Effect of Heat Stress on Immune Function in Firefighters

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Background

- Firefighters are challenged with extremely stressful and hazardous conditions in their occupational settings [1, 2]
- Firefighters are exposed to dangerous heat stress causing fatigue, cardiac death, cancer, kidney disease and other chronic diseases[2,3]
- As firefighters encounter extreme conditions of toxic chemical exposures and heat stress, an normal immune function dysfunction in firefighters cannot be ruled out.
- Recent studies on firefighters by our Department (Dept of Environmental Health, University of Cincinnati) and others has revealed high concentrations of PAHs on the firefighter's bodies which potentially exposes them to the risk of cancer [4], Type 2 diabetes, cardiovascular diseases as well as systemic and pulmonary inflammation disease [5].
- General studies in the literature provide evidence that chronic heat stress can alter innate immune response by inducing expression of stress proteins, (such as heat shock proteins-HSP) 6,7], neuropeptides such as orexin A [8], and stress hormones such as cortisol [9]
- Furthermore, some studies suggested heat stress lead immediate increase of leukocytosis, sustained elevation of neutrophil and monocyte count, plasma cortisol level, after post-firefighting [9]. One study also reported heat-stress induce inflammatory cytokines IL-6, TNF-A production from organ/tissue other than blood mononuclear cells[10]. Furthermore animal studies shows, hematopoietic system respond to heat stress by decreasing, hemoglobin synthesis, erythrocyte formation and packed cell volume and tilting T cell response towards immunosuppressive axis [11]
- Few reports shows chronic heat exposure weakened innate immune system leading to increase vulnerability for many communicable and noncommunicable disease including MRSA in firefighters [2,5,12, 13]

- **Hypothesis**: Collectively, these facts coupled with the reports of elevated exposure to heat stresses in high risk jobs lead us to hypothesize that heat stress during firefighting can significantly alter the physiological homeostasis in firefighters in terms of altered innate and adaptive immune parameters. This alteration in immune parameters , may at least in part, can serve as a tool for finding novel biomarkers and help understand the mechanism of different disease conditions as a result of firefighting- related exposures.

Objectives

Aim 1: Analyze for immune phenotyping and heat stress level in firefighters.

Aim 1a: To Collect blood samples from exposed firefighters, before and after the firefighting event and immune cell profiles by flow cytometry and ELISA.

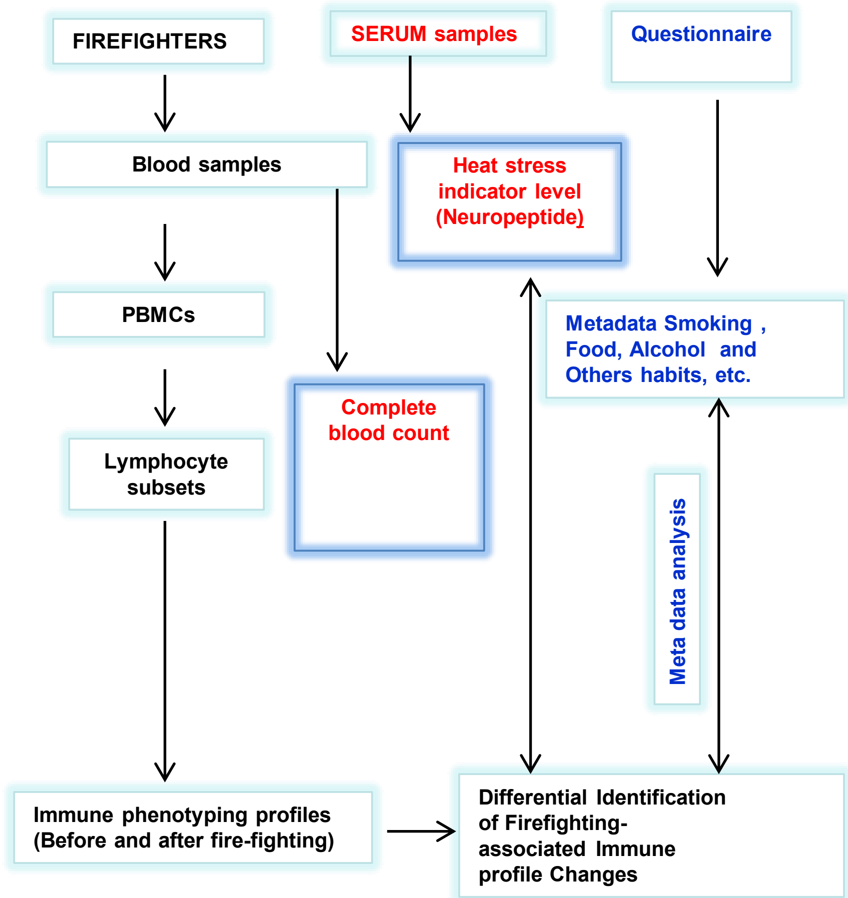
Aim 1b: To analyze heat stress associated bio-markers by ELISA in serum.

Aim 2: Integrated analysis to understand heat stress-associated immune changes in relation to the metadata collected from the Questionnaire.

Study population

For accessing of the firefighters cohort and their sampling will be carried out in association with our Co-investigators team from Western Kentucky University. In the present investigation, a subset of 20 firefighters actively engaged in firefighting will be considered, for sampling right before the fire event and 24 hrs. after the fire event (N = 20 subjects x 2 samples/subject = 40 samples).

Experimental design



Work flow for Effect of Heat Stress on Immune Function of Firefighters

Limitations

We anticipate no specific problems with the human blood/serum sampling and its relevance in obtaining the desired information on immunological changes. It may be possible that other factors such as alternate profession, age, medical history may be influencing the immune status. To account for all that data, we will use our existing specially-developed questionnaire in a way that it could provide us with the information on the other significant factors.

Expected results

1. We expect to identify the alterations in immune profile in the firefighters owing to their occupational exposure to firefighting-associated heat stress.
2. This will also give us insights into the interplay of the altered immune parameters with the levels of occupational exposure, health condition, stress levels and lifestyle of the Firefighters.

Future directions

1. This study will characterize the specific biomarkers and immune alterations that are critical in the induction and/or progression of occupational diseases in firefighter.
2. Modulation of the altered immune status might help restore the homeostasis of the firefighters to regain the healthy natural condition.
3. Preliminary data obtained through this pilot study will be used to submit a larger grant to NIOSH to pursue future expanded studies on the role of heat stress, fatigue in immune-mediated neurological health disorders and diseases in firefighters.

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Exposure to Traffic-Related Air Pollution, Home Dust, and the Respiratory Mycobiome

University of CINCINNATI

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Background

- Exposure to traffic-related air pollutants (TRAP) has been associated with exacerbation of existing asthma and incident asthma among young and adolescent children
- Aggregates of elemental carbon nanoparticles are retained by the lung tissue, can induce pulmonary oxidative stress, and stimulate the inflammatory response by the release of cytokines from airway cells
- TRAP can increase adherence of microorganisms to the epithelial cells of the respiratory tract by damaging cells in epithelial layers of respiratory tract
- Bacterial diversity in sputum was found to be greater in asthmatic vs. non-asthmatic adult subjects
- Similar to how the gut microflora affect the development of the immune system, the airway microbiome may interact with the immune system in the respiratory tract
- <u>Home health care workers are exposed to TRAP during travel between patients' homes. Indoor environment and work activities in patients' homes can contribute to elevated microbial exposures.</u>

Aims

- **<u>Specific Aim 1:</u>** Characterize the fungal community profiles of the lower respiratory tract mycobiome.
- **<u>Specific Aim 2:</u>** Determine the association between exposure to TRAP and the mycobiome of the lower respiratory tract.
- **<u>Specific Aim 3:</u>** Characterize the fungal community profiles of home dust samples and compare the taxa and diversity indices to those of the lower respiratory mycobiomes of the two exposure groups.

Methods

- 40 participants ages 13-15 were recruited from the Cincinnati Childhood Allergy and Air Pollution study (CCAAPS) cohort from two a priori TRAP exposure categories:
  A. high exposure through age one and high exposure at early adolescence
  B. low exposure through age one and low exposure at early adolescence

Methods, continued

- Collected induced **sputum**, saliva, and **home dust samples**
- Characterize fungal microbiome (**mycobiome**) of sputum and home dust samples using Illumina MiSeq with the amplification of the internal transcribed spacer (ITS) region of fungal ribosomal DNA
- Measure total fungal DNA using quantitative PCR with universal fungal primers
- Assess the associations between <u>total fungal DNA</u>, <u>fungal operational taxonomic units (OTUs)</u>, and <u>diversity indices</u> of sputum and <u>TRAP exposure</u>
- Compare the sputum mycobiome to the home dust mycobiome using principle component analysis of taxa and diversity indices

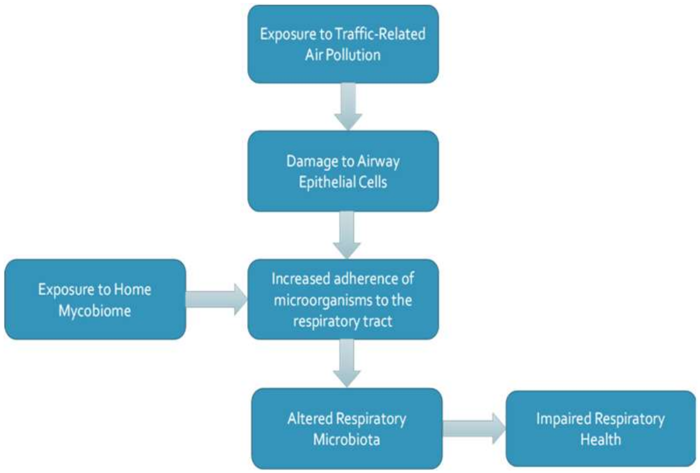

Figure 1. A flow chart describing the study rationale and expected results

Expected Results

- We hypothesize:
  - that high exposure to TRAP alters the lower respiratory tract microbiome
  - that there are taxa that overlap between that fungal community and the home dust mycobiome
- See Figure 1 for study rationale and expected results

Future Directions

- The knowledge gained from the proposed study provides preliminary data to conduct a larger investigation that focuses specifically on home health care workers and their occupational environments
- Further research into respiratory health outcomes from these combined exposures

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Questions or Comments?

