Fire Prevention and Safety (FP&S) Research and Development (R&D)

Grant Projects & Abstract Summaries

December 2020

Introduction

The goal of the Research & Development Activity within the Fire Prevention & Safety (FP&S) Grant Program is to reduce firefighter line-of-duty fatalities and injuries through research to improve firefighter safety, health, or wellness.

In November 2015, the National Fallen Firefighters' Foundation (NFFF) hosted the third National Fire Service Research Agenda Symposium (RAS) to update the agenda with current priorities. A copy of the research agenda is available on the NFFF Website at http://www.everyonegoeshome.com/resources/research-symposium-reports/.

Projects that meet the intent of this research agenda with respect to firefighter health and safety, as identified by the NFFF working group, were considered during the FP&S grant review. However, applicants were not limited to these specific projects. All proposed projects, regardless of whether they have been identified by this working group, were evaluated.

Appendix A provides visual alignment of awarded R&D Projects with the 2015 NFFF Research Agenda.
Appendix B provides the same information in a chart format.
Appendix C identifies 2015 NFFF Research Agenda Reccomendations that have not, or cannot be addressed with FP&S R&D funding.

Research & Development Awards

Below is an overview of Research and Development awards by Fiscal Year:

Fiscal Year	Total Number of Awards	Total Federal Funds Awarded*
2005	6	$3,310,824
2006	11	$9,921,057
2007	13	$11,604,465
2008	9	$8,172,639
2009	12	$9,590,457
2010	11	$10,352,759
2011	7	$5,695,893
2012	5	$4,065,272
2013	6	$8,493,980
2014	6	$8,326,972
2015	5	$6,100,101
2016	6	$8,365,202
2017	7	$8,191,961
2018	9	$8,671,722
2019	6	$8,217,101
Totals	**119**	**$119,080,405**

In the following pages you will find abstract summaries for all FEMA AFG Research and Development projects that have been awarded from Fiscal Year (FY) 2005 through FY 2019.

*All award amounts listed are of the Federal Share.

Table of Contents

FY 2019 Awards

FY 2019 FP&S R&D Grant Award

Project Title:	Surveillance of Coronavirus Infection among Indiana Firefighters
Organization:	National Institute For Public Safety Health, Inc.
Principle Investigator:	Steven M. Moffatt, MD
Grant Number:	EMW-2019-FP-00023
Award Total:	$1,582,500 ($1,500,000 Federal)
Period of Performance:	09/29/2020 - 09/28/2023
Grant Status:	Active

Abstract

Purpose and Aims:
The purpose of this project is to enhance the occupational health and safety of firefighters by understanding the nature and scope of SARS-CoV-2 infection in this occupational group.

Relevance:
The results of this study will be used to generate best practice guidelines to reduce firefighters' risk for developing communicable diseases, so they may continue providing essential first-responder services during a pandemic.

Methods:
An estimated 1,684 firefighters from randomly selected large, medium, and small sized fire departments will be recruited for SARS-CoV-2 antibodies testing during the study period. Early in year one a phlebotomist will travel to the selected fire houses to draw blood specimens for analysis. Follow-up blood draws will occur during the annual physical examination within 12 and 24-months after the initial blood draw in year one to track changes in the SARS-CoV-2 quantitative antibody measures due to exposure or vaccination. Depression and anxiety questionnaires will be completed by firefighters at each data collection time period.

Anticipated Outcomes:
SARS-CoV-2 antibody test results will be linked with the existing physical examination dataset to allow comparisons of the clinical, laboratory, fitness and health behavioral characteristics of firefighters who were infected and not infected with the SARS-CoV-2 virus, infected with and without symptoms and firefighters with and without serious health outcomes or complications. The impact of the COVID-19 pandemic on firefighters' behavioral health (depression and anxiety) will be determined and included in the comparison data analysis. A resource guide will be developed and disseminated using existing guidelines, the results of this study, and input from an expert advisory group.

FY 2019 FP&S R&D Grant Award

Project Title:	Effectiveness of Exposure Mitigation Strategies for Fire Investigators
Organization:	Fire Protection Research Foundation, The
Principle Investigator:	Amanda Kimball
Grant Number:	EMW-2019-FP-00392
Award Total:	$1,210,658 ($1,153,007 Federal)
Period of Performance:	09/29/2020 - 09/28/2023
Grant Status:	Active

Abstract

Purpose and Aims:
Our aim is to improve the health and safety of fire investigators by determining the effectiveness of PPE, post-fire skin-cleansing wipes, and on-scene decontamination methods for mitigating exposures to toxic fireground contaminants while conducting investigations.

Relevance:
This work will fill a significant gap surrounding currently-fielded PPE worn by fire investigators as there are no consensus standards/specifications to help them select the appropriate protective ensembles. Additionally, it will enable the fire service to confidently evaluate the effectiveness of skin-cleaning wipes to remove soot particulates as well as chemical contamination.

Methods:
Laboratory assessments of vapor and particulate protection and thermal burden will be conducted on fire investigator ensembles at NC State to determine a balance between protection and comfort. These findings will be compared with data collected from field evaluations in a burned structure intended for fire investigator training in conjunction with the NC Office of the State Fire Marshal. For wipe effectiveness, flow-through diffusion studies on skin surrogates will assess the dermal absorption characteristics with different chemicals and temperatures and assess the impact of wipe solution on absorption. Both particulate and chemical will be applied to the skin surrogate in a realistic and repeatable manner to reflect the fire investigator exposure. On-scene wet decontamination with simple soap and water spray will be evaluated as well as containment of gear following doffing.

Anticipated Outcomes:
This research will provide a through evaluation of performance across a wide range of currently-fielded PPE and recommendations to the NFPA committee governing appropriate standard. It will also provide new methods for evaluating particulate protection as well as a standard method for evaluating post-fire wipe efficacy.

FY 2019 FP&S R&D Grant Award

Project Title:	Preparing for the Next Spike: Impact and Response of the COVID-19 Pandemic
Organization:	NDRI - USA, Inc.
Principle Investigator:	Sara A. Jahnke
Grant Number:	EMW-2019-FP-00460
Award Total:	$1,122,328 ($1,068,884 Federal)
Period of Performance:	09/29/2020 - 09/28/2023
Grant Status:	Active

Abstract

Purpose and Aims:
The COVID19 pandemic is an unprecedented public health and economic crisis that has had a profound impact on the national fire service, individual fire departments and individual firefighters. The speed and virulence of the COVID19, as well as the constantly changing data, statistical models and scientific evidence is requiring the fire service to regularly update their standard operations, reassess and allocate resources and provide training for firefighters. Further, as the rest of the nation shelters in place, firefighters and EMS personnel have been deemed essential and required to continue their work on the frontlines in some of the highest-risk environments putting both themselves and their families at an uncertain level of risk.

Relevance:
Research to understand the immediate response, future impact, and best practice solutions to COVID19 is key to planning for and minimizing the negative impact in future pandemics and identifying the best "new normal" practices for fire and EMS.

Methods:
Leveraging data from national organizations, fire departments, and firefighters across the country, we will conduct both qualitative and quantitative assessments of the COVID19 impact. Interviews and content analysis of written text will provide an ethnographic perspective of the response while economic analysis, mining of National Fire Operations Reporting System (NFORS) data, and determining firefighters' behavioral health impact by comparing comprehensive assessments collected pre- and post-pandemic, will quantify the impact on organizations and individuals within the national fire service.

Anticipated Outcomes
Using a mixed-methods approach for data collection and a stakeholder panel of leading experts and key opinion leaders in the fire service, we will be able to synthesize data and deliver a roadmap for best practices in pandemic response.

FY 2019 FP&S R&D Grant Award

Project Title:	Cancer Risk and Risk Factors in Volunteer Firefighters: The NJ Firefighters Cancer Prevention Study (CAPS)
Organization:	Rutgers, The State University of New Jersey
Principle Investigator:	Judith Graber
Grant Number:	EMW-2019-FP-00517
Award Total:	$1,569,973 ($1,495,212 Federal)
Period of Performance:	09/29/2020 - 09/28/2023
Grant Status:	Active

Abstract

Purpose and Aims:
To address the knowledge gap about cancer risk and risk factors among volunteer firefighters, this project assesses how volunteer firefighters' exposures resemble and differ from career firefighters.

Relevance:
Firefighters have increased risk for cancer. However, almost all the supporting research has been conducted among career firefighters. Volunteer firefighters comprise 67% of the US fire service. They perform the same tasks as career firefighters, but often with less protection and risk reduction. Significant gaps in understanding exposures and cancer risk among volunteer firefighters exist.

Methods:
This three-year, two-phased sequential mixed-methods study will build on the existing Firefighters Cancer and Assessment and Prevention Study (CAPS). For Phase 1, we will enroll 500 volunteer firefighters and, using the national Fire Fighter Cancer Cohort Study (FFCCS) infrastructure and methods, we will collect survey information about firefighting experiences, behavioral risk factors, and decon practices. We will collect blood and urine to quantify environmental exposures. Phase 1 data will be used to compare volunteer and career firefighters' exposures and to design Phase 2 focus groups and interviews assessing practices, attitudes, and barriers toward decon among volunteers, including the impact thereon of the COVID-19 pandemic.

Anticipated Outcomes
This project will inform meaningful cancer risk reduction efforts for volunteer firefighters by providing much needed knowledge about their exposures while demonstrating methods for scientists to partner and engage with volunteer firefighters. CAPS data and specimens will become part of the FFCCS, providing a valuable resource for additional studies of volunteer firefighters.

FY 2019 FP&S R&D Grant Award

Project Title:	Women Fire Fighters Study: Stress, Cancer Risk and Reproductive Toxicity
Organization:	University of Arizona
Principle Investigator:	Jefferey L. Burgess, MD, MS, MPH
Grant Number:	EMW-2019-FP-00526
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	09/29/2020 - 09/28/2023
Grant Status:	Active

Abstract

Purpose and Aims:
To evaluate causes of stress, cancer, and adverse reproductive health effects in women firefighters, and plan effective interventions to mitigate these conditions. Specific aims: 1) Compare stress and biomarkers of cancer risk and reproductive health in incumbent and new recruit women firefighters; 2) Evaluate changes in these conditions over time in an inception cohort of women new recruits; and 3) Develop, beta test, and assess the feasibility of a peer support intervention for women firefighters.

Relevance:
Women firefighters have high rates of post-traumatic stress disorder (PTSD), cancer, and adverse reproductive outcomes. However, the lack of sufficient information on the causes of and mechanisms leading to these occupationally related illnesses prevent the creation of effective interventions. Stress is linked with PTSD. In addition, stress has been associated with epigenetic changes, cancer and adverse reproductive outcomes. Epigenetic changes are integral mechanisms in cancer development. Exposure to inhaled toxicants and stress can cause premature ovarian failure (early menopause), associated with reduced serum levels of anti-müllerian hormone (AMH).

Methods:
Building on the Fire Fighter Cancer Cohort Study, we will enroll at least 100 women new recruits and 100 incumbent career and volunteer firefighters across multiple fire departments. Self-reported stress, cancer risk, reproductive health, and occupational exposure data will be collected via survey on enrollment and annually for two years. Blood will be collected for epigenetic and AMH analysis at enrollment in all firefighters and again after 18-24 months in the recruits. Departmental fire incident response data will be supplemented by use of a personal exposure reporting application. We will work with the Women in Fire organization to develop a cross-department peer support intervention and carry out a feasibility study.

Anticipated Outcomes
We will identify exposures and risk factors for increased stress, cancer, and reduced ovarian reserve in women firefighters, which will inform future intervention studies. The peer support intervention will decrease stress and be suitable for a future large scale intervention study.

FY 2019 FP&S R&D Grant Award

Project Title:	Training Fire Exposures from the Source: Developing Risk-Benefit Framework
Organization:	Underwriters Laboratories Inc.
Principle Investigator:	Dr. Gavin Horn
Grant Number:	EMW-2019-FP-00770
Award Total:	$1,574,998 ($1,499,998 Federal)
Period of Performance:	09/29/2020 - 09/28/2023
Grant Status:	Active

Abstract

Purpose and Aims:
The purpose of this project is to reduce firefighter fatalities and injuries through improved understanding of holistic live-fire training risks and benefits. Chemical contaminants during training may result in larger carcinogenic exposures than typical fire ground activities, yet there exists limited understanding of how fuel source impacts this risk or how this risk can be balanced against the potential benefits of improved training experiences that can reduce injuries on the fireground.

Relevance:
Although epidemiological data reveal an increased risk of some cancers among firefighters and fire instructors, little information exists on the connection between training fuel source and chemicals available for exposures during training. Furthermore, no research has examined the effectiveness of different intervention approaches such as alternative training fuels or novel training props to reduce risk while providing high quality training.

Methods:
Using a multi-scale engineering approach, building off previous DHS FP&S studies, we will (a) characterize training fuel risk from controlled bench scale experiments to full scale training fire environments and b) qualitatively assess the value of training fire environments in the context of fire dynamics lesson against the risks generated by these fuels. The ability to link across scale could provide a screening method for currently suggested control measures as well as those proposed in the future.

Anticipated Outcomes
We anticipate finding a wide range of products of combustion from various training fuel choices and that intervention fuels may lower this risk while still providing high quality training environment. We will also develop an actionable risk benefit framework that can be implemented by the fire service and included in NFPA 1403. Our results will allow the fire service to make informed decisions about training fuel selection to balance contamination reduction and preparation for fire ground activities.

FY 2018 Awards

FY 2018 FP&S R&D Grant Award

Project Title:	Development of Hand-Specific Model and Systems Tool
Organization:	Iowa State University of Science and Technology
Principle Investigator:	Guowen Song, PhD
Grant Number:	EMW-2018-FP-00649
Award Total:	$1,574,989 ($1,499,989 Federal)
Period of Performance:	09/20/2019 - 09/19/2022
Grant Status:	Active

Abstract

Purpose and Objectives:
The overall purpose is to develop a systematic tool for hand responses/injury prediction, manual performance, and to explore next generation high performance gloves for firefighters and other emergency responders. The specific objectives include (1) a new hand-specific thermoregulation model, (2) hand-glove manual performance model, and (3) an instrumented hand form manikin to systematically simulate the physiological responses of hands, predict glove protective performance in term of cold or burn injury, and conduct manual performance analysis. Gloves as subsystems in personal protective equipment (PPE) ensemble are critical in response operations for firefighters to ensure their safety and health. However, the lack of full understanding of thermal physiology of hand and fingers, relationship between glove material properties and hand manual performance, as well as the nonexistence of a comprehensive glove evaluation system are the major challenges for further improving both thermal protection and manual performance. The inadequate design, engineering, and integration of the PPE system is evidenced to be the major reason for the protection failures and accidents, especially on the hazardous fireground for firefighters.

Study Design and Methods:
The proposed study is a collaborative effort with researchers in functional textiles, human physiology, numerical simulation, industrial and garment design, performance evaluation, and fire service departments, as well as PPE manufacturers. The goals and objectives of this study can be achieved and measured through carefully designed interdisciplinary labs and team work. The first approach is hand specific model development and the second is to develop a hand form manikin evaluation system with hazard simulation of radiation, hot liquid, and steam. The third is to generate biophysical data for model validation and improvement through a lab manikin system and special designed human trials. Finally, high performance gloves will be explored.

Results (projected):
The deliverable of this research is a systematic tool for hand responses/injury prediction, manual performance analysis, and next generation high performance gloves for firefighters and other emergency responders, including a new hand-specific thermoregulation model, hand-glove manual performance model and an instrumented hand form manikin. These include:

- Education and training tool: when coupling with a glove model that depicts the heat and moisture transfer through glove layers, cold or burn injury predictions for both bare and gloved hand can be calculated in various environments or against different thermal hazards. This knowledge will help educate and train firefighters to protect the vulnerable parts of their hands in training and firefighting to maintain safety and good manual performance that assures success of operations. In addition, the team will work with firefighter training center in Iowa and develop an inexpensive visualized demonstration software that will serve as an education, training, and awareness tool that can be widely available to fire service departments across the country.
- New standards and regulations: the knowledge developed will be applied to improve or develop new standards by ASTM and NFPA organizations, as well as manufacturers.
- The tool will provide enhanced understanding about hand thermal regulatory nature with consideration of hand anthropometry, anatomy, and thermal physical properties. This understanding can also assist fire chiefs to make informed decisions regarding proper training and firefighting operating procedures.

Conclusions (projected):
The significant results of the proposed interdisciplinary approach are therefore expected to enhance working efficiency, safety, health, and wellbeing for firefighters and other emergency responders. Thus, the outcomes will advance the protective clothing field and have a broader and highly positive social and economic impact.

FY 2018 FP&S R&D Grant Award

Project Title:	Characterization of Toxicants in the PMs of Wildfire Smoke
Organization:	Middle Tennessee State University
Principle Investigator:	Mengliang Zhang, PhD
Grant Number:	EMW-2018-FP-00668
Award Total:	$236,247 ($224,997 Federal)
Period of Performance:	09/18/2019 - 09/17/2022
Grant Status:	Active

Abstract

Purpose and Objectives:
Application of novel analytical strategy for the characterization and quantitation of toxicants in the particulate matter of wildfire smoke in order to improve the understanding of health-threatening hazard encountered by firefighters. Aims: (i) To develop a unique analytical method to study both non-polar and polar toxicants in the particulate matter without the cumbersome derivatization and compare it to traditional methods; (ii) To provide qualitative and quantitative data on the exposure of firefighters to harmful constituents in the particulate matter of wildfire smoke; (iii) To utilize the knowledge of toxic threat of airborne particulate matter to promote the development of protective practices to safeguard the health of firefighters.

Relevance:
This study provides a molecular basis to correlate particulate matter with health hazards of smoke from biomass combustion sources. The knowledge of chemical composition of particulate matter will enhance proactive actions in preparing firefighters to make informed decisions for protecting their health and safety during wildfire events. The results will be disseminated via publication of scientific findings and development of public outreach materials to benefit professional and public audiences, respectively.

Study Design and Methods:
Analytical methods and sampling strategies will be developed and validated under well-defined conditions at MTSU before their application in field studies. The methods will be evaluated for samples collected at a control burn or fire training exercise and eventually be used to characterize the chemical composition of the particulate matter of wildfire smoke in California. The health implications of particulate matter inhaled by firefighters and residents at the wildland-urban interface will be elucidated by our research results in combination with existing literature in air toxics.

Conclusions (projected):
The proposed project will generate scientific data for the specific constituents in the particulate matter of wildfire smoke by using chromatographic and mass spectrometric techniques optimized for unraveling the complex composition. Through research, we aim to provide a thorough understanding of the chemistry of particulate matter in wildfire emissions and contribute to the strategies for reducing the adverse health effects experienced by firefighters in wildfire suppression.

FY 2018 FP&S R&D Grant Award

Project Title:	Module for Rapid Detection of Gases from Fire and Smoke
Organization:	University of Central Florida Board of Trustees
Principle Investigator:	Kausik Mukhopadhyay, PhD
Grant Number:	EMW-2018-FP-00329
Award Total:	$565,825 ($538,881 Federal)
Period of Performance:	09/18/2019 - 09/17/2022
Grant Status:	Active

Abstract

Purpose and Objectives:
There is an urgent need for cost-effective, portable detection systems that can quickly and quantitaively analyze and monitor toxic and dangerous gases mixed with unwanted aerosols, such as smoke, soot, dust, mist, fog, haze, fumes in real time. Precise sensing and detection of hazardous, toxic, and flammable gases during the event of a fire is important for the victims and fire fighters to avoid the secondary disaster in the fire accident.

Relevance:
The National Interagency Fire Center (NIFC) recently reported more than 3 million acres have burned every year since 1999, and the acreage burned each year is increasing from more than 60,000 wildfires occurring in the United States each year. As the fires burn up homes, cars, businesses, and industries, they also release the components of modern daily life into the ground, water, and atmosphere. While the victims and responders tend to focus on the immediate effects of a fire, the ripple effects that flow from these events, ranging from the enormous respiratory and cardiac effects from the plumes of smoke, to the aftermath of the toxic chemicals, create enormous burdens faced by the firefighters and first responders.

Study Design and Methods:
In this effort, we propose to develop a novel photonic integration on chip for a reduced cost and deliver higher performance to rapidly detect gases and aerosols with almost no interference or fingerprints from other gases through chemical activity. The emitter array will generate narrow, high intensity, steerable beams, while the detector array allows for a fast, coherent detection of terahertz (THz) waves. We plan to fabricate THz emitter arrays increase detection rates significantly in this effort. Its success will lead to a truly portable THz-based detection system with high performance.

Conclusions (projected):
Our hand-held module will be easy to carry or maneuver using drones, robotic arms, retro-fit to aerial, sea, or land vehicles to detect toxic gases, aerosols and organics, thereby protecting lives and health of the firefighters and victims during fires or explosions. Compared to other approaches and detections methods that are bulky, expensive to maintain, space-constrained, in-lab units only and costly, our device can be carried by crews and civilians for services at a fraction of cost. We will work with firefighters and associations to train the crew on usability of such device.

FY 2018 FP&S R&D Grant Award

Project Title:	Investigation of Design, Comfort, and Mobility Issues for Female Firefighter PPC
Organization:	Florida State University
Principle Investigator:	Meredith McQuerry, PhD
Grant Number:	EMW-2018-FP-00202
Award Total:	$403,632 ($384,411 Federal)
Period of Performance:	09/18/2019 - 09/17/2021
Grant Status:	Active

Abstract

Purpose and Objectives:
To research and investigate the root causes of design, comfort, and mobility issues of firefighter personal protective clothing for the female human form. Structural and wildland firefighting turnout suits are primarily developed for the male firefighter, despite the growing number of women firefighters in the fire protection community. Women firefighters wear the same turnout suits as their male counterparts and are at a higher risk of injury and fatality due to ill-fitting PPE. An in-depth survey of female firefighters will be developed and implemented to gather the necessary and important data to highlight issues with the design, comfort, and mobility of their current turnout suit. This data will be shared and used as an awareness and education tool for PPE manufacturers and the firefighting community. Furthermore, a suggested sizing guideline will be developed to aid the user group on fit and support manufacturers as a reference guide.

Relevance:
Research has found that female firefighters are wearing turnout suits that are not sized for the female human form and therefore possess an unsatisfactory fit. Sizing data from other organizations have demonstrated the need for uniforms to be designed specifically for women and that simply sizing down the garment is not an appropriate solution. This research will provide the practical and marketing bases for the initial steps of developing a female turnout suit that meets NFPA standards.

Study Design and Methods:
In-depth surveys and multiple focus groups will be implemented over the course of the research timeline. This includes the participation of user groups for both structural and wildland firefighting, and key manufacturers that develop and produce personal protective clothing.

Conclusions (projected):
This research will contribute to ultimately improving female firefighter protection from high risks of injury or fatality due to design and mobility issues from the current turnout suit.

FY 2018 FP&S R&D Grant Award

Project Title:	Cancer among Indiana Firefighters: Case-Control Studies
Organization:	National Institute for Public Safety Health, Inc.
Principle Investigator:	Steven M. Moffatt, M.D.
Grant Number:	EMW-2018-FP-00562
Award Total:	$1,500,000 ($1,428,571 Federal)
Period of Performance:	09/20/2019 - 09/19/2022
Grant Status:	Active

Abstract

Purpose and Objectives:
Use fire department and medical records, a questionnaire, and blood tests to identify: 1) occupational, 2) medical, and 3) lifestyle factors statistically associated with cancer incidence and mortality among Indiana career and volunteer firefighters by conducting case-control studies. Both the cancer cases and controls will be Indiana firefighters.

Relevance:
Research has established that firefighters are occupationally exposed to carcinogens and have an increased risk of cancer as compared to the general population. However, previous studies generally lack detailed information on work exposures, medical, and lifestyle covariates. Case-control studies of cancer among firefighters can elucidate cancer risk factors - what makes some firefighters more likely to develop cancer than others- and thus, inform prevention.

Study Design and Methods:
Building on prior studies and existing medical databases/registries, we plan to conduct two case-control studies of cancer incidence and mortality among Indiana firefighters. For career firefighters, several hundred to thousand cancer cases will be drawn from three overlapping databases: death certificates from the Indiana State Department of Health, the Indiana State Cancer Registry, and the Regenstrief Institute. Matching career firefighter controls will be drawn from the Public Safety Medical (PSM) Database. For the volunteer study, as many cases as possible will be identified from the same sources, while matched controls will be drawn from the Indiana Volunteer Fire Council (IVFC) and the PSM database.

Conclusions (projected):
Case-control studies of cancer among firefighters can provide epidemiologic evidence regarding cancer risk factors among firefighters and thus, better inform fire service cancer prevention strategies.

FY 2018 FP&S R&D Grant Award

Project Title:	Total Worker Health For Wildland Firefighters
Organization:	Oregon Health & Science University
Principle Investigator:	Kerry Kuehl, MD DrPH
Grant Number:	EMW-2018-FP-00284
Award Total:	$1,497,401 ($1,426,096 Federal)
Period of Performance:	09/20/2019 - 09/19/2022
Grant Status:	Active

Abstract

Purpose and Objectives:
Our overarching goal is to develop, refine, and disseminate a comprehensive, easily accessible, and effective Total Worker Health (TWH) program for wildland firefighters (WFF).

Relevance:
Fire seasons are longer, with more and larger fires, placing increased demands and risks on all those fighting wildland fires. FEMA recognizes this critical need by encouraging research proposals to improve wildland firefighter safety, health, and wellness through applicable technology and product development; behavioral, clinical, and social research; and dissemination and implementation research. This project meets these high priority objectives.

Study Design and Methods:
This three-year, four-phase study begins with a mixed-methods cross-sectional study among multiple U.S. Forest Service regions and types of WFF (volunteers, Forest Service and other government workers, and career structural firefighters) to identify and prioritize needs for a TWH for WFFs in the domains of personal and work safety, physical health, mental/behavioral health and work environmental factors. Phase 2 is to build the TWH program, with a core group of training modules and electives to individualize the program for personal and professional needs. Once developed, we will assess the program with a prospective usability and interrupted time-series effectiveness trial, again involving varied locations and WFF groups. The final phase is to partner with the National Fallen Firefighter Foundation (NFFF) in formatting a durable web-based dissemination platform. In collaboration with the National Volunteer Fire Council, IAFF and IAFC, we will vigorously market, promote, and assist implementing the program with all WFF groups.

Conclusions (projected):
This project will result in an innovative, effective, and scalable TWH program and novel dissemination platform. The program will reduce mortality/morbidity and improve the safety, health, and well-being of those involved in fighting wildland fires. Its return on investment will be high.

FY 2018 FP&S R&D Grant Award

Project Title:	Evaluating Interoperability of Firefighter First Responder Ensembles
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2018-FP-00401
Award Total:	$787,500 ($750,000 Federal)
Period of Performance:	09/18/2019 - 09/17/2021
Grant Status:	Active

Abstract

Purpose and Objectives:
Critically review and assess NFPA standards and improve system-level testing methods by investigating application and relevance to fire service and responder communities. Current material-level tests outlined in NFPA standards are useful for characterizing fabrics used in protective garments; they do not capture the full system-level performance for user wear during various tasks. Full examination and range of system-level evaluations will be conducted and aid in developing an updated testing platform which firefighters can use to assess their own ensemble and support development of a new NFPA standard.

Relevance:
Full system-level tests in NFPA standards are impactful in assessing protective clothing as worn by the responder; however, some of these methods lack comprehensive evaluation for its application in integration and interoperability. This research will provide the basis and support for a new NFPA standard for system-level evaluations of the responder in addition to providing the responder community with testing protocols that can be conducted at their respective station for assessment.

Study Design and Methods:
Material and system level methods will be implemented to research, examine, and assess current test methods utilized in NFPA standards. NCSU's capabilities with manikin systems, in-depth knowledge of users and standards, and expertise in human wear testing will provide unprecedented evaluations specific to protective systems worn against a multitude of encountered hazards.

Conclusions (projected):
This research will contribute to improve firefighter protection and promote education through the creation and design of test methods implemented in a new NFPA standard focused on integration and interoperability of protective ensembles.

FY 2018 FP&S R&D Grant Award

Project Title:	Development and Testing of the Fire Service Health Drinking Toolkit
Organization:	Pacific Institute for Research and Evaluation
Principle Investigator:	Raul Caetano, MD, PhD
Grant Number:	EMW-2018-FP-00593
Award Total:	$1,039,714 ($990,204 Federal)
Period of Performance:	09/18/2019 - 09/17/2021
Grant Status:	Active

Abstract

Purpose and Objectives:
In addition to medical risks such as cancer, firefighters (FFs) are vulnerable to negative behavioral health outcomes including trauma, depression, and suicide. One issue which is central to these risks is the high rates of heavy and binge drinking among FFs. A team of scientists experienced in working with the fire service will join a national team of FFs and fire service leadership to develop and test the Fire Service Health Drinking Toolkit (FSHDT). The FSHDT will provide critical tools to better educate and effectively motivate FFs to take positive steps to reduce problem drinking.

Relevance:
The Secret List recently warned that FF alcohol misuse is a huge issue and one we continue to struggle with at every fire department. In our research with >3,500 FFs across the nation, over half reported heavy and binge drinking. In formative studies, FFs suggested that heavy drinking is used to cope with stress and trauma experienced on the job. This proposal is in response to High Priority Recommendation #18 of the 2nd Fire Service Research Agenda.

Study Design and Methods:
A mixed-methods research approach will be used to develop and test the FSHDT. Participating organizations include the International Association of Fire Fighters, International Association of Fire Chief's Safety, Health & Survival members, the National Volunteer Fire Council, and the National Fallen Firefighter Foundation. We are particularly excited that the NFFF's First Responder Center for Excellence has agreed to house and disseminate the FSHDT.

Conclusions (projected):
This study will develop and test the FSHDT, which will be used in initiatives to reduce unhealthy levels of alcohol use among FFs.

FY 2018 FP&S R&D Grant Award

Project Title:	Per- and Polyfluoroalkyl Substances (PFAS): Firefighter Exposures and Toxicity
Organization:	University of Arizona
Principle Investigator:	Jefferey Burgess, PhD
Grant Number:	EMW-2018-FP-00086
Award Total:	$1,500,000 ($1,428,571 Federal)
Period of Performance:	09/20/2019 - 09/19/2022
Grant Status:	Active

Abstract

Purpose and Objectives:
Exposure to per- and polyfluoroalkyl substances (PFAS) in the general population has been linked to cancer, elevated cholesterol, altered immune and endocrine response, respiratory disease, and reproductive toxicity, but PFAS exposures and health effects in firefighters are not well understood. PFAS from household items are released during fires, PFAS are in firefighter turnout gear, and PFAS are components of many aqueous film-forming foam (AFFF) products used by firefighters. Older generation persistent PFAS chemicals are known to be toxic, but much less is known about the toxicity of newer generation PFAS. Firefighters have a higher level of some PFAS chemicals in their bodies than the general public, but the relative extent of exposure from fireground responses, turnout gear, and use of fluorinated AFFF and associated toxicity are not known. The proposed research will provide information needed by the fire service to address these issues through completion of the following aims: 1) Administer a national survey on AFFF use; 2) Assess acute exposure to PFAS through fireground responses, turnout gear, and AFFF use; and 3) Evaluate acute in vitro and chronic human toxicity of PFAS exposure.

Study Design and Methods:
We will survey fire departments nationally on AFFF products and practices used for training and fire response. We will analyze the PFAS mixtures used in AFFF and turnout gear. We will measure PFAS concentrations in urine and blood before and after fireground responses. In training settings, we will separately evaluate the contributions of wearing new and used firefighter turnout ensembles and using AFFF to acute increases in urinary and blood PFAS concentrations. Acute toxicity testing of PFAS mixtures will be conducted using dilutions of AFFF products, and also PFAS mixtures modeling those found in firefighters. In vitro acute toxicity testing will include kidney, prostate and colon cells, given the increased cancer rates for these organs seen in firefighters. Chronic toxicity will be evaluated through comparison of serum PFAS levels in firefighters with those in the general population and with epigenetic markers associated with cancer and other diseases.

Results (projected):
We expect that firefighters will have increased blood and/or urine PFAS levels after firefighting and also after use of AFFF, and we anticipate that PFAS mixtures will have both acute and chronic toxic effects. We will increase situational awareness in regards to AFFF use and develop

best practice recommendations to reduce firefighter exposure to PFAS and prevent their toxic effects.

Conclusions (projected):
The results from this project will inform national standards, manufacturing guidelines, operational, training, and decontamination practices to reduce harmful PFAS exposure.

FY 2017 Awards

FY 2017 FP&S R&D Grant Award

Project Title:	Enhanced Cleaning to Reduce Firefighter Exposure to Carcinogens
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2017-FP-00601
Award Total:	$1,337,028 ($1,273,360 Federal)
Period of Performance:	09/14/18 - 09/13/21
Grant Status:	Active

Abstract

Purpose & Aims:
This research will develop deep-cleaning methods to remove residual smoke & vapor carcinogens present in turnout material components after conventional washing.

Relevance:
Current NFPA 1851 advanced washing procedures remove 40% or less of potentially carcinogenic contaminants found in turnout gear after firefighting smoke exposure. After wash contaminants can migrate from turnout suits & transfer to skin; semi-volatile compounds can off-gas, exposing firefighters to low-level, sustained doses of toxic vapors. Better cleaning methods, to extract residual smoke & fire ground contaminants, at reasonable cost & with less damage to gear, will reduce firefighter cancer risks.

Methods:
1) Determine the level of accumulated carcinogens in retired smoke-exposed turnout gear; assess potential transfer of carcinogens via skin contact & potential for off gassing of volatile organic compounds (VOCs). 2) Contaminate representative combinations of new turnout outer shell, moisture barrier and thermal liner materials with controlled doses of target chemicals; clean with CO2 & enhanced conventional processes; analyze for residual contaminants. 3) Use deep-clean wash procedures to launder new structural uniforms, gloves & hoods contaminated with known carcinogenic compound levels; following up to 10 cleaning cycles compare carcinogen content levels found in gear laundered using current NFPA 1851 cleaning procedures for cleaning effectiveness, cost, & turnout durability.

Anticipated Outcomes:
Provide fire service community with new hazard assessments for residual contaminants in smoke-exposed legacy gear; identify next-generation cleaning procedures to remove more contaminants from turnout suits; recommend procedures to relevant NFPA technical committees, fire departments, laundries, and Inspection Service Providers (ISPs).

FY 2017 FP&S R&D Grant Award

Project Title:	Impact of PPE and Base Layer on Fireground Vapor and Particulate Exposure Risk
Organization:	The Board of Trustees of the University of Illinois
Principle Investigator:	Gavin Horn, PhD
Grant Number:	EMW-2017-FP-00635
Award Total:	$1,303,506 ($1,241,435 Federal)
Period of Performance:	09/14/18 - 09/13/21
Grant Status:	Active

Abstract

Purpose and Objectives:
The objectives of this study are twofold: 1) investigate the vapor-phase AND solid-phase chemical exposure, with a particular emphasis on known, probable and possible carcinogenic products of combustion and 2) quantify the impacts of various control measures to reduce both the vapor and particulate products of combustion reaching the firefighters' skin and being absorbed into the body while assessing the trade-offs between increased chemical protection and potential impact on heat stress.

Study Design:
Using a smoke exposure prop developed, implemented and validated in previous DHS FP&S studies, a series of dressed mannequin trials will be conducted to isolate the interfaces without the variability of human movement and activity level. For this component of the study, four different PPE conditions will be studied using PPE with increasing levels of encapsulation. A human subjects study component will follow in the same smoke exposure prop; using a 3-way repeated measures design, three distinct combinations of PPE and base layer will be studied to understand the impact of base layer coverage and PPE closures on firefighter exposure and heat stress.

Results (Projected):
Results from this study will quantify the effectiveness of a) modified PPE interfaces, b) hood technologies c) common base layers and (d) doffing practices to mitigate dermal exposure to vapors and particulate in realistic fire smoke conditions. Initial studies using mannequins will allow extensive testing of various combinations of control techniques. Human subject trials will characterize the relative impact of these physical control methods on firefighters¿ systemic exposure and heat stress.

