbon nanotube layers for captured particulate matter.

FUTURE DIRECTION

This is to obtain external funding to further develop PPE apparel and to transition the technology to industry

REFERENCES

1. <https://www.epa.gov/air-research/research-health-effects-air-pollution>.
2. <https://www.fortunebusinessinsights.com/industry-reports/air-filters-market-101676>.
3. Schulz, Mark J., et al. "Carbon Nanotube Hybrid Material Fabric, Composite Fabric, and Personal Protective Apparel and Equipment." U.S. Patent Application No. 16/629,714.
4. Kubley, Ashley, et al. "Smart textiles and wearable technology innovation with carbon nanotube technology." *Nanotube Superfiber Materials*. William Andrew Publishing, 2019. 263-311.

ACKNOWLEDGEMENTS

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

Work Stress, Poor Recovery, and Burnout in Nurses

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INTRODUCTION

- Occupational stress contributes to organizational inefficiency, high staff turnover, increased healthcare costs, and decreased job satisfaction (Wheeler & Riding, 1994).
- Healthcare workers, especially nurses, experience a high level of daily work stressors, with COVID-19 adding additional burden (dealing with high levels of sickness while worrying about personal health).
- Although research has identified common sources of stress, due to the nature of the job, not all sources of stress can be reduced or eliminated.
- Though all sources of stress cannot be eliminated, stressed workers can protect their health, by engaging in stress recovery or recuperation and replenishment following stress at work (Sonnentag, Venz, & Casper, 2017).
- However, the role of recovery as a buffer to the positive relationship between work stress and burnout has not been sufficiently addressed in research, especially in high-risk occupations such as nursing.
- The present study examines how nurses engage in stress recovery and its potential effects on their overall well-being (i.e., physical and psychological health).

RESEARCH QUESTIONS / HYPOTHESES

Research Question 1: What recovery experiences do nurses engage in? Specifically, do nurses engage in particular recovery experiences (e.g., detachment, control, relaxation, mastery, enjoyment) more than others?

Research Question 2: Do nurses engage in different types of recovery experiences based on the type of occupational stressors they are exposed to?

Hypothesis 1: Recovery experiences are negatively related to burnout.

Hypothesis 2: Recovery experiences are positively related to well-being outcomes (physical health and sleep).

Hypothesis 3: Recovery experiences moderate the relationship between stress and burnout (energy and affect).

Hypothesis 4: Recovery experiences moderate the relationship between stress and well-being outcomes (physical health and sleep).

METHOD

Participants ($n \approx 200$):

- Recruited from Ohio Board of Nursing Database.
- Must work 30+ hours per week.

Design and Measures:

- Longitudinal daily diary design (2 daily online surveys for 14 days).
- Analyzed via Hierarchical Linear Modeling and Descriptive Statistics.
- Up to \$90 incentive + stress report for full participation.