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Neuromotor Effects of Manganese Exposure in Adolescents Entering Workforce

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BACKGROUND

Manganese (Mn) is an essential nutrient, yet neurotoxic in excess. Mn can negatively impact neuromotor function. Adolescence is a critical time of development, as many begin to enter the labor force for the first time. Marietta, Ohio is home to America's largest ferromanganese refinery, a significant source of ambient Mn. In this community-based longitudinal cohort study, we investigate the relationship between adolescent exposure to manganese and neuromotor function.

METHODS

Recruitment Criteria
Mother resided in community since 16th week pregnancy, child initial enrollment at 7-9 yrs; age at balance testing 13-17 yrs

Biological Measures
Blood Mn, Pb; Hair Mn

Covariates
Age, sex, height to weight ratio, parent IQ, parent education, serum cotinine

Neuromotor Measurement
Postural Balance; Gait

Acknowledgements
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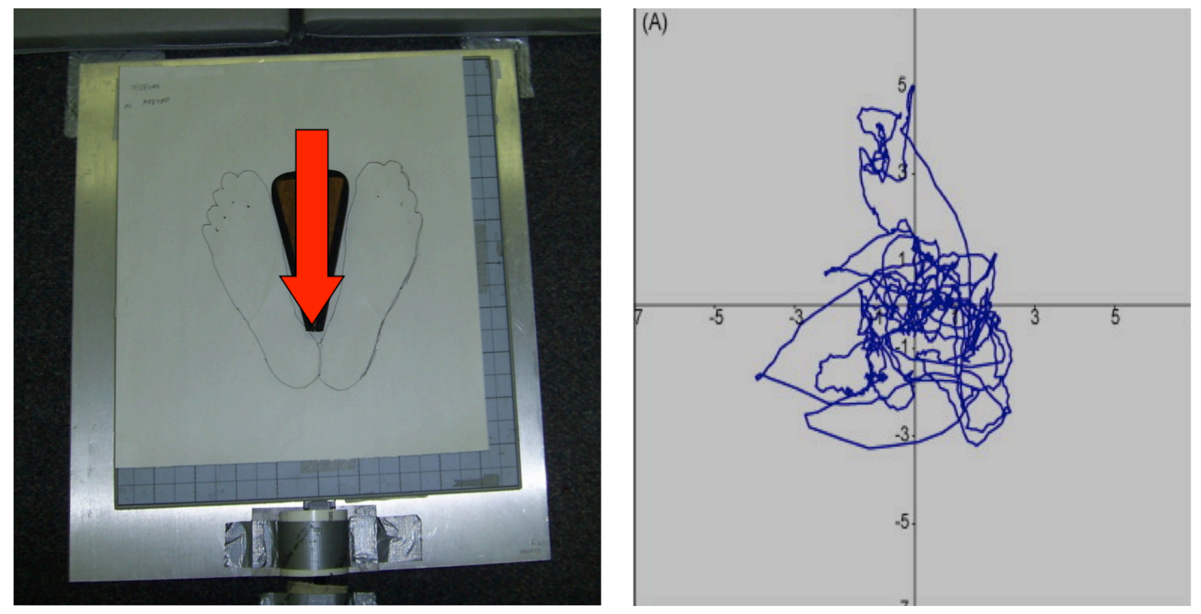
NEUROMOTOR MEASURES

Postural Balance



Battery of 8 tests designed to eliminate/and or challenge systems used in maintaining upright postural balance: vision, proprioception, vestibular

Gait

3 trials normal walk
3 trials obstacle walk

PRELIMINARY DEMOGRAPHICS/RESULTS (N=74)

Female	45%
Caucasian	92%
Biological Measures (7-9 yrs)	**GM ± GSD, Range (N=65-74)**
Hair Mn (ng/g)	447.4 ± 2.7 (63.2-7379.1)
Blood Mn (µg/L)	9.8 ± 1.3 (5.3-17.4)
Blood Pb (µg/dL)	0.8 ± 1.5 (0.4-2.6)
Postural Balance Measures (13-17 yrs)	
Mean Sway Area (cm^2)	53.30
Mean Sway Length (cm)	4.31

EXPECTED RESULTS

Given the role of Mn as both essential and neurotoxic, we expect to find a biphasic relationship between biomarkers of Mn exposure and adolescent neuromotor function, as measured by postural balance and gait.

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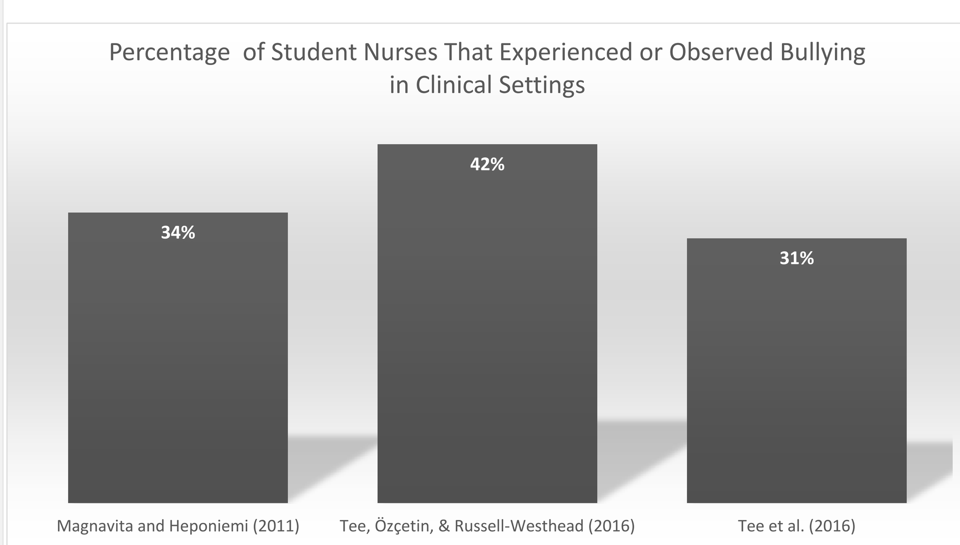
Educational Intervention to Mitigate Effects of Bullying in the Student Nurse Population

Dawna Rutherford, MSN, RN & Carolyn R. Smith, PhD, RN

Bullying in Nursing

Background

- Verbal abuse, non-verbal abuse, and interference or sabotaging workflow are often recognized as bullying behaviors in nursing that can be injurious to the victim as well as the patients.
- Bullying is pervasive in the profession and student nurses are victims without skills to mitigate the negative behaviors.



Purpose

The purpose of this study is to examine the feasibility and acceptability of education-based intervention to mitigate the effects of bullying on delivery of safe patient care by senior-level student nurses.

Objectives

- Test educational intervention with student nurses encountering bullying behaviors in the clinical setting
- Direct observation and quantification of how bullying can impact patient safety
- Analyze the effectiveness of intervention for student nurses

Methods

Study design: Exploratory randomized controlled trial using 3 groups

Sample population: Senior-level student nurses from the University of Cincinnati

Sampling strategy: Convenience

Outcome measures: Bullying Knowledge Survey & Medication Administration observation checklist

Method: *In a simulated health setting…*

- Control group will be asked to perform medication administration with a non-bullying distractions occurring
- Non-intervention group will be asked to perform medication administration with bullying distraction occurring
- Intervention group will receive a bullying education intervention first and then be asked to perform medication administration with bullying distraction occurring
- All distractions will be conducted by professional actors (Standardized Participants)

Expected Results

Hypothesis 1. Participants in the intervention group will have *increased scores on the bullying knowledge survey* after receiving the educational intervention.

Hypothesis 2. Participants in the intervention group will demonstrate a *higher medication administration score* than participants in the non-intervention group.

Hypothesis 3. There will be *no difference* in medication administration scores between the intervention and control group.

Future Direction

Future Research Goals

If the intervention shows preliminary efficacy, future steps will include seeking federal funding from CDC/NIOSH to conduct a large-scale randomized control trial study with several baccalaureate nursing programs to determine the overall effect of the intervention.

Long-Term Goal

The long-term goal is to reduce bullying and bullying behaviors in the nursing profession through integration of effective educational interventions addressing bullying into nursing program curricula nationwide**.**

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Acknowledgements

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Healthcare Workers In the Home Environment: What are the Hazards? Developing an Observation Tool.

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Dr. K. Davis, PhD, CPE
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WHO?

❖**Home healthcare workers (HHCWs)**

❖**Population:**

❖HHCWs make up 8% of healthcare jobs with 1,354,620 workers (BLS, 2016)

❖Expected increase of 716, 000 jobs between 2012 and 2022 (BLS, 2014)

WHAT?