Conclusions (Projected):
For the first time, we will enumerate the impact of increased encapsulation, barrier hoods and base layers on the ingress of BOTH particulate AND vapors through turnout gear along with the related biological uptake of these chemicals. By including human subjects and core temperature measurements, this study will also detail the impact of control measures on heat stress. We will also evaluate the effect of doffing procedures on these exposures. Our results will allow the fire service to make informed decisions about PPE, base layers, and other controls in a holistic manner from chemical protection of the firefighter to their influence on heat stress.

FY 2017 FP&S R&D Grant Award

Project Title:	Resonant Sensors for Heat Stress
Organization:	Iowa State University of Science and Technology
Principle Investigator:	Nigel Reuel, PhD
Grant Number:	EMW-2017-FP-00607
Award Total:	$236,250 ($225,000 Federal)
Period of Performance:	08/17/18 - 08/16/21
Grant Status:	Active

Abstract

Purpose and Objectives:
The purpose of this research is to develop a cost-effective sticker to apply under PPE on skin that wirelessly reports firefighter health status to warn against effects of heat stress. The objectives include 1) developing resonant sensors for water loss, electrolyte loss and local skin temperature, 2) developing a low-weight, low-power reader to transduce sensor signal through bulky PPE, and 3) begin demonstrating utility of sensors with local firefighter partners. Detecting heat stress is highly relevant as it is the leading cause of injury and death among firefighters. The method employed with these resonant sensors is different from all previous wearable technologies with regards to their completely passive and conformable design. There is no need for on-board power, rigid circuit board, or silicon based logic chips; thus the device can be worn with virtually no discomfort, load, and loss in mobility. The resonant sensors transduce changes in fluid volume, ion concentration, and skin temperature by altering their resonant frequencies. These can be interrogated wirelessly by a small unit worn on the tank pack, belt, or integrated in the jacket. Alternatively, the firefighter could be scanned periodically by a centralized reader (antenna set near response zone hydration station or in rehabilitation chair).

Study Design and Methods:
Resonant sensors will be developed in parallel with the readers. To develop a sensor for fluid loss measurement, sweat wicking materials will be coated on the resonator surface and tested for extent of response upon wetting. Ion screening will be achieved through resonator geometry studies and by applying ion selective coating to the surface. Temperature sensors will be built by coating the resonator with thermoresponsive polymer. These three sensors, along with needed reference resonators will be multiplexed on a single patch. The resonant sensors will be tested in lab as well as on human subjects (firefighters at state training classes). The readers will be developed as an on person unit and as a centralized unit that could be placed in a rehabilitation center to screen firefighters as they come to mandatory rest times.

Results (Projected):
Resonator response data for all prototypes of the three sensors will be collected and analyzed. These will help determine which sensor coatings, packaging, and interrogation methods works best for reliable and clear measurements. These results will come from tests with synthetic sweat in lab followed by human subject testing with firefighter trainees during mandatory training classes.

Conclusions (Projected):
Optimal sensor and reader designs will be found. Basic correlations between sensor response and level of thermal exertion (low, medium, and high) will be found. These findings will enable follow on studies to correlate theses sensors to actual levels of heat stress in a clinical study. The ultimate, desired outcome of this project would be a new method to conveniently track thermal status of firefighters and warn of heat stress before it becomes a dangerous and irreversible, medical complication.

FY 2017 FP&S R&D Grant Award

Project Title:	Expansion of the Fire Fighter Cancer Cohort Study
Organization:	University of Miami Miller School of Medicine
Principle Investigator:	Alberto Caban-Martinez, PhD
Grant Number:	EMW-2017-FP-00860
Award Total:	$1,574,774 ($1,499,785 Federal)
Period of Performance:	08/31/18 - 08/30/21
Grant Status:	Active

Abstract

Purpose and Objectives:
Not all firefighters are exposed to carcinogens equally. Epidemiologic studies on cancer incidence and mortality rates in the U.S. firefighter workforce have been largely limited to retrospective analyses of career firefighters, neglecting the critical workflow and unique exposures of other firefighter subgroups. The purpose of this new 36-month research proposal is to leverage the national Fire Fighter Cancer Cohort Study (FFCCS) infrastructure for expansion of research protocols in biomarker, carcinogenic exposure, and survey data collection to four firefighter subgroups: arson investigators, instructor, volunteers, and wildland-urban interface firefighters.

Study Design and Methods:
Project specific aims include: 1) Expansion of existing FFCCS advisory board membership to national leadership from each subgroup; 2) Adapting existing survey data collection instruments for priority cancer prevention and exposure control interventions identified by subgroup leadership; 3) Conduct biological exposure monitoring to identify determinants of exposure and expand the job exposure matrix for each subgroup; and 4) Collect and analyze biological samples for analysis of epigenetic markers of cancer pathway activation.

Relevance:
This FFCCS expansion is relevant to firefighter subgroups who are likely exposed to multiple workplace carcinogens, however we currently do not understand which individual exposures are responsible for cancer in each group.

Conclusions (Projected):
Our interdisciplinary research team collaborating with fire service partners, union leadership, and national organizations will use both qualitative and quantitative methodology across study aims to collect data on cancer prevention and control. This project will yield two main outcomes: 1) new longitudinal prospective biomarker, exposure and survey data; and 2) educational modules on cancer control for each firefighter subgroup.

FY 2017 FP&S R&D Grant Award

Project Title:	Study of Fire Service Residential Home Size-up and Search & Rescue Operations
Organization:	Underwriters Laboratories Inc.
Principle Investigator:	Stephen Kerber, PE
Grant Number:	EMW-2017-FP-00628
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	09/14/18 - 09/13/21
Grant Status:	Active

Abstract

Purpose and Objectives:
The UL Firefighter Safety Research Institute (FSRI) will lead a three-year Technology and Product Development Project examining fire service residential home size-up and search & rescue operations as part of a coordinated fire attack. The purpose of this study is to improve firefighter safety and save lives during residential fires by (1) increase the knowledge of the fire service on size-up components reinforced by research so they can operate safer and more efficiently to target searches; (2) improve situational awareness by linking the visual cues gained during initial size-up to search and rescue operations and the ongoing size-up during the residential fire; and (3) examine the impact of different search and rescue tactics on occupant survivability such as interior search, vent-enter-isolate-search (VEIS), and different isolation and removal options.

Study Design and Methods:
A proper size-up has been shown to result in favorable outcomes during structure fires. This study will build on the experience of the fire service by investigating common components of size-up such as reading smoke (volume, velocity, density, and color) and examining the ventilation profile (what changes when openings are made or taken away). It is paramount to determine the scientific based elements of size-up that the fire service can use to best understand the fire dynamics in order to make critical tactical choices such as hoseline placement and search locations. Previous fire service tactics research on suppression and ventilation indicated several tactical considerations that could increase the effectiveness of search and rescue operations by better understanding the impacts of timing, door position, entry point, victim removal route, removal technique and suppression. These tactical considerations need to be further examined and developed with the features of the old and new residential housing stock in mind.

Results (Projected):
The outcomes of this project will be used to improve firefighting tactics, fireground safety, fire dynamics knowledge, and firefighter standard operating procedures. Key measurements of this project will address critical needs by the fire service so that more lives, both civilians and firefighters, can be saved through smarter and more efficient fireground operations. Many traumatic line of duty deaths and injuries that occur in residential homes involve search and rescue operations, either by an attack crew advancing a hoseline or a dedicated search team. This study aims to reduce those losses and increase the efficiency of all searches that occur at every residential home fire across the country every day.

Conclusions (Projected):
The research will also include collaboration with the fire service via a technical panel and the University of Illinois to develop data on the potential impact of specific combustion products on civilians and firefighters. A comprehensive fire service outreach program will make sure that this science meets the street. This research addresses several High Priority Recommendations identified in the 2015 National Fire Service Research Agenda and will also support the NFPA 1700 Guide for Structural Fire Fighting currently under development.

FY 2017 FP&S R&D Grant Award

Project Title:	Broadening PPE Cleaning Validation Applications
Organization:	Fire Protection Research Foundation
Principle Investigator:	Casey Grant
Grant Number:	EMW-2017-FP-00582
Award Total:	$1,000,000 ($952,381 Federal)
Period of Performance:	08/31/18 - 08/30/21
Grant Status:	Active

Abstract

This project establishes a validated and scientifically-based cleaning methodology for the primary spectrum of potentially contaminated fire service personal protective equipment (PPE) and equipment, including PPE not addressed by previous work such as helmets, gloves, and footwear, and other key components subjected to contamination such as hand tools, fire hose, and apparatus seat covers. This study is important because it provides a critical contribution to effective contamination control, which is believed to be a significant contributor to fire fighter long term health concerns (e.g., cancer). This effort is a logical extension of an earlier research project that established a validated cleaning procedures focused on PPE textile garments that are traditionally cleaned in commercial laundering extractors.

Purpose and Objectives:
The overall goal of this project is to improve fire fighter health and safety by reducing repeated exposure to harmful contaminants in unclean or inadequately cleaned PPE and related equipment. Specifically, this effort will answer new questions about turnout clothing contamination removal to further refine recommended fire service advanced cleaning and sanitization procedures to levels of greater efficiency with conventional laundering/treatment approaches. It will adapt the established evaluation methods for the consistent measurement of cleaning effectiveness for washer/extractors used for garment outer shells, to address other critical contamination concerns involving other garment layers and components, helmets, boots, gloves, SCBA, and related response equipment that could include hand tools, fire hose, and fire apparatus.

Study Design and Methods:
This project is composed of six phases and multiple tasks as follows: Phase I – Initiate Project (Establish and convene panel; Engage contractors); Phase II – Investigate Cleaning Parameters (Prepare test plan to evaluate cleaning changes; Adapt kit-based procedures for other materials; Carry out kit-based testing and experiments; Specify updated cleaning procedures); Phase III – Characterize Other PPE Contaminants (Characterize PPE/equipment contamination; Devise methods to assess contamination; Establish overall evaluation approach; Establish overall evaluation approach; Hold panel meeting to set overall approach); Phase IV – Evaluate Cleaning for Other PPE (Confirm target contaminants; Determine appropriate metrics; Assess other PPE cleaning methods; Evaluate cleaning procedures at field test sites); Phase V – Refine Test Procedures and Utility (Carry out further validation efforts; Finalize test procedures for PPE assessment; Identify mitigation strategies); Phase VI – Document Project Output and Outreach

(Prepare project final report; Recommend standards public inputs/comments; Provide industry guidance document/outreach).

Results (Projected):
The following are the projected results from this effort: determine principal areas contamination retention; characterize current cleaning processes; identify and investigate specific adjustments to conventional laundering and presoaking techniques; adapt current contamination, extraction, and analysis techniques; demonstrate the reliability and appropriateness of proposed evaluation approaches; evaluate the effectiveness of selected processes; prepare industry guidance; facilitate proposed specific test methods; and facilitate proposed design, construction, and textile considerations for improved contamination resistance and reduction in equipment.

Conclusions (Projected):
This project seeks the following conclusions: improve baseline garment advanced cleaning and sanitization procedures; characterize contamination processes for other PPE and equipment: successfully adapt chemical and biological decontamination verification procedures to other PPE and equipment; and extend overall fire service guidance and proposed standards.

FY 2017 FP&S R&D Grant Award

Project Title:	Health Consequences Following Firefighter Exposure to Wildland Fire Smoke
Organization:	Northeastern University
Principle Investigator:	Jessica Oakes, PhD
Grant Number:	EMW-2017-FP-00446
Award Total:	$1,578,871 ($1,500,000 Federal)
Period of Performance:	09/14/18 - 09/13/21
Grant Status:	Active

Abstract

Purpose and Objectives:
The goal of this project is to quantify the burden of acute and chronic exposure to wildfire smoke on the cardiopulmonary system of wildland firefighters (WLFFs). Although several studies have characterized the emissions from wildland fires, their consequences on WLFF health remains unclear. Objectives are:
(1) to determine best practices for creating smoke in the laboratory with similar profiles to existing observations during different firefighting operations (fireline, mop up operations, etc.).
(2) to quantify changes in the cardiopulmonary function of mice following exposure to smoke. Exposure studies will be performed with different smoke profiles, mimicking conditions previously observed in the field.
(3) to determine the effectiveness of simple personal protective equipment (PPE, bandanas, face masks, etc.) in reducing the adverse health outcomes of smoke inhalation according to the same smoke profiles from obj 2.
(4) to predict health outcomes in WLFFs based on the results from animal studies (objs 2 & 3) by means of numerical simulations.

Study Design and Methods:
(1) A mixture of fuel types and smoldering/flaming conditions will be used to reproduce emissions from wildland fires in the laboratory. A smoke exposure device will be created to repeatedly generate these emissions.
(2) Mice will be exposed to the smoke five times per week for up to six months and sacrificed at various intervals during the exposure study. Body weight, heart & respiration rate, and blood pressure will be measured weekly to assess overall health. End-state measures of tissue/organ structure (histology) and function (lung & heart passive mechanics, heart contractility, aortic stiffness) will provide a measure of the physiological response to smoke inhalation. Local and systemic inflammation will be measured weekly (exhaled nitric oxide) and at end-point (BALF, immunohistochemistry, circulating inflammatory proteins).
(3) Smoke will be delivered to the mice with chosen PPEs interposed at the inhalation chamber inlet. The physiological response will be measured as described in (2).
(4) CT scans, measured particulate sizes/concentrations, and flow/transport numerical modeling methods will be used to predict the fate of inhaled particles in exposed mice. A similar approach will be used to predict dosimetry in WLFFs, using medical images from patients and literature data regarding particle concentration/sizes. Comparing these simulations, we will be able to correlate the amount of particles retained within WLFF¿s lungs with expected health outcomes.

Results (Projected):
The exposure to wildland fire smoke is expected to deteriorate the cardiopulmonary function in mice. Our study will be the first to quantify the extent of these effects in a systematic manner. Because smaller particles are more detrimental to human health, PPEs that can to retain particles within the respiratory range are expected to be the most effective in reducing the health risks associated with the inhalation of wildland fire smoke. Finally, by using our unique numerical approach, we are confident that we will be able to draw conclusions regarding firefighter health from the experimental data collected in mice.

Conclusions (Projected):
Deliverables from this project will include some of the first quantitative measurements of the health consequences of different smoke exposure levels. Our results will give an overall sense of the health risks that fighting wildland fires imposes on first responders, who currently use no sanctioned respiratory PPE. By assessing the impact of common but unofficial PPE (bandannas, face masks, etc.), a true sense of their effectiveness and future PPE research needs will be determined. Furthermore, our results will be translatable to firefighter operations by suggesting modifications of best periods to be present on the fireline and maximum exposure times.

FY 2016 Awards

FY 2016 FP&S R&D Grant Award

Project Title:	Developing a new Basis for Rating the Heat Strain of Firefighter Turnout Gear
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2016-FP-00744
Award Total:	$982,406 ($935,625 Federal)
Period of Performance:	09/01/2017 - 08/31/2020
Grant Status:	Completed

Abstract

Purpose & Aims:
This project will provide an improved technical basis for rating the heat strain performance of firefighter turnout suits.

Relevance:
NFPA 1971 heat strain requirements do not account for the range of use conditions and environments encountered by structural firefighters. The THL breathability index provides a single snapshot of turnout breathability valid for a single set of environmental conditions and workloads. It cannot account for the dynamic conditions involved in real firefighting operations. It may not accurately rate the heat strain potential of turnout materials that transfer body heat differently depending on the ambient temperatures and humidity.

Methods:
We will establish enhanced laboratory test protocols and criteria for rating and certifying turnout heat strain by obtaining a better understanding of firefighter sweat generating conditions when performing activities ranging from fire suppression to post-fire overhaul. We will develop a new laboratory testing procedure for measuring heat loss through turnout suit materials that approximates sweat production and evaporation by firefighters in dynamic firefighting conditions. It will account for radiant heating from fires and heated surfaces.

Anticipated Outcomes:
This research will address a critical ongoing need of the NFPA 1971
Technical Committee for scientifically based qualification of THL and Ret indexes for rating the breathability of turnout materials. It will produce a significant improvement in the way turnout materials are tested and certified for heat stress. This resulting upgrade in the standards requirement will translate into more comfortable turnout gear options for firefighters.

FY 2016 FP&S R&D Grant Award

Project Title:	Firefighter Safety in Battery Energy Storage System Fires
Organization:	University of Texas at Austin
Principle Investigator:	Ofodike Ezekoye, PhD
Grant Number:	EMW-2016-FP-00833
Award Total:	$1,501,414 ($1,429,919 Federal)
Period of Performance:	09/01/2017 - 12/30/2020
Grant Status:	Active

Abstract

Purpose & Aims:
The purpose of the project is to reduce the risk to firefighters responding to emergencies involving lithium ion battery energy storage systems (LiBESS) by improving fire service knowledge of LiBESS fires and explosions. The project seeks to fill in knowledge gaps on failure modes and effects of LiBESS by carefully testing and characterizing the thermal runaway and venting processes for several classes of battery systems at different scales.

Relevance:
The adoption of LiBESS requires an implied level of safety for civilians and firefighters. Standards play an important role in ensuring that failures are infrequent and not catastrophic. Standards organizations including National Fire Protection Association (NFPA), International Code Council (ICC), and International Electrotechnical Commission (IEC) are using best available data to develop and publish codes and standards related to energy storage systems. While these new standards are being developed to minimize the negative consequences of LiBESS failure, the underlying data supporting some of the specifications are quite sparse. To improve the efficacy of codes and standards for LiBESS, additional data on LiBESS hazard evolution are required.

Methods:
The purpose of the project is to fill in knowledge gaps on failure modes and effects of Li-BESS by carrying out detailed testing of these systems with a goal of expanding the test space using validated computational modeling tools. To achieve the project goals, the project will consist of five key parts¿(1) evaluation of Li-BESS fire scenarios to identify and address technical gaps in current understanding of Li-BESS fires, (2) small and medium-scale testing (3)large scale testing and field measurements and (4) development of validated models for battery thermal runaway and venting (5) dissemination of findings to stakeholders.

Anticipated Outcomes:
The goal and expected outcome of the project is to provide the fire service fire service with data on LiBESS hazards and a simulator and testing system for these hazard scenarios so that the fire service can develop effective SOGs. Through development of effective SOGs, injuries and potential death due to improper firefighting tactics can be significantly reduced and potentially eliminated.

FY 2016 FP&S R&D Grant Award

Project Title:	Stress and Violence in Fire-Based EMS Responders (SAVER)
Organization:	Drexel University
Principle Investigator:	Jennifer Taylor, PhD
Grant Number:	EMW-2016-FP-00277
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	09/01/2017 - 02/28/2021
Grant Status:	Active

Abstract

Purpose and Aims:
This Database System Development study seeks to determine the predictors and correlates of fire-based EMS responder injury and stress by: AIM 1 developing a multiteam systems checklist and establishing consensus via a stakeholder conference, AIM 2 creating departmental and organizational safety policies and practices through checklist implementation and evaluation, AIM 3 increasing reports of violent encounters by modifying an existing data system, and AIM 4 assessing community utilization of resources and impact on fire service injuries through GIS mapping of EMS calls.

Relevance:
This proposal responds to Fire Fighter Life Safety Summit initiatives 1, 2, 3, 8, 9, 10, and 12. Three metropolitan fire departments and their local IAFF partners will participate. Never before has FEMA R&D grant funding addressed the EMS aspect of fire, though EMS accounts for 70-90% of the work.

Methods:
Develop a systems-level checklist for violence against fire-based EMS responders using findings from a recently completed USFA-IAFF-funded systematic review of academic and industrial literature. Implement the checklist with fire departments in San Diego, Miami-Dade, and Philadelphia. Evaluate the effectiveness of the checklist using mixed methods: interviews and focus groups combined with a quasi-experimental repeated-measures design using previously validated psychological scales. Assess organizational outcomes (burnout, engagement, job satisfaction, etc.), mental health outcomes (depression, PTSD, etc.), and injuries pre- and post-intervention. Increase reporting of verbal and physical violence to fire-based EMS responders by modifying an existing data system, EVENT/EMERG. Using GIS methods, analyze EMS calls using CAD data and patient care reports. Describe community need for service, investigating clusters of high utilization. Conduct analysis on calls that result in verbal or physical injury.

Anticipated Outcomes:
This study will understand the organizational, mental health, and injury burden that fire-based EMS responders currently carry as they respond to an increasing community demand for services.

FY 2016 FP&S R&D Grant Award

Project Title:	Bullying Prevention in the U.S. Fire Service
Organization:	NDRI-USA, Inc.
Principle Investigator:	Sara Jahnke, PhD
Grant Number:	EMW-2016-FP-00806
Award Total:	$1,574,945 ($1,499,948 Federal)
Period of Performance:	09/01/2017 - 02/28/2021
Grant Status:	Active

Abstract

Purpose and Aims:
Bullying has become a critical area of concern in the fire service; from face to face and online intimidation to extreme instances of harassment resulting in assault. These negative behaviors erode safety and teamwork in addition to being in stark contrast to the fire service core values of duty, pride, and tradition and put departments at risk for litigation.

Unfortunately, efforts to quantify the extent of the problem remain piecemeal. Without a comprehensive understanding of the scope and root causes of bullying, we cannot estimate its impact on recruitment and retention, possible career disruption, behavioral health outcomes, and suicide risk. This research will collect appropriate information about bullying in the fire service and the prevalence, incidence, risk factors, and consequences of bullying behaviors in the fire service which will be used to inform prevention and intervention efforts.

Relevance:
Bullying/hazing and assault in the fire service are underreported and, in many instances, exist as traditionally accepted aspects of the job. Gathering national data on prevalence and incidence rates of bullying/assault in the fire service will allow investigators to objectively quantify the problem and will inform the tailoring of an empirically validated prevention training for departments.

Methods:
A mixed-methods research approach will be used to develop a comprehensive picture of the challenges and opportunities for prevention and intervention. This information will be used to develop bystander training modules and inclusive programs/policies that will be pilot tested.

Anticipated Outcomes:
The outcome of this research is to aid the fire service community in its mission to prevent bullying/harassment/assault, respond to firefighter mental health issues, and identify ways to improve resilience among firefighters. Data from this research will inform development and pilot testing of a tailored program that is responsive to the unique culture of the fire service.

FY 2016 FP&S R&D Grant Award

Project Title:	A Novel Approach for Measuring Firefighter Occupation Chemical Exposures
Organization:	Oregon State University
Principle Investigator:	Dr. Kim Anderson
Grant Number:	EMW-2016-FP-00754
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	09/01/2017 - 02/28/2021
Grant Status:	Active

Abstract

Purpose and Aims:
Occupational exposures are assumed to play a role in the cancer and cardiovascular disease risks among firefighters. Limited methodologies exist for monitoring chemical exposures, such as measuring metabolites in blood and urine, sampling smoke plumes, and having firefighters maintain diaries. However, the majority of firefighter disease risk studies have used simple surrogates for exposure, most often just job title. Unfortunately, even the more intensive methods represent an incomplete assessment of chemical exposure, are cost prohibitive, labor intensive, and often impractical. As a result, firefighter's often do not know what chemicals they may have been exposed to at a fire call. Our multidisciplinary team of researchers at Oregon State University (OSU) has developed a new suite of exposure measurement technologies and have applied them successfully to answer similar questions in other occupations. We propose to partner with occupational health, epidemiology, and outcomes researchers at the Center for Fire, Rescue, and EMS Health Research (CFREHR) to test the transferability of these technologies to the fire service.

Relevance:
Tailoring of this methodology to the fireground setting will not only provide an innovative approach for live fire analysis, but will create a usable technology for departments and firefighters to monitor and track their individual exposures and the impact of exposure mitigating techniques.

Methods:
This exposure monitoring technology includes a wristband dosimeter and innovative chemical methods including VOCs, SVOCs by thermal desorption and a 1,528 chemical screen with a *single,* cost-effective technique. We propose to determine the comparability of exposure sampling via the wristband (and neck) dosimeter with data captured from the more costly, labor intensive and invasive exhaled breath and urine samples with an on-going FEMA-sponsored firefighter cancer cohort study. We also propose to compare dosimeter exposure assessment between firefighters from Kansas City area fire departments from high and low call volume, within on-shift vs. off-shift times, and for levels of structural firefighting. We will screen for chemicals to explore previously unmonitored chemicals that may be quite unique to firefighters.

Anticipated Outcomes:
This study represents an exciting breakthrough in our ability to easily, cost-effectively, and comprehensively characterize the exposures firefighters face.

FY 2016 FP&S R&D Grant Award

Project Title:	Optimizing Circadian Rhythms by Regulating Eating Patterns to Reduce Cardiometabolic Disease Risk Among Firefighters
Organization:	The Salk Institute for Biological Studies
Principle Investigator:	Satchidan Panda, PhD
Grant Number:	EMW-2016-FP-00788
Award Total:	$1,574,695 ($1,499,710 Federal)
Period of Performance:	09/01/2017 - 02/28/2021
Grant Status:	Active

Abstract

Purpose and Aims:
Firefighters undergo chronic disruption of circadian rhythm in sleep-wake and eating-fasting cycles due to the nature of their work. These disruptions are known to compromise metabolic fitness, which can lead to cardiometabolic diseases such as cardiovascular diseases, diabetes, obesity, and cancer. Firefighters are at a higher risk of developing chronic diseases compared to the general public. These diseases compromise their fitness, personal safety, and wellbeing; it also increases their health care costs. Contemporary circadian rhythm research has shown that consuming all caloric containing food and beverages within a consistent 8-12 hours every day without an overt attempt to change nutrition quality, quantity, or physical activity can sustain a robust circadian rhythm, improve sleep, and reduce the risk of cardiometabolic disease while enhancing endurance and personal sense of energy.

Relevance:
Shift workers are indispensable to the functioning of modern societies. These shift workers include firefighters who work at night when the body is meant to rest; this results in detrimental health consequences for them. Epidemiological, animal, and clinical studies have shown chronic disruption of circadian or ~24 hour (h) daily rhythms among shift workers including firefighters increases the risk of obesity, diabetes, cardiovascular diseases, insomnia, and cancer. However, pragmatic lifestyle intervention to counteract the adverse health effects of shift work is lacking. Based on extensive studies in animals and human, this proposal will test the effectiveness of only changing the amount of time in which food is consumed during a 24h period in order to improve circadian rhythm and consequently cardiometabolic health outcomes for shift workers specifically firefighters.

While there is a groundswell of evidence that changing eating pattern is a powerful lifestyle intervention, it has never been tried among firefighters. Nearly 75% of firefighters are overweight or obese. Comorbidities associated with obesity are prevalent among firefighters. Obesity jeopardizes their safety and well-being as well as public safety. Obesity is also a significant risk factor for subsequent disability. Therefore, the proposed intervention will reduce body weight and lessen comorbidities among firefighters, which will have significant shortand long-term economic and societal benefits.

Methods:
In a randomized-cluster controlled trial design, the application of time-restricted feeding (TRF) will test the effectiveness of circadian diet intervention compared to the standard nutrition behavioral counseling on metabolic health. The intervention group will receive educational materials through a study website, daily prompts from a custom-made app (myCircadianClock, "mCC app"; see appendix for timeline and description of prompts), group educational sessions at fire stations, and peer education and support.

Anticipated Outcomes:
Primary outcome measures are changes in blood glucose as measured for up to 7 days by an ambulatory continuous glucose monitoring device and NMR-lipid profile. Secondary outcome measures are body weight, body composition, blood pressure, cholesterol, inflammatory markers, and sleep. After 12 weeks of intervention, the participant will enter a self-directed maintenance phase for up to 12 months to examine the long-term effect of behavior change and its impact on body weight regulation, vital signs, and sleep. Improvements in health and wellness and reduction in risks for cardiometabolic diseases are anticipated. Successful completion of the study will assess the effectiveness of circadian diet program and produce resources and educational materials for the fire service to adopt it nationally.

FY 2015 Awards

FY 2015 FP&S R&D Grant Award

Project Title:	Revolutionizing the Protective Hood: Particulate Protection, Cleaning Effectiveness
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2015-FP-00753
Award Total:	$1,499,997 ($1,428,569 Federal)
Period of Performance:	07/28/2016 - 12/31/2019
Grant Status:	Closed

Abstract

Purpose & Aims:
To enhance the safety of firefighters by developing a systems-level methodology for evaluating protective hood materials and designs for protection against toxic smoke particles while providing acceptable wear comfort and thermal protection. The trade-offs associated with particulate and flash fire protection and heat stress will be assessed and used as basis for identifying protective hoods systems that will provide the firefighter with barrier protection while also minimizing thermal strain. An inexpensive field-level particulate demonstration will be developed in conjunction Boston Fire Department that will serve as a training and awareness tool that can be adopted at fire departments across the country.

Relevance:
Analyses of fire ground exposures and cancers in firefighters have exposed limitations in current hoods. The NFPA 1971 standard on firefighter PPE does not have requirements in place to evaluate particulate protection or thermal heat stress associated with hoods. This research will provide the technical basis for performance criteria and evaluation methodologies for hoods as well as their durability and cleaning effectiveness.

Methods:
Material and product level methods will be utilized to study the effects of particulate resistant materials and innovative designs on the ability of the protective system to mitigate exposure to smoke particulates while providing breathability to reduce heat stress. NCSU's unique suite of instrumented upper body manikin systems will provide unprecedented evaluation levels specific to protective hoods that will be validated against live-fire field assessments.

Anticipated Outcomes:
This research will contribute to improve firefighter protection from dermal exposures to smoke contaminants; balance thermal protective, ergonomic, and stability requirements by providing validated methodologies and performance criteria that will serve as a basis for optimizing the protective performance of hood constructions that manufacturers offer to the firefighter.

FY 2015 FP&S R&D Grant Award

Project Title:	Study of Coordinated Fire Attack in Acquired Structures
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Stephen Kerber MS, PE
Grant Number:	EMW-2015-FP-00361
Award Total:	$1,566,802 ($1,492,192 Federal)
Period of Performance:	07/29/2016 - 01/29/2020
Grant Status:	Completed

Abstract

Relevance:
Many departments in the fire service are in the midst of revamping their tactics in order to adapt to the changing fire environment identified through previous research studies. These tactical changes require an evaluation of the principles of fire service operations, specifically ventilation and suppression. Many fire departments are working to revise standard operating procedures; however they lack the data to define what successful coordinated fire attack is and how to best provide their members with guidance on how to operate effectively while allowing enough room for decision making on the fireground based on the conditions the crews encounter. Every fire attack requires coordination whether a single crew or several crews are on scene, whether in a rural or urban environment or whether career or volunteer firefighters are responding to the structure fire. Understanding what makes coordination successful or not is relevant to the entire fire service.

Purpose:
The purpose of this study is to improve fire service knowledge of fire dynamics and the impact of their tactics through a better understanding of how suppression and ventilation are coordinated on the fire ground in different types of structures. This project will expand on previous research studies. This will assist in the development of thinking firefighters with a good foundation in fire dynamics and understanding of how their decision making will impact their safety and effectiveness. Coordination of fire attack is continuously cited in NIOSH LODD reports and fire service training materials but it is not well defined or explained. This study aims to provide the data necessary to understand the parameters of a successful coordinated fire attack so that firefighters become more effective and efficient on every fireground across the country.

Methods:
Using acquired structures, several different fire scenarios will be tested using tactics that include horizontal, vertical and positive pressure ventilation, interior only and combined interior/exterior fire attack. Measurements will be taken of gas temperatures, heat flux, flow velocities, differential pressure, gas concentrations, and moisture content throughout the structure along with recording standard and infrared video of the experiments. The fire service has historically been concerned with the potential negative effect on trapped occupants when steam is created via exterior water application. This study will also include collaboration with the University of Illinois to develop data on the potential impact of fire conditions on firefighters and civilians. In order to accomplish their tasks, they will participate in UL led fire tests and introduce pig skin samples in various rooms and locations to simulate potential human exposure to elevated

temperature and humidity. In addition they will provide moisture measurements to identify the effectiveness of the coordination between ventilation and suppression as it relates to steam production. This study will utilize full-scale field acquired structure experimental methods. Fuel loads will be representative of "real" fuels found in structures across the country. Fuels will be consistent across experimental series so that coordinated fire attacks can be compared. The fire service technical panel will determine the tactics that will be coordinated and how they will be coordinated to accomplish life safety, property conservation and incident stabilization strategic objectives. The variables of tactics, timing of tactics and coordination of tactics will be carefully controlled so that learning is maximized. Connections will be made between each of the research projects conducted to date as well as between the three series of experiments proposed. Utilizing structures that range from single family to multi-family to commercial will allow for the understanding of which tactics and fire dynamics are independent of structure type and which are dependent on the structure type.

Anticipated Outcomes:
The data collected from the fire experiments will provide firefighters with knowledge about how tactical choices and coordination of ventilation and suppression impact conditions through the structure where they are operating. This knowledge will allow fire officers to make informed decisions regarding methods to suppress structure fires and can significantly influence firefighter standard operating procedures and training. The fire test data generated (e.g., temperature, pressure, gas effluent, moisture) along with the complementary University of Illinois results on pig skin and moisture content will provide important conclusions for the safety of firefighters and occupants. This should lead to better decision making on the fireground and more effective and efficient firefighting. Results will also provide a much needed expansion into multifamily and commercial structures where data is needed to substantiate structural firefighting guidance being drafted for NFPA 1700.

FY 2015 FP&S R&D Grant Award

Project Title:	The Firefighter Multicenter Cancer Cohort Study: Framework Development and Testing
Organization:	Arizona Board of Regents, University of Arizona
Principle Investigator:	Jefferey Burgess, MD, MPH
Grant Number:	EMW-2015-FP-00213
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	07/20/2016 - 01/19/2020
Grant Status:	Completed

Abstract

Relevance:
Cancer is a leading cause of fire service morbidity and mortality, and a recent National Institute for Occupational Safety and Health study demonstrated an excess mortality rate for cancer in firefighters compared with the general population (Daniels et al., 2014). Firefighters are exposed to multiple carcinogens in the workplace through skin contamination and inhalation. However, we currently do not understand which individual exposures are responsible for cancer in firefighters, the mechanisms by which these exposures cause cancer, or effective means of reducing exposures. Since cancer has a long latency period, biomarkers are also needed that can measure the effects of carcinogen exposure well before the development of cancer, when interventions to prevent disease could be effective. Development of a large (>10,000 firefighter) multicenter firefighter cancer prospective cohort study will address these needs, but the framework for such a study needs to be first developed and tested among a smaller initial set of fire service partners.

Purpose:
The purpose of the proposed research is to develop and test a framework for establishing a long-term firefighter multicenter prospective cohort study focused on carcinogenic exposures and effects. The specific aims are to: 1) Establish an oversight and planning board to provide study oversight, foster communication among fire organizations and help develop a long-term funding plan; 2) Create and test a cohort study data coordinating center and harmonized survey data protocols; 3) Develop and evaluate an exposure tracking system paired with quantitative exposure data to construct a firefighter carcinogen exposure matrix; and 4) Create a biomarker analysis center and evaluate the association between cumulative firefighter exposures and epigenetic effects.

Methods:
The study will build on recent and developing firefighter cancer prevention studies in Arizona, Florida and Massachusetts, adding volunteer and combination fire departments. 1) An Oversight and Planning Board will be established by the Fire Protection Research Foundation in association with the NFFF Fire Service Occupational Cancer Alliance to provide oversight of the study through collaboration among fire service organizations, academia, and government agencies, and develop a long-term funding and sustainability plan. 2) A Data Coordination Center will design, develop and evaluate a framework for a multicenter prospective cohort study of firefighters and cancer risk, including standardized participant survey data collection tools and

analysis protocols sufficient to address the short- and long-term study objectives as well as linkage with long-term outcome data including cancer development. 3) An Exposure Assessment Center will develop a carcinogen exposure matrix using information gleaned from self-reported and quantitative exposure measurements to provide improved occupational exposure data for comparison with epigenetic outcomes and eventual cancer outcomes. Carcinogen exposures associated with specific fire types and job tasks will be evaluated across fire departments through exhaled breath monitoring and analysis of urine for absorbed contaminants, providing information to guide exposure reduction strategies. 4) The Biomarker Analysis Center will carry out pilot studies of epigenetic markers of cancer effect and cancer risk comparing firefighters with a range of cumulative exposures and non-firefighter controls. For these purposes, blood and buccal cells will be collected during annual medical surveillance evaluations.

Anticipated Outcomes:
The proposed research will: establish the framework necessary for the subsequent development of a large multicenter cohort study of cancer in the fire service; advance our understanding of firefighter exposures to carcinogens; and help identify biomarkers of carcinogen effect and cancer risk.