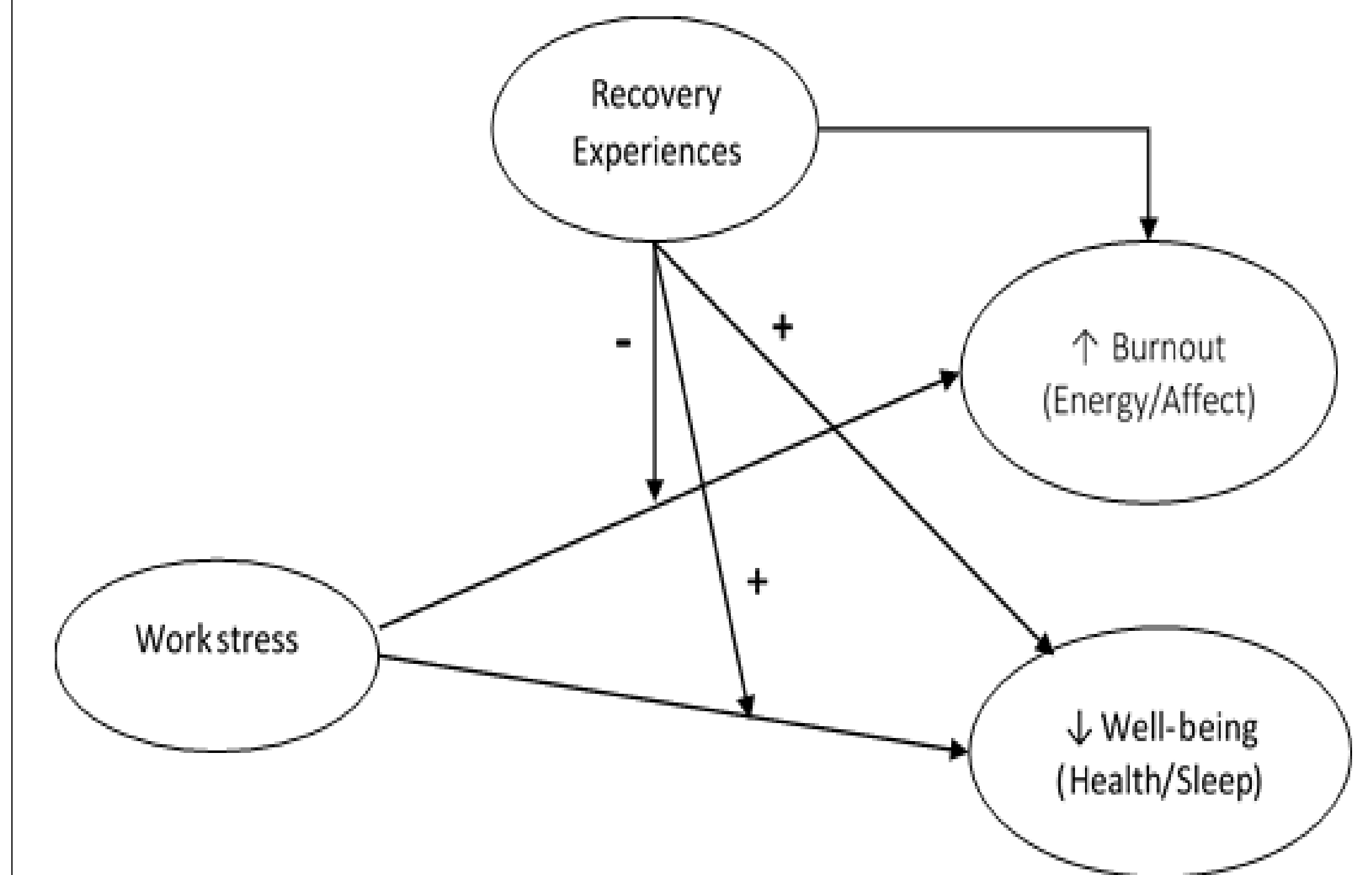
MEASURES

Variable	Measure	Psychometrics	Example Item	Survey 1	PM	AM
Affect	PANAS	$\alpha = .84-.90$ Test-retest = .79-.81	"Excited"	X	X	X
Burnout	MBI	$\alpha = 0.88$	"I feel emotionally drained from my work."	X		
Interpersonal Conflict	ICAWS	$\alpha = .74$	"How often do you get into arguments with others at work?"	X		
Job Autonomy	Self Determination	$\alpha = .81-.82$	"I can decide on my own how to go about doing my work."	X		
Stress	Nursing Stress Scale	$\alpha = .93$ Test-retest = .86	"Not enough staff to adequately cover unit."	X		
Organizational Constraints	OCS	$\alpha = .85$	"Poor equipment or supplies?"	X		
Social Support	Social Support Scale	$\alpha = .82$	"My coworkers help me get my work done."	X		
Workload	Quantitative Workload Inv.	$\alpha = .82$	"How often does your job require you to work very fast?"	X		
Well-being	WHO-Five	$\alpha = .82$	"I feel calm and relaxed."	X	X	X
Physical Strain	PSI	N/A	"Headache"	X	X	X
Stress Recovery	REQ	$\alpha = .79-.85$	"During time after work, I kick back and relax."	X	X	
Energy	State Self-Control	$\alpha = .72-.77$	"I have felt drained."	X	X	X
Daily Work Stress	Daily Stressor Checklist	N/A	"I got into an argument with someone at work."		X	
Sleep Quantity	1-item scale	N/A	"Number of hours you slept?"			X
Sleep Quality	1-item scale	N/A	"Overall quality of your sleep?"			X

EXPECTED RESULTS

We expect to find that recovery experiences will moderate the relationship between work stress and well-being outcomes, such that the positive relationship between work stress and burnout (and other negative well-being indicators) will be lower for nurses who engage in more recovery experiences (buffering effect).

CONCEPTUAL FRAMEWORK



FUTURE DIRECTIONS

- Examining more complex stress/recovery models (incorporating other stress sources and individual differences).
- Results could be useful in future interventions for stress/wellbeing in healthcare through additional studies.
- Integrating and replicating factors from previous research to strengthen understanding of *how* recovery experiencing help buffer stress effects in high-risk settings.

REFERENCES

- Shirey, M.R., (2006).** Stress and coping in nurse managers: two decades of research. *Nursing Economic\$, 24(4)*, 193.
- Sonnentag, S., Venz, L., & Casper, A. (2017).** Advances in recovery research: What have we learned? What should be done next? *Journal of Occupational Health Psychology, 22(3)*, 365-380.
- Wheeler, H. & Riding, R. (1994).** Occupational stress in general nurses and midwives. *British Journal of Nursing, 3(10)*, 527-534.