Descriptive Research

Describe the home care occupational environment

Descriptive Study collecting Objective Data

Observe

HHCWs in the home

Describe

the work and the occupational environment

Document

findings using the observation tool

Where?

In the patient homes with a home healthcare worker

Sample Aim:

30 HHCWs within 100 patient homes

In the Occupational Environment

WHY?

More complex health care delivered in the home

Unpredictable work environment

Previous studies focus on self-reported data

One on one interviews

Semi-structured interviews

Focus groups

(Hittle et al., 2016; Jones & Xia, 2016; Markkanen et al., 2007; Suarez et al., 2017; Wills et al., 2016).

HOW?

Observation Tool objectively identify hazards for HHCWs

Aim to **evaluate data** and **design future studies based on objective data**

❖Future development of **work design and/or mitigation strategies** for this unique occupational environment

University of Cincinnati
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Gender Differences in Nursing Job Demands and Resources

Katherine Barlow and Clare Barratt
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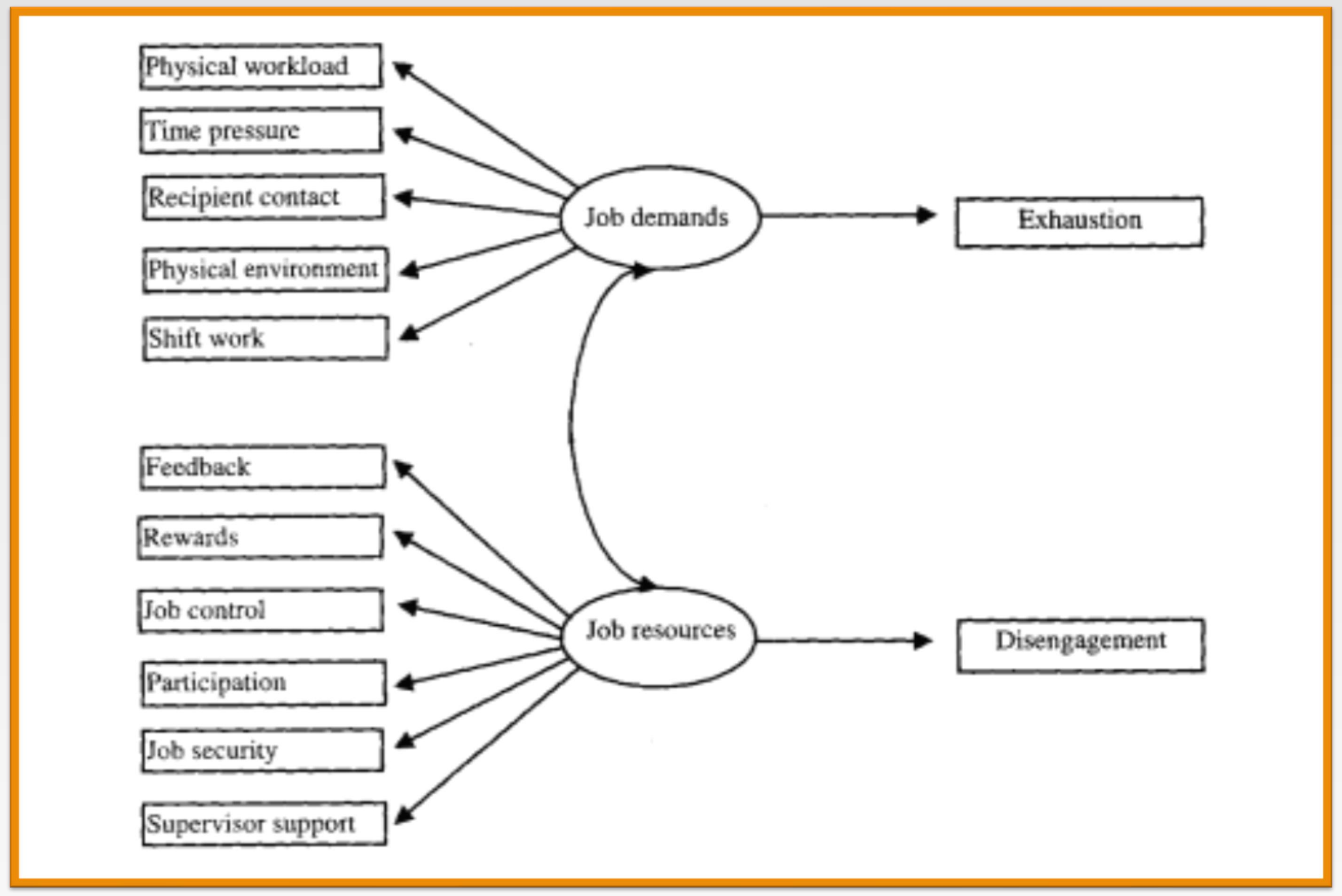
Background

Gender in Nursing

- 90% of nurses are female
  - 73% of male nurses report hesitations to pursuing nursing education due to stereotypes[2]
  - Half of male nurses report being "used as muscle"[2]
  - Female nurses report greater caregiver burden and time pressure[3]

Job Demands-Resources Theory

- Job demands lead to increased burnout, exhaustion, disengagement[4]
  - Physical workload, time pressure, shift work, harsh contact with patients, etc.
- Resources decrease burnout, exhaustion, disengagement and mitigate negative effects of demands
  - Feedback, autonomy, supervisor support, social support, rewards, etc.



Objectives

How do the experiences of male and female nurses differ at work?

- Identify areas of differential demands and/or preferential treatment based on gender.
- Examine how historically privileged groups operate when working as minorities in a field.
- Understand health and workplace outcomes of job demands and resources that may affect men and women differently.
- Point to areas for intervention in preventing injury, turnover, and burnout.

Hypotheses

Hypothesis 1a: Male nurses will report experiencing greater physical workload demands.

Hypothesis 1b: Female nurses will report greater time pressure and caregiver burden demands.

Hypothesis 2: Greater job demands will relate positively to experience burnout, such that for those with greater frequency and intensity of job demands, more experienced burnout will be reported.

Hypothesis 3a: The job demands-burnout relationship will be moderated by job resources such that for those experiencing greater job resources, the negative effects of greater job demands will be mitigated.

Hypothesis 3b: Male nurses will report greater job resources of autonomy, social support, and supervisor support.

Hypothesis 4: Male nurses will report lower experienced burnout as a result of these greater job resources

Hypothesis 5: Reported burnout will be positively related to injury frequency, pain experienced, intent to leave current job, and intent to leave the field of nursing.

Research Design

- Planned recruitment of 150 male and 150 female nurses via email through Ohio Board of Nursing and American Association of Men in Nursing
- Cross-sectional, online survey design taking approximately 40 minutes for $25 incentive
- Survey framed as "Nursing Job Demands" and demographics asked last to avoid undue influence

qualtrics.

AAMN Advancing Men In Nursing

Example Survey Measures

Variable	Measures	Components
Physical Job Demands	Trinkoff et al., 2003	lifting, overall physical effort, body positioning, strenuous activity by risk level
Other Job Demands	Alberta Context Tool	Time pressure
Job Resources	Xanhopouli et al., 2007	Autonomy, supervisor support, and social support
Burnout	Oldenburg Burnout Inventory	Exhaustion, disengagement
Health	Adapted from National Nursing Assistant Survey Questionnaire	Self-reported injuries from the past month

Implications

- Health
- Safety
- Burnout
- Turnover

Future Directions

- Targeted intervention based on differential job demands by gender
- Supervisor bias training to reduce gendered job expectations
- Guidance on gender biases in hiring, promotion, compensation
- Differing demands and resources for minorities, younger/older, LGBT nurses

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Development of a Risk Prioritization Framework to Evaluate Consumer Cleaning Product Chemical Ingredients

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UNIVERSITY OF Cincinnati

Introduction

- Associations have been reported between cleaning agent use and asthma in cleaners and hospital workers[1,2]
- Home healthcare workers perform similar tasks, but in residential environments, which have lower ventilation rates than hospitals and long-term care facilities.[3]
- Wide range of cleaning agents used makes it difficult to prioritize which chemical ingredients pose the greatest risk to users and warrant further study
- AIHA Exposure Control Categories may be used in ranking potential exposures under the same set of conditions[4]

Table 1. AIHA Exposure Control Rating Categories[4]

Exposure Category		Applicable Management/Controls
	0 (<1% of OEL)	No special action necessary
	1 (1-10% of OEL)	Standard training, general hazard communication
	2 (10-50% of OEL)	Chemical hazard communication, periodic exposure monitoring
	3 (50-100% of OEL)	Required exposure monitoring, verify work practice controls
	4+ (>100% of OEL)	Add hierarchy for controls, monitor effectiveness of controls

Objective

To prioritize cleaning product chemical ingredients by comparing hazard ratios (HR), which are calculated as realistic, worst-case predicted air concentrations (PACs) divided by occupational exposure limits (OELs).

Methods

Collection of Ingredient Information:

- Inventory of two local stores produced a list of 108 cleaning product sprays
- Safety Data Sheets (SDSs) were collected by visiting the manufacturer's website or emailing the company
- Ingredient information was compiled, with the highest ingredient concentration used for calculations.