FY 2015 FP&S R&D Grant Award

Project Title:	Health and Wellness of Women Firefighters
Organization:	NDRI-USA, Inc.
Principle Investigator:	Sara Jahnke, PhD
Grant Number:	EMW-2015-FP-00848
Award Total:	$1,574,999 ($1,5000,000 Federal)
Period of Performance:	07/20/2016 - 01/19/2020
Grant Status:	Completed

Abstract

Relevance:
The low number of and difficulty accessing women in the fire service has resulted in almost no information on female firefighters, despite evidence that significant gender-specific health concerns exist. Fire service leadership and health care professionals have no data on which to base important decisions about how to protect the health and safety of women in their departments. This study is the first step toward addressing this gap and correcting a critical omission.

Purpose:
While firefighter health research has experienced exponential growth over the past decade, the published literature has focused almost exclusively on males. The lack of data on how firefighting impacts women has been hypothesized to negatively impact recruitment, retention, and job satisfaction. Particularly lacking are details about female-specific health concerns (e.g. reproductive cancers, reproductive health, safety of breastfeeding). We also address other critical areas of concern including cancer, injury, and behavioral health issues among both career and volunteer female firefighters.

Methods:
Data will be collected as part of a longitudinal cohort study of critical issues as well as a chemical analysis of breastmilk. Based on these data, an expert panel will develop model policies and recommendations for protecting the health and safety of women in the fire service.

Anticipated Outcomes:
This study will result in foundational data on the health and safety of female firefighters and will develop model policy and practice recommendations for fire departments. The information from this research will provide an empirical foundation for decisions by both firefighters and management on appropriate measures to protect the health of current and future female firefighters.

FY 2015 FP&S R&D Grant Award

Project Title:	Synthesizing/Disseminating New Scientific Insights into Transient Wildfire Behavior
Organization:	University Corporation for Atmospheric Research
Principle Investigator:	Janice Coen, PhD
Grant Number:	EMW-2015-FP-00888
Award Total:	$188,307 ($179,340 Federal)
Period of Performance:	07/20/2016 - 01/19/2020
Grant Status:	Completed

Abstract

Purpose:
The purpose of this project is to improve wildland firefighter safety and reduce burnovers and entrapments by improving understanding of under-recognized, transient, difficult to understand weather-fire behavior combinations that are currently not well represented in static, two-dimensional training material. Examples include the impact of gust fronts and shifting winds on fire behavior, fire-induced winds, large fire whirls, transient plume behavior, coastal airflows, and complex topographic airflow effects.

Methods:
Guided by other fire scientists and practitioners from different geographical regions and agencies, we will use CAWFE, a coupled numerical weather prediction-wildland fire behavior model, to simulate several wildland fire events containing transient, hazardous fire behavior that led to (or could have led to) firefighter entrapment. We will visualize and narrate the output, creating engaging, three-dimensional, time dependent animations.

Anticipated Outcomes:
This project will generate knowledge on how complex atmospheric flows interact with fire behavior, infuse it further within the wildland fire community, and create high impact narrated animations that complement and enhance existing training material. Our team would then disseminate knowledge through research, education, and training within the wildland firefighting and scientific community through publications in professional society publications, practitioner journals, firefighter training, university class lessons, and safety-oriented conferences, as well as social media outlets including a wildland firefighter blog, narrated animations, webinars, and briefings.

We anticipate that these phenomena and behaviors that are considered unpredictable can be reproduced when fine-scale airflows and fire-induced winds are captured. Outflows will be enhanced by fire-induced winds.

FY 2014 Awards

FY 2014 FP&S R&D Grant Award

Project Title:	Cancer Prevention in the Fire Service: Exposure Assessment, Toxic Effects and Risk Management
Organization:	Arizona Board of Regents, University of Arizona
Principle Investigator:	Jefferey Burgess, MD, MPH
Grant Number:	EMW-2014-FP-00200
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	08/06/2015 - 03/05/2019
Grant Status:	Closed

Abstract

Relevance:
Cancer is a leading cause of fire service morbidity and mortality. Exposure to carcinogens occurs through skin contamination, through the lungs when respiratory protection is not worn during all phases of fire suppression and overhaul, and through inhalation during standby, operation of apparatus and off-gassing of equipment. In addition to fire smoke, diesel exhaust exposure can occur from operation of apparatus at the fire ground and in the station. Since cancer has a long latency period between exposure and disease onset, measurements are needed that can determine the effectiveness of new interventions on a much shorter time interval.

Purpose:
The purpose of this research project is to identify effective methods of reducing firefighter exposure to carcinogens and associated toxic effects through completion of the following specific aims: 1) Evaluate exposure to carcinogens throughout the work shift; 2) Measure biomarkers of carcinogenic effect in relation to workplace exposures; and 3) Within a risk management framework, test the effectiveness of interventions to reduce fire service carcinogen exposure and effects.

Methods:
Exposure to particulates and volatile chemicals will be measured at the fireground and intransit. Diesel particulate matter monitoring during responses and in the fire station will also be completed. Blood and urine collected during annual medical surveillance evaluations and post-fireground activities will be analyzed for chemical contaminants. Biomarkers of carcinogenic effect will also be
analyzed pre- and post-exposure, and evaluated for association with measured chemical contaminants. The extent to which firefighter chemical exposures and biomarkers of effect can be reduced by following risk management steps will be determined.

Anticipated Outcomes:
The proposed research will identify carcinogenic exposures throughout the fire shift and measure the effectiveness of interventions designed to reduce cancer risks.

FY 2014 FP&S R&D Grant Award

Project Title:	Validation of Cleaning Procedures for Firefighter Personal Protective Equipment (PPE)
Organization:	Fire Protection Research Foundation
Principle Investigator:	Casey Grant, MS, PE
Grant Number:	EMW-2014-FP-00403
Award Total:	$ 829,772.00
Period of Performance:	07/23/2015 - 12/22/2018
Grant Status:	Closed

Abstract

Relevance:
Firefighter exposure to personal protective equipment (PPE) that is dirty, soiled, and contaminated is an increasing concern for long-term firefighter health. Firefighter exposure to persistent harmful contaminants in PPE is an increasingly serious problem both on the fireground to highly toxic substances including a variety of carcinogens, and more insidiously to an increasing range of infectious pathogens that are encountered in patient care and different emergency operations. Firefighter PPE becomes contaminated during these exposures and there are no industry standards that conclusively and reliably show that clothing is being adequately cleaned.

Purpose:
This project is intended to establish clear and definitive guidance to the fire service for applying cleaning and decontamination procedures that effectively remove both chemical and biological contaminants. While general cleaning procedures have been established in NFPA 1851, Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting, there are no requirements that demonstrate whether current cleaning practices will adequately remove contaminants from firefighter PPE. Gear cleaning recommendations from many manufacturers are vague and most cleaning product/process claims are unsubstantiated regarding contaminant removal effectiveness. Prior studies have identified persistent chemical and biological contaminants in structural fire fighting PPE. Therefore, industry methodologies and practices are needed that can promote safe cleaning techniques so that firefighters are not continually exposed to unclean or inadequately cleaned gear. Also, it is important to set cleanliness criteria for the continued use of firefighter protective clothing.

Methods:
This project encompasses an investigation of both chemical and biological contamination removal effectiveness. Because chemical and biological contaminations are fundamentally different, separate research tracks will be conducted to address each area. However, the same general methods will be used for both tracks. The key steps involve: (1) identifying target or surrogate contaminants, (2) devising methodology for simulating field contamination, (3) validating that methodology through field comparisons, (4) applying methods to evaluate cleaning, decontamination, or disinfection/sanitization effectiveness of different processes, and (5) ensuring procedures can be applied in field together with the establishment of acceptance levels for determining decontamination effectiveness and assessments that cleaning methods do

not degrade the performance properties of protective clothing.

Anticipated Outcomes:
A key project deliverable will be a standalone industry Guidance Document on PPE Cleaning and Decontamination. The Guidance Document will be developed to offer maximum utility for firefighters, fire departments, independent service providers, and manufacturers in providing definitive instructions for how to properly clean and decontaminate firefighter protective clothing for structural fire fighting chemical contamination and blood/body fluid/biological contamination. The proposed cleaning verification procedures for demonstrating effective decontamination and ensuring clothing performance is minimally affected by cleaning will be a significant part of this document.

Working with the NFPA Technical Committee responsible for NFPA 1851, findings from this research will be used to substantiate specific recommended changes to the standard that will better define cleaning parameters, provide procedures for the verification that cleaning procedures effectively remove contaminants, and that demonstrate that selected cleaning techniques do not prematurely degrade PPE performance. This approach expands on existing verifications procedures built into NFPA 1851 that involved accredited verification organizations to oversee gear repairs but do not currently address the validation of cleaning effectiveness. The project team will submit and substantiate changes to the standard through public inputs and comments with supporting substantiation provided through the findings from this project.

FY 2014 FP&S R&D Grant Award

Project Title:	Study of the Fire Service Training Environment: Safety, Fidelity, and Exposure
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Stephen Kerber, MS, PE
Grant Number:	EMW-2014-FP-00471
Award Total:	$1,578,948 ($1,500,000 Federal)
Period of Performance:	08/06/2015 - 08/05/2018
Grant Status:	Closed

Abstract

Relevance
The fire service is in the midst of revamping their tactics as they adapt to the changing structural fire environment. These tactical changes require an evaluation of the principles of fire service operations, specifically ventilation and suppression. Traditionally, these tactics are taught with both classroom and hands-on evolutions in fire department training buildings. The modern fire environment responds much differently to ventilation and fire control than once believed. Current firefighter training lacks the visual, hands-on piece that teaches recruits how tactics can affect the fire behavior in a structure. Many fire departments are working to develop modern training scenarios, however they lack the data to bridge the gap between current training facilities and the fire behavior in residential structures that has been identified though research conducted over the last 10 years.

Purpose:
The purpose of this study is to improve fire service knowledge of fire dynamics and the impact of their tactics through a better understanding of how the safety, fidelity and exposure of the training ground relates to the fire ground. This project will expand on previous research studies (EMW-2008-FP-01774 - Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction, EMW-2010-FP-00661 - Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics, EMW-2012-FP-00490 – Effectiveness of Positive Pressure Ventilation and 2012 FDNY, NIST, UL Partnership - Governors Island Experiments) that examined fire dynamics and fire service tactics and improve firefighter hands-on training. This research will assist in the creation of thinking firefighters with a good foundation of fire dynamics from the beginning of their fire service careers that will impact their safety and effectiveness for many years.

Methods:
This study will utilize test methods from small-scale material tests to full- scale residential structure tests. In order to get the best understanding of the material and combustion properties of the training and realistic fuels to be used in this study, small-scale tests will utilize the cone calorimeter, Fourier Transform Infrared (FTIR) spectroscopic techniques, and gas chromatography and mass spectroscopy (GC/MS). These measurements will also be made throughout the study to understand the impact of ventilation and water application on smoke content and resulting exposure to firefighters. The fuel loads used in all of the experiments will be characterized for burning characteristics and heat release rate under a calorimetry hood in

UL's Large Fire Laboratory. Another series of experiments will take place under the calorimetry hood where training and realistic fuel loads will be placed in a fire service training prop with different wall lining materials that are commonly used by the fire service.

Additional experiments will be conducted in a ranch style test fixture that has been used for more than 50 horizontal, vertical, positive pressure and suppression experiments. Experiments in previous studies utilized "real" fuels. This series will utilize different training fuels with the same procedures used in the previous research experiments. This will show the difference between training fuels and "real" fuels providing context for firefighters and fire instructors. The same comparison will be made in a concrete fire training building. The same training fuels and "real" fuels will be used to quantify and qualify the differences in fire dynamics with the different structure and different fuels. Finally a series of experiments will examine different innovative training props and fuel loads that are being used in locations across the country. These props will be characterized and evaluated for safety, fidelity and exposure utilizing the experimental methods and measurements used in all of the previous experiments to make the connections where applicable.

Anticipated Outcomes:
It is anticipated that the data and visuals collected from these experiments will provide firefighters and fire instructors with the material and knowledge needed to bridge the gap between fire dynamics in the training environment and fire dynamics at actual emergencies. This improved context will enhance the limited hands-on training opportunities that firefighters receive. This should lead to better decision making on the fire ground and more effective and efficient firefighting.

FY 2014 FP&S R&D Grant Award

Project Title:	Feeding America's Bravest: Mediterranean Diet-based Interventions to Change Firefighters' Eating Habits and Improve Cardiovascular Risk Profiles
Organization:	President and Fellows of Harvard College
Principle Investigator:	Stefanos Kales, MD, MPH
Grant Number:	EMW-2014-FP-00612
Award Total:	$1,578,936 ($1,500,000 Federal)
Period of Performance:	08/06/2015 - 08/12/2018
Grant Status:	Closed

Abstract

Relevance:
Nutrition and medical experts agree that following a Mediterranean-style diet can improve firefighter health. However, despite the demonstrated benefits there has been very limited effectiveness in changing firefighter eating and other lifestyle behaviors. Adopting the healthy eating principals behind the Mediterranean diet by firefighters and their families would lower firefighters' risk for cardiovascular disease and cancer that are major concerns in the fire service.

Purpose:
The ultimate purpose of the study is to lower firefighters' risks for CVD and cancer by successfully getting more firefighters and their families to adopt and incorporate the healthy eating principles behind the Mediterranean diet.

Methods:
The Mediterranean Diet Nutritional Intervention (MDNI) overall development strategy will be to promote greater understanding, acceptance and adherence to Mediterranean diet principles through multi-pronged MDNIs combining evidence-based behavior change strategies. Strategies have been critically reviewed by the American Heart Association (AHA) for evidence of effectiveness and found to meet the highest standards. Our research indicates that volunteer firefighters take an average of three meals per week with their department (NVFC survey). Additionally, career firefighters usually consume six meals per week at the firehouse, and the nutritional quality of the workplace meals is significantly lower than home meals. Therefore, one target of our MDNIs will be directed at the level of the firehouse. Our preliminary work also indicates that firefighters eat more meals at home than any other location, and that over 80% opine that their spouse's/significant other's opinion/support are important for healthy eating. Therefore, the other major target of our MDNIs will be directed at the level of the family and spouse/significant other.

The MDNIs will also incorporate diet, fitness and lifestyle (sleep, stress, etc) education; individually accessed electronic education platforms and electronic reminders; and group and individual incentives/goals. Importantly, the MDNI's components will be adjusted and fine-tuned via surveys, literature review and national and local firefighter input including labor/management feedback and fire service focus groups in the development stage. The latter point recognizes the unique fire service culture and its traditions around food; and embraces the

principles of community-based participatory research. This means research participants and national fire service organizations will provide valuable collaborative input assisting the investigators to surmount obstacles and barriers to MDNI acceptance in the target groups. In collaboration with the firefighters, we endeavor to create a self-sustaining, positive culture of healthy eating and physical activity. Using firefighters' input, we will combine and others on fire service eating habits to develop strategies targeted at improving specific areas of Mediterranean diet adherence.

Anticipated Outcomes:
Successful Mediterranean diet interventions disseminated and implemented nationally in the fire service will reduce CVD morbidity and mortality; obesity-related costs on injuries, workers compensation and disability; and costs related to other chronic health conditions; as well as decrease cancer risks.

FY 2014 FP&S R&D Grant Award

Project Title:	Development of Real-time Particulate and Toxic-gas Sensors for Firefighter Health and Safety
Organization:	Case Western Reserve University
Principle Investigator:	Fumiaki Takahashi, PhD
Grant Number:	EMW-2014-FP-00688
Award Total:	$1,575,000 ($1,500,000 Federal)
Period of Performance:	08/06/2015- 05/05/2019
Grant Status:	Closed

Abstract

Relevance:
Post-fire (overhaul) phase is the firefighting stage in which fire suppression is complete and firefighters are searching the structure for hidden fire or hot embers. During the overhaul phase of a structure fire, when there is little or no smoke in the environment, firefighters is most likely to remove their respiratory facepiece and work in this environment without respiratory protection. Removal of respiratory protection could expose firefighters and investigators to a variety of toxic gases, vapors, and airborne particulates. Findings from previous AFG funded research performed by Underwriters Laboratories (EMW-2007-FP-02097), indicated that smoke particles collected during overhaul were too small to be visible by naked eye, suggesting that "clean" air was not really that clean.

Through a one-year preliminary study (EMW-2012-FP-01284), we obtained a sufficient amount of evidence to justify implementation of combined particulate and toxic-gas sensors for structural and wildland firefighter health and safety.

Purpose:
Removal of respiratory protection during fire overhaul activities can expose firefighters to unknown toxicants, but current practice relies solely on the CO concentration. Wildland firefighters do not even wear respiratory protection despite low-level but long-term exposure to smoke. Through a preliminary study, we obtained evidence to justify the needs for simultaneous monitoring of particulates (including ultrafines), aldehydes (formaldehyde, acrolein), and hydrocarbons (benzene) as they include carcinogens and frequently exceed recommended exposure limits during fire overhaul and wildland firefighting. The purpose of this project is to develop prototypes of compact, highly sensitive, real-time particulate/gas detection systems capable of alerting firefighters to hazardous conditions to reduce the number of firefighter fatalities and injuries.

Methods:
This study endeavors to develop and test prototype sensing packages by: (1) combining the NASA-developed compact particulate and gas (O2, CO, and hydrocarbons) sensors, (2) micro-fabricating and integrating new sensitive aldehyde sensors, and (3) evaluating prototypes in the laboratories, burn rooms, fire overhaul, and wildland fire environments in cooperation with the fire services.

Anticipated Outcomes:
The performance and accuracy of the prototypes will be demonstrated in the various testing environments. Compact real-time particulate and toxic-gas detectors to be derived from the prototypes maybe commercialized and nationally adopted by fire services eventually through NFPA standards and/or US Forest Service specifications.

FY 2014 FP&S R&D Grant Award

Project Title:	Evaluation of the NFFF's Behavioral Health Stress First Aid Intervention
Organization:	National Development and Research Institutes, Inc.
Principle Investigator:	Sara Jahnke, PhD
Grant Number:	EMW-2014-FP-00945
Award Total:	$1,572,060 ($1,497,200 Federal)
Period of Performance:	08/06/2015-02/05/19
Grant Status:	Closed

Abstract

Relevance:
The NFFF's Consenus Protocol on Firefighter Behavioral Health Stress First Aid Intervention (SFAI) was the result of one of the 16 Firefighter Life Safety Initiatives developed in consultation with the leading fire service organizations in the United States and experts from the traumatic stress research community. Failing to effectively address grief and trauma incidents or symptoms can have devastating effects for firefighters, fire departments, and families. The SFAI was developed to be the national model of trauma intervention to ensure that evidence-based cost-effective care is available to all firefighters.

Purpose:
Behavioral health interventions implemented to mitigate negative outcomes linked to trauma in the fire service have had limited or iatrogenic effects on firefighters. The National Fallen Firefighters Foundation (NFFF) and the national fire service community have invested considerable resources developing a new behavioral health model to address exposure to traumatic events. The proposed randomized controlled trial will be the first to determine the efficacy of the SFAI, as well as evaluating its implementation and acceptability.

Methods:
Using a cluster randomized clinical trial design (CRCT), experienced scientists and fire service personnel will evaluate the implementation, acceptability, and initial efficacy of the SFAI compared with usual care (i.e., delayed intervention) with 10 fire departments (8 Career, 2 Volunteer) located across the country. Study outcomes include measures assessing implementation of SFAI components, acceptability among firefighters and department leadership, changes in knowledge about and self-efficacy for managing trauma, changes in department morale, and individual firefighter behavioral health outcomes such as symptoms of PTSD and personal growth through coping with traumatic events.

Anticipated Outcomes:
Findings will provide the empirical basis for the newly developed SFAI.

FY 2013 Awards

FY 2013 FP&S R&D Grant Award

Project Title:	Risk Management Interventions to Reduce Vehicle-related Incidents and Fatalities
Organization:	Arizona Board of Regents, University of Arizona
Principle Investigator:	Dr. Jeffrey Burgess
Grant Number:	EMW-2013-FP-00351
Award Total:	$1,480,474 ($ 1,406,451 Federal)
Period of Performance:	08/01/2014 - 07/31/2018
Grant Status:	Closed

Abstract

Purpose and Objectives:
Emergency services vehicle crashes (ESVCs) and being struck by vehicles are the second leading cause of U.S. firefighter fatalities, averaging approximately 20 each year. An average of approximately 16,000 firefighter ESVCs and over 1,100 associated injuries are reported annually. We propose to research the effectiveness of proactive risk management-based training, administrative, and technological interventions to improve vehicle operation and reduce ESVCs in career, combination, and predominantly volunteer fire departments through completion of the following aims: 1) Evaluate risks and design and implement interventions to reduce ESVCs; 2) Measure program effectiveness and economic return; and 3) Develop and disseminate model guidance materials for vehicle-related program interventions.

Study Design and Methods:
A proactive risk management framework will be employed to tailor vehicle-related program interventions and test their effectiveness in three fire departments: Chicago (IL), Prince William County (VA) and Stayton (OR). Interventions will incorporate appropriate use of information from fire apparatus vehicle data recorders (VDRs), and additional interventions will be considered, including but not limited to increasing training, revising protocols for emergency and non-emergency response, and increasing supervisor responsibility for ESVCs. The effectiveness of the interventions will be assessed using a combination of VDR risk index data and ESVC frequency, process evaluation measures, and economic return on investment. A Fire Protection Research Foundation advisory board will review the study interventions, assist in evaluation and dissemination of the study results, inform applicable NFPA standards, and guide development of web-based model templates for training, evaluation and vehicle operation-related standard operating procedures (SOPs).

Results (projected):
Based on results reported from past risk management studies and interventions in the fire service and other industries, we anticipate that the implemented interventions will improve vehicle operation as measured by VDR risk index and reduce ESVCs by 35-50% in our partner fire departments.

Conclusions (projected):
Proactive risk management-based interventions will result in improved driving and reduced ESVCs and related firefighter injuries and fatalities.

FY 2013 FP&S R&D Grant Award

Project Title:	Study: Impact of Fire Attack Utilizing Interior and Exterior Streams on Fire
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Stephen Kerber, PE
Grant Number:	EMW-2013-FP-00644
Award Total:	$1,523,875 ($1,447,682 Federal)
Period of Performance:	08/01/2014 - 07/31/2017
Grant Status:	Closed

Abstract

Purpose and Aims:
Provide the fire service with scientific based knowledge on the impact of interior and transitional fire attack tactics on firefighter safety and trapped occupants to improve training and decision making on the fireground. We aim to expand on previous research studies (2008 DHS - Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction, 2010 DHS - Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics and 2012 FDNY, NIST, UL Partnership - Governors Island Experiments) that examined fire dynamics and water application and to examine the fire service questions that have arisen as a result of these studies and anecdotes of fire service experiences. Using common modern home furnishings and building layouts, along with state of the art measurement technology and animal models, we will provide the most comprehensive study of the fire environment to continue to improve fire service scientific evidence on which to base tactical decisions.

Relevance:
This study will build on all of the research conducted to date on fire service ventilation and suppression tactics. It will provide the most comprehensive measures of the effect of firefighting tactics on chemical and thermal exposures for victims trapped within a structure and firefighters advancing toward the fire or operating in other parts of the structure, which may result from interior suppression efforts and compared to tactics such as “transitional attack”. While research at UL and NIST has shown this approach to be a viable option for rapid knockdown of a large volume of fire, there remains some hesitation to adopt the tactic for fear of endangering trapped victims and pushing heat and steam.

Methods:
Using full-scale residential structures in UL’s Large Fire Laboratory, we will test several different fire scenarios using tactics that include interior only and combined interior/exterior fire attack. We will measure gas temperatures, heat flux, flow velocities, differential pressure, gas concentrations, and moisture content throughout the structure. Working in collaboration with the University of Illinois we will also introduce pig carcasses in various rooms and locations to simulate potential human exposure. Based on conditions measured in these experiments the team will work with experts at the University of Illinois to expose rodents in their laboratory to controlled levels of heat and moisture to examine the impact on their respiratory system. Studying blood gas and tissue concentrations in these rodents will provide a most complete and

powerful estimate of exposure to trapped victims currently possible.

Anticipated Outcomes:
We anticipate that the data collected regarding occupant exposure to heat, steam and effluent gasses will provide the most complete scientifically validated means of assessing the impact of firefighting tactics on risks for victims within a burning structure. Firefighters will also be provided knowledge about how flow paths, nozzle pattern selection and nozzle movement impact conditions through the structure they are operating at. This knowledge will allow fire officers to make informed decisions regarding methods to suppress residential structure fires and can significantly influence firefighter standard operating procedures and training.

FY 2013 FP&S R&D Grant Award

Project Title:	Worksite Exercise Interventions for Low Back Injury Prevention in Firefighters
Organization:	University of South Florida
Principle Investigator:	John Mayer, Ph.D
Grant Number:	EMW-2013-FP-00723
Award Total:	$ 1,332,106 ($1,265,501 Federal)
Period of Performance:	08/01/2014 - 04/30/2018
Grant Status:	Closed

Abstract

Purpose and Objectives (with rationale):
Low back injury is one of the most common and disabling disorders in firefighters. Thus, novel interventions are needed to counteract the adverse consequences of this disorder and its impact on firefighter safety. Our long-term objective is to develop and test interventions to reduce the incidence, morbidity, economic, and other adverse consequences of low back injury and illness in firefighters. Our previous studies funded by the FEMA Assistance to Firefighters Grant Program demonstrated that: 1) a relationship exists between poor back muscular endurance and increased prevalence of low back pain in firefighters (phase 1); and 2) a worksite intervention including back and core exercise training is safe and effective in improving back and core muscular endurance in firefighters (phase 2). The purpose of proposed study (phase 3) is to compare the effectiveness of 3 worksite exercise interventions (supervised, web-based, control) to reduce lost work days related to low back injury and illness in firefighters.

Study Design and Methods:
A cluster randomized controlled trial will be conducted in career, full active duty firefighters from 3 fire rescue departments in the Tampa Bay region of Florida. Firefighters (n = 345) will be randomly assigned (by fire station) to 1 of 3 exercise intervention groups - 1) supervised (n = 115), 2) web-based (n = 115), or 3) unsupervised (control, n = 115). All participants will perform back and core exercises previously tested in our recent FEMA-funded grant (EMW-2009-FP-00418), twice per week for 12 months while on duty, in addition to their usual physical fitness routine. The supervised group will perform exercise under direct supervision of certified exercise specialists. The web-based group will utilize a web-based exercise system developed by our group and partners, and the control group will exercise without supervision and without access to the web-based system. Outcome measures that will be used to test the study's hypotheses include low back injury and illness data obtained and cross-checked from various sources, including administrative reports from the fire department and participant self-reported questionnaires, along with validated physical fitness tests.

Results (projected):
We hypothesis that: the supervised exercise intervention will reduce the number of lost work days related to low back injury and illness over the 12-month intervention period by 40% compared with control; the web-based exercise intervention will reduce the number of lost work days related to low back injury and illness over the 12-month intervention period by 20% compared with control; and the supervised exercise intervention will reduce the number of lost

work days related to low back injury and illness over the 12-month intervention period by 20% compared with the web-based intervention.

Conclusions (projected):
The proposed study will provide pivotal evidence for dissemination and implementation throughout the fire service. Assuming positive results, this study will deliver the first evidence-based exercise intervention for low back injury prevention specifically designed for firefighters. If successfully implemented, a low back injury prevention program including this intervention will improve firefighter safety and health in order to enhance resilience and preparedness, so that they can more effectively carry out their duties to protect the community. Further, this low back injury prevention exercise program will help improve off-duty and long-term quality of life for firefighters.

FY 2013 FP&S R&D Grant Award

Project Title:	Understanding and Preventing SCD in the Fire Service
Organization:	Skidmore College
Principle Investigator:	Denise Smith, PhD
Grant Number:	EMW-2013-FP-00749
Award Total:	$1,509,683 ($1,434,199 Federal)
Period of Performance:	08/01/2014 - 04/30/2018
Grant Status:	Closed

Abstract

Purpose and Objectives:
Firefighters suffer the highest occupational cardiovascular disease (CVD) proportionate mortality—45% of on-duty deaths—of any occupational group. However, developing strategies to reduce these tragedies is hampered because the exact pathophysiologic mechanisms of these fatalities are poorly understood. The purpose of the study is to retrospectively analyze the most complete set of medical records, autopsies and descriptions of events ever available to evaluate the pathoanatomic causes of cardiovascular death and the underlying medical conditions of firefighter victims, and to identify the potential triggers for cardiovascular death during firefighting duties.

Study Design and Methods:
We will systematically review records from firefighter fatalities for the past 10 years and retrieve relevant information about cause of death (autopsies), cardiovascular disease risk factors and underlying medical conditions (medical records), and potential triggers related to firefighting duty (narrative accounts). We will use this data to describe the pathoanatomic cause of cardiac deaths and to describe the proximal causes of cardiovascular death and work-related triggers associated with sudden cardiac death (SCD). We will also use a retrospective case-control study design to compare the above cases (SCD victims) with firefighters who died from non-cardiac causes (fatality controls), and to also compare SCD victims to healthy occupationally active, age-matched career firefighters controls. The case-control study designs with statistical adjustments such as matching for age and other covariates, will offer higher epidemiologic rigor and statistical power than previous purely descriptive analyses.

Projected Results:
This study will result in the: a) compilation of a precise description of the proximal causes of cardiovascular death and work-related triggers in firefighting SCD victims; and b) completion of a rigorous evaluation of risk factors associated with on-duty SCD death in firefighters. These results will be published in medical and scientific journals. Projected Conclusion: Based on the findings of this study, we will work with leading experts in occupational medicine, cardiology and the fire service (using our Medical Advisory Panel and a Fire Service Advisory Panel) to develop targeted, evidence-based recommendations for screening, periodic monitoring and treatment modalities to improve firefighter health and decrease cardiovascular fatalities within the Fire Service. These recommendations will be distributed broadly in the Fire Service and to medical professionals who oversee the medical evaluations of firefighters.

FY 2013 FP&S R&D Grant Award

Project Title:	The First Twenty for Volunteer Firefighters
Organization:	The University of Texas Health Science Center at Houston
Principle Investigator:	R. Susie Day, PhD
Grant Number:	EMW-2013-FP-00983
Award Total:	$1,571,944 ($1,493,347 Federal)
Period of Performance:	08/01/2014 - 04/30/2018
Grant Status:	Closed

Abstract

Purpose and Aims:
Assess the efficacy of an internet-based firefighter health and wellness program for volunteer fire departments using a cluster randomized controlled trial (CRCT) in a national sample of volunteer firefighters (VFF).

Relevance:
Research has established a need for health and wellness programs tailored to the unique needs and culture of the volunteer fire service (VFS) as a means of improving readiness, decreasing injury, and preventing line of duty deaths related to cardiovascular disease. While the career fire service has the Wellness Fitness Initiative to guide their wellness efforts, there has been no intervention designed for the culture and needs of the VFS. Once proven successful, the proposed intervention will provide an immediately disseminable, cost effective, wellness intervention valued by VFF.

Methods:
A national sample of volunteer fire departments will be recruited for a 6 month, CRCT with a cross-over treatment design to determine the efficacy of The First Twenty (TF20), a wellness program focused on nutrition and fitness for firefighters. Modifications to the existing TF20 will be made to enhance the health coaching features and include tools for program evaluation. Study outcomes (changes in weight, BMI, body fat percentage, waist circumference, dietary intakes, blood pressure, and fitness activities) will be assessed pre- and post-intervention.

Projected Results & Conclusions:
This will be the first internet-based, occupationally tailored health and wellness program implemented for the VFS. TF20 will be an essential cost effective tool to address the epidemic of unhealthy body composition, nutrition and fitness among firefighters.

FY 2013 FP&S R&D Grant Award

Project Title:	Advanced Fire Blocking Materials for Enhanced Performance in Wildland Fire Shelter
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2013-FP-01070
Award Total:	$1,496,867 ($1,422,024 Federal)
Period of Performance:	08/01/2014 - 01/31/2018
Grant Status:	Closed

Abstract

Purpose & Aims:
This research project will explore performance advantages to be gained by using advanced heat resistant fabric technologies in the construction of wildland fire shelters. Novel materials concepts for shelters that have the potential to significantly improve on existing fabric technology (fiberglass and silica fabrics with aluminized outer surfaces) in fire blocking, weight, durability, and performance will be studied. A priority objective will be to demonstrate high performing heat resistant materials that do not generate toxic gases in the thermal exposures encountered in wildland fire environments.

Relevance:
Recent firefighter deaths in Yarnell Hill, Arizona (2013), exposed significant limitations in the current fire shelter. NFPA 1977 standard on wildland firefighting PPE does not currently have performance requirements or testing protocols for shelters, so this research will provide the technical basis for setting these requirements in the future.

Methods:
Bench-level and large-scale thermal testing will be performed on commercially available and novel material concepts using advanced laboratory testing technologies like NCSU's RadMan™ and PyroMan™ manikins. Prototype shelters will also be tested in controlled forest fire experiments, providing realistic performance data to validate lab scale testing.

Anticipated Outcomes:
This research will contribute to improve wildland firefighter safety by developing high performance fabric systems for fire shelter construction. This outcome will provide fire shelter manufacturers with more advanced materials options and an enhanced technical basis for evaluating shelter materials alternatives. The testing database will contribute to future revisions of NFPA 1977 and provide systems-level testing options to assess future shelter design changes.

FY 2012 Awards

FY 2012 FP&S R&D Grant Award

Project Title:	FIRST Reliability Study
Organization:	Drexel University
Principle Investigator:	Jennifer Taylor, PhD
Grant Number:	EMW-2012-FP-000205
Award Total:	$996,818 ($996,802 Federal)
Period of Performance:	07/11/2013 - 06/11/2017
Grant Status:	Closed

Abstract

Purpose and Objectives:
Firefighters and researchers lack a comprehensive data system documenting injuries and risk factors essential to informing policy and practice. It is not presently possible to systematically and reliably count firefighter injuries even those that result in hospitalization or long-term disability. We propose to test the reliability of findings from our previously awarded FEMA grant, Firefighter Injury Research & Safety Trends (FIRST), to examine if the initial data architecture investigated can be replicated successfully in additional states and fire departments across the United States.

Relevance:
This proposal responds to DHS/FEMA's Research and Development grant seeking proposals that "focus on the design and feasibility of a new database system". Currently, firefighter injury data are gathered by multiple groups, but these data are neither accurate, nor integrated, nor sufficiently accessible for tracking purposes. This proposal contributes to the following Firefighter Life Safety Summit Initiatives:

#7 - Create a national research agenda and data collection system that relates to the initiatives.
#9 - Thoroughly investigate all firefighter fatalities, injuries, and near misses.

Methods:
Test the reliability of data linkage methods and resulting data architecture from the FIRST project by (1) replicating FIRST with new state and fire department partners, (2) comparing firefighter injury data from all pilot sites, (3) petitioning organizations responsible for national data collection standards to add new variables in healthcare claims data that would benefit firefighters; and (4) disseminating recommendations for implementation of a national coordinated data system.

Results (projected):
This study will provide proof of concept that the FIRST findings can be successfully replicated, confirming the components needed to establish a realistic national data system.

FY 2012 FP&S R&D Grant Award

Project Title:	Quantification of Green Building Features on Firefighter Safety
Organization:	Worcester Polytechnic University
Principle Investigator:	Brian Meacham, PhD
Grant Number:	EMW-2012-FP-01336
Award Total:	$998,466
Period of Performance:	07/11/2013 - 07/10/2017
Grant Status:	Closed

Abstract

Purpose and Objectives (with rationale):
This effort will address needs identified by the National Association of State Fire Marshals, the Fire Protection Research Foundation and the National Fire Service Research Agenda to understand, quantify and address fire performance challenges of green or sustainable buildings and building elements as they impact firefighter safety. Objectives include quantifying fire impacts of green building features on firefighter safety, developing a screening tool to aid in identifying risk-significant green building features and mitigation options and better preparing the fire service for fires in green buildings.