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Investigation of Occupationally-Related Stress of At-Risk Workers During COVID-19

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Study Mentors: Jun Wang, PhD* & Peggy Zoccola, PhD**

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**College of Arts and Sciences, Ohio University

PROBLEM

- Occupational stress is a common public health issue, worsened by COVID-19.
- Job stress costs the U.S. \$300+ billion per year via health costs, absenteeism, & poor performance.⁽¹⁾
- Research Question:** Will self-reported levels of stress correlate with levels of salivary cortisol & will there be significant differences between samples taken in relation to the distinct stressor events?

BACKGROUND & SIGNIFICANCE

- Occ. stress sources: work responsibilities, atmosphere, & working relationships with peers & superiors
- Occ. Stress symptoms: anxiety, low productivity, & health issues^(2, 3)
- Health issues: suppressed immune system, increased risk of diabetes, hypertension & CVD, & psychological issues^(2, 3)
- Psychological issues: neuroses, depression, & schizophrenia.^(2, 3)
- Certain sectors are more at risk:
 - HHCW – Median income ~\$22,000 & heightened exposures to COVID-19⁽⁴⁾
 - Work-from-home (WFH) – Blurring of work-life balance exacerbated by pandemic
 - 1st Responders – Respond to traumatic events on daily basis⁽⁴⁾
- Expands knowledge on how the pandemic may influence occupational stressors.

AIM 1 - SURVEY

- Survey about occupational stress distributed online (email & social media)
 - Explore & gain an understanding of participants' perceptions of stress and how work, family, and other factors shape stress & related behavior.
 - Focused on:
 - Work-related stress (job structure & demands, job control, social support)
 - Health & related QOL (depressive symptoms, hypertension, diabetes)
 - How the pandemic may influence subjective occupational stress
- Responses recorded via REDCap:
 - Coded to capture key domains
 - Identify key themes
 - Findings analyzed via regression analysis
 - Will aid in targeting subjects for Aim 2



(Safety + Health Magazine)

AIM 2 – DIARY & CORTISOL COLLECTION

- Correlating salivary cortisol fluctuations with subjective work stressors
- Participant recruitment: 15 from Aim 1 will be solicited & provided informed consent
- Protocol:
 - 3 saliva samples per day on 3 consecutive working days: start of work shift, start of break, end of work shift
 - Samples collected via "passive drool" method in SalivaBio collection tubes
 - Diaries: completed throughout workday, documenting any subjective events causing stress while on the clock, in real-time
 - Diaries capture variations in broad experiences & severity of stressors affecting varying cortisol levels

SAMPLE STRESS DIARY

Name: Steve Occupation: Nurse
 Date: 8/25/21 Is this a typical day (describe): Yes
 CIRCLE ONE: SA M T W TH F SU
 Complete the Stress Diary Below. Copy this form for additional space.

Time of Day	Intensity of Stress (0-5) 0 = no stress, 5 = most stressful	Duration of Stress	Situation (circumstance, location, people, etc.)	Triggering Event (preceding event, if applicable)	Emotional Behavioral Reaction (your feelings about the event)
9:00am	4	30 min	Woke up too late and came in late to work.	I went out last night until 2:00am the night before.	I got mad at my spouse for not waking me up soon enough.
11:30am	5	1 hour	I couldn't finish a work assignment that needed to be completed by now. It took me longer than expected to finish.	My boss set an unrealistic time frame for this assignment.	I was extremely nervous because of not being able to finish the assignment on time.
2:00pm	3	30 min	I overheard my co-worker talking about my poor performance lately with my superior.	I have been feeling overburdened between work and family needs.	I feel that I am juggling too many things in life and overwhelmed.
3:30pm	2	2 hours	I feel like I need to find a different job that will be less stressful and I will be able to better provide for my family.	Repetitive negative thinking regarding where I am at in life.	I feel inadequate.