Defining Realistic Worst-Case Conditions

- Ingredient concentration was determined as highest % in the range given or as 1% default value if "no hazardous chemical in excess of 1%" statement was present on SDS
- Application mass= 15 grams,[5] Volume of small room= 10 m^3, no ventilation, 15 minute exposure
- OEL is the lowest STEL or 8-hour TWA from ACGIH, NIOSH, or OSHA. Chemicals with a TWA but no STEL had a surrogate STEL calculated as 3*TWA.[6]

Calculation of Predicted Air Concentration:

1) Mass in air = 15 grams * (% mass concentration)
2) Air Concentration= Mass in Air/Room Volume (10 m^3)
3) PAC (ppm)= PAC (mg/m^3) * (24.45/Molecular Weight)
4) STEL HR = PAC/STEL
   TWA HR= (PAC * 15/480)/TWA

Results

- ~20% of products did not have SDSs available
- ~20% of products had an SDS, but no chemicals listed under Section 3 (Statement: No Hazardous Ingredients Above 1%)
- Remaining 60% of products with volatile ingredients had hazard ratios calculated, with examples in Table 2 below:

Table 2. Hazard Ratios for Consumer Cleaning Product Ingredients

Chemical	% by Mass	STEL Hazard Ratio	AIHA Rating		TWA Hazard Ratio	AIHA Rating
2-butoxyethanol	10%[B]	2.10*	4		0.19	2
Ethanolamine	1%[A]	1.00	4		0.063	1
Ammonia	1%[A]	0.62	3		0.027	1
Ethanol	75%[B]	0.60	3		0.019	1
Acetic Acid	1%[A]	0.41	2		0.019	1
Diethylene Glycol Monobutyl Ether	5%[B]	0.37*	2		0.035	1
2-propanol	5%[B]	0.076	1		0.005	0
Methanol	1%[A]	0.046	1		0.002	0

*Surrogate STEL calculated as 3*TWA

Limitations

- Can't be used to evaluate ingredients that are nonvolatile (NaOH, Oxalic Acid) or depend on chemical reactions for generation/decomposition (bleach/chlorine, H_2O_2)

Conclusions

- Consumer cleaning products contain volatile irritant chemicals that can produce air concentrations of concern.
- Using AIHA's Exposure Category Framework, ingredients can be ranked by Hazard Ratio under similar conditions, prioritizing chemicals that warrant further study.
- High HRs were typically due to low OELs, except for ethanol, where the HR was due to high % concentration.

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Acknowledgements

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Unmanned Aerial Vehicles (UAVs) for Information Gathering during Urban Disaster Situations

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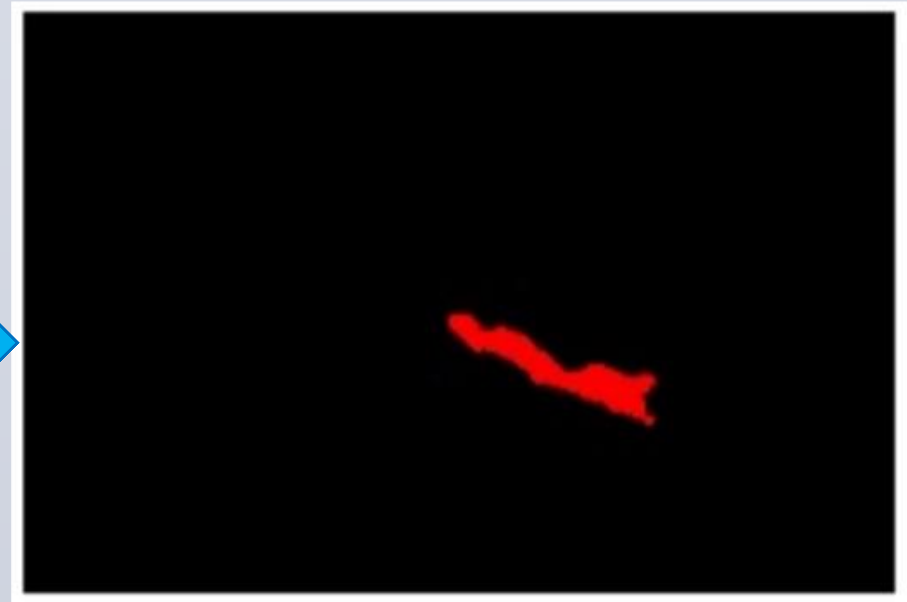
Background

As a safety aide to firefighters and first responders to remotely assess the health of the affected structure, a capability for structural damage detection by drones is desired that requires data processing and localization capability in drones. We propose to incorporate such intelligence [2] in the UAVs. On the other hand, to detect and assess the victims' health, one must be able to determine their consciousness. If first responders can evaluate this remotely, further decisions can be made easier. Based on the camera feed, it is possible to determine the posture of the person [3, 4, 5]. In previous attempts, the SIERRA (Surveillance for Intelligent Emergency Response Robotic Aircraft) Project, headed by Prof. Kelly Cohen and Prof. Manish Kumar, strived to develop an autonomous system that can help fire crew not only reach the scene of the fire faster, but also help in rescue operations by detecting human presence in the region. SIERRA is a collaboration between University of Cincinnati and West Virginia Forestry for forest environments [6].

Recent earthquakes have also seen UAV deployment for post-disaster imagery collection in [7] and [8] L'Aquila in 2009 and Haiti in 2010. Following the L'Aquila earthquake, quad-copter UAVs furnished with a camera evaluated the application of UAVs for fire service response [9]. After the Haiti earthquake, a private company flew a small UAV to assess orphanage damage in remote mountains near Port-au-Prince [8]. A more dynamic system for autonomous navigation in disaster areas such as that of vision-based navigation was further investigated by [10]. This study proposes a technique for a vision-based UAV navigation system utilizing Disaster Invariant Features (e.g. features that are likely to remain intact before and after events). This investigation suggests using road networks following the 2010 Haiti Earthquake for localization purposes. Co-PI Kumar et al [11] used a fuzzy logic based approach to detect fire and smoke from camera images. They, then, developed a technique using visual and thermal image fusion for UAV based tracking. By using the thermal images, all weather and night operations are possible. Visual and thermal image fusion is done and the fused image is given for target the benefit of enhanced target tracking application wherein only visual or thermal target tracking would not provide sufficient efficiency. Mentor Cohen developed algorithms to detect individuals in thermal video feed autonomously and in fast online mode [12]. PI Radmanesh, co-PI Kumar and his mentor Kelly Cohen have vastly studied the path planning, SLAM and image processing in disaster situation using mathematical and AI techniques [13, 14 and 15].

(a) ORIGINAL IMAGE



(b) PROCESSED IMAGE

Long Term Goals

In this work, we plan on addressing the pre-deployment situation. We believe that the actions taken during this stage prove valuable from the view point of saving lives of both first responders and victims, as it can ensure the safety and aids in decision making for the prior and as well as the acceleration of help for the later. Main objectives of this study are to accelerate localization of victims and predicting their initial health status along with the situational awareness of the affected area using robotic drones. Automating the pre-deployment phase will not only accelerate the help for the victims but will also enable the safety of first responders and efficient deployment strategy. These aims can be achieved using multiple autonomous Unmanned Aerial Vehicles (UAVs).

As an aide to the first responders, we aim to equip these automated vehicles with two cameras (visual and infrared cameras) to provide live feed of the environment as well as process the video feeds in real-time to enable efficient and faster decision-making during the area search. Through the video feed, the first responder crew is informed about the safety of the region and risk assessment of the rescue mission.

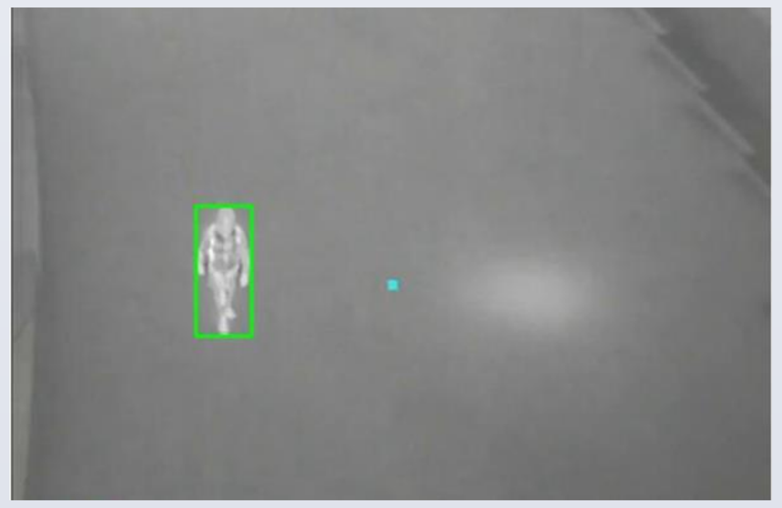
Specific Objectives

- **Developing area coverage algorithm to search the entire disaster area for survivors using multiple UAVs**
- **Simultaneous Localization and Mapping (SLAM) and Navigation of UAV**
- **Processing the video feed obtained from the quadcopter cameras to detect and provide the initial assessment of the affected area as well as victims**
- **Generating a rescue mission for the first responders based on disaster map and the victims' initial health assessment**
- **Creating a Graphical User Interface (GUI) for the first responder crew.**