Study Design and Methods:
In achieving these objectives we aim to: (a) Develop and test means by which to collect fire incident data specific to domestic fires involving green building features, particularly those resulting in firefighter injury or fatality. This will be achieved by review of MFIRS, NFIRS and NIOSH data and reports, identify gaps, recommend additional data needed, and testing collection of additional data in conjunction with fire service partners and NFPA. (b) Quantify increased fire hazards or risks, or decreased fire performance, associated with green building features in residential and commercial buildings by reviewing existing fire test data and by conducting fire performance tests on selected green building elements, including structural building envelop systems and naturally versus mechanically ventilated atria. This will be accomplished by reviewing existing reports on fire performance of green building elements, obtaining new data on the fire performance of exterior wall systems (SIPS, EFIS, insulated vinyl siding, high-performance glazing, double-skinned façade) and naturally ventilated atria, developing hazard/risk indicators, and quantifying the hazard/risk. (c) Develop a screening tool to aid fire risk and hazard assessment of green buildings and features for new and existing construction. This will make use of the hazard/risk indicators and development of a hazard/risk assessment and ranking tool. (d) Investigate modifications to firefighting tactics as appropriate to green building technologies. This will be undertaken in conjunction with fire service partners. (e) Develop fire service education and training materials on safety hazards and tactics for green buildings. This will be done in conjunction with fire service partners.

Results (projected):
Outcomes will include: (a) A more complete understanding of the fire hazards and risks to firefighters from fires involving green building elements. (b) A more complete understanding of existing data to support fire hazard and risk assessment associated with green building elements. (c) Recommended changes to data collection on fire incidents involving green building elements.

(d) New data on fire performance and associated hazards/risks of green façade systems, including SIPs, EFIS, insulated vinyl siding systems, high-performance glazing and double-skinned façades. (e) New data on fire performance and associated hazards/risks of naturally ventilated atria spaces. (f) A fire hazard/risk ranking tool for green building elements, with a focus on firefighter safety. (g) Potential changes to firefighting tactics in buildings with green building elements. (h) Fire service education and training materials for hazard, risks and responses in buildings with green building elements. (i) Potential changes to building codes, test standards and fire incident data collection and reporting.

Conclusions (projected):
Outcomes from this effort will contribute directly to reducing the potential for fire ground injuries and fatalities by facilitating recognition of green building related hazards, mitigating the hazards and risks where possible, and adopting tactical responses appropriate to expected fire environments and structural performance given green building elements and contemporary fire loads.

FY 2012 FP&S R&D Grant Award

Project Title:	Effectiveness of Positive Pressure Ventilation in Modern Homes
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Stephen Kerber
Grant Number:	EMW-2012-FP-00490
Award Total:	$ 1,000,000
Period of Performance:	07/26/2013 - 07/25/2016
Grant Status:	Closed

Abstract

Purpose and Objectives:
To increase firefighter safety by providing the fire service with credible scientific information developed from full-scale fire testing in representative modern single family homes, on the usage of positive pressure ventilation fans during fire attack. Improve firefighter safety by increasing knowledge of fire behavior. Develop knowledge of positive pressure ventilation tactics. Identify and disseminate standard best practices for use of positive pressure ventilation during fire attack based on science. Provide the knowledge to better understand fire dynamics and building response factors may mitigate fireground injuries and death through use of positive pressure ventilation fans. Generate understanding of modern construction practices such as open floor plans on positive pressure ventilation tactics. Bring the ‘Science to the Streets', transferring science based tactical considerations founded on experimental results that can be incorporated into firefighting standard operating guidelines.

Study Design and Methods:
Task 1 Formation of a Project Advisory Panel
Task 2 Incident Review
Task 3 Acquire Test supplies, Instrumentation and Contractor
Task 4 Test Fixture Design
Task 5 Design of Experiments
Task 6 Conduct Experiments

Task 6A: Heat Release Rate Fuel Load Characterization. Methodology (M): Conduct five heat release rate (HRR) experiments under the 10MW calorimeter in UL’s Large Fire Facility to characterize modern furnishings and to understand the heat release of today’s fire environment. This quantifies the fuel load used for the remainder of the experiments which will be designed for similar HRR curve and total heat released as two previous ventilation studies.

Task 6B: Air Flow and Pressure Experiments. M: Conduct air flow and pressure experiments prior to the introduction of fire. Variables characterized during this series of experiments will be fan technology (shrouded, jet, turbo), fan placement (setback from the doorway and angle), impact of inlet and outlet sizes and ratios, impact of furniture placement, and impact of volume between the houses.

Task 6C: Full-Scale PPV House Fire Experiments. M: Two full scale test props will be fabricated in UL's large fire facility; the structures will use the same floor plan design as used in previous research on fire service horizontal ventilation tactics (EMW2008FP01774) and vertical ventilation tactics (EMW2010FP00661). These experiments will provide the scientific basis necessary to fill knowledge gaps that exist regarding the proper usage and limitations of this tool and tactic.

Task 6D: Void Space and Eave Experiments. M: A section of wall on an outer wall of the test prop will be fixed to represent normal wall construction including outlets, HVAC registers, insulation and fire blocking per the International Residential Building Code. Fire extension into the eaves: a section of roof outside the windows to be used for exhaust during the PPV fire experiments.

Task 6E: Fire Suppression Experiments. M: All fire attacks require coordination of ventilation and suppression to be successful. Monitor nozzles will be placed inside the props and fire hardened to simulate interior fire attack and water will be flowed from the outside of the props to support recent research done to examine the inability to push fire.

Task 7 Data Compilation & Analysis
Task 8 Design & Develop Outreach
Task 9 Develop Final Project Report
Task 10 Disseminate Project Results.

Projected Results and Conclusions:
This project will address the concerns the firefighter community has expressed and provide a baseline for choosing the most appropriate type or types of ventilation on the fire ground. The results and conclusions of this project will be used to improve firefighting tactics, fireground safety and fire dynamics knowledge. A comprehensive fire service outreach program will make sure that this science meets the street.

FY 2012 FP&S R&D Grant Award

Project Title:	Particulate and Toxic-Gas Sensors for Firefighter Health and Safety: A Preliminary Study
Organization:	Case Western Reserve
Principle Investigator:	Fumiaki Takahashi
Grant Number:	EMW-2012-FP-01284
Award Total:	$ 70,000
Period of Performance:	07/12/2013 – 09/11/2014
Grant Status:	Closed

Abstract

Purpose and Objectives:
Case Western Reserve University, in close collaboration with NASA, will conduct a one-year, preliminary study in partnership with the Cleveland Division of Fire, Cleveland Airport System Aircraft Rescue and Firefighting Department, and the Fire Protection Research Foundation. The purpose of this project is to obtain a sufficient amount of evidence to justify implementation of combined NASA-developed miniaturized sensor technologies (multi-parameter aerosol scattering sensor [MPASS] and micro-fabricated gas sensors) into portable, hand-held, and/or wearable equipment to be used in firefighting environments.

Study Design and Methods:
The compact MPASS (volume: <100 cm3, weight: <100 g) can inherently recognize the specific properties of an unknown aerosol (smoke) and measure the real-time total mass and surface area of a given aerosol cloud, thereby eliminating need for standard dust calibration. The micro-fabricated gas sensors detect various species (CO, CO2, O2, H2, hydrocarbons—currently available; HCN/HCl—under development). Selected sensors will undergo field fire testing at firefighter training. A literature search for measured data will identify chemical species particularly harmful (exceeding NIOSH and OSHA defined toxicant levels) to firefighters in different types of fires (structure, aircraft, and wildland) and stages (attack, knockdown, and overhaul) and a need to develop new sensors for specific species.

Results (projected):
The performance of candidate miniature sensors is demonstrated for use in firefighting environments, and additional species needed to be monitored in various types of fire grounds to protect firefighters are identified.

Conclusions (projected):
NASA-developed miniaturized particulate and toxic-gas sensors can be combined to build portable, hand-held, and/or wearable equipment for real-time environmental monitoring to protect firefighter health and life safety.

FY 2012 FP&S R&D Grant Award

Project Title:	Revolutionizing the Modern Turnout Suit
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2012-FP-01185
Award Total:	$ 999,988
Period of Performance:	07/11/2013 - 07/10/2016
Grant Status:	Closed

Abstract

Purpose:
This research will develop and test new structural firefighter turnout suit constructions having a combined thermal comfort and protective performance that exceeds anything currently available for structural firefighters. These prototype turnouts will incorporate advanced materials and design innovations that "push the envelope" to achieve major advances in lightweight turnout wear comfort.

Methods:
A trio of advanced instrumented manikin test systems, including PyroMan™, RadMan™, and SweatMan™ will provide ensemble level performance assessments that are more accurate than what is obtained using the fabric level tests that have heretofore guided turnout suit designs and criteria in the NFPA 1971 Standard. Used with improved instrumented test of ensemble water penetration integrity, they will facilitate significant improvements in turnout comfort with protection. Advances in systems level heat stress reduction will be confirmed and documented using human subject physiological wear trials.

Results:
This project will produce concept turnout suit prototypes that reflect a systems level understanding on optimum balance between TPP and THL requirements for structural firefighter turnout suits.

Conclusions:
This research will redefine the comfort/protection model of the turnout suit, the most basic of structural firefighter PPE. It will provide technical basis for considering long overdue changes in NFPA 1971 performance requirements for turnout TPP and THL performance, enabling revolutionary turnout designs and materials to be offered by manufacturers. The resulting changes will significantly reduce injuries related to heat stress and exertion in structural firefighting operations. Mechanisms are incorporated that will ensure widespread input and dissemination throughout the structural firefighting community.

FY 2011 Awards

FY 2011 FP&S R&D Grant Award

Project Title:	Understanding Culture: Assessing Firefighter Safety Climate
Organization:	Drexel University
Principle Investigator:	Jennifer A. Taylor, PhD, MPH
Grant Number:	EMW-2011-FP-00069
Award Total:	$ 999,978
Period of Performance:	09/12/2012 - 06/11/2016
Grant Status:	Closed

Abstract

Purpose and Aims:
The fire service is aware of the need to address aspects of its culture that will help reduce firefighter fatalities and injuries. Research has repeatedly indicated that factors related to safety culture are causal factors underlying safety outcomes. Safety climate constitutes the measurable aspect of culture and offers the potential for quantifying and comparing climate across firefighting units. Once a baseline climate is established, an appropriate intervention can be implemented and the anticipated effect on climate re-measured. Industries including health care, construction, manufacturing, and transportation have utilized safety climate findings to improve their safety performance and reduce adverse outcomes, but the fire service currently lacks an industry-specific tool to measure safety climate. The purpose of this proposal is to develop a firefighter safety climate survey and test its association with injuries.

Relevance:
This proposal responds to the Fire Fighter Life Safety Summit initiative; “define and advocate the need for a cultural change within the fire service relating to safety; incorporating leadership, management, supervision, accountability and personal responsibility.”

Methods:
This mixed-method study introduces rigorous qualitative methods to the science of safety climate survey development by conducting interviews and focus groups with firefighters as a basis for generating culturally-relevant survey items. The resulting survey will be psychometrically validated through structural equation modeling and factor analysis, and examined for its predictive validity against firefighter injuries.

Projected Results and Conclusions:
This study will produce a validated safety climate survey that will be freely available to fire departments and researchers nationwide for baseline and evaluative examination of interventions addressing firefighter culture.

FY 2011 FP&S R&D Grant Award

Project Title:	Safety Climate and Firefighter Injury
Organization:	University of Georgia Research Foundation, Inc.
Principle Investigator:	David M. DeJoy
Grant Number:	EMW-2011-FP-00582
Award Total:	$ 580,619
Period of Performance:	09/19/2012 - 09/18/2016
Grant Status:	Closed

Abstract

Over the past 25 years approximately 100 firefighters died and more than 80,000 were injured in the line-of-duty in the U.S each year. Although slight reductions in firefighter fatalities were noticed in 2010 and 2011, there have been 32 firefighter fatalities in 2012(through mid-April), indicating a monthly rate similar to past trends and greater than 2010 and 2011. Both the firefighting and scientific communities have recognized the need to change the safety climate-culture of firefighting, but there has been little systematic empirical research on this topic.

The proposed research builds upon a partnership involving the University of Georgia, Embry Riddle Aeronautical University, and the Atlanta (GA) Fire and Rescue Department (AFRD). The research outlined in this proposal is structured around three aims:
(1) finalize a multi-level model of safety climate-culture in firefighting;
(2) field test this model among active firefighters and assess the relationship of safety climate-culture factors to line-of-duty injury and illness using both cross-sectional and lagged outcomes; and
(3) disseminate the results and other products from this research to the national firefighter community.

The proposed conceptual model merges firefighter safety and health research with the growing body of general industry research on safety climate-culture. Structural equation modeling and multi-level analysis techniques will be employed in model testing, including the assessment of lagged effects. Expert and firefighter input will be sought throughout the project and study results will be disseminated using a multi-pronged strategy.

FY 2011 FP&S R&D Grant Award

Project Title:	Study of the Residential Attic Fire Mitigation Tactics and Exterior Fire Spread Hazards on Fire Fighter Safety
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	J. Thomas Chapin
Grant Number:	EMW-2011-FP-00611
Award Total:	$ 1,000,000
Period of Performance:	09/07/2012 - 09/06/2014
Grant Status:	Closed

Abstract

Underwriters Laboratories will lead a 2-year study to examine fire service attic fire mitigation tactics and the hazards posed to firefighter safety by the changing modern residential fire environment and construction practices. The US Fire Administration estimates 10,000 residential building attic fires are reported to U.S. fire departments each year and cause an estimated 30 civilian deaths, 125 civilian injuries and $477 million in property loss. These attic fires are a very challenging for the fire service to mitigate and have led to numerous line of duty deaths and injuries. Further complicating attic fires, current building practices include new products to achieve better energy performance to meet newer code requirements with little understanding of fire performance or the impact on firefighter safety. This study will provide the fire service with the science necessary to improve their standard operating procedures utilized during fires that start of the outside of the structure and during attic fires.

Purpose:
The purpose of this study is to increase firefighter safety by providing the fire service with scientific knowledge on the dynamics of attic and exterior fires and the influence of coordinated fire mitigation tactics from full-scale fire testing in realistic residential structures.

Goals and Objectives:
- Improve firefighter safety by increasing knowledge of fire behavior.
- Develop an understanding of the impact of new construction materials and techniques and 'green' building technologies on fire spread spreading along the building envelope and propagation into and growth within the attic.
- Identify and disseminate standard best practices for mitigating attic fires based on science.
- Provide the knowledge to better understand the fire dynamics and building response factors that cause and contribute to fireground injuries and fatalities during attic fire incidents.
- Disseminate knowledge gained pertaining to the built environment to stakeholders that are able to impact the code process to improve the safety of the public and the fire service.
- Bring the 'Science to the Streets' by transferring science based tactical considerations founded on experimental results that can be incorporated into firefighting standard operating guidelines. Research findings will be communicated to the fire service

community through an eLearning training course and class room presentations at major fire department conferences.

All five of the Technology & Fire Service Science issues facing the fire service determined during the 2nd National Fire Service Research Symposium are incorporated into the goals and objectives of this study.

FY 2011 FP&S R&D Grant Award

Project Title:	Impact of work: Rest + Fitness on performance and CV Recovery
Organization:	The Research Foundation at SUNY on behalf of the University at Buffalo *Transferred from University of Pittsburgh
Principle Investigator:	Dave Hostler
Grant Number:	EMW-2011-FP-01475
Award Total:	$ 997,133
Period of Performance:	08/22/2012 – 11/13/2015
Grant Status:	Closed

Abstract

Fireground rehab has been extensively studied. However, firefighter physiology beyond the incident (e.g. the next 24 hours) is largely unknown even though many line-of-duty heart attacks occur during this period. The cause of these post fire deaths may be related both to firefighter fitness and the ratio of work performed to rehab time. The work: rest ratio (W:R) specified in NFPA 1584 (commonly referred to as the "2-cylinder rule") is consensus derived and not supported by research data. We have shown that aggressive rehabilitation following 40 minutes of work in thermal protective clothing is not sufficient to allow most firefighters to complete a second bout of work. In spite of this, longer W:R ratios are still prevalent in the fire service.

Using lab and field studies, we will examine the interaction of W:R and fitness on 1) subsequent physical and mental performance, 2) functional hemostasis (e.g. clotting and clot resolution) measured by thromboelastography, and 3) overnight changes in ECG (e.g. heart rate. QT variability, episodes of non-sustained VT) and overnight blood pressure patterns. We hypothesize that increasing W:R and decreasing fitness impairs subsequent performance and results in persistent physiologic derangements that may alter physiology for up to 24-hours. Furthermore, these changes may be related to line-of-duty heart attacks occurring after fire suppression. This study benefits the fire service by 1) understanding the ramifications of longer W:R ratios, 2) appreciating the potential alterations in cardiovascular recovery, and 3) the role of fitness on short- and long-term performance/recovery.

FY 2011 FP&S R&D Grant Award

Project Title:	Non-Invasive ID of LVH/Cariomiology in Firefighters
Organization:	The President and Fellows of Harvard College
Principle Investigator:	Stefanos Kales
Grant Number:	EMW-2011-FP-00663
Award Total:	$ 998,567
Period of Performance:	08/31/2012 – 08/30/2016
Grant Status:	Closed

Abstract

Objectives:
1) Determine the prevalence of left ventricular hypertrophy (LVH) and cardiomegaly among firefighters; 2) quantify major risk factors for LVH/cardiomegaly; 3) develop prediction models/screening algorithms; 4) validate the models/screening algorithms.

Rationale:
Cardiovascular disease (CVD) causes 45% of firefighters' on-duty deaths. LVH/cardiomegaly increase arrhythmia, myocardial infarction, stroke and death risks. Autopsies demonstrate LVH/cardiomegaly in most firefighter CVD fatalities. If recognized beforehand, however, effective treatments are available.

Methods:
Phase I- using a population of municipal firefighters medically characterized with annual exams, randomly select 400 participants: 100 from the entire population; 75 low-risk participants (age <40, non-obese, free of hypertension (HTN) and cardiorespiratory fitness (CRF) (>/= 12 METS); and 225 high risk participants (at least 2 risk factors (age, obesity, HTN, low CRF)). All participants will receive a screening echocardiogram (Echo), followed by cardiac MRI (CMR), the gold standard for determining cardiac dimensions and mass. Prediction models/screening algorithms will be developed using imaging along with questionnaire and annual medical data. Phase II- parallel random participant selection of 200 additional firefighters from a second medically characterized municipal cohort to validate echo screening algorithms for LVH/cardiomegaly developed in Phase I using CMR as the reference standard.

Projected Results:
Age >/=40, BMI >/=30, HTN, low CRF and sleep apnea will be significant predictors of LVH/cardiomegaly. Echo will usually be sufficient for screening; but some obese firefighters may need CMR to identify LVH/cardiomegaly.

Projected Conclusion:
Cost effective methods for identifying LVH/cardiomegaly will be developed and validated; enabling clinical interventions to decrease firefighters' morbidity and mortality.

FY 2011 FP&S R&D Grant Award

Project Title:	Improving Firefighter Health and Safety with Real Time Personal IDLH Sensors
Organization:	Worcester Polytechnic Institute
Principle Investigator:	David Cyganski
Grant Number:	EMW-2011-FP-00991
Award Total:	$ 1,000,000
Period of Performance:	08/31/2012 – 04/10/2015
Grant Status:	Closed

Abstract

The project goal is to develop a sensor which if adopted would significantly reduce and potentially eliminate line of duty injuries and deaths of firefighters caused by the inadvertent inhalation of toxic gases during firefighting and overhaul. It aims to reduce deaths, injury, and the progressive disease processes that lead to cardiac and other long term health problems for fire fighters. It is motivated by findings of recent studies that connect both line of duty deaths and progressive disease processes with exposure to toxic combustion products and studies that implicate insufficient data about conditions and insufficient adherence to SCBA best-practices with exposure to Immediately Dangerous to Life or Health (IDLH) and to lower level, but dangerous, Chronic Exposure Danger (CED) conditions.

The new toxic gas sensor would provide each firefighter with real-time information about IDLH/CED conditions. Existing, commercial monitors are not suitable as high toxin levels, heat and humidity cause failures, prolonged service outage and constant alarm signals that prompt users to turn them off. Proposed tasks include development and testing of a robust portable CO/HCN sensor that operates without interruption throughout and after knockdown with alarm capability providing immediate feedback. The proposed design is based on work we have carried out over the last year. The Massachusetts Firefighting Academy and Worcester Fire Department will be engaged to verify usability of the device and to study the influence of improved situational awareness about asphyxiants on firefighter decisions. If successful, decisions about SCBA use would be enhanced and ultimately lives saved.

FY 2011 FP&S R&D Grant Award

Project Title:	Disseminating New Scientific Understanding of Wildland Fire Phenomena
Organization:	University Corporation for Atmospheric Research
Principle Investigator:	Janice Coen, PhD
Grant Number:	EMW-2011-FP-01124
Award Total:	$ 119,596
Period of Performance:	08/22/2012 - 06/21/2015
Grant Status:	Closed

Abstract

Large wildland fires are dynamic phenomena that may encounter a wide range of fuels, terrain, and environments often during one event and produce extreme phenomena not observable in laboratory or prescribed fires such as fire whirls, blow-ups, 100-m long bursts of flame shooting ahead of the fireline, fire winds 10 times stronger than ambient wind speeds, deep pyrocumulus, and firestorms in which the fire-generated winds overwhelm ambient winds – all resulting from the interactions between a fire and its atmospheric environment, notably the production of fire winds.

This work will distill research aimed at understanding wildfire phenomena and wildfire events and bring it to the firefighter community to improve firefighter safety and prevent burnover accidents. Both observational and modeling research have unearthed dynamic fire phenomena and confluences of atmospheric, fuel, and topographic conditions that have likely contributed to numerous firefighter fatality incidents but which are not yet part of training curricula. Here, we will use previous observational studies as well as past and ongoing simulations to understand past wildfire events and distill knowledge for dissemination with the wildland firefighting and scientific community through publications in a wildland firefighter practitioner journal, wildland fire professional society publications, a project webpage, wildland fire management university classes, and a wildland fire safety conference.

In addition to improving safety, ancillary benefits to the wildland fire community will be further development of freely available community models such as the fire behavior physics package WRF-Fire in the Weather Research and Forecasting (WRF) model and the Coupled Atmosphere - Wildland Fire Environment (CAWFE) model.

FY 2010 Awards

FY 2010 FP&S R&D Grant Award

Project Title:	Clinical Trial of an Intervention to Reduce Fatigue and Improve Safety and Health in Firefighters
Organization:	The Brigham & Women's Hospital, Inc.
Principle Investigator:	Charles A. Czeisler, Ph.D, MD
Grant Number:	EMW-2010-FP-00521
Award Total:	$ 1,000,000
Period of Performance:	07/01/2011 – 12/31/2014
Grant Status:	Closed

Abstract

Purposes and Aims:
We propose to conduct a station-level, randomized clinical trial of policies designed to maximize sleep opportunities during current 24-hour shifts to improve alertness, performance, health and safety in firefighters.

Relevance:
Firefighters work some of the most challenging schedules known under highly stressful and demanding conditions. The need to work frequent extended shifts leads to acute and chronic sleep deficiency as well as disruption of circadian rhythms. Firefighters on-call overnight are also particularly susceptible to sleep inertia, the neurocognitive impairment experienced immediately upon waking. In addition, it is likely that a significant proportion of firefighters suffer from undiagnosed sleep disorders, which further impair sleep and exacerbate fatigue. The proposed fatigue countermeasure aims to increase sleep opportunities, and thereby improve firefighter safety and health.

Methods:
We propose to conduct a randomized clinical trial, providing the most rigorous evaluation possible in an operational setting. Half the fire stations in a department will be randomly assigned to complete the intervention, termed Operation Fight Fatigue, in the first year of the study. The other half of the fire stations will complete the intervention in the second year. In this way, all firefighters will have the chance to benefit.

(Projected) Results:
We expect the fatigue countermeasure intervention to improve the alertness, performance, health and safety of firefighters.

Conclusion:
We propose to evaluate a cost-effective intervention to improve the safety and health of firefighters in departments throughout the United States.

FY 2010 FP&S R&D Grant Award

Project Title:	Motivational Intervention to Maximize Peer Behavioral Health Awareness and Skill
Organization:	The Texas A&M University System (TAMUS) Health Science Center Research Foundation
Principle Investigator:	Suzie Bird Gulliver, PhD
Grant Number:	EMW-2010-FP-00597
Award Total:	$ 996,505.00
Period of Performance:	07/09/2011-07/08/2013
Grant Status:	Closed

Abstract

Purpose & Objectives:
Firefighters are more than twice as likely to develop behavioral health problems as the general public, but they often do not seek out the treatment they need. This underutilization of behavioral health services compromises the safety and well-being of affected firefighters and their co-workers. The purpose of the proposed research is to evaluate an adaptation of Motivational Interviewing among firefighters. Adapted Motivational Interviewing Training (AMIT) represents an ideal, cost-effective intervention because firefighters can be trained to use AMIT to encourage fellow firefighters to seek out appropriate treatment when needed.

Study Design and Methods:
Participants will include career and volunteer firefighters who report an interest in learning behavioral health intervention skills. Participants will be randomly assigned to a peer- and counselor-led AMIT condition, a computer-based AMIT condition, or a computer-based behavioral health awareness control condition. Measures assessing AMIT skills, frequency of interventions and behavioral health knowledge will be administered before and after the trainings and at 3- and 6-month follow-ups.

Projected Results:
We expect firefighters in the peer and counselor-led AMIT condition to exhibit greater gains in AMIT skills, to be more confident in their ability to intervene, and to report a higher frequency of interventions at 3- and 6-months relative to firefighters in the computer-based AMIT and behavioral health awareness conditions.

Projected Conclusions:
We expect the proposed research to: (1) Demonstrate that AMIT is a viable intervention for firefighters; and (2) Demonstrate that peer and counselor-led AMIT is most the efficacious training format for firefighters.

FY 2010 FP&S R&D Grant Award

Project Title:	Investigating the Impact of Cognitive Training for Firefighters with Tinnitus
Organization:	Washington University
Principle Investigator:	Jay F. Piccirillo, MD
Grant Number:	EMW-2010-FP-00601
Award Total:	$ 999,988
Period of Performance:	07/13/2011 – 05/31/2014
Grant Status:	Closed

Abstract

Purpose and Aims:
Tinnitus is an auditory sensation without acoustic stimulus and it is estimated to affect more than 1 million firefighters. *Brain Fitness Program* (*BFP*) is a software program proven to improve cognitive function by engaging the brain's neuroplasticity. *BFP* is novel, non-invasive, and inexpensive.

Specific Aims:
1. To evaluate *BFP* on the perception of tinnitus,
2. To evaluate the effect of *BFP* on the attention, cognition, and memory deficits experienced by firefighters with bothersome tinnitus
3. Use a validated task-based functional MRI paradigm to explore the dorsal frontoparietal, ventral temporoparietal, and frontal cognitive control cortical attention networks and assess the impact of the *BFP* on these networks.

Relevance:
Bothersome tinnitus is associated with deficits in attention, memory, anxiety, depression, and sleep disturbances all of which interfere with firefighter readiness and performance. Neural rehabilitation programs, like *BFP,* may mend the cognitive impairments associated with tinnitus and should be assessed as a cost-effective treatment for firefighters with tinnitus.

Methods:
RCT of *BFP* in 40 firefighters with bothersome tinnitus. In addition, a previously developed task-based functional MRI paradigm will be used to study brain activity in regions associated with voluntary, involuntary, and executive control of attention.

Projected Results:
BFP found to improve cognition and blunt the percept of tinnitus through alterations in key cortical attention networks.

Conclusions:
Tinnitus is more than head noise – it hijacks cognitive function and can impact on firefighter readiness. Computer-based programs may be a simple, non-invasive, cost-effective neural rehabilitation program for firefighters with tinnitus.

FY 2010 FP&S R&D Grant Award

Project Title:	Study of the Effectiveness of Fire Service Vertical Ventilation and Suppression
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Tom Fabian, PhD
Grant Number:	EMW-2010-FP-00661
Award Total:	$ 999,998.00
Period of Performance:	06/12/2011-06/11/2013
Grant Status:	Closed

Abstract

Purpose:
The purpose of this study is to increase firefighter safety by providing the fire service with credible scientific information that is developed from full-scale fire testing in realistic single family homes.
There is a continued tragic loss of firefighters' and civilian lives, as shown by fire statistics. One significant contributing factor is the lack of understanding of fire behavior in residential structures resulting from the use of ventilation as a firefighter practice on the fire ground. The changing dynamics of residential fires as a result of the changes in home construction materials, contents, size and geometry over the past 30 years compounds our lack of understanding of the effects of ventilation on fire behavior. If used properly, ventilation improves visibility and reduces the chance of flashover or back draft. If a fire is not properly ventilated, it could build up enough unburned smoke to create a back draft or smoke explosion, or enough heat to create flashover, greatly reducing firefighter safety.
This fire research project will develop empirical data from full-scale house fire experiments to examine vertical ventilation, suppression techniques and the resulting fire behavior. The experimental results will be used to develop tactical considerations outlining firefighting ventilation and suppression practices that will reduce firefighter death and injury. This fire research project will further work from previously DHS AFG sponsored research (EMW-2008-FP-01774) which studied the impact of horizontal ventilation through doors and windows. Additionally, this fire research project will further utilize the experimental houses to address questions of smoke alarm response associated with different smoke alarm technologies and alarm location to support fire department smoke alarm distribution programs including those sponsored by DHS Fire Prevention and Safety Grant program.

Goals and Objectives:
- Improve firefighter safety by increasing knowledge of fire behavior.
- Develop knowledge of vertical ventilation tactics.
- Generate understanding of modern construction practices such as open floor plans and emerging attic construction design on fire growth.
- Address concerns about smoke alarm technologies and placement to support fire department smoke alarm distribution programs.
- Develop tactical considerations based on the experimental results that can be incorporated into firefighting standard operating guidelines.

FY 2010 FP&S R&D Grant Award

Project Title:	Battery-Free Flashover Alarm for Firefighters
Organization:	Center for Firefighter Safety Research & Development, University of Maryland
Principle Investigator:	Marino diMarzo, Ph.D
Grant Number:	EMW-2010-FP-00851
Award Total:	$ 581,769
Period of Performance:	07/09/2011 – 05/08/2014
Grant Status:	Closed

Abstract

Relevance:
Flashover contributes significantly to firefighter fatalities and injuries. It is very difficult for firefighters to recognize impending flashover in structures especially when visibility is poor and they are engaged in other life saving or suppression activities.

Purpose:
The primary purpose of this research effort is to develop a passive helmet-mounted flashover alarm that audibly alerts firefighters to conditions of impending flashover. This alarm will not involve any electronics. The alarm will provide adequate warning of flashover conditions for firefighters to evacuate hazardous areas in structures.

Methods:
The proposed alarm device will be a thermo-acoustic flashover detector that emits a loud tone when flashover approaches. It will be powered by radiant heat from the fire and will involve no electronics or batteries. A porous disk inside a pipe will induce acoustic waves in an air column when a sufficient thermal gradient in a room indicating a flashover potential is present. The system will be developed in the laboratory, and will be tested with radiant panels and small-scale fires. Full-scale tests will then be performed in training facilities to optimize the system design.

Projected Results and Conclusions:
Working with an industrial partner, the flashover warning device will be integrated into a firefighter helmet. In that way every firefighter will be provided with an individual warning device that will sense the local conditions in the area of that firefighter. This passive device will provide an audible warning of potential flashover conditions to the firefighter during all fire fighting conditions.

FY 2010 FP&S R&D Grant Award

Project Title:	Evaluation and Enhancement of PASS Effectiveness
Organization:	Fire Protection Research Foundation
Principle Investigator:	Casey C. Grant, P.E.
Grant Number:	EMW-2010-FP-00885
Award Total:	$ 834,388
Period of Performance:	07/13/2011 – 12/31/2014
Grant Status:	Closed

Abstract

Relevance:
When firefighters are overcome by the heat or smoke from a fire and become disoriented or trapped in a structure, it is crucial that there is a reliable means to alert other fire ground personnel to their need for assistance. Personal Alert Safety System (PASS) devices are designed to alert aid using audible signal technology. Normal operation is for the PASS devices to activate a 95-decibel multiple-frequency alarm signal if a firefighter does not move during a specific and pre-set time period. Foremost, among the concerns about PASS devices is that nationally recognized standards currently allow a range of performance for the PASS alarm signal, and this has resulted in multiple different PASS alarm signals being used in the fire service.

Purpose:
This project seeks to establish a scientific basis for a single optimized PASS alarm signal for use throughout the U.S fire service, and additionally addresses possible technological enhancements such as receiver enhancements that would allow the device to be addressable using non-audible frequencies.

Methods:
This project is comprised of five major research components: characterize the noise environment of the fire ground during fire fighting operations, characterize alarm signals from currently used PASS alarms, development and validate a sound transmission model that can be used to analyze the audibility of PASS alarms under fire ground background noise environments, evaluate firefighter response to existing and proposed PASS alarm sounds, and investigate of technological enhancements to PASS alarms that would prove additional means to locate firefighters.

Projected Results and Conclusions:
The anticipated results of this project directly support fire fighter safety by providing science-based guidance to PASS device manufacturers, firefighters, researchers, and standards developing organizations for the optimization of PASS alarm sounds, recommending readily implemented alternate technological enhancements to PASS devices that would facilitate locating firefighters in structures, and producing a methodology by which to optimize audible alarms that can be applied in a wide range of research areas.

FY 2010 FP&S R&D Grant Award

Project Title:	Investigation and Testing of Compressed Air Foam Systems for Structural Firefighting
Organization:	California Polytechnic State University
Principle Investigator:	Thomas Korman, Ph.D, P.E.
Grant Number:	EMW-2010-FP-01369
Award Total:	$ 940,571
Period of Performance:	07/28/2011 – 10/31/2013
Grant Status:	Closed

Abstract

Relevance:
Many fire departments throughout the United States have acquired and deployed CAFS (Compressed Air Foam System) for use in structural firefighting. Although the technology has many qualities that would be advantageous to firefighting, such as reduced weight of hoses and reduced water damage during fire suppression, concerns over the potential limitations of the technology with regard to safety of firefighters have curtailed its use. A comprehensive unbiased study of the performance of CAFS for structural fire fighting is needed to determine the conditions where CAFS may be used safely and those where it cannot.

Purpose:
This project will investigate the capabilities and limitations of compressed air foam systems (CAFS) for structural fire fighting with the aim of generating sufficient science-based knowledge regarding the effectiveness and safety of the technology for structural fire fighting.

Methods:
A workshop will be conducted to gather input from interested parties about the possible performance and firefighter safety issues associated with the use of CAFS for structural fire fighting. This group will also provide guidance on the plan for the experiments to be conducted. The experiments will involve well-instrumented large-scale enclosure fires using both CAFS and plain water for fire suppression. Fire tests will include ventilation limited compartments such as an attic space or basement. Other tests will burn under conditions where the structure has horizontal ventilation opening such as doorways and windows. Fire ground evolutions will be used to evaluate differences between CAFS and plain water hose lines issues such as effective hose stream throw and distribution, forces needed to carry and move hoses streams both horizontally and vertically, and the forces need to kink hose lines.

Projected Results and Conclusions:
This project is expected to increase the body of knowledge regarding the safety and effectiveness of CAFS for structural firefighting. Information regarding the safety and effectiveness of CAFS for structural firefighting will be provided, so that firefighter can determine the fires where the technology can be safely used. The project will examine a wide range of potential issues identified by a workshop group for the use of CAFS for interior firefighting.

FY 2010 FP&S R&D Grant Award

Project Title:	Balancing Heat Stress and Thermal Protective Performance in Wildland Firefighters
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, Ph.D
Grant Number:	EMW-2010-FP-01575
Award Total:	$ 999,993
Period of Performance:	06/12/2011 – 11/22/2013
Grant Status:	Closed

Abstract

Relevance:
Wildland firefighter protective clothing provides a barrier to help prevent burn injuries but at the same time increases heat stress during fire fighting operations. Obtaining the optimum balance between thermal protection and thermal comfort in wildland firefighter protective clothing promotes effective and safer wildland firefighting.