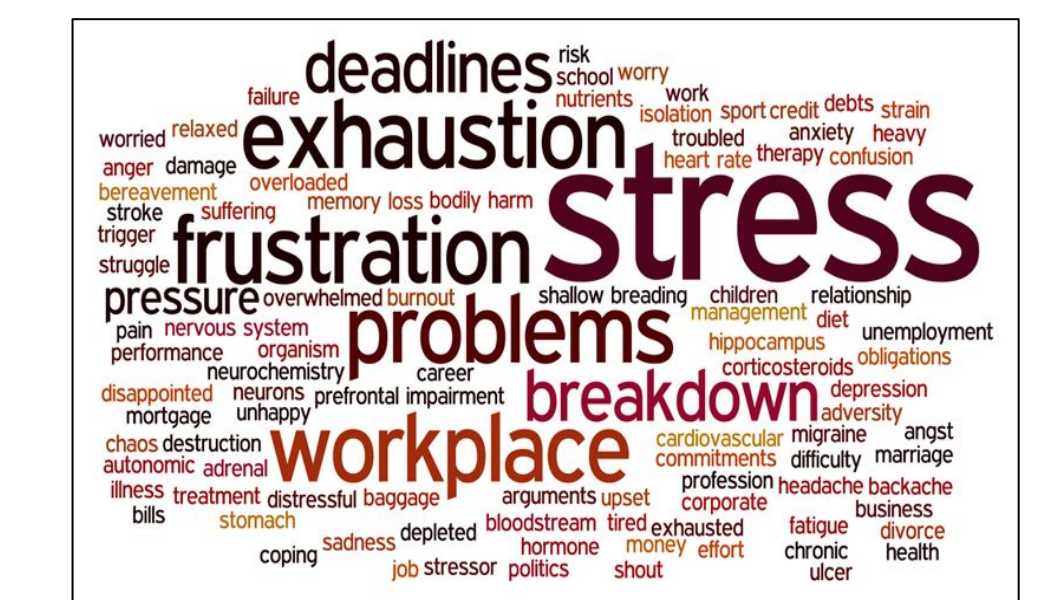
Figure 1. Sample Stress Diary

DATA ANALYSIS

- Returned samples analyzed at UC via standard enzyme-linked immunosorbent assays (ELISA)
 - All samples ran in duplicate for QA/QC purposes
 - Models created to explore associations of self-reported stress with 6 cortisol variables: Average morning rise, average slope, average area under the curve, maximum morning rise, minimum slope, & minimum area under the curve
 - ANOVA – statistical differences between the samples collected at sampling times at intrapersonal & interpersonal levels.



(SalivaBio – Salimetrics)



(Rehab Alternatives)

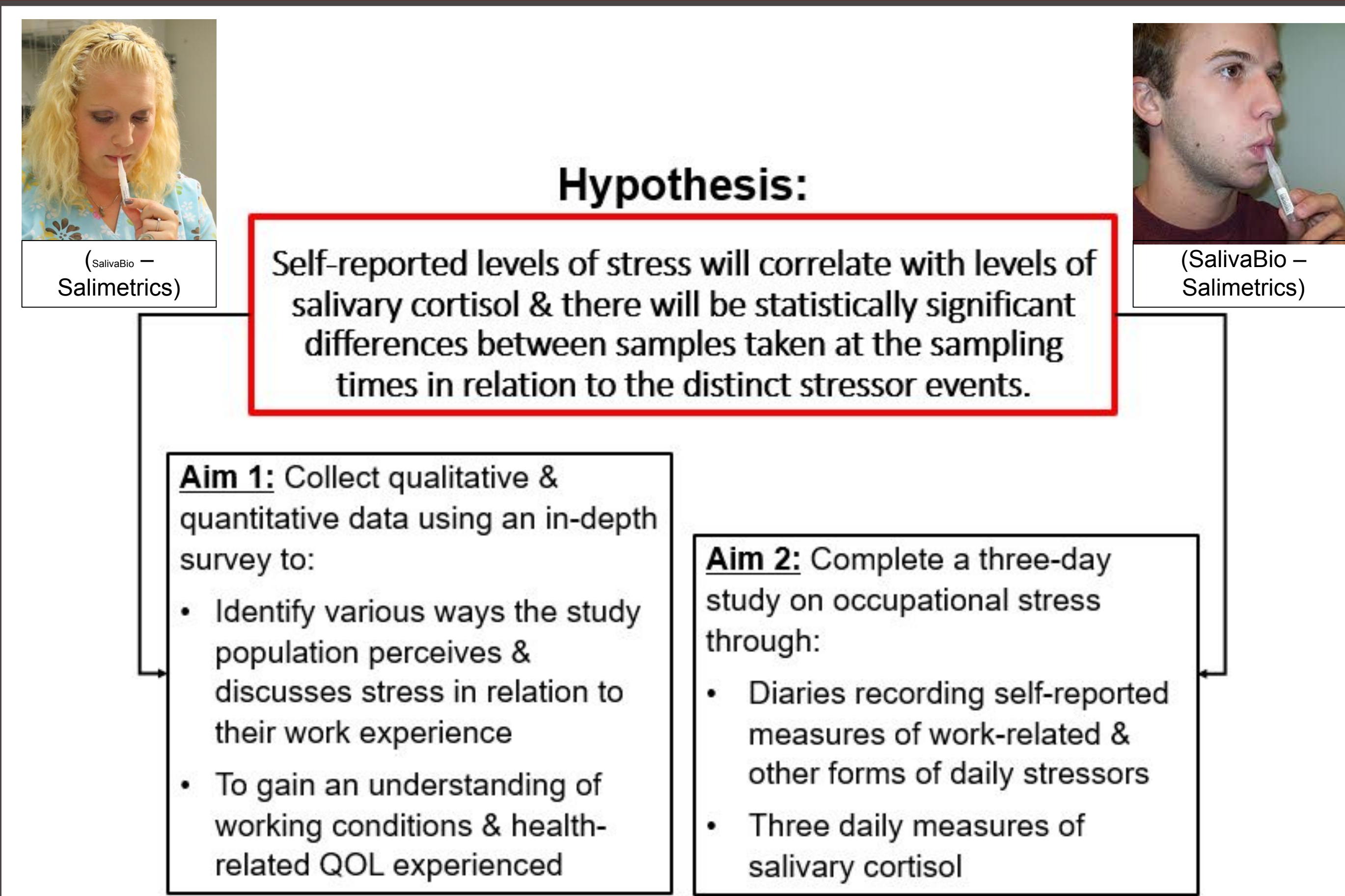
9 color-coded SalivaBio collection tubes (Salimetrics, State College, PA) provided to each participant (3 tubes used per day)