Methods and Study Requirement

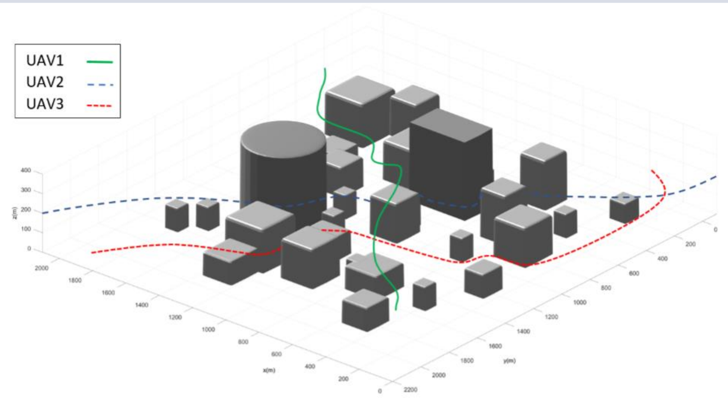
(a) Image processing:

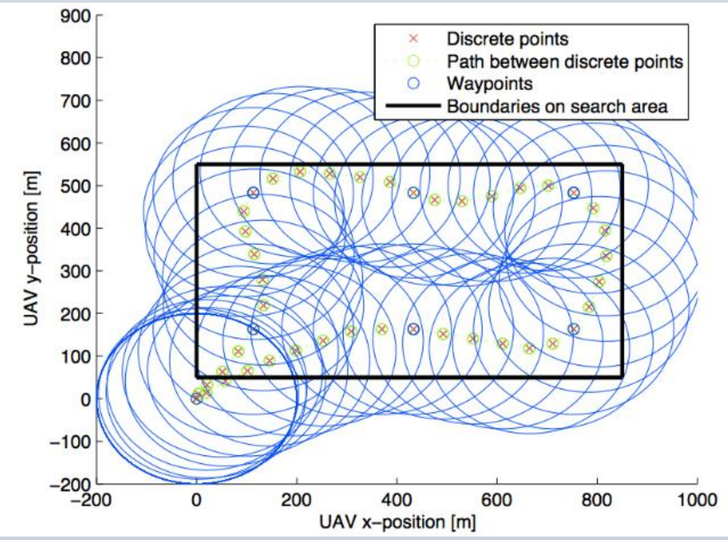
We propose a Convolution Neural Network (CNN) based image processing algorithm to detect victims and do the first report of health assessment using video feed from the thermal camera and the vision camera. Initial results of CNN for detecting a person and following the mobility based on this method are provided in Figure below.



(b) UAV Path planning, area coverage and TSP with time windows:

We propose to solve all stages of path planning, area coverage and TSP with time windows within the MILP framework. MILP can be solved using the fast solver proposed by PI Radmanesh. Then by having a software interface that connects the method, written in C++ language, to a single window GUI, the Aims 1 to 5 are sought to fulfill. Fig. 2 represents different implementation of MILP for area coverage, path planning in presence of obstacles and TSP problem solved via MILP.





Expected Results

The final output of the project will be an effective software and a fully autonomous UAV that is capable of recognizing fire and detecting victims along-with providing the locations and health assessment of them in global reference frame. Using the GUI that we develop, the first responders crew would be able to effectively optimize their rescue mission as well as enhance the chances of their as well as victims' survivals in the disastrous situations.

Future Direction

We will work with emergency personnel and other potential users of the system to improve the functionality of the final GUI so that it is tailor made to their requirements. We will employ a user-centered design process to develop the beta version of the software. We will then use multiple user studies of simulations and eventually field operations to refine the design in order to address their concerns. We will also make our research materials, processes, and models available to students in order to enhance student learning. This will be achieved by posting educational materials online. A web portal could be developed for this purpose.

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Fragility Analysis of Steel Buildings in Fire

Rachel Chicchi, Assistant Professor, University of Cincinnati
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MOTIVATION

Fires in buildings have long been a public safety concern for occupants and first-responders. The World Trade Center building collapses on September 11, 2001 motivated a focus on understanding structural behavior in fires.

This work will help to better understand building behavior to fire, thereby minimizing damage and prolonging the time of collapse in order to permit occupants and first-responders to safely exit the building.

This project aims to provide recommendations and guidance on performance-based fire analysis that can be implemented in the design industry.

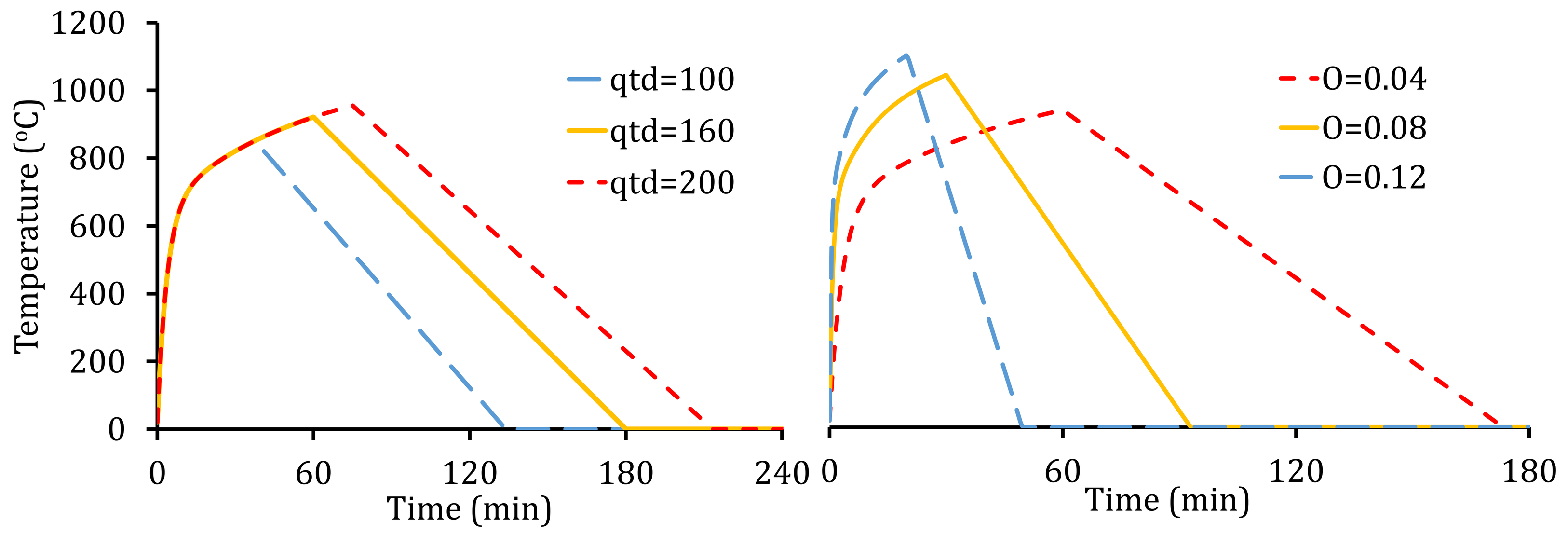
BACKGROUND

Structural engineers in the United States do not currently design structures to withstand fire loads. The amount of fireproofing on a structure and the fire rating of the structure is based on furnace testing of select components and assemblies by testing agencies such as Underwriter's Laboratory.

A performance-based approach for analyzing structures subjected to fires has been developed, which considers not only the time of failure but also the extent of damage. Instead of relying on empirical data from testing that may not translate well into building behavior, system behavior can be evaluated using finite element method (FEM) modeling. This approach, however, tends to considers one design-basis fire and does not adequately consider the possible variability in fire loading.

Incremental Dynamic Analysis (IDA) is a procedure used to create parametric analyses of building behavior to seismic loads through modeling. Earthquakes are scaled by an intensity measure (i.e. - peak ground acceleration or spectral acceleration) and the damage parameter (i.e. – story drift ratio) is recorded at each intensity level. This research will apply the IDA approach to fire through Incremental Fire Analysis (IFA) and providing recommendations for effective intensity measures and damage parameters for overall building behavior.

Eurocode Parametric Time-Temperature Curves

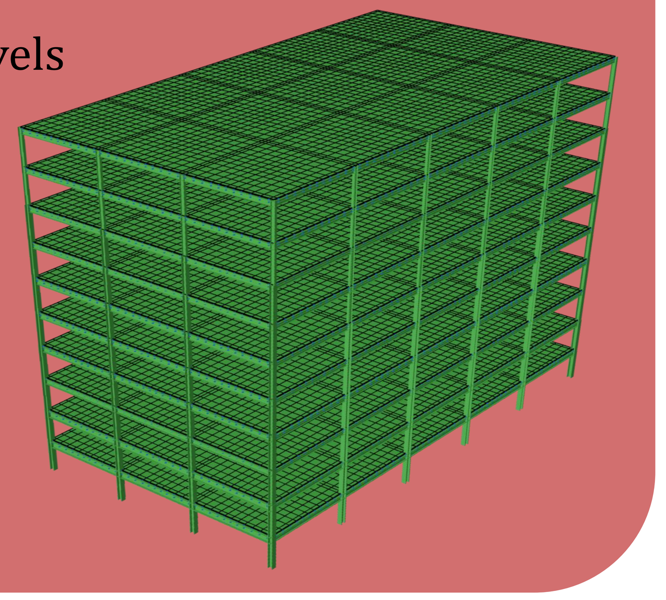


TASK DESCRIPTION

Selection & Design of Prototype Buildings and Fires

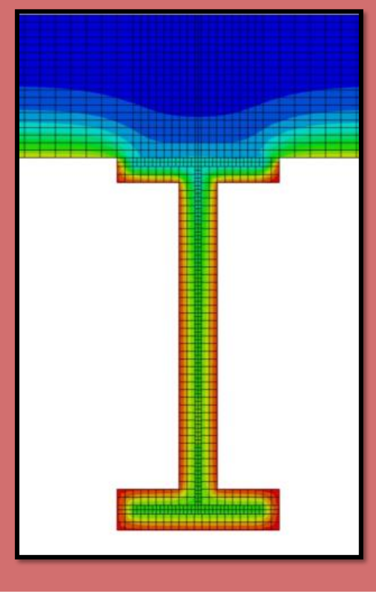
Select prototype buildings of varying hazard levels and number of stories
- 3, 9, and 20-story buildings
- Located in Boston (low seismic), Seattle, and Los Angeles (high seismic)
- Perimeter moment resisting frames