Purpose:
The present standard test methods that rely on evaluation of flat material samples are not as accurate or complete as evaluations of the entire ensemble in determining the optimum balance between thermal protective performance and reduced heat stress of wildland firefighter protective clothing. The purpose of this project is to develop and demonstrate new full garment level testing technologies and to produce the associated knowledge basis needed to overcome the limitations of present test methods.

Methods:
The relationships between the breathability of protective clothing materials and heat stress will be established using an advanced sweating manikin and physiological wear trials. A newly developed radiant protective performance (RPP) test will provide more accurate assessment of protection against radiant heat exposures relevant to wildland fire fighting operations. The RadMan Instrumented Manikin Fire Test System will be developed to enable garment level assessment of thermal protective performance in radiant heat exposures. These testing methodologies will be incorporated in a series of integrated thermal comfort and heat protection studies made on a systematically selected set of wildland firefighter protective clothing. This research will be coordinated with ongoing field testing being conducted by the California Department of Forestry and Fire Protection (CAL FIRE).

Projected Results and Conclusions:
The combined technical data bases from measurements made in this project will result in quantification of the balance between thermal comfort and hazardous heat protection that greatly exceeds anything that has ever been available for wildland protective gear. The results will be made available to the technical committee considering changes for the next edition of the NFPA 1977, *Standard on Protective Clothing and Equipment for Wildland Fire Fighting*, in requirements for heat stress, or total heat loss (THL) and radiant protective performance (RPP). CAL FIRE will assist in the widespread dissemination of the results of this project throughout

the wildland fire fighting community.

FY 2010 FP&S R&D Grant Award

Project Title:	Effect of SCBA Design & Fire Fighting Induced Fatigue on Balance, Gait and Safety
Organization:	The Board of Trustees of the University of Illinois, Urbana-Champaign
Principle Investigator:	Gavin Horn, Ph.D
Grant Number:	EMW-2010-FP-01606
Award Total:	$ 999,596
Period of Performance:	07/9/2011 – 02/27/2015
Grant Status:	Closed

Abstract

Relevance:
The two leading causes of fireground injuries in the Fire Service are slips trips and falls, and overexertion/strain. The design of self-contained breathing apparatus (SCBA), including size, weight and geometry can have an impact on these injuries. This project will provide important information for firefighters, officers and purchasing agents to more fully understand the effects of firefighting activities and alternate SCBA designs on metabolic stress and safety of movement, which will have substantial implications on the risk for these injuries.

Purpose:
This project will study the impact of self contained breathing apparatus (SCBA) size, weight and design, on firefighter metabolic stress and safety of movement (balance, gait and situational awareness) before and after simulated firefighting activities. Identifying the interactions between SCBA design and changes in firefighters' physiology and biomechanics during fire fighting activities holds promise to reduce the risk for fireground injuries.

Methods:
Using state-of-the-art energy expenditure measurements, motion capture technology and novel balance, gait and obstacle crossing assessments, we propose to study: 1) the effect of firefighting SCBA design (conventional air cylinder versus prototype designs), and 2) SCBA cylinder size [30-minute, 45-minute and 60-minute] and how these factors impact metabolic stress from simulated firefighting activities of different durations.

Projected Results and Conclusions:
SCBA designs that reduce the center of mass displacement of the firefighter will result in smaller deficits in safety of movement and less metabolic stress during fire fighting activities than conventional SCBA design, which will lower the risk of slip, trip and fall injuries and the risk of overexertion/strain injuries. Furthermore, the increased weight from extended duration SCBA will produce significantly greater metabolic stress and larger deficits in safety of movement when compared to conventional design 30-minute SCBA air cylinders and therefore increasing the risk of injuries.

FY 2010 FP&S R&D Grant Award

Project Title:	Impact of Adenovirus-36 and Obesity in the Fire Service on Health & Safety
Organization:	University of Texas Health Science, Houston
Principle Investigator:	R. Sue Day, Ph.D
Grant Number:	EMW-2010-FP-01812
Award Total:	$ 999,972
Period of Performance:	06/04/2011 – 10/03/2013
Grant Status:	Closed

Abstract

Relevance:
Obesity is associated with psychosocial and metabolic co-morbidities including cardiovascular disease (CVD). Firefighters have high rates of overweight and obesity, a relatively high incidence of CVD and injury, and low physical fitness. A recent and novel finding indicates that Adenovirus 36 (Ad-36) causes the development of obesity in animals and may act similarly in humans.

Purpose:
This study will examine the role of naturally-acquired Ad-36 in the etiology of obesity in firefighters. Ad-36 may exacerbate the development of adiposity, independent of diet and physical activity, and impact blood lipids and hormones associated with CVD risk.

Methods:
This project will capitalize on the ongoing firefighter cohort (EMW-2009-FP-01971), sharing the epidemiologic and adiposity data collected in the initial project. Analyses will include: the association of naturally-acquired Ad-36 exposure with obesity (e.g., BMI, body fat percentage, or waist circumference); the longitudinal relationship of Ad-36 exposure with obesity and adiposity measures; the impact of dietary intake and physical activity on the relationship of Ad-36 and adiposity; and the relationship of Ad-36 exposure to serum lipids and hormones, dietary intake, fitness, and key indicators of firefighter health and readiness. Phlebotomists will accompany the research team to collect fasting blood on site.

Projected Results and Conclusions:
This study will provide data for the first report of Ad-36 exposure and obesity in firefighters and the first longitudinal study in any human population of this obesity risk factor. Results will include careful examination of Ad-36's role with modifiable risk factors for obesity and CVD and assessment of key indicators of firefighters' health and readiness. Each firefighter will receive results of their lipid panel for participation. If Ad-36 contributes to the development of obesity in firefighters, wellness intervention strategies could offer cause-specific, effective prevention of future exposure so that negative health effects could be avoided.

FY 2010 FP&S R&D Grant Award

Project Title:	Effect of Dehydration and Heat Stress on Vascular and Hemostatic Functions
Organization:	Skidmore College
Principle Investigator:	Denise Smith, Ph.D
Grant Number:	EMW-2010-FP-01992
Award Total:	$ 999,996
Period of Performance:	06/12/2011 – 12/11/2014
Grant Status:	Closed

Abstract

Relevance:
This study will investigate the effect of dehydration and heat stress on factors that are mechanistically linked to sudden cardiac events and that have been shown to be altered by firefighting activity.

Purpose:
There has been no scientific study of the effect of dehydration or heat stress on arterial function and hemostatic responses to muscular effort. Designing interventions to mitigate deleterious arterial and hemostatic changes requires an understanding of the independent influences of dehydration and heat stress on these parameters. This study aims to examine the independent and combined effects of dehydration and alteration in core temperature on vascular function and hemostatic responses to maximal exercise.

Methods:
In order to investigate the effect of dehydration and heat stress on arterial and hemostatic function, the study will employ a repeated measures design and will require the participant to perform 4 exercise trials: a) normal body temperature and normal hydration, b) normal body temperature and dehydrated, c) elevated body temperature and normal hydration, and d) elevated body temperature and dehydration.

Projected Results and Conclusions:
It is hypothesized that dehydration and hyperthermia will have detrimental effects on arterial function and will lead to increased coagulatory potential. Determining the contributions of these twin challenges allows recommendations for specific interventions that will lessen arterial and hemostatic disruptions associated with firefighting.

FY 2009 Awards

FY 2009 FP&S R&D Grant Award

Project Title:	Firefighter Statin Trial: Reducing Atherosclerotic Disease and Risk Factors
Organization:	Arizona Board of Regents, University of Arizona
Principle Investigator:	Jeffrey L. Burgess, MD, MS, MPH
Grant Number:	EMW-2009-FP-00343
Award Total:	$ 1,000,000
Period of Performance:	04/23/2010 - 10/22/2013
Grant Status:	Closed

Abstract

Relevance:
This project focuses on treatment that may reduce cardiovascular risk among firefighters.

Purpose:
Preliminary analyses of findings from an earlier AFG-funded study (2007), carried out by the Arizona team with 597 Phoenix and Tucson area firefighters, showed that even mildly increased low density lipoprotein cholesterol (LDL-C), above 100 mg/dl, is associated with increased carotid intima-media thickness (CIMT). CIMT is a measure of the extent of atherosclerosis present in an individual and is associated with a higher likelihood of future cardiac events.

Statin therapy is generally well-tolerated and has been shown to reduce risk of future cardiac events in individuals with cardiac risk factors and has also been shown to reduce CIMT in high risk individuals. However, firefighters without hypercholesterolemia rarely receive statin therapy. This project uses a two year randomized interventional trial of statin therapy in firefighters with LDL-C 100-160 mg/dl to determine if this treatment prevents progression of their CIMT and improves other cardiovascular disease risk factors.

Methods:
Phoenix area firefighters who have mildly elevated LDL-C and are not currently taking statin therapy will be eligible for participation. Among these firefighters, 124 will be selected. Half of these will be randomly assigned to receive rosuvastatin at 10 mg per day for two years and the other half will be followed over this same period as a control group. At baseline and the end of 12 and 24 months, CIMT measurements of common carotid artery, carotid bifurcation and internal carotid artery segments will be obtained, as will blood samples for lipid, C-reactive protein (CRP) and other biomarkers for risk of atherosclerosis. Primary and secondary study endpoints are specified.

Projected Results and Conclusions:
Existing studies demonstrate that statin therapy limits progression of CIMT and reduces other cardiovascular disease risk factors and future cardiac events, even in subjects without hypercholesterolemia. Therefore we anticipate that the firefighters receiving statin therapy will

have lower CIMT compared to the control group at the end of the two year study period. We also expect levels of LDL-C will be reduced and other specified biomarkers of atherosclerotic risk will likewise be significantly decreased. The proposed study will help determine if medical intervention with statin therapy is indicated for firefighters with mildly elevated LDL-C.

FY 2009 FP&S R&D Grant Award

Project Title:	Low Back Injury Prevention in Firefighters
Organization:	University of South Florida
Principle Investigator:	John Mayer, DC, Ph.D
Grant Number:	EMW-2009-FP-00418
Award Total:	$ 701,173
Period of Performance:	04/30/2010 - 02/08/2013
Grant Status:	Closed

Abstract

Purpose and Objectives (with rationale):
Our long-term research goal is to develop and test exercise interventions for preventing and treating low back injuries in firefighters.
Aim 1: Assess the effectiveness of a core muscle exercise intervention to improve core trunk muscular endurance (the desired physiological response) in firefighters.
Aim 2: Assess the implementation of this intervention at one fire rescue department.
Rationale. Low back injury is a leading cause of disability in U.S. workers, including firefighters. Firefighters have several risk factors for low back injury, including poor core trunk muscular endurance. Exercise interventions for the core trunk muscles have not been tested in firefighters.

Study Design and Methods:
A controlled clinical trial will be conducted with firefighters (n=74) from Tampa Fire Rescue. Firefighters will be randomly assigned (by fire station) to: experimental (n=37) who will perform core trunk muscle progressive resistance exercises; or control (n=37) who will perform flexibility exercises. Both groups will train 2X/week for 24 weeks, and receive a web-based back school. Focus groups and surveys will be administered to determine facilitators/barriers of implementation.

Results (projected):
Hypothesis: The core exercise intervention will result in a significant (40%) increase in core trunk muscular endurance compared with control, and will be successfully implemented as indicated by acceptable safety, participation, compliance, and satisfaction.

Conclusions (projected):
Assuming positive results in this study and subsequent prevention trials, an exercise intervention will be delivered that can help prevent low back injury in firefighters, thereby improving their health and safety so they can effectively carry out their duties.

FY 2009 FP&S R&D Grant Award

Project Title:	Firefighter Nonfatal Injury Data System Development
Organization:	Drexel University
Principle Investigator:	Jennifer A. Taylor, Ph.D, MPH
Grant Number:	EMW-2009-FP-00427
Award Total:	$ 867,749
Period of Performance:	06/11/2010 - 09/10/2013
Grant Status:	Closed

Abstract

Relevance:
This proposal will seek to focus on the design and feasibility of a new database system. Currently, firefighter data are gathered by multiple groups, but these data are neither accurate, nor integrated, nor sufficiently accessible for purpose of identifying injury trends. This project aims to contribute to the following Firefighter Life Safety Summit Initiatives:
#7 - Create a national research agenda and data collection system that relates to the initiatives.
#9 - Thoroughly investigate all firefighter fatalities, injuries, and near misses.

Purpose:
Firefighters and researchers lack a comprehensive system documenting injuries and risk factors essential to informing policy and practice. It is not presently possible even to count firefighter injuries resulting in hospitalization or long-term disability. We propose to examine the feasibility of comprehensive firefighter non-fatal injury data system, standardizing information from various systems and unifying these into a minimum core data set describing firefighter injuries accurately and consistently at the national, regional, and local levels. This effort is entitled, Firefighter Injury Research and Safety Trends (FIRST) http://publichealth.drexel.edu/first/

Methods:
Design and test the feasibility of the system to serve the planning and evaluation needs of the fire service and the scientific needs of researchers. The system will build on an analysis of existing fire surveillance and exemplary non-fire surveillance programs by evaluating (1) existing data systems, (2) government regulations, and (3) novel data sources, culminating in (4) demonstration in Pennsylvania and Florida, and (5) recommendations for national implementation.

Projected Results and Conclusions:
This study will produce a tested architecture, ready for national implementation. With this information, AFG and the fire service will understand the facilitators, barriers, and feasibility of implementation issues so that decision making about implementation will be well informed.

FY 2009 FP&S R&D Grant Award

Project Title:	Effect of Aspirin on Hemostatic and Vascular Function After Live Fire Fighting
Organization:	The Board of Trustees of the University of Illinois, Urbana-Champaign
Principle Investigator:	Gavin P. Horn, PhD
Grant Number:	EMW-2009-FP-00544
Award Total:	$ 999,801
Period of Performance:	04/23/2010 - 09/22/2013
Grant Status:	Closed

Abstract

Purpose and Aims:
The Illinois based interdisciplinary research team proposes to study the effects of acute and chronic aspirin interventions on vascular and hemostatic function before and after live fire fighting activities in order to assess its ability to reduce cardiovascular risk post-fire suppression. This study will provide a novel approach, important and significant information in response to live fire fighting that is currently not available, but may have substantial implications for firefighter health.

Relevance:
This study will improve our understanding of the mechanisms for the most common source of fatalities in the Fire Service; sudden cardiac death. More importantly, we propose to study an intervention that has promise to reduce the cardiovascular risk through a variety of mechanisms in the most complete manner with state-of-the-art techniques.

Methods:
The study will employ a double-blind fully crossed over design that will include four treatments: a two week aspirin/placebo treatment ("chronic") and a single pre-fire fighting aspirin/placebo treatment ("acute"). A complete profile of vascular health as well as hemostatic and inflammatory conditions will be collected immediately before and after fire fighting to determine the effect of aspirin therapy on the detrimental vascular and hemostatic changes post live fire fighting.

Projected Results and Conclusions:
We anticipate platelet activation and coagulatory potential will decrease, while fibrinolytic potential will increase in response to live fire fighting after an acute aspirin dosage versus placebo. These same affects are expected in response to the chronic treatment with aspirin in addition to improved arterial function post fire fighting.

FY 2009 FP&S R&D Grant Award

Project Title:	Exercise Tolerance as a Predictor of Firefighters Future Risks
Organization:	Harvard University
Principle Investigator:	Stefanos Kales, MD, MPH
Grant Number:	EMW-2009-FP-00835
Award Total:	$ 978,517
Period of Performance:	04/23/2010 – 04/30/2013
Grant Status:	Closed

Abstract

Relevance:
Cardiovascular events represent 45% of on-duty deaths among firefighters, occurring primarily in firefighters with underlying disease or excess risk factors. Experts have suggested 12 METS as the minimum exercise capacity for safe firefighting, making exercise testing an attractive risk stratification tool.

Purpose:
Exercise tolerance tests will be used to predict health and employment consequences.

Methods:
The study will use two cohorts: (1) an established cohort of career firefighters (expected n=1000) who have all undergone maximal exercise testing and comprehensive medical evaluations (dietary and medical history, body composition and blood pressure, metabolic profiles), and (2) a cohort (n=2000) of firefighters from the Phoenix Fire Department and several surrounding departments. For the second cohort, records include submaximal exercise testing and comprehensive medical evaluations. Both cohorts of firefighters will be stratified according to their baseline exercise tolerance and then undergo follow-up for adverse health/employment events.

Projected Results and Conclusions:
Decreased exercise tolerance will be associated with increased risks for adverse health and employment outcomes in both prospective and retrospective analyses.

With these findings, exercise tolerance as determined by METS achieved and/or total treadmill time will be a useful risk stratification tool among firefighters.

FY 2009 FP&S R&D Grant Award

Project Title:	The Role of Statins in Preventing Cardiovascular Dysfunction Associated with Fire Suppression
Organization:	University of Pittsburgh
Principle Investigator:	David Hostler, PhD
Grant Number:	EMW-2009-FP-00921
Award Total:	$ 696,303
Period of Performance:	04/30/2010 - 08/31/2012
Grant Status:	Closed

Abstract

Firefighters suffer the highest line of duty death rate of any occupation with the majority of deaths resulting from cardiovascular events. In recent years, studies have identified the potential triggers of sudden cardiac death among firefighters. These triggers are generally associated with inflammatory and coagulation cascades that occur during acute and chronic exposure to exhaustive cardiovascular strain while hyperthermic and dehydrated. Although these pathologic pathways are becoming clearer as they are investigated, very little is known about the role that preventative pharmacological measures may play in potentially decreasing these internal derangements in otherwise healthy individuals.

The purpose of this double blind, placebo-controlled study is to investigate the role of a statin (Lipitor) in the prevention of abnormal cardiovascular responses associated with fire suppression activities. Statins are expected to prevent the abnormal cardiovascular responses due to their ability to systemically improve arterial endothelial function and reduce inflammation. Accordingly, we will investigate the effects of six weeks of statin therapy on cardiovascular function, inflammation, and physiologic stress responses in 50 firefighters who participate in a live-burn evolution.

We will also conduct a case study to quantify the costs associated with implementing a preventative therapy program, such as pharmacotherapy with statins, in both paid and volunteer fire departments.

FY 2009 FP&S R&D Grant Award

Project Title:	Firefighter Safety and Photovoltaic Systems
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Pravinray Gandhi, Ph.D
Grant Number:	EMW-2009-FP-01487
Award Total:	$ 999,401
Period of Performance:	04/19/2010 – 10/18/2011
Grant Status:	Closed

Abstract

Underwriters Laboratories, Inc. (UL) proposes to conduct a research project to address firefighter vulnerability to electrical and casualty hazards when mitigating a fire involving photovoltaic (PV) modules and support systems installed in residential and commercial building structures. The need for this project is significant due to the increasing use of photovoltaic systems, growing at a rate of 30% annually. As a result of greater utilization, the traditional firefighter tactics have been complicated, leaving firefighters vulnerable to severe hazards. Though the electrical and fire hazards associated with PV systems have been known for some time, a very limited body of knowledge and insufficient data exists to understand the risks to the extent that the fire service has been unable to develop safety solutions and respond in a safe manner.

UL's approach to evaluating the hazards associated with PV systems in firefighting operations will require the design of experimental methodologies based on UL's current expertise in product testing and standards development. The experiments will develop empirical data to understand the magnitude of the hazards. Methodologies will be based on electrical principals, fire dynamics, and firefighting tactics.

UL will share the results and knowledge gained through the research with the fire service community through web-based educational programs, presentations and articles. The conclusions from the study will provide the foundation for code improvements on the installation of PV systems and creation of firefighter tactical and operational guidelines resulting in improved firefighter preparedness and safety.

FY 2009 FP&S R&D Grant Award

Project Title:	Hazard Assessment of Fire Service Training Fires
Organization:	Fire Protection Research Foundation
Principle Investigator:	Casey C. Grant
Grant Number:	EMW-2009-FP-01645
Award Total:	$ 141,670
Period of Performance:	04/30/2010 - 07/29/2011
Grant Status:	Closed

Abstract

Each year thousands of fire fighters are injured during training, and occasionally some are fatally injured. The dangers of fire fighting are well recognized. Live fire training evolution is an effective and popular training method, but it's also one that exposes the trainees to significant hazards. When fire fighter deaths occur during training, they tend to be particularly troubling since training is meant to prevent deaths and injuries and not be its cause. One common cause of fire fighter death and injury is a lack of understanding of the hazard assessment of live fires used for training.

This two-year project will provide data, information, and a fire hazard assessment methodology to fire training officers and fire fighters. The project results will provide a validated and data supported/driven thermal hazard assessment method that is fire service friendly as a means to improve firefighter safety. This will be made directly available for consideration to NFPA 1403, Standard on Live Fire Training Evolutions, which needs this information and is considering revisions on this topic.

This research project will achieve its goal through the following:
• Determine the Heat Release Rates for common fuel package types and configurations (involving pallets) used for fire service live fire training;
• Summarize this information in the form of a pictorial and quantitative catalog for consideration and adoption by NFPA 1403; and
• Provide practical guidance information for fire fighter training based on this information and the known thermal performance of personal protective clothing and equipment.

FY 2009 FP&S R&D Grant Award

Project Title:	Assessment of Web-Based Interactive Methodology for Dissemination and Diffusion
Organization:	New York University
Principle Investigator:	Sunil Kumar, Ph.D
Grant Number:	EMW-2009-FP-01892
Award Total:	$ 850,000
Period of Performance:	05/28/2010 – 11/27/2013
Grant Status:	Closed

Abstract

Relevance:
Research projects conducted around the world have made substantial progress in the development of technologies and tactics for improving firefighter safety. However, the gap between science-based interventions and widespread practice remains large. This is because the fire service not only needs information and knowledge, but also methods for effective and efficient ongoing dissemination and training.

Purpose:
The study purposes are: (1) to assess and establish that a web-based interactive (aka game system) platform is an effective means for training and improving firefighter knowledge and skills, and (2) to evaluate whether web-based interactive training offers the most effective and efficient instrument for dissemination and diffusion for a wide variety of fire situations and topics when compared to traditional methods.

Methods:
Experiments will be conducted using random assignment of New York City (FDNY) and Chicago (CFD) firefighters to different training methods (traditional classroom and web-based game system) for comparative effectiveness and cost analyses. A third non-urban fire department also will participate, including random assignment to both training methods.

To determine the generalizability of the platform for various fire training scenarios, three very different cases – each with prior AFG funding to establish effectiveness -- will be examined: (1) strategies for fighting wind-drive high-rise fires (identified in previous study by NYU-Poly), (2) fighting residential fires with engineered lumber (evidence determined in prior UL- CFD study), and fatigue management (developed and tested by Brigham Women's Hospital). Each scenario will be observed in each of the three fire service settings and with both of the training methods.

Projected Results and Conclusions:
Web-based interactive tools can provide at least the same level of knowledge and skills to trainees as achieved with a traditional classroom approach. Importantly, such new tools can accomplish fire service training goals more efficiently and with lower cost, enhancing dissemination and implementation of new training products.

With these findings, web-based interactive training will allow fire services to rapidly absorb and implement procedures and tools developed via recent scientific endeavors for improving firefighter safety, health, and wellness.

FY 2009 FP&S R&D Grant Award

Project Title:	Project SDD: Stair Descent Device Performance for Firefighters
Organization:	Board of Trustees of the University of Illinois at Chicago
Principle Investigator:	Glenn Hedman
Grant Number:	EMW-2009-FP-01944
Award Total:	$ 788,205
Period of Performance:	04/19/2010 – 10/31/2013
Grant Status:	Closed

Abstract

Relevance:
Stair Descent Devices (SDDs) are becoming more prevalent in high-rise buildings as a means of transporting individuals with disabilities down stairways during partial- or full-building evacuations. As firefighters perform evacuations with individuals with disabilities from high-rises, stair descent device designs, building layout, and emergency conditions put them at risk for injury or cardiac event.

Purpose:
This project will provide quantitative data on the physical demands made on firefighters as they use SDDs.

Methods:
In the study, a process by which new and existing SDDs can be quantitatively evaluated will be developed. An ergonomic evaluation of evacuation devices used by firefighters in high-rise buildings will be conducted to collect data on firefighter muscle activity, heart rate, and perceived exertion level. Interviews with firefighters following the trials will yield information on the operability, safety, and comfort of the devices to operators as well as respondents' thoughts on safety and comfort for the occupant. Several different commercial SDDs will be used, representing 3 different design approaches (carry-type chairs, track-type chairs, and sled-type devices), during trials where stairway width and landing size are varied, and where regular and urgent travel is encouraged. Randomized tests will be performed with 36 participants and 12 different stair descent devices.

Projected Results and Conclusions:
The results of this research may significantly affect the selection of stair descent devices. The study will quantify the demands on the firefighters using loaded SDDs that are anticipated to increase with narrower stairways and urgent conditions. The physical demands on firefighters are also anticipated to be different based on SDD design type. This study will shed significant light on the impact on firefighter health and safety of stair descent device design features, stairway designs, and urgent travel vs. comfortable pace. The results may influence a range of factors, from device design to building layout.

FY 2009 FP&S R&D Grant Award

Project Title:	The Impact of Nutrition Environment in the Fire Service on Health and Safety
Organization:	National Development and Research Institutes, Inc.
Principle Investigator:	Sara Jahnke, PhD
Grant Number:	EMW-2009-FP-01971
Award Total:	$ 998,235
Period of Performance:	04/19/2010 - 03/31/2013
Grant Status:	Closed

Abstract

Firefighting requires a high level of physical fitness and health in order to respond to unpredictable emergencies at a moment's notice. However, previous research suggests that, as a group, firefighters have a relatively high incidence of cardiovascular disease (CVD), injury, and low physical fitness, and very high rates of overweight and obesity. Although a host of factors likely account for negative health outcomes in firefighters, preliminary data and reports from many within the fire service community point to the unhealthy food environment in fire houses as a primary cause of poor health outcomes. Unfortunately, there is a complete lack of epidemiological data on the nutrition environment in the fire service.

This study will fill this important gap in the public health literature. Using a longitudinal cohort design, we will examine dietary intake and the food environment among 1,000 firefighters housed in 60 fire stations within 20 fire department across the nation. Departments will be stratified on adherence to guidelines in the IAFF-IAFC Wellness and Fitness Initiative (WFI).

Study aims include developing: 1) a comprehensive epidemiological picture of the food environment in the fire service; and 2) statistical models of the relationship between diet and health and performance outcomes among firefighters, and 3) examining the impact of the WFI on diet quality, weight changes, health risk, and readiness across time.

We predict that participants from WFI departments and those with the healthiest diets will experience significantly less weight gain and fewer negative health outcomes.

FY 2009 FP&S R&D Grant Award

Project Title:	Improving Structural Firefighting Gear - From the Inside Out
Organization:	Skidmore College
Principle Investigator:	Denise Smith, PhD
Grant Number:	EMW-2009-FP-02044
Award Total:	$ 569,403
Period of Performance:	03/29/2010 - 09/28/2012
Grant Status:	Closed

Abstract

Purpose and Objectives:
Firefighting leads to considerable thermal, cardiovascular and perceptual strain. Paradoxically, turnout gear that is designed to protect firefighters from burn injury also adds to the cardiovascular and thermal strain fire fighters experience. The purpose of this development and research project is to develop a novel integrated ensemble of turnout gear that causes the firefighter less cardiovascular, thermal and perceptual strain.

Study Design and Methods:
This research and development project includes a series of steps to better understand the effect of the base layer on physiological responses of performing work in firefighting turnout gear and then to optimize the base layer and station uniform into an integrated ensemble for turnout gear that lessens the physiological strain of the firefighter while providing the same level of thermal protection. We will apply an integrated systems approach to our work, drawing on the methodology employed by the US military for developing soldier clothing ensembles. We will conduct the project in two phases. During the Phase 1, we will undertake laboratory bench testing to describe the materials properties (TPP and THL) of promising base layers when worn in conjunction with turnout gear. Base layers will include fire-resistant fibers that improve wicking and thermal control, and phase change materials (PCM). In Phase 1, we will also document the effect of different base layers on physiological strain during a carefully controlled laboratory-based study involving repeated work/rest bouts. In Phase 2, we will use the information gained from the Activities in Phase I to design a new integrated turnout ensemble that optimizes the base layer and station uniform to allow the outer gear to be reconfigured in a way that maintains current level of protection from burn injury, while decreasing the weight and restrictiveness, and optimizing the breathability of the gear. We will then test this newly developed gear in rigorous laboratory testing and in a field setting that involves live-fire drills. We have developed five specific aims (that correspond to individual activities within the project) that include: a) selecting and designing base layers that have potential to maximize moisture and thermal control next to the skin; b) describing the material performance (TPP and THL) properties of the base layers and station uniform when worn with turnout gear; c) testing the effectiveness of the selected base layers to lessen cardiovascular, thermal and perceptual strain during repeated work cycles (20 min) with planned cooling between work bouts; d) developing a novel firefighting turnout ensemble using an integrated systems approach; and e) comparing the cardiovascular, thermal and perceptual strain of the newly developed integrated turnout ensemble and current turnout gear under laboratory and live fire conditions.

Results (projected):
We expect to find that base layers that take advantage of newly developed materials/textiles can promote heat dissipation during planned cooling periods. Furthermore, we believe that an integrated turnout ensemble that optimizes all layers of clothing worn by a firefighter will prove to be lighter and less restrictive, and will result in less physiological and perceptual strain during the same amount of work.

Conclusions (projected):
Fire Departments across the country will immediately benefit from the results from Phase 1 which will provide clear evidence of the usefulness of new, and highly touted base layer garments. Furthermore, the Fire Service will benefit tremendously from the application of an integrated systems approach to designing structural firefighting gear (Phase 2). Additionally, the integrated ensemble for structural firefighting gear that we develop will undoubtedly stimulate additional ideas that will help improve firefighting gear. Our prototype gear may well usher in the next generation of firefighting turnout gear.

FY 2008 Awards

FY 2008 FP&S R&D Grant Award

Project Title:	Smart Firefighter Garments for Burn Mitigation and Firefighter Safety
Organization:	Center for Firefighter Safety Research & Development, University of Maryland
Principle Investigator:	Marino diMarzo, PhD
Grant Number:	EMW-2008-FP-00653
Award Total:	$ 723,110
Period of Performance:	08/14/2009 - 12/31/2012
Grant Status:	Closed

Abstract

Purpose and Objectives:
The primary purpose of this research effort is to develop novel firefighter turnout gear technology utilizing shape memory fibers (SMF) to enhance firefighter safety. Burn injuries in firefighters are a major safety concern and the performance of the firefighter gear is an important factor. The smart garments will rely on shape memory fibers (SMF) which are inter-woven with the garment fabric. The SMF are passively activated whenever excessive thermal exposures are detected because of their unique phase transformation characteristics. Once activated, the SMF will introduce air pockets in the garments that will reduce their thermal conductivity and hence eliminate the likelihood of burn injuries. The stacking and placement of SMF will be optimally determined and the garments performance will be evaluated under different thermal and humidity exposures.

Study Design and Methods:
During the first year of the project, efforts will focus on monitoring the thermal conductivity of various configurations of firefighter garments under different exposures to known temperature and humidity fields. These findings will guide the development of a model to simulate the complex transport phenomena. During the second year of funding, the mathematical models will be implemented on a micro-computer to warn firefighters against dangerous exposures to excessive heat and humidity. The exposure computer will be integrated in the firefighter gear and during the third year of funding will be field tested in the high temperature burn building at the Maryland Fire and Rescue Institute (MFRI) to demonstrate its function and practicality.

Projected Results:
The proposed research will be implemented by a multi-disciplinary team that includes the Fire Protection and Mechanical Engineering Departments at the University of Maryland (UMCP), MFRI, and Lion Apparel, Inc. The mathematical models validated with the measurements will provide a design tool for the industry. This design tool will enable scoping performance evaluations of new turnout gear design and will significantly reduce the cost while increasing the performance of new protective gear. Special emphasis will be placed in the modeling of moisture and steam behavior within the gear to limit and possibly eliminate steam burn injuries.

Projected Conclusions:
This project directly supports several high priority research efforts identified during the National Fallen Firefighters Foundation (NFFF) National Fire Service Research Agenda Symposium held in Emmitsburg, MD in June of 2005 and specifically addresses the FEMA/USFA mission of reducing line-of-duty deaths by 25% within five years and by 50% within ten years.

This project impacts firefighter safety in several ways. The computational tools developed will enhance understanding of thermal properties of different gear configurations and allow manufacturers to design and experiment with different assemblies prior to building the garments. This will enhance innovation and result in safer, more effective firefighter gear reaching the firefighter more quickly.

The new gear design and integration of the SMF technology promises to provide the firefighter with a more comfortable garment without sacrificing thermal protection and gear performance. The ability of the gear to transform in different conditions will enhance the firefighter's physiological cooling mechanisms in standby situations and offer greater protection from steam and thermal burns when exposed to fire.

The integration of the micro-computer system into the firefighter gear will warn the firefighter of excessive heat exposure that as a result of advancements in the gear may not otherwise be known. This has the potential to save many firefighters from burn injuries or worse.

FY 2008 FP&S R&D Grant Award

Project Title:	Whole Glove Test Technologies to Advance Performance Standards for Firefighter Gloves
Organization:	North Carolina State University
Principle Investigator:	Roger Barker, PhD
Grant Number:	EMW-2008-FP-00664
Award Total:	$ 831,568
Period of Performance:	08/21/2009 - 12/31/2011
Grant Status:	Closed

Abstract

Purpose/Objectives:
Performance and utility of structural firefighter gloves have been longstanding areas of concern. Firefighters will greatly benefit by having gloves that provide fire protection to hands, with less bulk and in more flexible design constructions. The availability of such gloves would provide greater hand dexterity and increased comfort and functionality in firefighting activities.

Many of the glove tests in the National Fire Protection Association (NFPA) 1971 Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting are focused on component tests, including the thermal protective performance (TPP) rating, of flat composite materials used in manufacture of gloves. New whole glove tests for thermal protection, insulation and breathability, available in the Textile Protection and Comfort Center (T-PACC) at North Carolina State University (NCSU), present an opportunity to modernize NFPA 1971 glove performance requirements. This research will produce data on glove performance using the PyroHands Fire Test System, Sweating Hand, and other advanced whole glove tests that are more realistic test simulations of glove performance. These whole glove tests will provide the technical basis for improving requirements in the NFPA 1971 Standard.

Study Design and Methods:
Firefighters, through a technical panel organized by the National Fire Protection Research Foundation (NFPRF), will identify a representative range of NFPA 1971 compliant firefighter gloves for evaluation using advanced whole glove instrumentation at NCSU's T-PACC.

Data from whole glove testing will be used in conjunction with component tests, to identify an optimum battery of test methods and performance data to be recommended for the NFPA 1971 Standard for glove requirements. Data will be provided as a study to assist glove manufacturers in developing improved designs for structural fire fighting applications. Physical properties of test gloves including materials weight, thickness and flexibility, and details of glove design and construction will be documented and included in the analysis of glove functional performance. Details of glove construction will then be correlated to establish a database relating functional performance with features of glove materials and design. Laboratory test data will be further integrated with firefighter feedback on the perceived field performance of the specific glove examples tested.

Expected Results:
A representative sampling of commercial firefighter gloves will be evaluated using revolutionary whole glove test methods with results compiled into a performance database correlated to glove design and construction features. The resulting database will be disseminated and will provide the basis for new performance criteria for improved designs with uncompromised protective performance.
PyroHands fire test, for example, shows the distribution of predicted 2nd and 3rd degree burn injury over front, back, wrist, and fingers in fire exposures. This contrasts with TPP tests that give information only on protective insulation of flat composite materials used in glove constructions. The PyroHands method is not only a greatly improved test method for glove evaluation, it shows the location on the glove where fire protective insulation may be reduced without compromising thermal protective performance.
Documented test procedures will be presented to the NFPA 1971 committee for application to upcoming revisions of that Standard; to relevant ASTM subcommittees for developing new whole glove test methods; to users, professional organizations, and other NFPA committees.

Conclusions:
This project will provide the technical basis for a significant advance in NFPA standards and requirements for structural firefighter gloves. It will provide glove manufacturers with an unprecedented evaluation tool and data that can guide the development of more functional glove constructions for firefighters.