REFERENCES

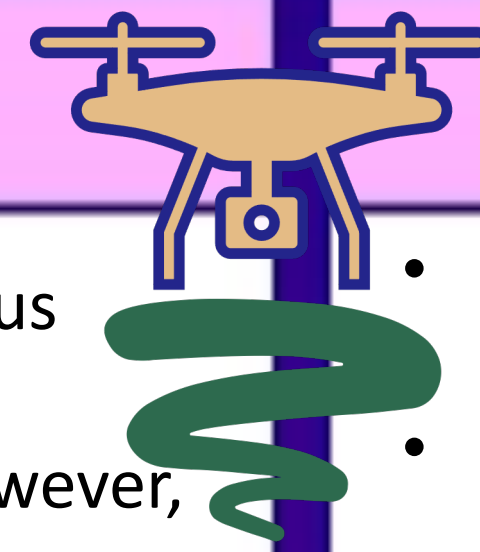
- The Center for the Promotion of Health in the New England Workplace (CPH-N21). The Financial Burden of Job Stress. <https://www.uml.edu/research/cph-new/worker/stress-at-work/financial-costs.aspx#:~:text=Job%20stress%20is%20estimated%20to, costs%2C%20absenteeism%20and%20poor%20performance.&text=Job%20stress%20is%20the%20source, salary%20of%20the%20position%20affected.> (accessed 3/20/2021).
- NIOSH, Stress At Work. Department of Health and Human Services, C. f. D. C., Ed. Government Printing Office: 1999.
- Zhang, X.; Zhao, K.; Zhang, G.; Feng, R.; Chen, J.; Xu, D.; Liu, X.; Ngoubene-Atioky, A. J.; Huang, H.; Liu, Y.; Chen, L.; Wang, W., Occupational Stress and Mental Health: A Comparison Between Frontline Medical Staff and Non-frontline Medical Staff During the 2019 Novel Coronavirus Disease Outbreak. *Front Psychiatry* 2020, 11, 555703.
- NORA, National Occupational Research Agenda for Healthcare and Social Assistance (HCSA). Department of Health and Human Services, C.D.C., Ed. NIOSH: 2019.

ACKNOWLEDGEMENTS

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



BACKGROUND



- The use of Unmanned Aerial Vehicles (UAV), drones, in business can unlock tremendous savings in terms of increased productivity and decreased downtime.
- At first glance, drones provide a safe, eco-friendly, and efficient service to humans, however, flying the UAV near workers can pose significant and unprecedented risks.
- Mounting evidence suggests that both technical issues and human factors cause UAV incidents. Organizational influences, operator vigilance and fatigue associated with shift work, situational awareness, training, display design, as well as human-system integration problems were identified as main human factors-related issues in UAV mishaps (Arrabito et al., 2010; Nasir & Shi-Yin, 2011; Wild et al., 2016).
- Although using drones indoors can help avoid severe weather conditions, flying a drone is easier outdoors where there is ample space for take-offs and landings compared to indoor environments cluttered with obstacles (Waibel et al., 2017).
- Blunt force trauma, penetration, and laceration injuries are the most prevalent injuries among non-participating public and drone pilots which may lead to fatality or permanent disability as outlined in table below (Arterburn et al., 2017).
- Personal Protective Equipment (PPE) including hard hats, gloves, safety glasses, steel-toe boots, earplugs, vests, and full body suits can minimize exposure to potential safety threats when operating a drone.
- The spike in drone industry growth has outpaced the formulation of rules, regulations, and standards for governing the safe use of UAV. Hence, the envision of safety leading and lagging indicators, hazards, as well as mitigation strategies are required to eliminate or control risks and hazards associated with deploying drones in a work environment.

Body Part	Injury	AIS
Head	Penetrating Injury - Superficial; ≤ 2cm beneath the entrance	AIS 2
	Laceration resulting in blood loss of > 20% by volume	AIS 3
	Total scalp loss or blood loss of > 20% by volume	AIS 3
	Severing of the Optic Nerve	AIS 2
	Severing of the Facial Nerve	AIS 3
Brain	Superficial cerebellum contusions ≤ 15cc; 1-3 cm	< AIS 3
	Concussive Injury Loss of Consciousness 1-6 hours	AIS 3
	All other concussions	AIS 2
Face	Penetrating Injury; with blood loss > 25 cm ²	AIS 2
	Penetrating Injury with blood loss 20% by volume	AIS 3
	Massive destruction of whole face including both eyes	AIS 4
	Complete separation of the facial bones from their cranial attachments or any injury resulting in blood loss > 20% by volume	AIS 3
Neck	Penetrating Injury with blood loss 20% by volume	AIS 3
	Bilateral laceration of the carotid artery	AIS 3
Upper Limbs	Single amputation at the shoulder	AIS 4
	Amputation of a single hand, partial of complete	AIS 2
	Amputation of the thumb	AIS 2
	Amputation of other fingers, single or multiple	AIS 1

OBJECTIVES

- The purpose of this study is to examine the prevalence of drone-related mishaps and identify possible risk factors by comparing the use of drones in construction sites with manufacturing plants.
- The overarching research question for this study is: "What factors most affect drone-related mishaps in the construction (outdoor flights) and manufacturing (indoor flights) industries?"

STUDY POPULATION

- The desired sample size for this study is to recruit 384 participants from both constructions and manufacturing sectors equally.
- Primary inclusion criterion for recruiting the participants is whether they use UAV in the workplace.

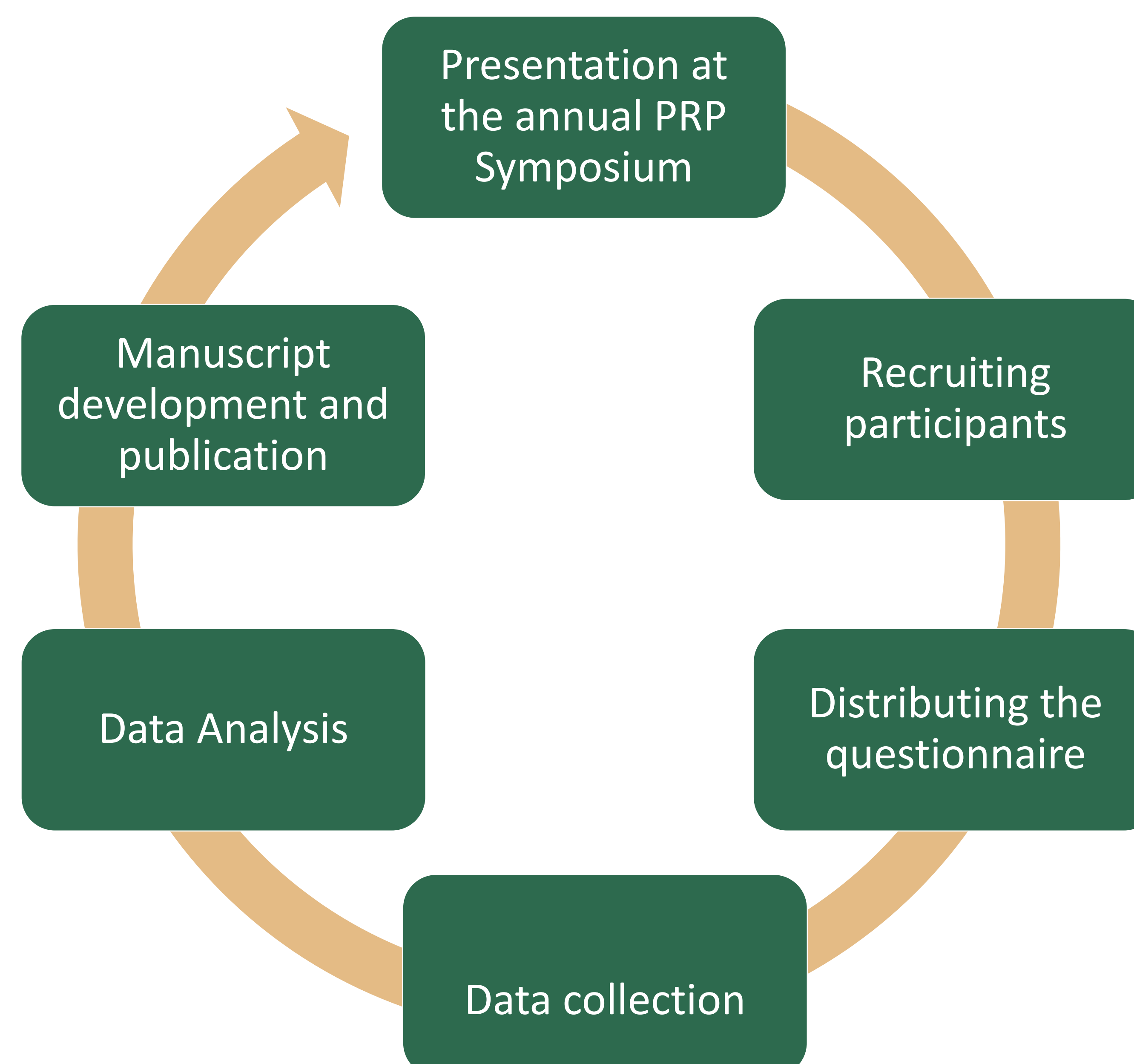
EXPERIMENTAL DESIGN

- The research question will be explored by asking different types of questions from participants.
- An online questionnaire was crafted using Qualtrics which contains Likert, continuous, and open-ended questions.
- The dependent variable in this study is drone accidents, incidents, and mishaps.
- There are various independent variables including human errors, technical issues, environmental effects, effectiveness of using PPE, as well as presence of regular onsite trainings and risk assessment practices for drone operation in construction and manufacturing sectors.
- For the purpose of data analysis, two data mining techniques, the random forest and association rule mining algorithms, will be performed to find meaningful associations, patterns, and trends in data as well as significant factors that have an impact on the occurrence of drone-related mishaps in construction and manufacturing industries.
- Spearman's correlation and chi-square tests will be used to measure possible correlation between variables.
- All algorithms will be implemented in Python 3.0 and Minitab.
- The reliability of the questionnaire will be assessed using the Split-half method.
- The validity of the questionnaire will be evaluated both in terms of content and construct using correlation matrices.



Retrieved from: <https://utilitycontractoronline.com/komatsu-propeller-partner-to-bring-drone-solutions-to-construction-industry/>

TASK DESCRIPTION



LIMITATIONS

- Under-reporting of occupational injuries and accidents by companies
- Lack of prior studies on the topic
- Use of self-reported data which in turn may make study findings prone to bias



Retrieved from: <https://www.japantimes.co.jp/2020/12/16/special-supplements/drone-business-attracts-attention-growth-industry/>

EXPECTED RESULTS

- This study will raise awareness about the prevalence of drone-related mishaps and address contemporary and emerging challenges of occupational safety and health.
- The current work can contribute to data-driven insights into UAV-related incidents and recommend applicable ergonomic practices through identification, elimination, and mitigation of risks associated with expanded drone operations.
- The findings of this research will have the potential to transform the ways policy-makers' approach to maintain the balance between promoting the use of new technologies and ensuring workplace safety.



FUTURE DIRECTION

- Additional studies will be needed in NORA's other sectors such as mining or oil and gas extraction. The environmental factors in these industries including high temperature and presence of chemical substances can cause an electrical spark in drones.
- Furtherance of research is required beyond the scope of hazard identification and mitigation to provide a comprehensive understanding of how to integrate drones effectively and safely into workplace.
- This study has the potential for receiving future grants and funding opportunities from the Center for Construction Research and Training to advance research in the field of construction safety.

REFERENCES

- Arrabito, G. R., Ho, G., Lambert, A., Rutley, M., Keillor, J., Chiu, A., Au, H., Defence, M. H., & Canada, R. (2010). *Human Factors Issues for Controlling Uninhabited Aerial Vehicles: Preliminary Findings in support of the Canadian Forces Joint Unmanned Aerial Vehicle Surveillance Target Acquisition System Project*.
- Arterburn, D., Ewing, M., Prabhu, R., Zhu, F., Francis, D., & Excellence, U. S. F. A. A. U. A. S. C. of. (2017). *Final Report FAA UAS Center of Excellence Task A4: UAS Ground Collision Severity Evaluation Revision 2*. United States. Federal Aviation Administration. Unmanned Aircraft Systems. Center of Excellence.
- Nasir, M. M. & Shi-Yin, Q. (2011). Notice of Violation of IEEE Publication Principles: Investigation of Human Factors in UAV Accidents Based on Analysis of Statistical Data. *2011 First International Conference on Instrumentation, Measurement, Computer, Communication and Control*. pp. 1011-1015, doi: 10.1109/IMCCC.2011.255.
- Wild, G., Murray, J., & Baxter, G. (2016). Exploring Civil Drone Accidents and Incidents to Help Prevent Potential Air Disasters. *Aerospace*, 3(3), 22. <https://doi.org/10.3390/aerospace3030022>
- Waibel, M., Keays, B., & Augugliaro, F. (2017). *Drone shows: Creative potential and best practices*. ETH Zurich. <https://doi.org/10.3929/ethz-a-010831954>

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.