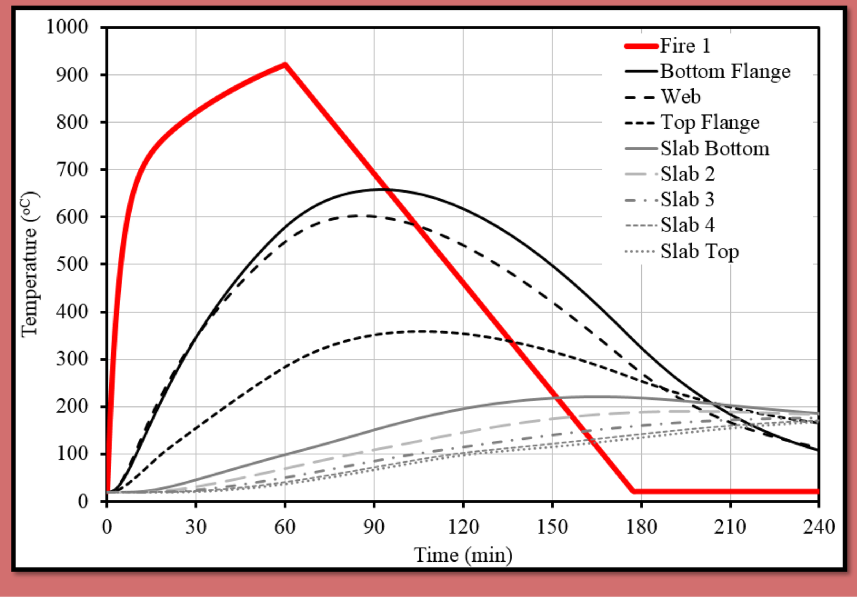
Design buildings using current building codes
Select Eurocode time-temperature fire curve



Determine Primary Failure Modes for Each Building

Use heat transfer analyses to determine internal temperatures of structural members subjected to selected time-temperature fire curve
Model building behavior at elevated temperatures using ABAQUS

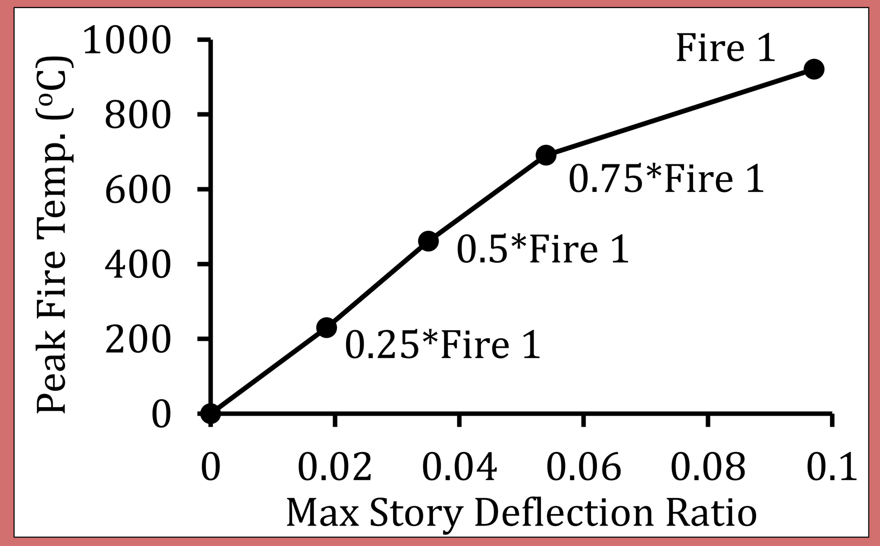




Conduct Parametric Study

The overall building response will be analyzed using Incremental Fire Analysis (IFA).
- Intensity Measure: peak fire temperature, fuel load density, fire duration, etc.
- Damage Measure: deformation, bending moment, etc.

Most useful intensity measure will be chosen.