FY 2008 FP&S R&D Grant Award

Project Title:	Fireground Injuries: An International Evaluation of Causes and Best Practices
Organization:	Arizona Board of Regents, University of Arizona
Principle Investigator:	Jeff Burgess, MD, MS, MPH
Grant Number:	EMW-2008-FP-01536
Award Total:	$ 1,000,000
Period of Performance:	09/14/2009 – 02/31/2012
Grant Status:	Closed

Abstract

Purpose and Objectives:
Firefighting has one of the highest occupational incident rates for injury and fatalities, a large number of which occur during fireground operations. An international comparison of fireground operations provides a unique opportunity to discover effective procedures for preventing injuries. We hypothesize that fireground injury rates will vary by department and country, lower injury rates will be associated with more extensive training, and a majority of injuries will occur despite following standard operating guidelines (SOGs). Our objectives are to evaluate for the association of training with lower fireground injury rates and to identify SOGs incorporating best practices.
Study Design and Methods: In a three year international study we will partner with fire departments in the U.S. (Phoenix AZ, Columbus OH and Washington DC), UK (Lancashire), Australia (Melbourne) and Japan (to be determined), based on their willingness to participate, reputation for safety and use of best-practices.

Specific Aim #1. Compare fireground injury rates by department. Fireground injury rates, including travel to and from the fire and injury type (nature of injury, body part and activity), will be determined for the period 2004-2008. Adjusted injury rates will be calculated for specific fireground activities resulting in the majority of injuries; average overall rates for each department will be adjusted for hours of training on each of the selected fireground activities, general environmental conditions and firefighter demographics using Poisson regression modeling. Analyses will be restricted to 1-2 family dwelling fires to minimize the confounding effect of differential construction types.

Specific Aim #2. Evaluate the relationship between training and following SOGs among injured firefighters. Fireground SOGs for each department will be obtained. Each department will prospectively collect data on a minimum of 150 injuries occurring during fireground operations. Data will be obtained for each incident using standardized National Fire Incident Reporting System (NFIRS) variables plus questionnaire responses collected from the injured firefighters using the Behavioral Sequence Interview Technique (BSIT). The BSIT data fields will be customized to the fireground SOGs used by each department. Injuries will be classified as having occurred while not following SOGs or occurring despite following SOGs. Linear regression, based on transformed rates of injury, will be used to determine the contribution of hours of training on the extent to which injured firefighters follow their SOGs.

Specific Aim #3. Determine SOG best practices. Injury events occurring while following SOGs will be assessed for each department. Based on these data, best practices will be determined through a consensus based approach, using an international panel convened by the Fire Protection Research Foundation (FPRF) of the National Fire Protection Association (NFPA) and the Metropolitan Fire Chiefs Association. The results of the previous aims and determination of best practices will be incorporated into NFPA standards when possible and disseminated to the larger fire service community through publications, the FPRF website, presentation at the NFPA Annual Meeting, and presentation of the work at other fire service meetings.

Projected Results:
Based on NFIRS data, the majority of fireground injuries should fall under specific activities including handling charged hose lines, overhaul, extinguishing a fire using hand tools and carrying out ventilation with hand tools. We anticipate that more training will be associated with lower injury rates and that higher quality SOGs containing best practices will be identified.

Projected Conclusions: The effect of training and SOGs incorporating best practices for the reduction of fireground injuries will be identified and distributed among fire departments to improve firefighter health and safety.

FY 2008 FP&S R&D Grant Award

Project Title:	Enhanced Firefighter Rehab Trial (EFFORT)
Organization:	University of Pittsburgh
Principle Investigator:	David Hostler, Ph.D.
Grant Number:	EMW-2008-FP-01638
Award Total:	$ 977,079
Period of Performance:	08/14/2009 - 12/31/2011
Grant Status:	Closed

Abstract

Firefighters suffer the highest line-of-duty death rate of any profession. More than half of these deaths are cardiovascular in nature occurring during or in the hours immediately following fire suppression. These deaths are likely related to the uncompensable heat stress (UHS) induced after nearly every significant fire suppression response.

Purpose and Objectives:
Traditional fireground rehab is typically limited to rest, rehydration, and cooling in order to safely return the firefighter to duty. However, these interventions are performed without consideration for correcting the underlying cardiovascular pathophysiology associated with UHS such as platelet activation and blood vessel dysfunction. Furthermore, the options for monitoring firefighters during the rehab period are limited, making it difficult to determine when the firefighter can safely return to the fire line.

This prospective trial will 1) examine the ability of active cooling to correct platelet activation and blood vessel dysfunction following exertion in thermal protective clothing (TPC), 2) examine the role of aspirin to prevent platelet activation and blood vessel dysfunction associated with exertion in TPC, and 3) investigate a novel optical scanning instrument and its role in identifying changes in body temperature and plasma volume in the firefighter.

Study Design and Methods:
This is a prospective trial of enhanced fireground rehab interventions and monitoring both following exercise in TPC and in the hour following rehab. 160 subjects will be recruited to perform a 50-minute bout of exercise in a heated room while wearing TPC to simulate the duration of a room and contents fire and overhaul. Subjects will be randomized to two weeks of daily aspirin therapy or placebo prior to exercise. Following exercise the subject will be randomly assigned to active vs. passive cooling and a single dose of aspirin vs. placebo during rehab. The subjects will have temperature and vital signs monitored during exercise, during the 30-minute rehab, and 60 minutes following rehab. Tests will be performed to identify activation of platelets and blood vessel dysfunction. Blood assays will be performed to check for changes in multiple markers of cardiovascular stress.

Anticipated Results:
We anticipate that active cooling will partially correct platelet and blood vessel dysfunction occurring after UHS which may contribute to cardiovascular injuries and fatalities in the hours following an incident. If confirmed, the data would indicate that active cooling practices should

be invoked after all fire suppression incidents including small alarms involving a limited number of companies. Furthermore, we suspect that aspirin may blunt the platelet dysfunction associated with UHS potentially protecting the firefighter from fatal heart attack in the hours following fire suppression. Finally, we anticipate that a novel optical scanning incident, currently being tested to identify carbon monoxide and cyanide exposure in firefighters can also be used to identify changes in body temperature and blood plasma volume following UHS. However, if aspirin is found to be detrimental to thermoregulation or performance in TPC then this information must be communicated to the fire service so that firefighter can avoid this exposure and consider other preventative therapies to extend cardiovascular health.

Anticipated conclusions:
The results of the study will significantly advance firefighter health and safety by examining interventions targeted at the underlying cardiovascular pathophysiology associated with exertion in TPC. It will also provide critical data about the potential need for active cooling after all fire suppression incidents. Finally, this study will advance the tools available to monitor the firefighter during rehab and assess the effectiveness of rehydration and cooling beyond simple tracking of heart and respiratory rate.

FY 2008 FP&S R&D Grant Award

Project Title:	Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Stephen Kerber
Grant Number:	EMW-2008-FP-01774
Award Total:	$ 999,200
Period of Performance:	08/14/2009 - 09/30/2010
Grant Status:	Closed

Abstract

Purpose and Objectives:
The proposed research project, "Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction", is a problem-focused fire research study to improve firefighter safety by enhancing the understanding of fire behavior in residential structures resulting from natural ventilation and use of ventilation as a firefighter practice during a fire event. Fire fighters depend on visual cues to respond to a fire. However, the cues have changed as a result of the development in residential building construction materials, techniques and footprints. Everyday firefighters respond to ventilation limited fires where a ventilation action such as opening the front door, or breaking windows can have dramatic impact on the fire behavior in the structure.

The fire records show that ventilation-impacted residential fires have caused flashover conditions resulting in many firefighter near misses injuries, and deaths. This project will investigate and analyze the impact of ventilation on fire behavior comparing legacy and contemporary residential construction. These two construction types result in significantly different fire behaviors due to the differences in building construction materials and contents, building geometry, types of windows, and other elements of building construction.

Study Design and Methods:
The proposed project will focus on more frequently occurring - naturally and tactically - ventilated fires in residential building structures that result in significant firefighter deaths and injuries. The fire research project will develop the empirical data, through real-scale residential structure fire tests, to quantify the fire behavior associated with multiple ventilation scenarios comparing legacy and contemporary residential construction. Ventilation scenarios will vary the location and number of openings and location of ignition within the residential structures. The data collected and the video recordings from these tests will be used to design and create outreach programs including the following: 1) formal technical report; 2) articles in publications widely read by the fire service community; 3) presentations to fire service community; and 4) a stand-alone web-based training module. The fire service can immediately transfer the test results and outreach programs into firefighting strategies and tactics to fight fires using improved ventilation practices to reduce firefighter death and injury.

Results (projected):
The proposed research has the potential to benefit both professional and volunteer fire services

and allied safety organizations across the United States. The project will directly respond to one of Department of Homeland Security's key goals to reduce firefighter fatalities and injuries through increasing scientific understanding of fire behavior in residential structural fires and improving firefighters awareness of potential hazards of naturally vented residential structures and proper use of ventilation as a firefighting tactic.

Conclusions (projected):
The project will quantify the influence of ventilation tactics on fire behavior in a modern residential structure as compared to a legacy residential structure with varied locations of ignition in the building. The key project deliverable will be the fire test data from kitchen and living/bedroom scenarios, including temperature, heat flux, fire effluents, smoke obscuration, and digital and thermal imaging (i.e. infrared) videos to assist in reviewing and revising guidelines for proper use of ventilation as a safe and effective firefighting tactic in residential structures.

FY 2008 FP&S R&D Grant Award

Project Title:	Fire-ground Environment Sensor System (FESS)
Organization:	Worcester Polytechnic Institute
Principle Investigator:	R. James Duckworth, PhD
Grant Number:	EMW-2008-FP-02051
Award Total:	$ 1,000,000
Period of Performance:	08/21/2009 - 09/20/2010
Grant Status:	Closed

Abstract

Purpose and Objectives:
The goal of this project is to reduce the number of injuries and Line of Duty Deaths (LODD) of fire fighters from traumatic injuries while operating inside structures, especially those due to burns, smoke inhalation, stress, and becoming lost or trapped. The specific aim of the project is to meet this goal by developing firefighter-deployed 'dynamic instrumentation' of the interior of a burning structure to improve the situational awareness of the incident commander. Most significantly, a key objective is the creation of a new firefighter deployable sensor that will provide ample warning of the potential for and estimated time until flashover.

WPI, a leader in precision deployable wireless indoor/outdoor personnel location and fire protection engineering, and Foster Miller Inc., a leader in sensors, robotics, physiological monitoring and display, and NIST, will jointly construct and test a unique proof-of-concept firefighter safety system to improve situational awareness for firefighters and provide a new vital warning system. The integrated system will provide critical safety information about the interior sector of the fireground, location and physiological information about each firefighter on an incident commander graphic display with continuous real-time updates. A central contribution will be development of a small, automatically deploying sensor that will collect the data needed to compute the flashover potential for the room it is in as well as a floor to ceiling thermal profile. The interior sector's thermal profile, estimated time till flashover onset and the firefighters' locations and status will be shown on a unified graphical display for enhanced situational awareness.

Study Design and Methods:
This Research and Development project comprises several integral studies which determine design choices within the development process. The new deployable sensor system design will be driven by the results of fire chamber studies of sensor performance versus laboratory standard equipment in a variety of fire settings and mechanical performance studies under various load factors. The prototype system will be evaluated in a 'burn' building under various design fire conditions for quantitative performance of the flashover potential and onset time estimates, and for ease-of-use by firefighters. Objectives include testing the practical utility of this technology and identifying challenges that must be met before commercialization. Another component study involves assessment by firefighters who deploy the sensors and by incident commands must interpret the situational display. To achieve this, debriefings of firefighters involved in the burn building experiments and focus group discussions will be employed.

Results(projected):
The proposed one year program integrates, for the first time, a unique firefighter 3-D location and physiological stress monitoring system with real-time monitoring of interior sector environmental conditions. This type of improved situational awareness was judged to have the highest group priority and symposium ranking on the National Fire Service Research Agenda. Improving protective equipment, fitness, education and training alone does not address the root cause – this requires warning of overexertion or incapacitation before it is too late; and precise location of the user on the fireground. Current fire equipment does not do this, while the proposed system will address creation of a firefighter specific system aimed at important causes of injury and death in structure fires. Results will be disseminated by the end of 2010.

Conclusion (projected):
We intend to demonstrate that deployable, dynamic thermal sensors can be used in conjunction with location/ physiological information to greatly enhance situational awareness and to provide sufficient advanced warning of impending flashover and other thermal threats so as to greatly impact firefighter safety in structural fires.

FY 2008 FP&S R&D Grant Award

Project Title:	SuperCritical Air Mobility Pack (SCAMPER) - Development of an Integrated SuperCritical Breathing Apparatus and Powered Air Purified Respirator with Operator Cooling
Organization:	Colorado State University
Principle Investigator:	Thomas H. Bradley, PhD
Grant Number:	EMW-2008-FP-02216
Award Total:	$ 916,923
Period of Performance:	08/7/2009 -11/09/2011
Grant Status:	Closed

Abstract

Purpose and Objectives:
Heat stress is one of the recognized factors that can immediately debilitate emergency responders and cause long-term cardiovascular health problems. The cause of heat stress among responders is the fully encapsulated ensemble which protects user from the outside environment. This clothing cannot remove the metabolic heat being produced by the user, causing heat stress.

This proposal describes a plan for research and development of a combined breathing apparatus which provides supplied and purified air with integrated body cooling to firefighters for a period of up to four hours. This system, named SCAMPRER, is made up of a supercritical, cryogenic air supply module, an integrated Powered Air Purifying Respirator, and a cooling suit with heat exchanger to both the cryogenic air and a thermo-electric cooler. SCAMPRER takes advantage of synergies among its components to reduce the parts count, complexity, weight, and cost of providing these features to firefighting personnel.

The purposes of this work are to improve state of the art of firefighter personal protective equipment, to improve the situational awareness of firefighters to environmental and physiological conditions, to reduce the heat stress experienced by firefighters in the line of duty, and thereby to reduce the incidence of cardiovascular disease due to heat stress.
The societal objectives of this work are to advance the technology of integrated SCBA/body cooling technologies to achieve widespread use by first responders. The academic objectives of this work are to understand and quantify the capabilities of a state-of-the-art SCBA/body cooling system to achieve the goals of reduction in user heat stress.

Study Design and Methods:
This proposal will accomplish these goals by first performing applied research on the system design and integration of the SCAMPRER unit. This research will define the component scaling, synthesis and product design of the SCAMPRER so as to realize an robust system design. Second, the SCAMPRER system will be developed, constructed and then subjected to rigorous testing for usability, robustness, production cost minimization and functionality for both heat stress reduction and improved supplied air duration. Finally, the SCAMPRER system will undergo NIOSH certification to enable its implementation in the field.
This research and development proposal is a joint proposal between Colorado State University

(CSU) and Niwot Technologies. This study is performed with the explicit cooperation of the Poudre Fire Authority (PFA).

Results (projected):
The experimental and analytical outcomes from this research will be as follows: Pre-NIOSH Testing–Measured characteristics of the unit will include a quantification of the thermal, reliability and air-storage performance of these baseline units.
NIOSH Testing–The cryogenic air storage and cooling units will be subjected to the NIOSH validation test. The full suite of test data from NIOSH will be analyzed.
SCAMPRER Lab Testing-Niwot Tech. and CSU will develop a facility for development and testing of the SCAMPRER. Measured characteristics of the unit will include a quantification of the thermal, reliability and air-storage performance of these next-generation units.
SCAMPRER Field Testing–Niwot Tech., CSU and PFA will develop a test protocol that is responsive to the uses anticipated by the PFA and to the protocols used by NIOSH. The data will be acquired and analyzed so as to inform the commercialization and design review tasks.

Conclusions (projected):
Addressing the problems of heat stress and environmental protection of firefighters will require the development of new technologies and systems that can provide significant improvements to the current state of the art. This proposal responds to the calls for action from the NFFF research agenda with a development study that will support the implementation and commercialization of integrated air supply/cooling technologies in the short-term.

FY 2008 FP&S R&D Grant Award

Project Title:	Escape Rope Performance and Design in Fireground Application
Organization:	The Board of Trustees of the University of Illinois, Urbana-Champaign
Principle Investigator:	Gavin P. Horn, PhD
Grant Number:	EMW-2008-FP-02504
Award Total:	$ 724,759
Period of Performance:	07/31/2009 - 1/30/2013
Grant Status:	Closed

Abstract

Purpose and Objectives (with rationale):
Escape rope systems provide a critical lifeline for firefighters who are trapped by oncoming fire on elevated floors. Fatalities and severe injuries continue to occur when firefighters attempt to jump to safety from as low as the third floor when reliable escape rope systems are not available. Despite this fact, the escape rope systems that are on the market are not required to be tested in conditions that are representative of the likely service environment, so there is no scientifically-based confidence in the fitness for duty of these systems. The purpose of this study by the research team lead by the University of Illinois' is to bridge this gap in what is known about escape rope systems. We will develop and validate standardized tests to quantify the strength of escape rope systems deployed at elevated temperatures and with sharp bends and provide a reliable measure of the time available for rescue from these escape rope systems. We propose to design and test alternative solutions to reduce the high temperature strength loss to increase available escape time prior to system failure. Finally, we will broadly disseminate these findings through a wide range of mechanisms to raise awareness in the Fire Service and suggest modifications to the NFPA 1983 standard.

Study Design and Methods:
We propose to develop a standard methodology for testing temperature sensitivity and bend sensitivity by modifying a uniaxial screw-driven machine. Data will be collected over a range of temperatures and bend radii on four different commercially available escape ropes. The main effects of rope construction and temperature/ bend radius on rope strength will be analyzed within the rope samples. At the same time, the reliability of the rope systems will be computed via analysis of the strength distribution and loading distribution. The team will also develop two methods to determine available safe on-rope time by adapting standard creep test frames. Intersample differences in ASOT time and the reliability of the ropes will be computed from this data. Finally, the battery of tests will be repeated for a series of ropes that are treated with an intumescent coating that should provide an insulative layer and incrase the ASOT tiem for this rope.

Results (projected):
We hypothesize that:
1. Strength of escape rope systems will decrease dramatically as temperature is increased.
2. Strength of escape rope systems will decrease dramatically as the bend radius decreases.

3. Available safe on-rope time for the escape rope systems will decrease dramatically as the temperature increases.
4. Rope systems treated with an intumescent coating will provide longer ASOT for firefighters allowing more time for rescue from the rope.

Conclusions (projected):
We project that our conclusions will validate the need for escape rope testing in conditions which accurately and reliably replicate the service environments. These tests will provide the Fire Service with data regarding likely service limitations, and will be formalized for standardization for NFPA 1983. Finally, escape rope systems can be coated with an intumescent material that will reliably protect the ropes from high temperatures, allowing longer ASOT.

FY 2008 FP&S R&D Grant Award

Project Title:	National Firefighter Sleep Disorders Management Program: Translation to Practice
Organization:	The Brigham and Women's Hospital, Inc.
Principle Investigator:	Charles Czeisler, PhD, MD
Grant Number:	EMW-2008-FP-02566
Award Total:	$ 1,000,000
Period of Performance:	08/21/2009 - 08/20/2012
Grant Status:	Closed

Abstract

As part of the DHS/FEMA Assistance to Firefighters Grants Program, we are currently conducting a study entitled 'A Comprehensive Firefighter Fatigue Management Program: Operation Healthy Sleep' (OHS) that aims to develop a novel sleep disorders detection and treatment program to improve health, safety, and productivity of firefighters. The program includes sleep health education, caffeine-use education and a large-scale screening, diagnosis and treatment program for clinical sleep disorders. We are currently conducting demonstration projects in two major fire departments using a randomized clinical trial design to evaluate the overall impact of this health promotion program on firefighter health and safety. Approximately 1500 firefighters will attend the educational component of the program and be offered screening for sleep disorders. A similar program for police officers revealed a particularly high prevalence (~40%) of clinical sleep disorder risk, with obstructive sleep apnea and insomnia the most prevalent. The police treatment initiative was highly successful, with over 170 previously undiagnosed police officers initiating treatment for sleep disorders from more than 1200 officers screened, which represents a very high success rate for a workplace health intervention.

The current program is labor-intensive, however, requiring sleep researchers to provide the program. While this method is appropriate for demonstration projects, it is not a sustainable model for implementation nationally. The aim of this proposed Research to Practice project is to evaluate the optimal dissemination strategy to provide OHS to firefighters nationally. In addition to the data from the sleep-researcher-led model, we aim to evaluate formally the acceptability, feasibility and health and safety impact of the program using two other methodologies: 'train-the-trainer', where we will train the existing Fire Department Training teams and provide them with all the necessary education and materials for conducting the OHS program 'in-house'; and an entirely web-based version of the program, where the educational materials will be presented on-line using high quality video and interactive tools, followed by an on-line screening survey with automated sleep disorder risk feedback, printable additional information and automated referral to American Academy of Medicine-certified sleep clinics.

In this current application, we propose to conduct a detailed evaluation of the OHS program and to investigate the advantages and disadvantages of our three implementation approaches. The effectiveness of the OHS program will be evaluated using the program participation rate, the knowledge gained on sleep health, and the percentage of individuals who seek treatment following identification of being at high risk for a sleep disorder. Moreover, by conducting a series of focus group interviews with the stake-holders in the program and performing a cost

benefit analysis, we will seek to further understand how the different methodologies influence the effectiveness. Finally, we will formally evaluate the acceptability, feasibility and sustainability of the OHS program using the RE-AIM (Reach, Effectiveness, Adoption, Implementation, and Maintenance) model. The final target deliverable for this study is to produce a validated, cost-effective education, screening and treatment toolbox that is demonstrably beneficial for improving the health and safety of the two million firefighters nationwide, and the public whom they serve.

FY 2007 Awards

FY 2007 FP&S R&D Grant Award

Project Title:	Reducing Occupational Hearing Impairment in Firefighters
Organization:	The Regents of the University of California, San Francisco
Principle Investigator:	Oisaeng Hong, Ph.D, RN
Grant Number:	EMW-2007-FP-00785
Award Total:	$ 999,965
Period of Performance:	05/12/2008 - 09/30/2012
Grant Status:	Closed

Abstract

Purposes and Objectives:
Firefighting is one of the most hazardous occupations, with work-related injury rates exceeding those for most other industries. The U.S. Bureau of Labor has reported that firefighting ranks among the top 10% of occupations in terms of total annual cost and average cost per worker of occupational injuries and illnesses. Noise-induced hearing loss (NIHL) is a significant occupational injury for firefighters (FFs). Approximately one in five FFs suffer hearing loss that results from intermittent noise exposure on the job. It has also been suggested that hearing loss can put FFs at risk for other types of injuries by reducing their ability to hear warnings. Reducing NIHL among FFs has the potential not only to improve quality of life and work safety, but also to reduce morbidity and mortality.

The purpose of the proposed study is to develop and evaluate a theory-driven, tailored, internet-based hearing protection intervention (NOISE-e) to prevent NIHL in FFs. In addition, the study seeks to explore the relationship between noise exposure and hearing loss and occupational injuries in FFs. Objectives include: 1) to test the effectiveness of NOISE-e to increase FFs' level of knowledge about NIHL and hearing protection behavior; 2) to determine the extent of hearing loss and the association between hearing loss and occupational injuries in FFs; 3) to test and refine the Predictors of Use of Hearing Protection Model, a causal model designed to explain FFs' hearing protection behaviors; and 4) to evaluate the format and medium of internet delivery from a user's perspective.

Study Design and Methods:
This project will be conducted in three phases over three years (I) Development of NOISE-e, (II) Intervention study, and (III) Post-study evaluation of intervention. In Phase I, qualitative data on FFs' perceptions, opinions, and attitudes on use of hearing protection devices will be obtained through focus groups to guide software development. With inputs of an expert panel, the NOISE-e will be refined and pilot tested. Phase II will test the effectiveness of NOISE-e using a randomized, pretest/posttest, experimental and control group design, with post intervention measures one year following the intervention. Phase III will include evaluation of the intervention (posttest) and data analysis. The study will be conducted with over 600 FFs in collaboration with a university-based occupational health clinic and several fire departments in the Chicago area.

Results (projected):
The main projected result of the project is that the tailored NOISE-e intervention will increase FFs' level of knowledge about NIHL and will promote hearing protection behavior. In addition, it is projected that about 40% of participating FFs will show hearing loss at high frequencies, a characteristic of NIHL. The study will also reveal a significant association between hearing loss and injuries. FFs with impaired hearing will report more injuries than FFs with normal hearing. It is anticipated that participants will provide favorable feedback on NOISE-e, and that the individually tailored computer-based approach is effective for delivering interventions to a noise-exposed population.

Conclusions (projected):
Results from this study will provide data regarding the seriousness of NIHL, the importance of interventions to promote FFs' use of hearing protection devices, and the association between noise exposure and hearing loss and occupational injuries in FFs. This project is one of the first to apply behavioral theory and incorporate multimedia computer technology and the internet to develop an intervention program for FFs. Such advances are critical to reaching the large numbers of noise-exposed working individuals who are not able to receive hearing protection training at their worksites, communities or health clinics. This will facilitate reducing the prevalence of NIHL, a costly, dangerous, and potentially career-ending disability for FFs.

FY 2007 FP&S R&D Grant Award

Project Title:	Firefighters and Wellness: Building A Healthy Future Through Partnership and Science
Organization:	Johns Hopkins University
Principle Investigator:	Keshia Pollack, PhD
Grant Number:	EMW-2007-FP-01040
Award Total:	$ 1,000,000
Period of Performance:	06/13/2008 – 06/30/2012
Grant Status:	Closed

Abstract

In the United States, firefighters are the first responders to fires, medical emergencies, traffic-related crashes, and other catastrophic events that are a leading cause of morbidity and mortality. There are approximately 1.1 million career and volunteer firefighters in the U.S. (Bureau of Labor Statistics U.S. Department of Labor 2007). While highly public calamitous events have resulted in widespread admiration of firefighters for their prowess, many among the general public do not appreciate and understand the extreme danger and hazards associated with firefighting. Each year, approximately 100 firefighters die and 80,000 are injured while on duty (US Fire Administration 2006; National Institute for Occupational Safety and Health 2007). The total annual economic burden of firefighter injuries alone has been estimated between 2.7 and 7.8 billion dollars (TriData Corporation August 2004). In addition to injuries, chronic disease is also a significant risk: nearly half of the on-duty firefighter fatalities are related to cardiovascular events (US Fire Administration 2006).

Reducing firefighter fatalities from preventable cardiovascular conditions is a priority for a number of federal agencies, including the Department of Homeland Security and the National Institute for Occupational Safety and Health. This proposal addresses a need for research that informs programs and policies that aim to reduce on-duty deaths among firefighters. Based on priorities identified in the Program Guidance for the Fiscal Year 2007 Assistance to Firefighters Grant Program and by the National Fallen Firefighters Foundation, we are proposing a multi-faceted project with specific aims related to the categories of Social Science Study and Database Systems.

This proposal describes three distinct but complementary projects: 1) identifying barriers to implementing wellness and fitness interventions among firefighters and fire departments; 2) developing and testing a pilot intervention; and 3) creating a national database to facilitate the longitudinal collection of health and injury-related measures for firefighters. This project is being proposed by researchers from the Johns Hopkins Bloomberg School of Public Health, in collaboration with the National Volunteer Fire Council.

FY 2007 FP&S R&D Grant Award

Project Title:	Determination of Risk Factors for Cardiovascular Disease in Firefighters
Organization:	Arizona Board of Regents, University of Arizona
Principle Investigator:	Jeff Burgess, MD, MS, MPH
Grant Number:	EMW-2007-FP-01499
Award Total:	$ 1,000,000
Period of Performance:	07/25/2008 - 07/24/2010
Grant Status:	Closed

Abstract

Purpose and Objectives:
Sudden cardiac deaths account for 44% of the line of duty deaths in firefighters, and generally occur in firefighters with underlying cardiovascular disease, many of whom have been previously asymptomatic. Current screening tests are therefore not adequate to identify firefighters at high risk of an on-duty cardiovascular event. Electron beam computed tomography (EBCT) has become much more prevalent as a screening test for atherosclerotic heart disease, but it has never been tested for its utility in the fire service. Fire suppression carries the highest risk for cardiovascular deaths, and yet we do not understand the effects of this activity, including the contribution of smoke and heat exposure, on pathways involved in the development of a myocardial infarction. Our proposed study objectives are to evaluate the use of cardiac EBCT as a medical surveillance tool in firefighters, to determine the acute effects of fire suppression on biomarkers associated with heart attacks and to evaluate a new cooling method.

Study Design and Methods Aims:
1a) A total of 500 Phoenix and Tucson firefighters aged 40 years or older with at least 5 years of service and without known cardiovascular disease will undergo chest EBCT to determine the distribution of coronary artery calcification. 1b) Data on traditional risk factors (family history, cholesterol, HDL, LDL, triglycerides, hypertension, smoking, diabetes, exercise tolerance, BMI, and C-reactive protein (CRP)), as well as new biomarkers collected as part of the proposed study (serum interleukin 6 (IL-6), lipoprotein-associated phospholipase A2 (Lp-PLA2) and intercellular adhesion molecule 1 (ICAM-1)) will be analyzed to determine their ability to predict the presence of coronary calcification in this population using logistic regression models.
2a) The effects of fire suppression on acute measures of systemic inflammation and cardiac function will be evaluated in 50 firefighters post-exposure and at baseline. 2b) The contribution of exposure to smoke contaminants (particulates, carbon monoxide, hydrogen cyanide and aldehydes) and elevation in core body temperature (measured using an internal probe) to changes in serum sE-selectin, sL-selectin, CRP, troponin I and plasma fibrinogen will be assessed using multiple regression analysis.
3) In an interventional trial, more aggressive cardiac rehabilitation in 50 firefighters using a cooling glove at the fire scene will be tested to determine its effectiveness in reducing core body temperature and adverse cardiovascular effects as identified in specific aim #2.

Results (projected):
Based on a study of healthy individuals with similarities to firefighters (active duty U.S. army personnel aged 40-50), we expect to find coronary calcium in over 20% of firefighters. We anticipate that the addition of serum IL-6, Lp-PLA2 and ICAM-1 tests will improve our ability to predict coronary calcification in firefighters, and will provide new outcome biomarkers for potential future pharmacological intervention studies for firefighters with increased EBCT calcium scores. Based on previous studies of populations exposed to air pollution particulate matter, we also anticipate that firefighters will demonstrate biomarker activation in pathways associated with development of myocardial infarction, and that specific smoke components and heat will be positively associated with changes in these biomarkers. Improved cooling during rehabilitation should increase the rate at which core body temperature is reduced and simultaneously reduce heart rate and may mitigate changes in the biomarkers associated with myocardial infarction.

Conclusions (projected):
EBCT will improve detection of cardiovascular disease in firefighters, permitting appropriate treatment, and active cooling following fire suppression will more rapidly reduce core temperature and help prevent systemic changes in pathways leading to heart attacks.

FY 2007 FP&S R&D Grant Award

Project Title:	Firefighter Accountability Technology
Organization:	Center for Firefighter Safety Research & Development, University of Maryland
Principle Investigator:	Marino diMarzo, PhD
Grant Number:	EMW-2007-FP-01637
Award Total:	$ 355,860
Period of Performance:	08/15/2008 - 08/14/2009
Grant Status:	Closed

Abstract

Purpose:
The primary purpose of this project is to continue current research efforts started with FY05 and FY06 DHS Fire Prevention and Safety funding and further develop interoperable firefighter accountability location and monitoring devices and incorporate them into a system applicable to real world scenarios, using a combination of current and new technology. Specifically, we will continue to research and develop technology, including a novel Integrated Positioning technique, to continuously monitor the location and physiological status of firefighters, along with information about the fire, and the transmission of critical data from firefighters inside and outside buildings to a remote location. This system will provide the fire service on a national level with a reliable way to reduce the number and seriousness of fire ground-related injuries and deaths.

Methods:
In this third year of effort, work will be concentrated on further developing the mapping components of the location system. The end result will be a fieldable tracking system for firefighters. The work will involve development work to address any usability or tracking performance issues discovered in the beta testing conducted with FY06 funding, development and testing of a scalable user friendly system to enter and georeference available floor plans, as well as a system to generate and archive floor plans that are dynamically generated by user path data either at an emergency event or in preplanning visits to a building, development and testing of an interface for the incident commander to update incident information on the map such as blocked paths due to fire or other collapse that able to be used in search/evacuation path algorithms and to integrate the RSSI technology developed with FY05 and FY06 funding into the larger framework that is being developed by TRX Systems. This will allow the developed RSSI methodologies to be implemented into a commercial, robust platform.

Results (projected):
The long-term benefit of this project is to develop, and bring to market, an affordable system that is able to accurately determine the position and physiological condition of each firefighter at an incident scene and also monitor environmental factors through the development of new technologies. This system will be comprised of several devices and methods that will be operate together. Our project directly supports several of the highest priority research efforts identified during the 2005 National Fallen Firefighters Foundation (NFFF) National Fire Service Research Agenda Symposium. Through the results of this research, the fire service can expect to begin

seeing a reduction in fireground-related firefighter injuries and deaths, with less lost work time and fewer disability claims.

FY 2007 FP&S R&D Grant Award

Project Title:	Firefighter Exposures to Smoke Particulars
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Pravinray Gandhi, PhD
Grant Number:	EMW-2007-FP-02093
Award Total:	$ 995,584
Period of Performance:	05/27/2008 - 09/25/2009
Grant Status:	Closed

Abstract

This unique, problem-focused fire research study fills gaps identified in previous studies on fire fighters' exposure to combustion products. The study focuses on gas effluent and smoke particulates generated during residential structure and automobile fires and subsequent contact exposure resulting from residual contamination from personal protective equipment. Exposure to gas and particulates has been linked to acute and chronic effects resulting in increased fire fighter mortality and morbidity (higher risk of specific cancers and cardiovascular disease).

Currently gaps exist in the knowledge of the size distribution of smoke particles generated in fires and the absorbed chemicals on the particles' surfaces. Some gas effluents may condense on the protective equipment and exposed skin leaving an oily residue or film. These factors can pose a significant threat to firefighter health (e.g., skin, eye, inhalation). More research is required to document the gas effluent composition from fires involving residential construction and contents.

This project will investigate and analyze the combustion gases and particulates generated from three scales of fires: residential structure and automobile fires; simulated real-scale fire tests; and material based small-scale fire tests. Working in collaboration with University of Cincinnati College of Medicine, the data will be reviewed to assess the potential adverse health effects of the gas effluents and smoke particles to the firefighter professional.

This research has the potential to benefit the target audiences including both professional and volunteer fire services and allied safety organizations across the United States. The information developed from this research will provide a valuable background to interpret fire hazards and can be used by: (a) the medical community to advance their understanding of the epidemiological effects of smoke exposure; (b) first responders to develop situational assessment guidelines for self-contained breathing apparatus (SCBA) usage and personal protection equipment cleaning regimen; (c) organizations such as NIOSH and NFPA to develop new test method standards and performance criteria for respirators used by first responders and the care and maintenance of personal protection equipment.

The proposed research directly responds to one of Department of Homeland Security's key goals to reduce firefighter fatalities and injuries through increasing scientific understanding of fire combustion products in residential structural and automobile fires and improving firefighters awareness of potential hazards of exposure to smoke particles and gases.

FY 2007 FP&S R&D Grant Award

Project Title:	A Comprehensive Firefighter Fatigue Management Program: Operation Healthy Sleep
Organization:	The Brigham & Women's Hospital, Inc.
Principle Investigator:	Charles Czeisler, PhD
Grant Number:	EMW-2007-FP-02197
Award Total:	$ 1,000,000
Period of Performance:	06/13/2008 - 12/12/2011
Grant Status:	Closed

Abstract

Firefighters work some of the most demanding schedules known under highly stressful and demanding conditions. The need to work frequent extended shifts and long work weeks leads to acute and chronic partial sleep deprivation as well as misalignment of circadian phase. Firefighters on-call overnight are also particularly susceptible to sleep inertia, the cognitive impairment experienced immediately upon waking. The public expects firefighters to be available around-the-clock and to perform flawlessly when called upon, but 24/7 coverage, by definition, leads to severe sleep deprivation which significantly degrades firefighters' ability to react and think quickly, to make good decisions, or to recognize when fatigue is impairing their own performance and safety. In addition, it is likely that a significant proportion of firefighters suffer from undiagnosed sleep disorders which will further impair their sleep and exacerbate fatigue.