Advocacy for Occupational Safety and Health Policy and Practices to Address Stressors and Workplace Violence in Home Health Care Workers

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Background

Home Healthcare workers (HHCW) are an at-risk working population. HHCWs work alone in the isolated environment of patient homes and may encounter risks from unique work stressors including workplace violence. Potentially unregulated workplace hazards unique to the home healthcare environment include fall risks, musculoskeletal injury, viral exposure, violence, and chemical exposures risks (Bien, et al., 2021; Davis, et al., 2021). The possibility of workplace danger without proper intervention is increased by poorly regulated interventions for violence and hazards which are often attributed to profit-driven models and lack of management accountability (Liu, et al., 2019; Blando, et al., 2015). The result of poor intervention planning is negative health outcomes caused by a lack of evidence-based interventions, stress, and turnover of home healthcare workers (Franzosa, et al., 2017).

Purpose & Aims

This study represents the first phase of a larger mixed methods research project to examine the role of HHCW advocacy for policy to address common stressors and violence encountered in the work environment.

The aims of this study include:

Aim 1: Explore home healthcare workers' experiences of common stressors and violence encountered in the work environment and role of current policy

Aim 2: Explore HHCWs' attitudes and beliefs towards advocating for organizational policy to address common stressors and WPV



Methods

Design: Exploratory qualitative phase using in-depth individual interviews

Setting/Sample: 25 HHCW employed in Tri-State areas (Ohio, Kentucky, Indiana) will be recruited using convenience sampling

Inclusion criteria: Work setting in community home healthcare locations, active home healthcare worker, at least 6 months experience in current organization

Exclusion criteria: Cannot read and write in English, works less than 20 hours per week in current setting

Topics Addressed during Interview:

- Common stressors and WPV experienced by HHCW
- HHCW's perceptions of current policies/practices
- HHCW's attitudes and beliefs about HHCW role in policy development
- Reasons why HHCW would get involved in policy/practice development

Individual interviews will be approximately 45 minutes long and will be audio-recorded to facilitate analysis of verbatim interview transcripts. Each participant will receive a \$40 gift card as compensation for their time. Thematic analysis of interview data will be used to identify recurring themes that address each of the study aims.



Anticipated Results

Qualitative results should reveal common stressors and violence experienced by HHCW, the current role of policy to address said stressors, and HHCW attitudes and beliefs about organizational policy. Data will be used to inform the development of an instrument that measures advocacy experience in HHCWs.

Significance for Practice

Obtaining qualitative data is the first step to understand current HHCW experiences of stressors and their perception of how policy can assist them. Furthermore, qualitative data will assist in the development of an instrument to measure changes in advocacy experiences. The development of an instrument to measure advocacy experiences in Home Healthcare worker (HHCW) populations will be necessary to measure outcomes of follow-on research testing interventions to promote HHCW self advocacy.



References

- Bien, E., Davis, K., Reutman, S., Gillespie, G. (2021). Occupational Exposures in the Homecare Environment: Piloting an Observation Tool. *Home Health Care Management and Practice*. Advance online publication. <https://doi.org/10.1177/1084822320986917>
- Blando, J., et al. (2015). Barriers to effective implementation of programs for the prevention of workplace violence in hospitals. *Online Journal of Issues in Nursing*, 20(1), 1-1. <https://doi.org/10.3912/OJIN.Vol20No01PPT01>
- Davis, K.G., Freeman, A.M., Ying, J., Huth, J.R. (2021). Workers' compensation costs for healthcare caregivers: Home healthcare, long-term care, and hospital nurses and nursing aides. *American Journal of Industrial Medicine*. Advance online publication. <https://doi.org/10.1002/ajim.23237>
- Franzosa, E., Tsui, E. K., Barron, S. (2017). Home Health Aides' Perceptions of Quality Care: Goals, Challenges, and Implications for a Rapidly Changing Industry. *New Solutions*. Advance online publication. <https://doi.org.proxy.libraries.uc.edu/10.1177/1048291117740818>
- Liu, J., et al. (2019). Prevalence of workplace violence against healthcare workers: A systematic review and meta-analysis. *Occupational and Environmental Medicine*, 76(12), 927-937. <https://doi.org/10.1136/oemed-2019-105849>

Acknowledgement

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