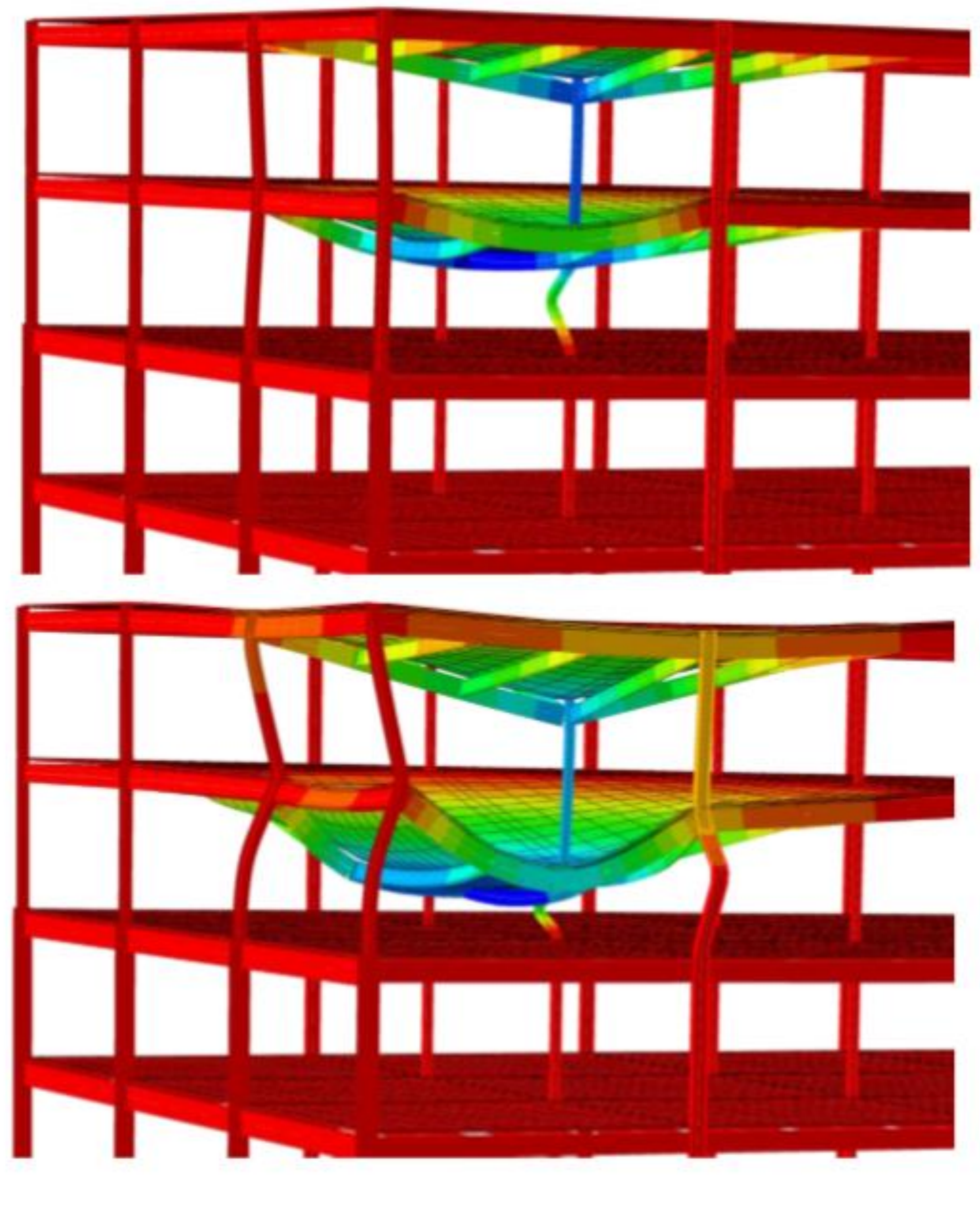


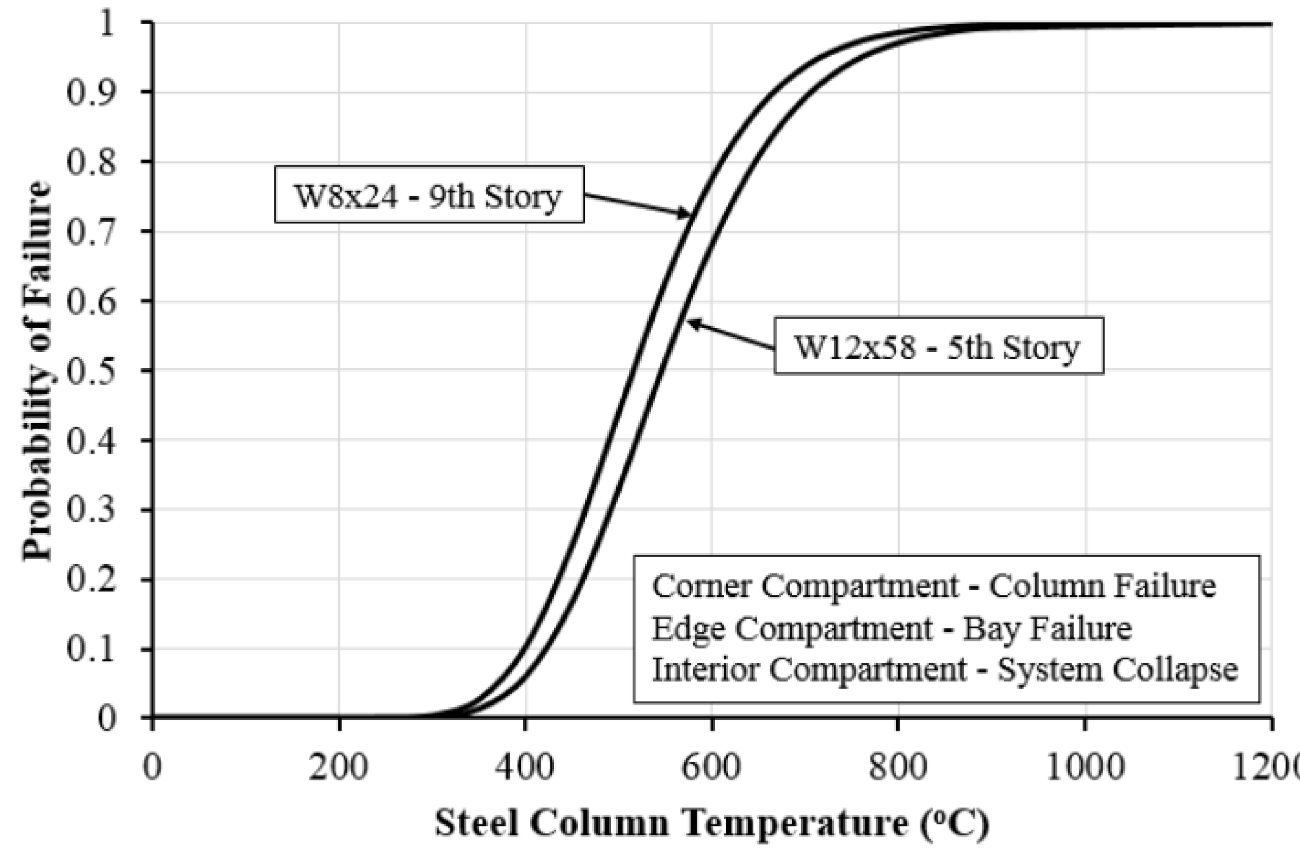
Generation of Fragility Functions

Calculate probability of failure of the structures at different fire intensity levels.
Compare for each building to identify trends amongst buildings.

EXPECTED RESULTS

Primary focus will be on the fire response of gravity columns, as this is the anticipated initiating failure mode. The internal temperatures of the columns will be evaluated to generate fragility curves that capture probability of failure (i.e. – column buckling load) at different fire intensities.





Acknowledgements

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Predicting changes in driving safety performance on an individualized level under naturalistic driving conditions

Bob Leonard[1], Nicholas Jerdack[1], Fedal Magahed[1], Lora Cavuoto[2], and Tessa Chen[3]
[1] Miami University, [2] University at Buffalo, [3] University of Dayton

Background

What do we know about crash risk?

Selected Factors Associated with Crash Risk[1]

Selected Factors Associated With Crash Risk.

Predictor domain	Sample predictors	Possible data sources	Outcome variables
Driver	• Demographics • Health history • Sleep history • Hours driving; hours on the job • Medications • Experience • Safety Record	• Bureau of Labor Statistics; • Driver surveys	• Crash rate • Serious crash rate • Fatal crash rate • Safety critical event rate • Fatigue
Vehicle	• Type of truck/bus • Maintenance history • Crash history • Technology installed	• Carriers	
Carrier	• Fleet size • Turnover rate • Compensation method • Safety culture • Safety record	• US DOT • Carriers	
Environment	• Weather • Precipitation • Traffic density • Road type • Safety features	• Police accident reports	

Driving Conditions[2,3,4]

- Fatal crashes tend to occur in rural areas. Approximately 61% of all fatal crashes involving large trucks occurred in rural areas, 27% occurred on Interstate highways, and 15% fell into both categories by occurring on rural Interstate highways.
- 37% of all fatal crashes, 23% of all injury crashes, and 20% of all property damage only crashes involving large trucks occurred at night (6:00 pm to 6:00 am).
- The vast majority of fatal crashes (84%) and nonfatal crashes (88%) involving large trucks occurred on weekdays (Monday through Friday).

Environmental Factors[3,4]

- Clear weather conditions were reported in approximately 70% of all fatal, injury, and property only crashes involving large trucks (70.7%, 69%, and 72,7% respectively).
- Rain, snow, and fog or smog were reported in only 6.2%, 1.5%, and 1.4% respectively in fatal crashes involving large trucks.

Driver Related Factors[5]

- Compared to 55% in passenger vehicles, 87.7% of crashes in the SHRP 2 NDS had at least one of the error/impairment or distraction factors present. Prior research estimates that as much as 94% of crashes involve these factors.
- At least one behavioral factor was recorded for 32% of large truck drivers in fatal crashes.

Limitations of Existing Research

1. Few statistical models for detecting changes in **trucking** performance (particularly for large datasets) ⟶ *Unclear whether the models should be individualized by driver or if they apply to a network of vehicles*
1. Driver performance studies typically consider performance independent of driving conditions
2. Few datasets have included driver characteristics, driving behaviors, and **driver distraction** in a naturalistic environment for a large number of drivers and routes

Research Questions

How can we understand, along the time sequence of a trip, how driver behavior changes before a safety-related incident occurs?

- *Can we utilize existing fleet support technology for real-time behavior and fatigue detection?*
- *If so, what factors lead to changes in behavior?*

Premise:

- Driver-related/behavioral factors are the most controllable
- Understanding the factors leading to behavior change will allow for intervention to minimize risk

Data and Important Factors

Behavioral Outcome Measure: Change in Mirror Check Rate

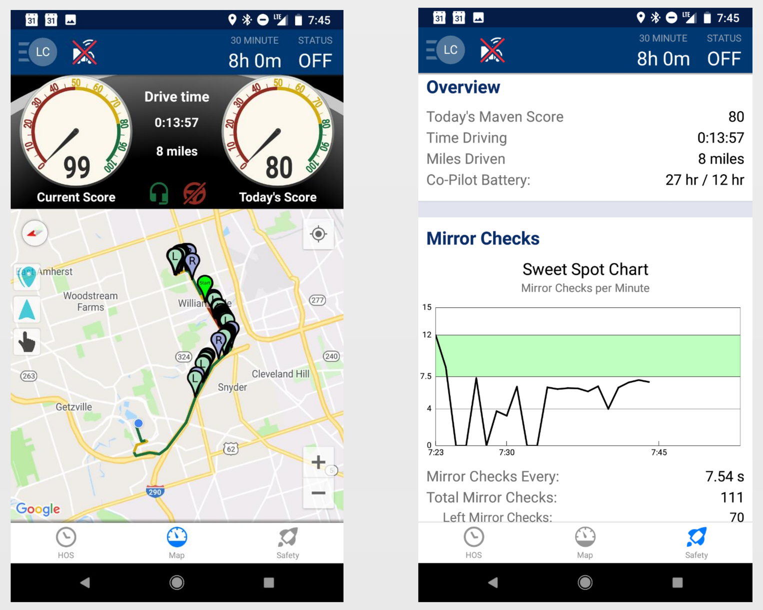
- Defined as the time-based change in the number of mirror checks per minute. Why important?

Change in Mirror Check Rate ⟶ Indicator of Driver Inattention ⟶ Increased Likelihood of Adverse Outcomes or Near Misses

Data Sources

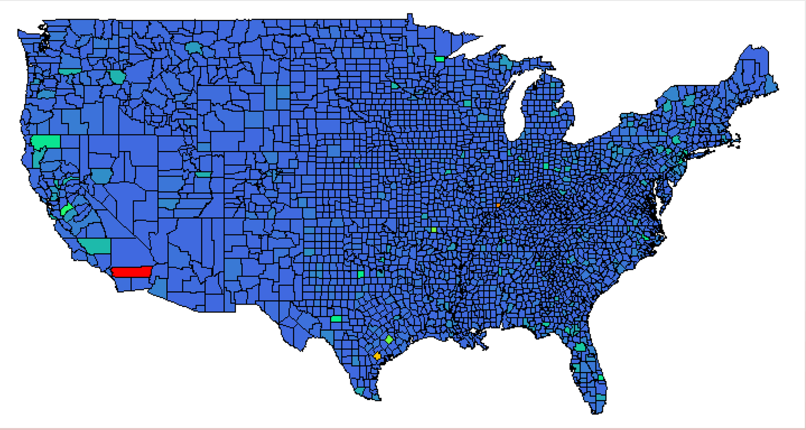
Naturalistic driving captured by **Maven** Machines on-driver sensor

- Dataset of ~200 drivers, more than 9 million events, across a 15-month period between Aug – Oct 2016.



Crash data for large trucks and buses by the Federal Motor Carrier Safety Administration (**FMCSA**)

- Date, location, and weather information covering years 2015-2017, for all 50 states and 3 US territories



Plan of Action

Task		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Data Preparation and Integration		■	■										
Aim 1	Identify most influential variables		■	■	■								
	Characterize road characteristics via clustering			■	■	■	■						
Aim 2	Develop and validate predictive models					■	■	■	■	■			
	App development and data integration								■	■	■	■	
Manuscript and Report Preparation												■	■
Dissemination to Safety Stakeholders												■	■

The overarching goal of this project is to enable trucking practitioners to quantify and consequently, mitigate their real-time (or predicted for a given trip) crash risk. To achieve this goal, we have defined two specific aims.

- **Aim 1: Determine how to group the road network.** This aim examines the use of *large-scale clustering* to obtain a data-driven grouping of the road network
- **Aim 2: Develop a dynamic real-time crash risk predictor (DCRP).** We will develop a model that computes the probability of a crash given a set of driving conditions and a given road segment.

Expected Results

This project will advance trucking safety research and practice by:

a) creating a "composite risk score" that quantifies the effects of traffic conditions, weather, road characteristics, and their interaction on crash risk; and
b) utilizing the risk score in quantifying the crash risk (in real-time) for the recommended routes on Google Maps

To translate this research to practice, we will:

- develop interactive visualizations that explain the insights from goals (a) and (b) **in a simple manner** to the different trucking safety stakeholders
- make the developed models/code **openly available** to researchers

References

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(5)

Acknowledgments

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Development of a sensor frame based gait assessment device for occupational health in nursing

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Background

When nurses are directly interacting with patients, they often have to bear large loads in non-ergonomic postures, thus leading to injuries[1]. The NIOSH[4] proposes a safe lifting guide that specifies the maximum limit some one can lift given specific variables, including lifting frequency, angle of rotation of body and hand placement.

Patil proposed a control method for the sit-to-stand movement involving trajectory planning using the center of mass trajectory of the system converted to joint angle trajectories using a deep Long Short-Term Memory (LSTM) network[2]. However the study has shown that different velocities of the motion results in different joint trajectories.

Liu modeled and predicted suitable joint trajectories while using a recurrent neural network with a LSTM nodes layer[3]. They were able to train the neural network from the data collected by the exoskeleton. The only drawback is that they had a small participant set, which resulted in fluctuations in the results.

Objectives

- Construction and fabrication of a lower-limb wearable sensor frame
- Algorithm derivation for position to joint angle transformation
- Data collection and training of a deep neural network to identify differences in ergonomic and non-ergonomic gait

Experimental Design

The following method will be used for designing, and manufacturing the sensor frame.

1. Collect sample data
2. Create a preliminary model to use for reference.
3. Manufacture a sensor frame model that will house the sensors that will record the lower body movements
4. Implement the preliminary model onto the just created sensor frame
5. Define ergonomic motions that are related to occupational health based on the NIOSH lifting guide [5].
6. Record the ergonomic motions with the sensor frame and/or the IMU system.
7. Validate and adjust the preliminary model
8. Test the applicability of the model/frame setup on uninstructed users.

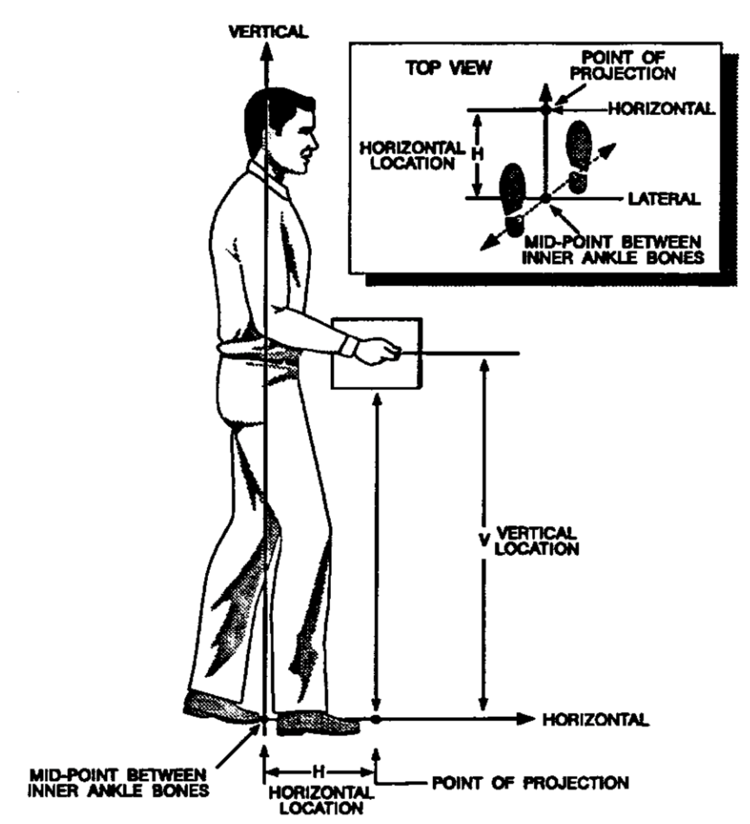

Figure 1. Parameters for Lifting an Object[4]

Figure 2. Preliminary Sensor Frame Model

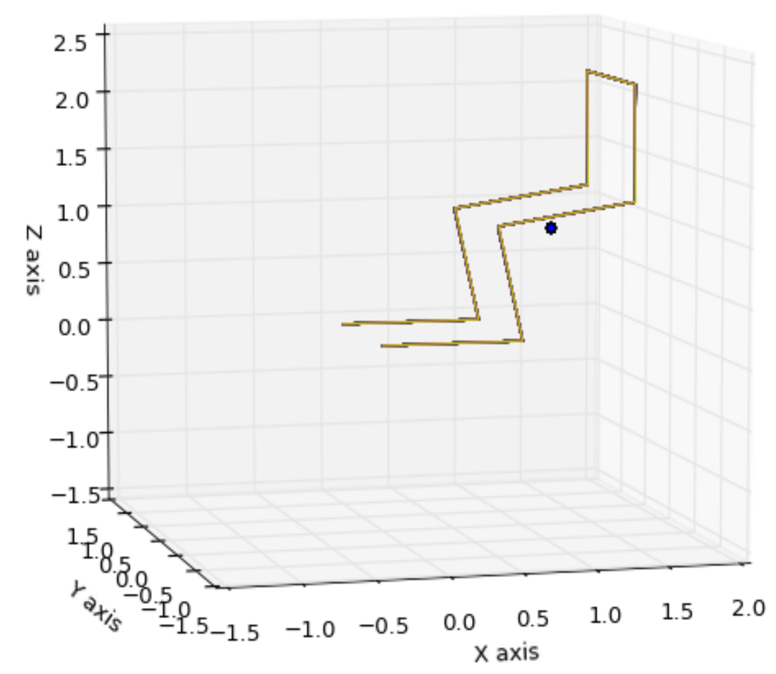

Figure 3. Preliminary joint position calculations (seated)

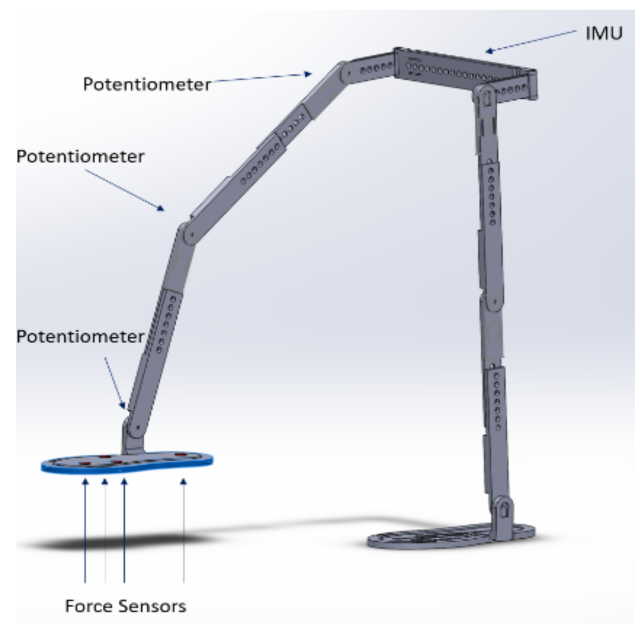

Figure 4. Sensor frame model with sensor locations

Study Population

In order to derive ergonomic and non-ergonomic walking profiles using the developed wearable sensor-frame, data from 15 healthy individuals between 20 and 40 years of age will be collected. Participants will complete a 1-hour data collection session. The following variables will be manipulated:

1) **Surface:** walking on paved and flat terrain, uneven terrain; this will allow for comparing normal ergonomic walking to impacted walking.
2) **Load:** walking with and without load; these conditions will allow for detecting the impact of load carrying on gait dynamics as expressed in joint angle variations.

The expected walking distance is 10 m in all conditions. We expect that participants will perform 40 walks during each session, with plenty of rest breaks.

Preliminary and Expected Results

What has currently been done is a preliminary design and manufacturing of the sensor frame, as seen in Figure 2. Investigations have also begun into the distinct movement related to occupational health that can lead to injury. This can be seen in Figure 1 below for the different characteristics of lifting objects. Finally, some sample data has been collected and is being processed to acquire the necessary information of the lower body human movement.

It is expected that a functioning sensor model will be created that can alert the user when they have postures that will be putting them at risk for injury.

Limitations

One limitation of this project is that since only the lower body data will be recorded and processed, the information that the system and model will be fed may be misrepresentative of the full body movement intentions.

Another limitation will be due to how the sensor frame will be redesigned, where it may affect the user's movements.

The final limitation will be of the sensor selection choices, since there will be benefits and detriments for each.

Acknowledgments

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