Sleep disorders are common, costly, and treatable, but often remain undiagnosed and untreated (1). A recent survey that we conducted in over 5000 police officers found that 40% of active officers were at high risk of a primary sleep disorder, particularly obstructive sleep apnea (OSA) (see Preliminary Results). OSA is a serious disease caused by obstruction of breathing during sleep that leads to repeated awakenings, disrupted sleep and daytime fatigue. It is most prevalent in middle-aged men, and risk of OSA increases with increased weight. We anticipate that firefighters will have a similar risk of OSA to police officers. Furthermore, sleep deprivation, due to any reason, significantly degrades cognition, alertness, reaction time and performance and leads to an increase the risk of injury due to motor vehicle crashes, which is an important occupational risk for firefighters. Sleep disorders and sleep deprivation also adversely affects personal health longer-term, increasing the risk of hypertension, stroke and cardiovascular disease, and impairing glucose metabolism, increasing the risk of obesity and diabetes.

We hypothesize that the additional stress experienced by firefighters combines with the effects of sleep deprivation to further exacerbates these disease risks in firefighters compared to others who work in 24/7 professions.

In the current proposal, we aim to address the health, performance and safety issues related to fatigue in firefighters and test the effectiveness of a Comprehensive Firefighter Fatigue Management Program (CFFMP) that we have termed 'Operation Healthy Sleep.' Motor vehicle crashes and heart attacks are the two leading causes of death in firefighters (2) and sleepiness and sleep disorders have been shown to increase the risk of both. The goals of this program are to

reduce the adverse consequences of fatigue on firefighters' health, safety, and performance. We have assembled an experienced, multi-disciplinary team that has carried out landmark workplace health promotion programs in the field of sleep medicine, including the implementation of similar programs in several police forces.

The overall goal of our team will be to develop and test the effects of a sleep health and sleep disorder detection and treatment program specifically designed for firefighters that can be disseminated to practitioners, policymakers and researchers nationwide to reduce firefighter fatigue, stress and disease; treat serious undiagnosed sleep disorders; enhance the ability of firefighters and their families to cope with difficult work schedules; and ultimately improve the health, safety and performance of firefighters, and improve the safety of the public whom they serve.

Specifically, we propose to use a station-level, randomized experimental design to test the hypotheses that implementation of a Comprehensive Firefighter Fatigue Management Program will:

1. improve the mean total sleep, alertness and cognitive performance of firefighters;
2. improve firefighter safety, as determined by:
a. decreased rates of motor vehicle crashes;
b. decreased on-the-job injuries;
3. improve firefighters' performance, as determined by decreased response time;
4. improve firefighters' health, as determined by:
a. diagnosis and treatment of sleep disorders
b. improved general health indices
c. decreased number of 'sick' days
5. improve firefighters' and families' job satisfaction and ability to cope with extended work hours.

FY 2007 FP&S R&D Grant Award

Project Title:	Changes in Cardiovascular Function as a Result of Prolonged Firefighting
Organization:	The Board of Trustees of the University of Illinois, Urbana-Champaign
Principle Investigator:	Gavin P. Horn, PhD
Grant Number:	EMW-2007-FP-02328
Award Total:	$985,661
Period of Performance:	06/20/2008 – 01/19/2011
Grant Status:	Closed

Abstract

Purpose and Objectives:
Firefighter fatalities and injuries continue to plague the Fire Service. Over the past 10 years, approximately 40-50% of deaths in the line of duty have been attributed to heart attacks. Additionally another 600-1,000 Firefighters suffer non-fatal heart attacks in the line of duty each year. Whereas sudden cardiac events are responsible for the majority of line of duty deaths each year, the "cause" of these cardiovascular deaths is routinely attributed to "overexertion". Yet, it is unclear both how "overexertion" leads to sudden cardiac events and why some individuals are vulnerable to "overexertion" whereas others are not.

We propose a study with the following Specific Aims:
1. To document changes in cardiovascular function (specifically heart function, vascular function, hemostatic balance, and inflammatory/vascular biomarkers that mediate the interaction of cardiovascular variables) as a result of prolonged fire fighting activities.
2. To examine the ability of individual cardiovascular measures (carotid intimal thickness, endothelial function) to predict firefighters who will have an exaggerated/high risk, cardiovascular response to fire fighting activity.
3. To explore the effectiveness of preloading with Vitamin C (a powerful antioxidant) to improve cardiovascular function and lower cardiovascular risk at rest and following fire fighting activity.

Study Design and Methods:
We will use a double-blind randomized control trial to investigate the effects of Vitamin C. supplementation on cardiovascular function (heart, vessels, blood and inflammatory markers) of firefighters before and after prolonged fire fighting activity. Firefighters will be measured before fire fighting activities and immediately following 3-4 hours of fire fighting drills performed in training structures that contains live fire.
Before and after firefighter, heart function will be assessed through: a myocardial function assessment; a cardiac systolic and diastolic function test; Color Tissue Doppler imaging; and pulse contour analysis-derived indices of cardiac function. Vascular function will be assessed through measurement of Augmentation Index, regional arterial stiffness, carotid artery compliance and β-stiffness index, and microvascular function. A venous blood sample will be drawn from the anticubital vein by a trained phlebotomist. Blood samples will subsequently by analyzed to assess hemostatic balance and measures of inflammatory and vascular biomarkers.

Results (projected):
We anticipate that our analysis will show significant effects of vitamin C supplementation following fire fighting as follows:
*A greater decrease in carotid artery stiffness in the Vitamin C group
*A greater decrease in central aortic stiffness and augmentation index in the Vitamin C group
*A greater decrease in left ventricular function in the Placebo group
*A greater increase in microvessel vasodilatory capacity (endothelial function) in the Vitamin C group
*A lesser increase in coagulatory markers in the Vitamin C group
*A greater increase in fibrinolytic markers in the Vitamin C group
*A greater change in platelet function in the Placebo group

Conclusions (projected):
With a comprehensive physiological model that is attentive to the intricate interactions between the components of the cardiovascular system, and employing sophisticated equipment and research techniques to accurately quantify the most important changes in cardiovascular function, this research project will directly address sudden cardiac events - the leading source of line of duty deaths in the fire service. The proposed project will also test an intervention that holds promise to have a potent protective effect on the cardiovascular variables of interest. If effective, this Vitamin C intervention is an attractive intervention for the fire service because it is safe, readily available, and inexpensive.

FY 2007 FP&S R&D Grant Award

Project Title:	Effectiveness of Pre-Applied Wetting Agents in Prevention of Urban Wildland Interface Fires
Organization:	University of North Carolina Charlotte
Principle Investigator:	Jozef Urbas, PhD
Grant Number:	EMW-2007-FP-02372
Award Total:	$ 456,249
Period of Performance:	08/22/2008 - 08/21/2011
Grant Status:	Closed

Abstract

Urban Wildland Interface (UWI) fires have become a serious problem in the United States and pose a serious threat to firefighters. Fatalities and injuries most often occur from exertion and stress typical for situations when firefighters are understaffed or when firefighters are trapped by fire progress.

The use of pre-wetting of vegetation, dead fuels, and structures has been found to be an efficient way to prevent the spread of UWI fires and thus reduce firefighter casualties and injuries. Correct application of wetting agents and self-contained pre-wetting systems can be an extremely valuable approach for mitigating UWI fires and safeguarding firefighters. However, the use of pre-wetting systems can only be successful if their performance and efficiency is systematically examined and well understood for the applicable range of UWI fire conditions. The design of a successful pre-wetting system that delivers a wetting agent prior to a UWI fire arrival is not possible without proper engineering, and proper engineering is not possible without the scientific knowledge about the performance and effectiveness of the agents in various UWI fire situations.

This research evaluates and quantifies the performance and effectiveness of pre-applied wetting agents in prevention of UWI fire spread to structures in firefighting of residential, wildland, and other structural fires. We will evaluate the fire performance of three categories of wetting agents (water, Class A foams and gels) on vegetation fuels surrounding structures and structural materials and assess the effectiveness of these wetting agents on fire spread and ignition prevention. The evaluation and assessment will be achieved through the determination of required amounts of wetting agents applied to individual plants and building structural elements as well as the timing of the application before the arrival of the fire front to account for water evaporation and run off. A series of well-instrumented tests will be conducted where typical regional water-stressed plants and structural elements, pre-wetted with wetting agents, will be exposed to fire conditions similar to those encountered during a UWI fire exposure. The Intermediate Scale Calorimeter will be used to provide the fire exposure in laboratory conditions. The results of the laboratory tests will be verified on a series of full-scale outdoor tests.

Data collected from these tests will be used to develop a testing standard for evaluating UWI wetting agents, and to design and construct an educational module that will be disseminated to fire services within North Carolina and nationwide. The fire service and building owners can immediately transfer the research results into special extinguishing agent purchasing decisions

and firefighting tactics related to the use of wetting agents to increase the level of firefighter safety involving UWI fires.

FY 2007 FP&S R&D Grant Award

Project Title:	Designing a Health, Wellness and Fitness Minimum Data Set for the Fire Service
Organization:	University of Maryland, Baltimore
Principle Investigator:	Carrie Dorsey, M.D.
Grant Number:	EMW-2007-FP-02380
Award Total:	$ 812,029
Period of Performance:	07/18/2008 - 03/01/2010
Grant Status:	Closed

Abstract

Specific Aims:
To prevent injuries, protect the health and safety and promote the wellness of fire fighters by assisting fire departments in the design and implementation of a health/wellness/fitness data base that will enable tracking of medical, work-related and fitness factors with health outcomes, injury and disease occurrence.

Building on preliminary work completed by the International Association of Fire Fighters (IAFF) Wellness- Fitness Initiative (WFI), the aims of this project will be accomplished by:

1) Crafting and refining a Minimum Data Set (MDS) of health/wellness/fitness data for individual fire fighters;
2) Building and implementing a web-based platform to support and maintain the MDS data base allowing remote access; and
3) Piloting implementation in two fire departments which will demonstrate the feasibility of collecting the MDS elements of individual department members at the local level and up-loading the data to the web-based platform, as a prelude to national implementation.

FY 2007 FP&S R&D Grant Award

Project Title:	Hearing Loss: SAFIRE: Situational Awareness for Firefighters
Organization:	Regents of the University of California, Irvine
Principle Investigator:	Sharad Mehrotra, PhD
Grant Number:	EMW-2007-FP-02535
Award Total:	$ 999,971
Period of Performance:	05/27/2008 - 08/26/2010
Grant Status:	Closed

Abstract

Emergency responders in all roles must process information, make critical decisions, take appropriate actions, and communicate effectively with others around them in order to preserve the safety of firefighters. These activities must be accomplished under dynamic and dangerous conditions where time is of the essence, and rarely with complete situational awareness. When a high level of situational awareness is achieved, more informed decisions can be made, resulting in much more effective actions and better management of risks. The quality of situational awareness that exists throughout all levels of the emergency response hierarchy has a direct impact on the safety of individual firefighters.

Achieving situational awareness requires acquisition of knowledge of past events, an in-context understanding of present circumstances, and anticipation of future events. It also requires a high degree of communication and coordination up-and-down the chain of command, as well as between peers, whether the peers are individual firefighters, incident commanders, or cities within an operational area. Situational awareness is traditionally defined as three increasing levels of understanding of a situation (Figure 1). The seminal work by Endsley [1] identifies the three levels as (1) perception, where elements of the current situation are observed, 2) comprehension, where information obtained through observation is combined and interpreted, and 3) projection, where sufficient information and understanding exists to make predictions about impending events.

Fire responders are well aware of the importance of actionable situational awareness. Extensive efforts are made to ensure decision makers such as incident commanders have timely access to accurate and reliable information about the incident, the state of the infrastructure, and of available resources. However, a number of factors [2, 3] work against maintaining situational awareness in the context of fire response. These include incomplete, inaccurate, or uncertain information, as well as lack of information prioritization, incomplete sharing of information, and cultural factors. Achieving and maintaining situation awareness throughout an incident is often a difficult task, but it has an immediate and direct impact on the health and safety of firefighters.

This proposal lays out a plan for the research, development, and evaluation of a next-generation, end-to-end situational awareness system that empowers individual firefighters, incident commanders and emergency / department operations center staff to make effective decisions in dynamic environments. The key deliverable is a Fire Incident Command Board (FICB) through which the user can establish and maintain situational awareness utilizing a wide range of sensor and data streams from the field as well as existing centralized information systems such as CAD

and GIS. The FICB prototype that will be delivered as a result of the project will be specifically targeted towards the needs of an incident commander. We anticipate that future efforts could expand upon the FICB prototype created during this project in order to provide FICB variants specific to needs of other users, e.g. planning and intelligence analysts in EOCs.

Other groups are attempting to improve situational awareness in the context of firefighting by developing new types of messaging systems linking firefighters [4], on-demand networks delivering information to firefighters via displays integrated in their equipment [5, 6], and improved firefighter localization devices. While these approaches are all useful, we believe many of the most direct and dramatic impacts of situational awareness on firefighter safety can be achieved at the incident commander level. We therefore focus the majority of our effort on needs specific to that role, with the expectation that future projects may expand this work significantly to other roles. The proposed system will address basic communication of relevant information between the incident site and regional operations centers, and will enable distribution of relevant situational awareness to individual firefighters; however, full implementation of this functionality will require substantial research and engineering effort which is outside the scope of this proposal.

The focus of the proposed research and system development activity will be on situational awareness technologies which can feasibly have a high impact in the near term. A high priority will be placed on ensuring the processes and systems developed can be easily incorporated into existing firefighting standard operating procedures (SOPs) with minimal or no changes. Since this system is intended to supplement and/or replace some procedures which today are highly reliable due to their low-tech implementation (e.g. writing with dry erase marker), special considerations will be made to establish redundancies and fallback mechanisms to insure potential system failures themselves do not negatively impact firefighter safety. This will also facilitate field testing and evaluation of the system in late-prototype stages as it will be able to be run side-by-side with current procedures and tools. Additional priorities will be placed on utilizing existing, off-the-shelf components, considering compatibility with existing information and communications systems, and minimizing deployment and maintenance costs of the system in order to make it accessible to as many fire response organizations as possible.

FY 2007 FP&S R&D Grant Award

Project Title:	FIRE Study: A Prospective Evaluation of Health Behavior Risk for Injury Among Firefighters
Organization:	National Development and Research Institutes, Inc.
Principle Investigator:	Sara Jahnke, PhD
Grant Number:	EMW-2007-FP-02571
Award Total:	$ 999,806
Period of Performance:	05/27/2008 – 01/31/2011
Grant Status:	Closed

Abstract

Rates of cardiovascular disease (CVD) and line of duty injuries (LODI) are at epidemic proportions among fire service personnel. Both CVD and LODI and their risk factors are key determinants of a lack of fitness for duty in the fire service. Previous research has largely focused on how exposures during calls and protective equipment impact CVD and LODI. However, it is likely that health behavior factors, in addition to line-of-duty activities, have strong independent influences on the high rates of CVD and LODI observed among fire service personnel. Research among similar populations such as United States (U.S.) military personnel has demonstrated that targeted epidemiological surveillance systems are crucial to identifying key modifiable causes for disease and injury and the effective planning of prevention programs. Unfortunately, no mandated systematic health surveillance program exists for the fire service and our knowledge of causes for disease and injury among fire personnel is limited. For example, the joint Health and Wellness Initiative of the IAFF and the IAFC collects health data on firefighters from departments that voluntarily contribute information to the program. However, participation in this program is voluntary and participation levels currently are unknown. The Safety, Health and Survival Section of the International Association of Fire Chiefs supports the Kansas City University of Medicine & Biosciences proposal to improve firefighter health and wellness by establishing a surveillance system that not only would describe the extent of firefighter health issues, such as injury in the line of duty, but also would provide insight into what health behaviors might be contributing to increasing risk for these outcomes

This lack of data represents a critical gap in efforts to ensure that fire service personnel are ready to respond when deployed, a very significant issue since the fire service provides emergency health care and disaster response. The purpose of this research is to provide the empirical groundwork for a health surveillance tool for the fire service and to examine key risks for CVD and LODI using both a cross-sectional and a prospective cohort study. This research is based on our team's similar work over the past decade with the U.S. military and on our formative research among fire departments in the Midwest. Importantly, the design of this proposal was developed with significant input from important national advisory groups such as the International Association of Fire Chief's Safety, Health, and Survival Section. Unique strengths of this application include strong support from the national fire service community, a successful history of epidemiological research supporting the health and readiness of first response personnel, and an outstanding team of epidemiologists, behavioral scientists, biostatisticians, and exercise physiologists.

FY 2007 FP&S R&D Grant Award

Project Title:	Effect of Physical Fitness on Physiological Recovery from Firefighting Duties
Organization:	Skidmore College
Principle Investigator:	Denise Smith, PhD
Grant Number:	EMW-2007-FP-02581
Award Total:	$999,342
Period of Performance:	06/18/2008 – 12/17/2010
Grant Status:	Closed

Abstract

Background:
It is well known in the Fire Service that sudden cardiac death (SCD) is the leading cause of line of duty deaths. Physical fitness is a critical component to being able to perform the strenuous work of firefighting and to do so without undue risk of suffering a heart attack. Major organizations, such as the IAFF, IAFC, NVFC have investigated a great deal of resources into encouraging physical fitness. However, there is a glaring lack of scientific research to document the role that specific types of physical fitness play in modulating the cardiovascular response to firefighting or the period following firefighting when firefighters appear to be most susceptible to SCD. We believe that the mechanisms by which firefighting leads to SCD are mediated largely by sympathetic nervous stimulation due to psychological stress, neurohormonal changes due to physical exertion, and changes in vascular function and coagulatory potential due to the combination of sympathetic nervous stimulation, neurohormonal changes, and hyperthermia. The magnitude of the physiological response to firefighting (the degree of sympathetic activation, exertion, and hyperthermia) is influenced by multiple factors, including, cardiovascular risk factors, work requirements, environmental factors, and physical fitness. This project will focus on physical fitness as a modulator of cardiovascular responses and recovery.

Purpose/Objectives:
This integrated research project will study the physiological changes that occur during firefighting and the vulnerable period following firefighting activity, and the role of specific physical fitness in modulating those responses. Additionally, we will: 1) provide physiological data specific to firefighting duties that encourage adoption of physical fitness programs tailored to the demands of firefighting and 2) investigate the extent to which a wearable device can provide useful information about the degree of physiological strain during firefighting activities and recovery.

Study Design/Methods:
The project includes two closely linked studies: a field study and a laboratory study. The field study will stratify career firefighters (Oxnard, CA) into 3 fitness groups (aerobically trained (AT), strength trained (ST) and untrained (UT). Firefighters will wear a physiologic status monitor, PSM (Foster-Miller Inc.) for a week of duty each month, over the course of one year. The PSM will gather heart rate (HR), heart rate variability (HRV), respiration rate (RR) skin temperature and activity data. PSM data will be analyzed for up to 60 minutes after firefighting. This study is unique in providing physiological data on a large number of firefighters and fire

calls over an extended period. In the laboratory study, aerobic (AT) and strength trained (ST) subjects will participate in 2 exercise trials – exercise (EX) and exercise in turnout gear (EX+G). Participants will perform a standardized workload during which oxygen consumption, HR, and RR will be measured. During the 2-hour recovery core temperature, autonomic nervous system function, neurohormonal, and cardiovascular variables that are related mechanistically to SCD will be measured.

Anticipated Results/Conclusions:
AT individuals will have a faster recovery of autonomic function in both the field and laboratory study than ST or UT. Furthermore, AT individuals will have less physiological disruption and faster recovery in all cardiovascular, neurohormonal and coagulatory variables in the laboratory study. We will investigate physical fitness as a modulator of cardiovascular strain associated with firefighting and recovery, and study the effectiveness of a wearable device to provide meaningful data about the degree of physiological strain during and following firefighting activities. We plan to develop a firefighter-specific ideal fitness profile, including guidelines for specific fitness elements, and to share these ideas broadly in the Fire Service.

FY 2007 FP&S R&D Grant Award

Project Title:	High-Performance Fire Blankets for Suppression and Protection
Organization:	Case Western Reserve University
Principle Investigator:	Fumiaki Takahashi, PhD
Grant Number:	EMW-2007-FP-02677
Award Total:	$ 999,998
Period of Performance:	05/12/2008 - 09/11/2011
Grant Status:	Closed

Abstract

Purpose and Objectives:
The purpose and objectives of this project are to advance the fire blanket technology and, more specifically, to develop, design, and fabricate integrated fire blankets and their deployment systems, specifically optimized for (1) housing structure protection in wildland-urban interface (WUI) fires and (2) aviation fuel pool fire suppression. If a large sheet of fire blanket made of materials suitable to protect structures from radiative and conductive heat transfer and subsequent ignition is developed with an appropriate deployment system, a probability of destruction of high-valued homes in WUI fires can be reduced. Aviation fuel pool fires occur on the ground at airport as a result of fuel leakage from aircraft, a tank truck, or a storage tank due to accidental (e.g., mechanical failure, overruns, ground collisions) or manmade (e.g., maintenance error, terrorism) causes. If multiple sheets of fire blankets suitable for liquid fires are deployed quickly, the hot fuel surface can be covered and separated from air, the fire underneath the fuel tank can be controlled and suppressed, and thus a further disaster can be prevented.

Study Design and Methods:
This experimental R&D consists of two phases: (1) surveying and developing fire blanket materials and their combinations with testing and (2) designing and fabricating the deployment system prototypes for the two applications. The experimental work in this project consists of three types of systematic laboratory-based tests: (1) flammability and heat-transfer tests of sample materials combinations using standard test procedures, (2) fire protection tests, and (3) fire suppression tests. The instrumentation includes, visible and IR thermography video recording, time-resolved radiometer, temperature, and heat-flux measurements.

Results (projected):
The physical and performing characteristics testing of materials and their combinations will lead to prototype fire blankets with deployment systems, specifically optimized for (1) housing structure protection in WUI fires and (2) aviation fuel pool fire suppression. The results of this project will be disseminated through peer-reviewed journal publications and technical conference presentations. The technology transfer and implementation of the target outcomes into commercial products can be achieved through the CWRU Technology Transfer Office (beyond the scope of the current proposal).

Conclusions:
If successful, this R&D effort will give significant technological and economical impacts. The proposed new uses of fire blankets for structure protection in WUI fires and aviation fuel fire suppression may revolutionize firefighting strategies in these catastrophic fire scenarios. Protecting structures and communities is a major component of the current $3 billion annual cost of wildland fuel treatment and wildfire suppression in the U.S. A Federal financial assistance is needed to enable this innovative technology R&D to enhance the safety of the public and firefighters with respect to fire and fire-related hazards.

FY 2006 Awards

FY 2006 FP&S R&D Grant Award

Project Title:	Project 1: Firefighter Accountability Technology Project 2: Physical Assessment and Screening of Firefighters
Organization:	Center for Firefighter Safety Research & Development, University of Maryland
Principle Investigator:	Marino diMarzo, PhD
Grant Number:	EMW-2006-FP-00471
Award Total:	$915,474
Period of Performance:	8/3/2007-11/2/2008
Grant Status:	Closed

Project 1 - Firefighter Accountability Technology Abstract:
The primary purpose of this project is to continue current research efforts and further develop interoperable firefighter accountability location and monitoring devices and incorporate them into a system applicable to real world scenarios, using a combination of current and new technology. Specifically, we will research and develop technology, including a novel Integrated Positioning technique, to continuously monitor the location and physiological status of firefighters, along with information about the fire, and the trasmission of critical data from firefighters inside and outside buildings to a remote location. This system will provide the fire service on a national level with a reliable way to reduce the number and seriousness of fire ground-related injuries and deaths.

Anticipated Results:
The long-term benefit of this project is to develop, and bring to market, an affordable system that is able to accurately determine the position and physiological condition of each firefighter at an incident scene and also monitor environmental factors through the development of new technologies. This system will be comprised of several devices and methods that will be operate together. Our project directly supports several of the highest priority research efforts identified during the 2005 National Fallen Firefighters Foundation (NFFF) National Fire Service Research Agenda Symposium. Through the results of this research, the fire service can expect to begin seeing a reduction in fireground-related firefighter injuries and deaths, with less lost work time and fewer disability claims.

Project 2 - Physical Assessment and Screening of Firefighters Abstract:
The primary purpose of this project is to improve screening procedures of candidate firefighters on a national level as a means to reduce the number and severity of injuries and death,improve the quality and safety of performance in firefighter recruits,develop better screening procedures for recruits,provide better information to recruits and trainers concerning the physical attributes most important for firefighting,establish a scientific basis for individualized exercise training programs for recruits and experienced firefighters,and to reduce the cost of screening and training recruits. To accomplish these goals we will determine the fitness and body composition attributes most important for optimal performance in the CPAT and simulated firefighting tasks.

Anticipated Results:
This project will provide a scientific basis for better screening and being able to specify the qualities needed for success in major aspects of job performance. Implementing the results of this study into policy in combination with enforcement of medical screening procedures, a reduction in adverse events (e.g., injury, exertion-induced heart attacks, etc) are expected. The results should help to provide better and safer progressions of recruits by ensuring that they possess the necessary prerequisite physical or functional qualities for safe performance. This translates into a reduction in lost work time and disability claims, and improved quality of life for firefighters. The cost savings associated with a reduction of injuries and deaths can be measured in the millions of dollars.

FY 2006 FP&S R&D Grant Award

Project Title:	Project 1: Thermal Capacity Evaluation of Fire Fighter Protective Clothing Project 2: Examining Fire Fighting Tactics Under Wind Driven Conditions
Organization:	Fire Protection Research Foundation
Principle Investigator:	Casey C. Grant, P.E.
Grant Number:	EMW-2006-FP-00636
Award Total:	$ 991,040
Period of Performance:	07/27/2007 - 09/26/2008
Grant Status:	Closed

Abstracts

Project 1- Thermal Capacity Evaluation of Fire Fighter Protective Clothing Abstract:
The goal of this work is to develop new information on the impact of stored energy on the thermal response of fire fighters' protective clothing and improve test methods to measure this property that may be integrated into national consensus standards and training materials that will reduce the number of fire service burn injuries.

The development of validated standard test methods for fire fighter protective clothing will result in improvements in their stored energy characteristics and consequent reduction in firefighter burn injuries.

Project 2- Examining Fire Fighting Tactics Under Wind Driven Conditions Abstract:
To improve the safety of fire fighters and building occupants by enabling a better understanding of high-rise firefighting tactics, including structural ventilation, suppression and accountability. Further objectives include developing technical information that will enhance our understanding of the dynamics of fire phenomena and prediction of fire intensity and growth in high rise structures. The data of this research will help to identify methods and promulgation of improved standard operating procedures (SOP) for the fire service to enhance firefighter safety, fire ground operations, and use of equipment. This project complements full scale fire ground activities to be undertaken by the Fire Department of the City of New York.

The program will provide information to enable fire departments to develop tactics to limit the adverse impact of wind driven fires in structures. The data will feed directly into expected next phases which will include comprehensive CFD modeling to extend the results and full scale fire ground testing using lessons learned in this program. The data from this research will help to identify methods and promulgation of improved standard operating guidelines (SOG) for the fire service to enhance firefighter safety, fire ground operations, and use of equipment. It will also be used to enhance standards development for the installation and use of fire blankets/curtains and positive pressure ventilation fans. This will result in improved life safety for both fire fighters and occupants.

FY 2006 FP&S R&D Grant Award

Project Title:	Project 1: Structural Stability of Engineered Lumber in Fire Conditions Project 2: Performance of Special Extinguishment Agents for Firefighter Use
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	Pravinray Gandhi, PhD
Grant Number:	EMW-2006-FP-01437
Award Total:	$ 991,900
Period of Performance:	08/3/2007 - 01/02/2009
Grant Status:	Closed

Abstracts

Jointly, Underwriters Laboratories Inc (UL), the International Association of Fire Chiefs (IAFC), the Chicago Fire Department (CFD), and the University of Maryland Fire Protection Engineering Department submited the following two projects under the FY 2006 Firefighter Safety Research and Development Grants:

Structural Stability of Engineered Lumber in Fire Conditions:
This is a problem-focused fire research study to enhance understanding of hazards to firefighters posed by use of lightweight construction of wood trusses and engineered lumber in roof and floor designs that are increasingly replacing conventional solid joist construction in residential structures. The project will investigate and compare the fire performance of conventional solid joist lumber and lightweight lumber as used in floor and roof construction and will correlate these to fully instrumented fire tests. The fire tests in combination with fire performance data on lumber will allow fire professionals to better interpret fire hazards and assess risk for life safety of building occupants and firefighters. UL will transfer the knowledge gained through the research to the fire service community by creating educational programs using a web-based training module approach that can be disseminated to fire services nationwide and would be used to enhance firefighter preparedness and safety and would provide substantiation for code requirements for fire rating of lightweight construction in residential structures to further enhance firefighter safety.

Performance of Special Extinguishment Agents for Firefighter Use:
This is a research study to evaluate the performance and effectiveness of special extinguishment agents in firefighting of residential structural fires. The project will evaluate the fire performance of various special agents including wetting agents and Class A foams and compare their performance to that of a baseline, traditional water application. A series of fully instrumented fire tests will be conducted using a standardized fuel package that will be designed to simulate a residential living area and hallway fire setting to evaluate the effectiveness of each extinguishing agent in controlling the fire. Additionally, the room temperature and smoke environment experienced by the firefighter will be evaluated to determine safety conditions when special agents are used. The data collected and the video recordings from these tests will be used to design and construct an educational course using a stand-alone web-based training module approach that will be disseminated to fire services nationwide. The fire service can immediately

transfer the test results into a) special extinguishing agent purchasing decisions and b) firefighting tactics related to use of special agents to increase the level of firefighter safety when special extinguishing agents are in use.

The target audiences that will directly benefit from both of the projects include the fire services and allied fire safety organizations. The primary audience includes firefighters, incident commanders, fire marshals, and fire investigators. Additionally, fire and building code officials, public health officials, fire protection engineers, architects, building owners, contractors, manufacturers and installers of fire protection equipment and insurance companies will be targeted as secondary audiences and course work will be modified for the different groups.

Acknowledging that the reduction of the firefighter fatalities and injuries is one of DHS's key goals, UL believes that the proposed research projects directly respond to this goal by increasing firefighters awareness of potential collapse of structures as well as reducing exposure to heat and smoke by use of more effective fire extinguishing agents.

FY 2006 FP&S R&D Grant Award

Project Title:	Predicting Cardiovascular Risk and Fitness in Firefighters
Organization:	The President and Fellows of Harvard College
Principle Investigator:	Stefanos Kales, PhD
Grant Number:	EMW-2006-FP-01493
Award Total:	$ 999,836
Period of Performance:	08/29/2007 - 08/28/2011
Grant Status:	Closed

Abstract

Our proposal examines and stratifies cardiovascular risk among approximately 1250 firefighters across the US. We will use comprehensive information from annual examinations, including: dietary and medical history, body composition and blood pressure, metabolic profiles (glucose and lipids), inflammatory cardiovascular markers and exercise stress testing. We will analyze the information collected to determine: 1) baseline predictors of exercise stress test results among firefighters; and 2) how exercise stress test results predict health and employment consequences over the next two years. In one sub-group of firefighters, we also have historical medical information going back to 1996. Thus, in this sub-cohort, we can examine early predictors of abnormal exercise results 11 years later.

The potential impact of our proposal is very significant. Cardiovascular disease remains the primary cause of on-duty and lifetime mortality in firefighters (45% and 36% of deaths, respectively) and 37 US states provide benefits to firefighters developing cardiovascular diseases. Within several years, our results will help determine: which firefighters with what degree of risk factors/disease might require restriction from certain emergency duties; which should undergo further testing to better determine their fitness for duty; and which should receive early risk reduction interventions (beyond routine wellness programs) in order to prevent on-duty cardiovascular events years later. By developing such evidence, our research will help decrease cardiovascular disease in the fire service.

FY 2006 FP&S R&D Grant Award

Project Title:	Firefighters Heart Disease Detection and Prevention Project
Organization:	Saint Joseph's Hospital Research Institute
Principle Investigator:	Robert Superko, PhD
Grant Number:	EMW-2006-FP-01744
Award Total:	$ 790,766
Period of Performance:	09/7/2007 - 04/06/2009
Grant Status:	Closed

Abstract

Firefighters have a higher incidence of coronary heart disease (CHD) than the public and undetected CHD is a major health and safety issue. The problem this project will address is how best to identify firefighters at high CHD risk and implement validated, individualized detection and treatment strategies, thus protecting firefighters. The true prevalence of undetected CHD and it's metabolic and genetic causes in firefighters are unknown. Attributes of the firefighting profession that interact with metabolic and genetic attributes may place a subgroup of firefighters at high CHD risk. This project will utilize sophisticated noninvasive imaging techniques and advanced blood tests to develop cost effective algorithms that can be applied to firefighters across the USA.

The results of this project will provide all fire services access to a validated advanced heart disease risk algorithm that will identify firefighters most at risk for heart attack. By identifying high heart attack risk firefighters early individualized treatment plans can reduce the adverse personal, public safety, and financial impact of heart disease on firefighters. Finally, this project will be cost effective by reducing the medical costs of premature heart disease in firefighters and medical disability costs (31).

FY 2006 FP&S R&D Grant Award

Project Title:	Integrated Firefighter Locator and Physiological Monitor
Organization:	Worcester Polytechnic Institute
Principle Investigator:	R. James Duckworth, PhD
Grant Number:	EMW-2006-FP-02010
Award Total:	$ 999,303
Period of Performance:	07/27/2007 - 10/26/2008
Grant Status:	Closed

Abstract

WPI, a leader in precision deployable wireless indoor/outdoor personnel location and Foster Miller Inc., a leader in physiological monitoring and display, will jointly construct and test a unique proof-of-concept firefighter safety system that directly mitigates two of the three major causes of firefighter deaths - stress, man lost/trapped or down. The shirt-integrated system will provide location, body and environment temperature, heart and breath rates, recent motion and a status assessment for each firefighter on a graphic display. The system will be evaluated in various buildings for specific performance measures and for ease-of-use by fire fighters. Goals include testing the viability of this technology and identifying challenges that must be met before commercialization.

The proposed one year program integrates, for the first time, a unique 3-D location system and 'wear and forget' physiological stress monitoring system for the fire service. This will significantly address the 2005 USFA goal to reduce line-of-duty deaths by 25% by 2010 and 50% by 2015. Improved "situational awareness" was judged to have the highest group priority and symposium ranking on the National Fire Service Research Agenda. Improving protective equipment, fitness, education and training alone does not address the root cause – this requires warning of overexertion or incapacitation before it's too late and precise location on the fireground. Current fire equipment does not do this while the proposed system will. Results will be disseminated by the end of 2008.

FY 2006 FP&S R&D Grant Award

Project Title:	Investigation of Heat and Smoke Control Methods of Wind-Driven High Rise Fires
Organization:	New York University
Principle Investigator:	Sunil Kumar, PhD
Grant Number:	EMW-2006-FP-02072
Award Total:	$ 1,000,000
Period of Performance:	08/29/2007 - 02/28/2011
Grant Status:	Closed

Abstract

This effort will focus on validating the effectiveness of PPV for high rise buildings and will develop optimal approaches to pressurization. In addition, alternative strategies will be developed that utilize thermal blankets and aim-able water nozzles to enhance the effectiveness of PPV and to facilitate fire-fighting operation in high rise buildings.

The FDNY has indicated its commitment to incorporating new procedures to enhance safety during high rise operations, particularly during windy conditions.T he Department requires a comprehensive body of empirical evidence to justify making changes to standard procedures. Polytechnic University, located adjacent to FDNY Headquarters, is a nationally recognized research institution. Through Polytechnic's Urban Security Initiative, its engineers will conduct a study to test the optimal use of techniques of interest to the FDNY. The University will build on NIST's previous and current data to research the use of the following:1) positive pressure ventilation, 2) aimable nozzles for water delivery from floor below the fire floor 3)using flexible thermal fire blankets.

Should the data support implementation, the technologies and techniques proposed are relatively low-cost, actionable innovations that can be efficiently implemented into operations. It is expected that the successful implementation of these new procedures will have benefits including reduced civilian and firefighter deaths and injuries, faster containment and extinguishment of fires, reduction of smoke damage throughout the building and the prompt return of the building to normal functioning. The FDNY expects to reformulate operational procedures within 36 months of the start of the research. A detailed timeline is included in the narrative section of this proposal.

FY 2006 FP&S R&D Grant Award

Project Title:	Fireground Rehab Evaluation (FIRE) Trial
Organization:	University of Pittsburgh
Principle Investigator:	David Hostler, PhD
Grant Number:	EMW-2006-FP-02245
Award Total:	$333,469
Period of Performance:	08/03/07 - 12/03/2009
Grant Status:	Closed

Abstract

This proposal directly addresses multiple high-priority items from the National Fire Service Research Agenda by examining fireground rehabilitation programs in both the laboratory and fireground settings. We will determine the benefit of hydration and cooling protocols on firefighter physiology and decision making capacity. At the conclusion of the study we will disseminate to the fire service optimal protocols to enhance firefighter safety and performance. We will also obtain important physiological data about the effect of fireground activities on cardiovascular disease and atherosclerosis and the potential protective benefit of rehabilitation protocols. These data will be used to design future studies ensuring the fire service benefits beyond the life of this single study.

We will test all commonly available methods for cooling, rehydration, and temperature monitoring in both the laboratory and the training ground. During the lab phase, will determine both the physiological (ability to continue working) and the cognitive effects (ability to make good decisions) of these interventions. Concurrent with the laboratory studies, we will ask fire and EMS professionals to deliver the interventions on the training ground to firefighters performing a standardized fire suppression scenario. At the conclusion of the project we will rate the interventions for effectiveness and ease/cost of implementation. The results will be disseminated to the fire service through trade journals, national and regional conferences, and made available for download on our website.

FY 2006 FP&S R&D Grant Award

Project Title:	Physiological and Psychological Stress Associated with Structural Firefighting
Organization:	Trustees of Indiana University
Principle Investigator:	Jim Brown, PhD
Grant Number:	EMW-2006-FP-02258
Award Total:	$1,000,000
Period of Performance:	09/07/2007 - 06/06/2009
Grant Status:	Closed

Abstract

The proposed project will examine physical and emotional stress caused by work and heat exposure during structural firefighting activity. It will be the first to extensively measure firefighter physiology during real fire ground activity. In addition, the project will monitor the fire scene to determine aspects of the work environment that affect physical and emotional responses. Together these data will enable us to describe the range of firefighter responses to work stress and provide a thorough understanding of the interaction between the fire scene and firefighter physiology. A physiology response model will be developed that enables the prediction of physiological responses to specific fire ground scenarios. The model should prove to be a valuable education and training tool.

The proposed project will be the first to track firefighter physiological and psychological responses to actual work conditions. The data set produced will enable us to develop better physical training programs for firefighters and the number of line of duty deaths. In addition, the study will relate observed responses to the work environment by monitoring the fire ground environment. As a result, the primary effectors of firefighter physiology will be identified. The resulting model will enable instructors and command personnel to predict firefighter responses to different fire scene scenarios. All of these benefits will be published in written and video form and delivered to the fires service upon completion of the study. Report delivery is expected to be complete by September 2008.

FY 2006 FP&S R&D Grant Award

Project Title:	Multi-Phase Study on Firefighter Safety and the Deployment of Resources
Organization:	CFAI-Risk, Inc.
Principle Investigator:	Lori Moore-Merrell, PhD
Grant Number:	EMW-2006-FP-02327
Award Total:	$ 1,000,000
Period of Performance:	09/14/2007 - 09/13/2009
Grant Status:	Closed

Abstract

This project in fire fighter safety and deployment of resources seeks to enable fire departments and city/county managers to make sound decisions regarding optimal resource allocation and service based upon scientifically-based community risk assessment, strategic emergency response system design and the local government's service commitment to the community. The research plan is broken into three phases, each with multiple tasks and subtasks to be completed over multiple years.
1. validation of scientifically based risk assessment software.
2. Model deployment strategies based on community risks and expectations that provide for safe, efficient, and effective on scene operations.
3. Performance measurement instrument for assessing emergency operations based on model deployment.

This study on fire fighter safety based on community risk assessment and resource deployment is needed to enable fire departments, cities, counties and fire districts to design acceptable levels of resource deployment based upon community risks and service provision commitment. Notable results from Phase I and II of the study are expected in year 2 including simulation and testing of staffing and deployment models for fire department response to residential fire and EMS and integration of geographical information systems analysis capability into the community risk assessment model. Results/outcomes will be published in partner newsletters, magazines and web sites as well as in archival and scientific journals.

FY 2006 FP&S R&D Grant Award

Project Title:	Cardiovascular and Biomechanical Responses to Firefighting and Personal Protective Equipment
Organization:	The Board of Trustees of the University of Illinois, Urbana-Champaign
Principle Investigator:	Gavin P. Horn, PhD
Grant Number:	EMW-2006-FP-02459
Award Total:	$ 899,269
Period of Performance:	07/27/2007 - 09/26/2008
Grant Status:	Closed

Abstract

The overarching goal of this research project is to decrease the number of FF fatalities and injuries. Results from our study will provide scientific evidence regarding the extent to which "enhanced PPE" can minimize detrimental changes in cardiovascular and biomechanical variables related heart attacks (HA) and slips, trips, and falls (STF). The project will a) develop enhanced PPE, b) investigate changes in blood clotting (which can lead to HA) and biomechanical function (which contributes to STF) following strenuous firefighting activity, c) compare data from enhanced PPE to standard PPE to determine if modified PPE can minimize these dangerous physiological changes associated with firefighting, and d) distribute our findings and recommendations broadly to the Fire Service.

This effort is the first systematic study of firefighting activities on cardiovascular and biomechanical function, and a scientifically rigorous study that documents the extent to which PPE can mitigate detrimental changes in the function of these systems. These results can guide local FD in determining the type of PPE they should issue to their FF and in determining SOPs regarding FF medical clearance, rehab, and fitness (based on relationship between cardiovascular risk factors and coagulatory response). This research can also influence manufacturers of PPE and PPE standards making bodies. Finally, this study will provide data that can be used to individual FF regarding their own health and fitness, on scene rehab, and PPE. All lessons learned will be disseminated within 12 months.

FY 2005 Awards

FY 2005 FP&S R&D Grant Award

Project Title:	Firefighter Accountability Technology
Organization:	Center for Firefighter Safety Research & Development, University of Maryland
Principle Investigator:	Marino diMarzo, PhD
Grant Number:	EMW-2005-FP-01786
Award Total:	$ 825,000
Period of Performance:	03/31/2006 - 03/30/2007
Grant Status:	Closed

Abstract

The primary goal of this project is to research and develop interoperable firefighter accountability location and monitoring devices and incorporate them into a system applicable to real world scenarios, using a combination of current and new technology. Specifically, we will research and develop technology that will continuously monitor the location and physiological status of firefighters, along with information about the fire, and transmit that data from firefighters inside and outside buildings to a remote location for use by incident commanders and incident safety officers. This system will provide the fire service on a national level with a reliable way to reduce the number and seriousness of fire ground-related injuries and deaths.

Scientific research will be the basis of developing several interoperable tools that will help fire department officers to identify the location and condition of all firefighters at the scene of an emergency, with special emphasis on locating an at-risk firefighter before an injury or illness occurs. In addition, the tools developed through this research will provide the means to physically rescue at-risk firefighters from demanding emergency response activities as quickly as possible. We will collaborate with Grace Industries, Inc., a well-known and respected national fire service product manufacturer and developer of the T-PASS Evacuate System. We will also maintain contact with fire service organizations to gain input and acceptance on the usefulness of the devices and systems under development.

The final project goal is to see a reduction in the number of training-related firefighter deaths and injuries in the United States. While all of the previous goals are easily measurable, the final goal is only measurable over the long-term. The Center for Firefighter Safety Research and Development will continue to monitor firefighter safety over time. The Center, housed at the Maryland Fire and Rescue Institute, and located at the University of Maryland, has the full support of the University and is seen as a high-priority, long-term effort by University President Dr. C. D. Mote.

YEAR TWO
Project goals for Year Two will be to fully field test our newly developed systems and devices in buildings with various construction types, uses, and sizes. Field tests will also be conducted in other unique target hazards such as federal government buildings, subways, airports, and large

public assembly structures. Once the product development tasks to be completed during this research are accomplished, the Center will pursue the option of introducing them to the fire service through the University of Maryland, Maryland Technology Enterprise Institute (MTECH), Maryland Industrial Partnerships program (MIPS). MTECH has been successfully pioneering technology entrepreneurships and research programs for 20 years.

The research results will be also publicized at major fire services conferences, such as Fire/Rescue International and the Fire Department Instructors Conference, to ensure that fire departments throughout the country are aware of the latest technology available to them.

FY 2005 FP&S R&D Grant Award

Project Title:	Residential Occupancy Fire Safety Research Project
Organization:	Underwriters Laboratories, Inc.
Principle Investigator:	J. Thomas Chapin, PhD
Grant Number:	EMW-2005-FP-02644
Award Total:	$ 653,375
Period of Performance:	04/07/2006 – 06/15/2007
Grant Status:	Closed

Abstract

This is a problem-focused fire research study to improve firefighter safety through enhanced understanding of hazards posed by various fire incidents in residential occupancies where firefighters respond. The project will investigate the fire performance of typical products and furnishings found in residential occupancies and will correlate these to fully instrumented fire tests in simulated residential settings. The program will develop valuable data to demonstrate the effectiveness of smoke detectors and residential sprinklers, as well as investigate use of localized sprinklers in food preparation areas. These fire tests, in combination with fire performance data on products and furnishings, would provide a valuable background to interpret fire hazards.

UL's proposed project will develop and share knowledge that the fire services and allied organizations need to drive down the number of fire deaths and injuries. We expect immediate results, upon completion of the courses, demonstrating increased effectiveness of firefighting, code enforcement, and fire investigations - as a result of this increased knowledge. The deliverables provide a)Knowledge of changes in fire performance characteristics of products and materials that reduce time to untenable conditions; b)Knowledge of product standards, their applications and relevance in codes needed to reduce misapplication of standards that lead to catastrophic fires; c)Test data inputs to fire models for fire services to better understand fire dynamics and application of performance based codes.

FY 2005 FP&S R&D Grant Award

Project Title:	Determining the Effectiveness of Self-Instruction as an Educational Method to Impact Volunteer Firefighter Health and Safety
Organization:	Oklahoma State University
Principle Investigator:	Steve McKeever, PhD
Grant Number:	EMW-2005-FP-02795
Award Total:	$ 186,164
Period of Performance:	04/14/2006 – 03/13/2008
Grant Status:	Closed

Abstract

The National Fallen Firefighters Foundation facilitated the development of a national firefighter health and safety research agenda. The research agenda issue, Educational Methodologies to Effectively Reduce Fire Service Injuries and Fatalities is directly addressed by this proposal.

Education and training are critical components of any plan to address firefighter health and safety. This project is directed toward determining the effectiveness of self-instruction as an educational methodology to promote firefighter safety and health policy and practice within the volunteer fire service.

Research design will be a pre-test / post-test, treatment and control group design, using volunteer firefighters from five states representing the Southeast, Northeast, Midwest, South and Pacific Coast regions of the United States. This population will be sampled by randomly selecting 50 volunteer fire departments from each of five states of which 25 will be used as a treatment group and 25 as a control group.

FY 2005 FP&S R&D Grant Award

Project Title:	Multicultural Safety and Health Research Projects
Organization:	Fire 20/20
Principle Investigator:	Larry Sagan
Grant Number:	EMW-2005-FP-02951
Award Total:	$ 496,335
Period of Performance:	04/21/2006 – 09/26/2007
Grant Status:	Closed

Abstract

The Multicultural Health and Safety Research Project is a one-year descriptive and evaluative study examining how the fire service culture positively and negatively impacts the health and safety of both firefighters and community members in multicultural communities. The research will be conducted in 4 geographically diverse, metropolitan areas. The MHSRP specifically addresses three priorities identified by The National Fire Service Research Agenda Symposium, two findings identified by the "AMERICA BURNING Recomissioned" report and it will re-examine the findings of a 1997 report commissioned by FEMA and the National Fire Administration, "Socioeconomic Factors and The Incidence of Fire".

National Fallen Firefighters Foundation has agreed to use the MSHRP results in support of their 16 Life Safety initiatives. Results can also be directly applied in career, combination and volunteer departments for: risk reduction and increased capacity for firefighters and first responders in multicultural communities; executive strategic planning; proactive multicultural community outreach; multicultural training programs for fire departments; policy changes and SOPs for working more effectively with multicultural communities; strategies for developing and implementing multicultural recruitment programs; and prevention and public service campaigns.

FY 2005 FP&S R&D Grant Award

Project Title:	National Center for Fire and Emergency Doctrine and Policy
Organization:	International Association of Fire Chiefs
Principle Investigator:	Harriet Parker
Grant Number:	EMW-2005-FP-03134
Award Total:	$ 149,996
Period of Performance:	04/03/2006 - 01/30/2008
Grant Status:	Closed

Abstract

The National Center for Fire and Emergency Doctrine and Policy will create well-reasoned, nationally standardized policies, procedures and doctrine that will improve the fire service's ability to offer consistent national response while continuing to accommodate local needs.

Firefighter death and injury rates are negatively impacted by the lack of standardized national policies, procedures and doctrine. The creation of the National Center for Fire and Emergency Doctrine and Policy will provide the fire service with well-informed, national policies, procedures and doctrine that will aim to decrease the number of firefighter deaths and injuries. Nationally standardized policies, procedures and doctrine would help to address the problem of heterogeneous safety standards in local fire departments, and in turn decrease injury and fatality rates among firefighters. The National Center is envisioned to be an on-going project. Results will happen gradually as new national policies; procedures and doctrine are developed and implemented.

FY 2005 FP&S R&D Grant Award

Project Title:	Multi-phase study on Firefighter Safety and the Deployment of Resources
Organization:	CFAI-Risk, Inc.
Principle Investigator:	Lori Moore-Merrell, PhD
Grant Number:	EMW-2005-FP-02287
Award Total:	$ 999,954
Period of Performance:	03/24/2006 – 06/22/2008
Grant Status:	Closed

Abstract

This project in fire fighter safety and deployment of resources seeks to enable fire departments and city/county managers to make sound decisions regarding optimal resource allocation and service based upon scientifically-based community risk assessment, strategic emergency response system design and the local government's service commitment to the community. The research plan is broken into three phases, each with multiple tasks and subtasks to be completed over multiple years.

1. validation of scientifically based risk assessment software.
2. Model deployment strategies based on community risks and expectations that provide for safe, efficient, and effective on scene operations.
3. Performance measurement instrument for assessing emergency operations based on model deployment.

This study on fire fighter safety based on community risk assessment and resource deployment is needed to enable fire departments, cities, counties and fire districts to design acceptable levels of resource deployment based upon community risks and service provision commitment. Notable results from Phase I and II of the study are expected in year 1 including the formation of an expert advisory team, validation of community risk assessment software, and software adaptation to include downloads from geographical information systems (GIS) for more detailed system analysis. Results/outcomes will be published in partner newsletters, magazines and web sites as well as in archival and scientific journals.

APPENDIX A: NFFF Research Agenda Alignment (Detailed Version)

The 2015 NFFF Research Agenda consists of three themes and three priority levels:

Theme A Data Collection & Data Analysis	High Medium Low
Theme B Problem or Program Analysis & Evaluation	
Theme C Research to Practice	

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#1: Conduct research directed toward identifying those individuals within the fire service who are at a higher risk for specific occupational injury/illness/disease.	A-HIGH	Health and Wellness of Women Firefighters NDRI – USA, Inc. PI: Jahnke	Bullying, Harassment & Resilience in the Fire Service NDRI – USA, Inc. PI: Jahnke Stress and Violence in Fire-based EMS Responders (SAVER) Drexel University PI: Taylor		Cancer among Indiana Firefighters: Case-Control Studies National Institute for Public Safety Health, Inc. PI: Moffatt	Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity University of Arizona PI: Burgess Cancer Risk and Risk Factors in Volunteer Firefighters: The NJ Firefighter Cancer Prevention Study (CAPS) Rutgers University PI: Graber Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

NFFF Research Agenda Recommendations (54)	NFFF Priority Theme & Level	R&D FY 2015 Award	R&D FY 2016 Award	R&D FY 2017 Award	R&D FY 2018 Award	R&D FY 2019 Award
#3: Develop a centralized data warehouse and common data elements to facilitate research related to wildland firefighting.	A-HIGH			Expansion of the Fire Fighter Cancer Cohort Study: Arson Investigators, Instructors, Volunteers, and Wildland-Urban Interface Firefighters University of Miami PI: Caban-Martinez		
#4: Develop a unified national database with common definitions on fire service fatalities, injuries and occupational illnesses.	A-HIGH	The Firefighter Multicenter Cancer Cohort Study: Framework Development and Testing University of Arizona PI: Burgess				
#5: Evaluate behavior modification strategies that will lead to lasting cultural changes resulting in improvements in data collection and use.	A-HIGH	Health and Wellness of Women Firefighters NDRI – USA, Inc. PI: Jahnke				Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity University of Arizona PI: Burgess

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#6: Identify and develop methods to capture operational data on fireground performance, mental resiliency, effective communications and operational benchmarks.	A-HIGH		A Novel Approach for Measuring Firefighter Occupational Chemical Exposures Oregon State University PI: Anderson	Study of Fire Service Residential Home Size-up and Search & Rescue Operations Underwriters Laboratories, Inc. PI: Kerber Resonant Sensors for Monitoring Undercoat Perspiration to Indicate Heat Stress Iowa State University of Science and Technology PI: Reuel		
#7 Identify and make use of traditional and non-traditional data to supplement, update and enhance fire service programs, including fire suppression and emergency opertions, public education, fire prevention and community risk reduction efforts	A-HIGH					Preparing for the Next Spike: Impact and Response of the Covid-19 Pandemic NDRI – USA, Inc. PI: Jahnke Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#9: Determine the incidence and frequency of occupational diseases/illness/injury/conditions in underrepresented groups and those with unique exposures.	A-MEDIUM	Health and Wellness of Women Firefighters NDRI – USA, Inc. PI: Jahnke	Bullying, Harassment & Resilience in the Fire Service NDRI – USA, Inc. PI: Jahnke Stress and Violence in Fire-based EMS Responders (SAVER) Drexel University PI: Taylor	Expansion of the Fire Fighter Cancer Cohort Study: Arson Investigators, Instructors, Volunteers, and Wildland-Urban Interface Firefighters University of Miami PI: Caban-Martinez	Cancer among Indiana Firefighters: Case-Control Studies National Institute for Public Safety Health, Inc. PI: Moffatt	Preparing for the Next Spike: Impact and Response of the Covid-19 Pandemic NDRI – USA, Inc. PI: Jahnke Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity University of Arizona PI: Burgess Cancer Risk and Risk Factors in Volunteer Firefighters: The NJ Firefighter Cancer Prevention Study (CAPS) Rutgers University PI: Graber Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt
#11: Research total worker health of the wildland firefighter population to improve health and wellness.	A-MEDIUM			Expansion of the Fire Fighter Cancer Cohort Study: Arson Investigators, Instructors, Volunteers, and Wildland-Urban Interface Firefighters University of Miami PI: Caban-Martinez	Total Worker Health For Wildland Firefighters Oregon Health and Science University PI: Kuehl	

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#17: Conduct research based on fire dynamics to identify best practices at the strategic, tactical and task levels for firefighting operations in new and existing commercial and residential structures. The research should include the creation of on-scene risk assessment tools based on specific fire factors to assist company officers and incident commanders.	B-HIGH	Study of Coordinated Fire Attack Utilizing Acquired Structures Underwriters Laboratories, Inc. PI: Kerber	Firefighter Safety in Battery Energy Storage System Fires University of Texas at Austin PI: Ezekoye	Study of Fire Service Residential Home Size-up and Search & Rescue Operations Underwriters Laboratories, Inc. PI: Kerber		
#18: Conduct research directed toward identifying and overcoming barriers to the implementation of tobacco cessation programs and the elimination of all forms of tobacco and nicotine use (e.g. cigarettes, smokeless tobacco, e-cigarettes, other vape products). Conduct studies related to alcohol abuse, misuse and abuse of prescription drugs and illicit drugs.	B-HIGH				Development and Testing of the Fire Service Health Drinking Toolkit Pacific Institute for Research and Evaluation PI: Caetano	

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#19: Conduct research on enhanced dermal protection provided by firefighter structural protective clothing, particularly as it relates to reducing exposures to known and suspected carcinogens.	B-HIGH	Revolutionizing the Protective Hood: Particulate Protection, Cleaning Effectiveness, and Training Demonstration North Carolina State University PI: Barker	A Novel Approach for Measuring Firefighter Occupational Chemical Exposures Oregon State University PI: Anderson Developing a New Basis for Rating the Heat Strain of Firefighter Turnout Gear. North Carolina State University PI: Barker	Impact of PPE and Base Layer on Fireground Vapor and Particulate Exposure Risk University of Illinois PI: Horn Enhanced Cleaning to Reduce Firefighter Exposure to Carcinogens North Carolina State University PI: Barker	Development of Hand-specific Model and Systematic Tool (HMST) for Next Generation Gloves Used for Firefighters and Other Emergency Responders Iowa State University of Science and Technology, PI: Song Assessment, Improvement, and Application of Multi-Hazard System-Level Performance Evaluations of First Responder Ensembles North Carolina State University PI: Barker	Effectiveness of Exposure Mitigation Strategies for Fire Investigators Fire Protection Research Foundation PI: Kimball
#20: Conduct research on how science can improve wildland firefighting training, tactics and response to reduce fatalities, injuries and unintended outcomes.	B-HIGH	Synthesizing and Diseminating New Scientific Insights into Transient Wildfire Behavior to Prevent Firefighter Entrapment University Corporation for Atmospheric Research PI: Coen				

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#21: Continue research into operational practices directed toward more effective tactics, improvements in firefighter safety and victim survivability and reductions in property losses. These studies should specifically address staffing and deployment, fire dynamics research and victim survivability. The focus should include high-rise residential and commercial buildings, private dwellings, multiple unit residential occupancies, strip malls, taxpayer buildings and warehouses.	B-HIGH	Study of Coordinated Fire Attack Utilizing Acquired Structures Underwriters Laboratories, Inc. PI: Kerber	Firefighter Safety in Battery Energy Storage System Fires University of Texas at Austin PI: Ezekoye	Study of Fire Service Residential Home Size-up and Search & Rescue Operations Underwriters Laboratories, Inc. PI: Kerber		

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#22: Continue research on firefighter health, injury and diseases related to chronic and repeated exposures to the risks of emergency incidents and the fire service work environment. The research should encompass all disciplines including wildland and wildland-urban interface.	B-HIGH	The Firefighter Multicenter Cancer Cohort Study: Framework Development and Testing University of Arizona PI: Burgess	A Novel Approach for Measuring Firefighter Occupational Chemical Exposures Oregon State University PI: Anderson	Expansion of the Fire Fighter Cancer Cohort Study: Arson Investigators, Instructors, Volunteers, and Wildland-Urban Interface Firefighters University of Miami PI: Caban-Martinez Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke Northeastern University PI: Oakes	Cancer among Indiana Firefighters: Case-Control Studies National Institute for Public Safety Health, Inc. PI: Moffatt Per- and Polyfluoroalkyl Substances (PFAS): Firefighter Exposures and Toxicity University of Arizona PI: Burgess	Preparing for the Next Spike: Impact and Response of the Covid-19 Pandemic NDRI – USA, Inc. PI: Jahnke Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity University of Arizona PI: Burgess Training Fire Exposures from the Source: Developing Risk-Benefit Framework Underwriters Laboratories, Inc. PI: Horn Effectiveness of Exposure Mitigation Strategies for Fire Investigators Fire Protection Research Foundation PI: Kimball Cancer Risk and Risk Factors in Volunteer Firefighters: The NJ Firefighter Cancer Prevention Study (CAPS) Rutgers University PI: Graber Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#23: Continue research on firefighter health, injury and diseases related to the risks of acute exposures that may result from emergency incidents.	B-HIGH			Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke Northeastern University PI: Oakes	Module for Rapid Detection of Gases from Fire and Smoke University of Central Florida, PI: Mukhopadhyay Per- and Polyfluoroalkyl Substances (PFAS): Firefighter Exposures and Toxicity University of Arizona PI: Burgess	Preparing for the Next Spike: Impact and Response of the Covid-19 Pandemic NDRI – USA, Inc. PI: Jahnke Cancer Risk and Risk Factors in Volunteer Firefighters: The NJ Firefighter Cancer Prevention Study (CAPS) Rutgers University PI: Graber Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#24: Determine the efficacy/effectiveness of interventions/programs/systems designed to decrease disease/exposure/injury/death and increase medical evaluations, occupational health and surveillance. The research should include under-researched populations within the fire service and include a focus on reproductive, maternal and child health issues, cardiovascular risk factors, injuries and cancer.	B-HIGH	Health and Wellness of Women Firefighters NDRI – USA, Inc. PI: Jahnke The Firefighter Multicenter Cancer Cohort Study: Framework Development and Testing University of Arizona PI: Burgess	Optimizing Circadian Rhythms by Regulating Eating Patterns to Reduce Cardiometabolic Disease Risk among Firefighters Salk Institute for Biological Studies PI: Panda	Expansion of the Fire Fighter Cancer Cohort Study: Arson Investigators, Instructors, Volunteers, and Wildland-Urban Interface Firefighters University of Miami PI: Caban-Martinez	Total Worker Health For Wildland Firefighters Oregon Health and Science University PI: Kuehl Development and Testing of the Fire Service Health Drinking Toolkit Pacific Institute for Research and Evaluation PI: Caetano	Preparing for the Next Spike: Impact and Response of the Covid-19 Pandemic NDRI - USA, Inc. PI: Jahnke Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity University of Arizona PI: Burgess Effectiveness of Exposure Mitigation Strategies for Fire Investigators Fire Protection Research Foundation PI: Kimball Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#25: Identify respiratory contaminants and determine the potential adverse health outcomes associated with wildland and wildland- urban interface fire operations. Also, determine the adequate respiratory protection for wildland firefighters.	B-HIGH			Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke Northeastern University PI: Oakes	Characterization of Toxicants Found in the Particulate Phase of Wildfire Smoke and Their Health Implications for Firefighters and Residents at the Wildland-Urban Interface Middle Tennessee State University, PI: Zhang	Training Fire Exposures from the Source: Developing Risk-Benefit Framework Underwriters Laboratories, Inc. PI: Horn
#26: Identify, develop and refine evidence-based tools and approaches for behavioral health screening, assessment and intervention.	B-HIGH		Bullying, Harassment & Resilience in the Fire Service NDRI – USA, Inc. PI: Jahnke		Development and Testing of the Fire Service Health Drinking Toolkit Pacific Institute for Research and Evaluation PI: Caetano	
#28: Assess substance misuse and abuse in the fire service (including, but not limited to alcohol, prescription drugs and illicit drugs). Focus research on the identification of effective prevention efforts, interventions and rehabilitation strategies.	B-MEDIUM				Development and Testing of the Fire Service Health Drinking Toolkit Pacific Institute for Research and Evaluation PI: Caetano	

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#33: Conduct research on cleaning methods for firefighter protective clothing, including potential impacts on the protective properties and useful life of the clothing, and determining effectiveness of removal of suspected carcinogens and other contaminants.	B-MEDIUM	Revolutionizing the Protective Hood: Particulate Protection, Cleaning Effectiveness, and Training Demonstration North Carolina State University PI: Barker		Enhanced Cleaning to Reduce Firefighter Exposure to Carcinogens North Carolina State University PI: Barker Impact of PPE and Base Layer on Fireground Vapor and Particulate Exposure Risk University of Illinois PI: Horn Application of Cleaning Verification Procedures to Establish Contamination Control Best Practices for Firefighter Personal Protective Equipment (PPE) and Related Equipment Fire Protection Research Foundation PI: Grant		

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#36 Determine the most effective implementation methods to institute occupational health programs.	B-MEDIUM				Development and Testing of the Fire Service Health Drinking Toolkit Pacific Institute for Research and Evaluation PI: Caetano	
#38: Evaluate the impact of modern and evolving building technology (i.e. green buildings, solar and battery storage systems) on fire service operations. Create a knowledge base for incident commanders, company officers and firefighters to support operational safely and proficiently.	B-MEDIUM		Firefighter Safety in Battery Energy Storage System Fires University of Texas at Austin PI: Ezekoye			

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#39: Identify contributing factors to firefighter injuries and fatalities related to non-fireground events (i.e. EMS, special operations and roadway).	B-MEDIUM		Bullying, Harassment & Resilience in the Fire Service NDRI – USA, Inc. PI: Jahnke Stress and Violence in Fire-based EMS Responders (SAVER) Drexel University PI: Taylor			Preparing for the Next Spike: Impact and Response of the Covid-19 Pandemic NDRI – USA, Inc. PI: Jahnke Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity University of Arizona PI: Burgess Training Fire Exposures from the Source: Developing Risk-Benefit Framework Underwriters Laboratories, Inc. PI: Horn Surveillance of Coronavirus Infection among Indiana Firefighters NIPSH PI: Moffatt
#40: Research the effectiveness of alternative learning mechanisms in order to identify and develop the best firefighter training delivery system(s) for strategic, tactical and task level operations.	B-MEDIUM					Training Fire Exposures from the Source: Developing Risk-Benefit Framework Underwriters Laboratories, Inc. PI: Horn

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#43: Conduct research on the efficacy and effectiveness of health and wellness programs for individuals and organizations. Focus on programs directed toward preventive behavioral change. The research areas should include fitness, nutrition, hydration, sleep and hygiene.	B-LOW		Optimizing Circadian Rhythms by Regulating Eating Patterns to Reduce Cardiometabolic Disease Risk among Firefighters Salk Institute for Biological Studies PI: Panda		Total Worker Health For Wildland Firefighters Oregon Health and Science University PI: Kuehl Development and Testing of the Fire Service Health Drinking Toolkit Pacific Institute for Research and Evaluation PI: Caetano	
#44: Measure the fire growth rate in new homes which are built to modern energy codes and specifications and furnished with contemporary fire loads. Simulate and evaluate escape times based on the realistic capabilities of individuals.	B-LOW			Study of Fire Service Residential Home Size-up and Search & Rescue Operations Underwriters Laboratories, Inc. PI: Kerber		
#45: Conduct research on the effectiveness of alternative implementation strategies and policies for health and wellness programs.	B-LOW					Training Fire Exposures from the Source: Developing Risk-Benefit Framework Underwriters Laboratories, Inc. PI: Horn

2015 NFFF Research Agenda Recommendations Closely Aligned with FP&S R&D Awards:

#47: Continue to employ fire modeling and full scale re-creations of specific incidents that resulted in firefighter injuries and deaths to identify contributing factors and recommended changes in strategy, tactics and tasks.	C-HIGH	Synthesizing and Diseminating New Scientific Insights into Transient Wildfire Behavior to Prevent Firefighter Entrapment University Corporation for Atmospheric Research PI: Coen				
#48: Research the development of technology, tactics and response standards in the wildland-urban interface. Include PPE requirements for all responders.	C-HIGH			Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke Northeastern University PI: Oakes	Investigation of Design, Comfort, and Mobility Issues for Female Firefighter Personal Protective Clothing Florida State University PI: McQuerry	

APPENDIX B: NFFF Research Agenda Alignment (Chart)

2015 NFFF Research Agenda Recommendations Closely Aligned with FY2019 FP&S R&D Awards:

	1	3	4	5	6	7	9	11	17	18	19	20	21	22	23	24	25	26	28	33	36	38	39	40	43	44	45	47	48
Prepring for the Next Spike: Impact and Response of the Covid-19 Pandemic						●	●							●	●	●							●						
Women Firefighters Study: Stress, Cancer Risk, and Reproductive Toxicity	●			●			●							●		●							●						
Training Fire Exposures from the source: Developing Risk-benefit Framework														●			●						●	●			●		
Effectiveness of Eposure Mitigation Strategies for Fire Investigators											●			●		●													
Cancer Risk and Risk Factors in Volunteer Firefighters: The NJ Firefighter Cancer Prevention Study (CAPS)	●						●							●	●														
Surveillance of Coronavirus Infection among Indiana Firefighters	●					●	●							●	●	●							●						

2015 NFFF Research Agenda Recommendations Closely Aligned with FY2018 FP&S R&D Awards:

	1	3	4	5	6	7	9	11	17	18	19	20	21	22	23	24	25	26	28	33	36	38	39	40	43	44	45	47	48
Development of Hand-specific Model and Systematic Tool (HMST) for Next Generation Gloves Used for Firefighters and Other Emergency Responders											●																		
Characterization of Toxicants Found in the Particulate Phase of Wildfire Smoke and Their Health Implications for Firefighters and Residents at the Wildland-Urban Interface																	●												
Module for Rapid Detection of Gases from Fire and Smoke															●														
Investigation of Design, Comfort, and Mobility Issues for Female Firefighter Personal Protective Clothing																													●
Cancer among Indiana Firefighters: Case-Control Studies	●						●							●															
Total Worker Health For Wildland Firefighters								●								●									●				
Assessment, Improvement, and Application of Multi-Hazard System-Level Performance Evaluations of First Responder Ensembles											●																		
Development and Testing of the Fire Service Health Drinking Toolkit										●						●		●	●		●				●				
Per- and Polyfluoroalkyl Substances (PFAS): Firefighter Exposures and Toxicity														●	●														

2015 NFFF Research Agenda Recommendations Closely Aligned with FY2017 FP&S R&D Awards:

	1	3	4	5	6	7	9	11	17	18	19	20	21	22	23	24	25	26	28	33	36	38	39	40	43	44	45	47	48
Enhanced Cleaning to Reduce Firefighter Exposure to Carcinogens											●									●									
Impact of PPE and Base Layer on Fireground Vapor and Particulate Exposure Risk											●									●									
Resonant Sensors for Monitoring Undercoat Perspiration to Indicate Heat Stress					●																								
Expansion of the Fire Fighter Cancer Cohort Study: Arson Investigators, Instructors, Volunteers, and Wildland-Urban Interface Firefighters		●					●	●						●		●													
Study of Fire Service Residential Home Size-up and Search & Rescue Operations					●				●				●													●			
Application of Cleaning Verification Procedures to Establish Contamination Control Best Practices for Firefighter Personal Protective Equipment (PPE) and Related Equipment																				●									
Health Consequences Following Acute and Chronic Firefighter Exposure to Wildland Fire Smoke														●	●		●												●

2015 NFFF Research Agenda Recommendations Closely Aligned with FY2016 FP&S R&D Awards:

	1	3	4	5	6	7	9	11	17	18	19	20	21	22	23	24	25	26	28	33	36	38	39	40	43	44	45	47	48
Developing a new Basis for Rating the Heat Strain of Firefighter Turnout Gear											●																		
Firefighter Safety in Battery Energy Storage System Fires									●				●									●							
Stress and Violence in Fire-Based EMS Responders (SAVER)	●						●																●						
Bullying, Harassment & Resilience in the Fire Service	●						●											●					●						
A Novel Approach for Measuring Firefighter Occupational Chemical Exposures					●						●			●															
Optimizing Circadian Rhythms by Regulating Eating Patterns to Reduce Cardiometabolic Disease Risk Among Firefighters																●									●				

2015 NFFF Research Agenda Recommendations Closely Aligned with FY2015 FP&S R&D Awards:

	1	3	4	5	6	7	9	11	17	18	19	20	21	22	23	24	25	26	28	33	36	38	39	40	43	44	45	47	48
Revolutionizing the Protective Hood: Particulate Protection, Cleaning Effectiveness, and Training Demonstration											●									●									
Study of Coordinated Fire Attack Utilizing Acquired Structures									●				●																
The Firefighter Multicenter Cancer Cohort Study: Framework Development and Testing			●											●		●													
Health and Wellness of Women Firefighters	●			●			●									●													
Synthesizing and Disseminating New Scientific Insights into Transient Wildfire Behavior to Prevent Firefighter Entrapment												●																●	

APPENDIX C: NFFF Research Agenda Recommendations - Not Addressed with Closely Aligned FP&S R&D Awards

The table below shows NFFF Research Agenda Recommendations that have not been addressed with closely aligned R&D awards:

#16: Conduct a study of the life span of PPE.	

The table below shows NFFF Research Agenda Recommendations that have not been addressed with closely aligned R&D awards:
