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Journal Team

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Dr. John Granito Award for Excellence in Fire Leadership and Management Research

The Dr. John Granito Award for Excellence in Fire Leadership and Management Research is presented at the *International Fire Service Journal of Leadership and Management (IFSJLM)* Research Symposium held annually in July at the International Fire Service Training Association (IFSTA) Validation Conference. The award honors Dr. John Granito.

Until his retirement, John was one of the premier fire and public safety consultants in the United States. Just a few of his many Fire, Rescue, and Emergency Services research projects include: Oklahoma State University-Fire Protection Publications Line of Duty Death Reduction project (3 years); Centaur National Study (3 years); Research Triangle Institute/National Fire Protection Association/International City/County Management Association project (4 years); Fire Department Analysis Project (FireDAP) of the Urban Fire Forum (13 years); *Combination Department Leadership* project, University of Maryland, Maryland Fire & Rescue Institute (4 years); Worcester Polytechnic/International Association of Fire Fighters/International Association of Fire Chiefs/ National Institute for Occupational Safety and Health *Fire Ground Performance Study*. John participated in more than 400 fire department studies.

John also has strong ties to academia. He served in a number of academic positions for almost 30 years, including 16 years at the State University of New York at Binghamton. He is Professor Emeritus and Retired Vice President for Public Service and External Affairs at SUNY Binghamton, which is consistently ranked in the top public universities by *U.S. News and World Report*.

John has published numerous articles, chapters, and technical papers, served as co-editor of the 2002 book published by the International City/County Management Association entitled, *Managing Fire and Rescue Service*, and is a Section Editor of the NFPA® 2008 *Fire Protection Handbook.*

Dr. Granito was the first recipient of the award that honors him and his service to the fire service and to academia. Each year the recipient of the Dr. Granito Award presents the Keynote Address at the annual *IFSJLM* Research Symposium. The Keynote Address is subsequently published as the lead article in the following year's volume of the *International Fire Service Journal of Leadership and Management*.

Message from Dr. Robert E. England

Founding Editor, *International Fire Service Journal of Leadership and Management* (*IFSJLM*), Fire Protection Publications, Oklahoma State University

Welcome to Volume 13 of the *International Fire Service Journal of Leadership and Management*. Typically, readers should expect to see the annual volume released in late October or in November.

We hope you enjoy Volume 13 of the *IFSJLM*.

Eleventh Annual Dr. John Granito Award for Excellence in Fire Leadership and Management Keynote Address presented at Research Symposium 2018 (RS 18) on July 21, 2018, by **Dr. Jefferey L. Burgess.** Contributing authors were: **Drs. Adrian Bevan**, **Stephane Bergzoll**, **Albane Perot**, **David Bui**, **and Alexis Descatha**.

Case Studies of Fire and Emergency Medical Services: Risk Management in the European Union

Abstract

European Union (EU) legislation requires proactive risk management for all industry, including the fire service and Emergency Medical Services (EMS). Information was collected from select EU fire/EMS organizations to identify risk management practices to share at an international level. Highlighted approaches included a national system for documenting and prioritizing risks, identifying unique hazards for each fire brigade, embedding occupational medical programs within fire brigades, planning for terrorist threats, and regional sharing of risk management practices and outcomes.

Keywords: fire and emergency medical services, risk management, European Union

Introduction

Risk management is a proactive cyclical process whereby departments review occupational hazards, implement interventions to address high-priority risks and hazards, and monitor and update interventions to further mitigate risks. Risk management strategies originated in a number of high-risk industries over 40 years ago (Joy & Griffiths, 2007), and the first national risk-based regulations were introduced in the United Kingdom (U.K.) in the same decade (Robens, 1972). Risk management legislation was subsequently implemented in the European Union (EU) via the European Framework Directive on Safety and Health at Work (Directive 89/391 EEC) in 1989. This legislation introduced general principles for prevention of occupational risks including making an assessment of the risks. The EU risk management framework guarantees minimum safety and health requirements while Member States are allowed to maintain or establish more stringent measures.

The Framework Directive contains basic obligations for employers and workers. However, it is the employer's obligation to ensure the safety and health of workers in every aspect related to work; moreover, financial costs may not be imposed on the worker to achieve this aim. The general principles of prevention listed in the Directive include:

- Avoiding risks.
- Evaluating the risks.
- Combating the risks at their source.
- Adapting the work to the individual.
- Adapting to technical progress.
- Replacing the dangerous by the non- or the less dangerous.
- Developing a coherent overall prevention policy.
- Prioritizing collective protective measures (over individual protective measures).
- Giving appropriate instructions to the workers.

International standards are used to inform the risk management process. ISO 31000 describes the broader issue of risk management in the organizational context. Within this broad framework, organizations generally use more specific standards including:

- ISO 9001: Quality Management Systems.
- ISO 14001: Environmental Management Systems.
- ISO 45001: 2018 Occupational Health and Safety Management Systems – Requirements with Guidance for Use (ISO 45001 replaced ISO 18001 *Occupational Health and Safety Management* in 2018).

The purpose of occupational health and safety management systems is to:

- Underpin the creation of safe and healthy workplaces.
- Prevent work-related injury and ill health.
- Strive to continually improve its occupational health and safety performance.

ISO 45001 adopts a risk management approach founded on the universally applied *Plan-Do-Check-Act* model, which provides a framework for organizations to plan what they need to put in place in order to minimize the risk of harm. The measures address concerns that can lead to long-term health issues and absence from work, as well as those that give rise to accidents.

Previous research has demonstrated the effectiveness of risk management approaches. Introduction of risk management legislation in Australia was associated with a marked reduction in lost-time injuries in the mining industry as compared with the United States (U.S.) that maintains a predominantly compliance-based regulatory approach (Poplin et al., 2008). Comparing among fire departments or fire brigades in several countries, the fire brigade in the U.K. had lower injury rates, and its distinguishing characteristic was an advanced risk management system (Burgess et al., 2014). Implementation research also shows that risk management interventions are associated with reduced injury rates and costs within a U.S. fire department (Poplin et al., 2018) and that risk management approaches can be successfully used to reduce fire service vehicle crashes (Bui et al., 2018).

While existing EU legislation requires risk management for all organizations in all countries, including the fire service and EMS, it has not been implemented *to the same extent* in all EU countries. The organizational structure of the fire service and EMS varies by country, and each country has success stories or best practices to share both within its own borders and across nations. This sharing of information has the potential to advance fire service and EMS health and safety within the EU, U.S., and globally.

The main objectives of this study were to evaluate risk management practices in the following select British and French organizations and to collect, where possible, the frequency and distribution of firefighter and/or EMS injuries and illnesses:

- The London Fire Brigade (LFB).
- Le Service de Sante' et de Secours Médicale (SSSM) Haute-Corse du Service Départemental d'Incendie et de Secours (SDIS-2B) in Corsica (The Health and Medical Rescue Service of the North Corsican Fire and Rescue Service Department).
- The Paris West suburb division (Hauts-de-Seine 92) of the Service d'Aide Médicale Urgente/Service Mobile d'Urgence et Reanimation (SAMU/SMUR) (The Urgent Medical Assistance Service and Mobile Emergency and Resuscitation Service).

In addition, a convenience survey of fire service and related organizations in other EU countries, such as the Netherlands, Denmark, Belgium, Germany, and Spain, was undertaken to assess specific safety and health interventions that they implemented. The long-term goal of the study was to develop a road map for future EU and U.S. fire/EMS safety and health policy and program development focused specifically on risk management.

Methods

The research was focused on health and safety policy research with EU fire and EMS service partners. Data collection was completed from July through December of 2016. The partner institutions included:

- The LFB.
- The SSSM/SDIS-2B.
- The SAMU/SMUR-92.

For the LFB and the SSSM/SDIS-2B, the study involved evaluating the frequency and distribution of firefighter injuries and illnesses and assessing how specific safety and health interventions that they implemented had changed injury and illness patterns and costs. For the SAMU/SMUR-92, the focus was addressing terrorist threats to EMS personnel when using a proactive risk management approach. At each location, to gather additional information, further visits were made to other fire and rescue service organizations within the region.

Finally, shorter visits were made to fire service partners in the Netherlands, Denmark, Belgium, Germany, and Spain. These visits included, but were limited to:

- Meetings on firefighter exposures and cancer risks with The Instituut Fysieke Veiligheid IFV (Institute for Safety in Zoetermeer, the Netherlands).
- Symposium organized by the BrandFolkenes Cancerforening (The People's Cancer Association) in Copenhagen.
- Meeting with the Antwerp (Belgium) Fire and Rescue Service.
- Risk management meetings with the Berliner Feuerwehr (Berlin Fire Department) and the München Feuerwehr (Munich Fire Department) in Germany.
- Risk management meetings with the Bombers de Barcelona (Barcelona Fire Service) and the Bomberos Madrid (Madrid firefighters) in Spain.

Based on previous research and experiences working with fire departments and other organizations, the best chance for making improvements is through focusing on issues that are a high priority for the partners, and these issues often change over time (Bui et al., 2017). The focus of the work with the two primary fire service partners and one primary EMS partner

was, therefore, based on their requests rather than a need determined by the research team *a priori*.

Results

U.K./London Fire Brigade (LFB)

Lord Robens in 1970 led a review of health and safety legislation in the U.K. that resulted in the unification of multiple prescriptive health and safety statutes/regulations**.** He also led the introduction of an approach that was more self-regulatory (those that create the risks are responsible for managing the risks) and *goal-setting* in that it describes objectives to be met rather than requirements for detailed measures to be taken. This review led to the Health and Safety at Work Act (1974). The general principles of this Act are to set health and safety objectives for employers rather than to tell them prescriptively how to manage certain risks, such as:

- Ensure the health, safety, and welfare of employees.
- Provide and maintain machinery and safe systems of work such that they present no risks to health and safety.
- Provide information, instruction, training, and supervision as necessary to ensure the health and safety at work of employees.

As employers were no longer being prescriptively told which risks to control and how to control them, this led to employers taking more time to identify and control a broader range of risks/hazards.

In the U.K., the EU Framework Directive resulted in the creation of the Management of Health and Safety at Work Regulations (1992), which requires all employers to make a suitable and sufficient assessment of the risks to health and safety of their employees while at work. The Health and Safety Executive produced guidance, (Managing for Health and Safety (HSG65), http://www.hse.gov.uk/pubns/books/hsg65.htm), to accompany these regulations that describe how to put in place an effective health and safety management system. HSG65 is the most commonly used reference for the management of health and safety at work by employers in the U.K., including the fire and rescue services. Also, in common usage in the U.K. for the management of health and safety at work are British and international standards for health and safety management. Unlike the Management of Health and Safety at Work Regulations, these standards are not legally enforceable. Instead, they are voluntary management tools for use by organizations whose aim is to eliminate or minimize the risk of harm and to demonstrate to their staff and clients that they operate an effective health and safety management system.

Although risk management legislation was established in the 1970s in the U.K. for all employers, including the fire service, it was not until the 1990s that the fire service began to implement risk management in earnest. A major factor in this timing appears to be the threat of criminal liability starting in the 1990s for fire service supervisors not fully addressing the safety and health of their employees. Separately, a general characteristic of the U.K. fire service is the inclusion of individuals, often civilians, with formal risk management training in the health and safety component of the fire brigades.

For this study, the LFB requested the following research priorities: 1) review of risk management interventions for slips, trips, and falls; 2) evaluation of risk management interventions for training injuries and fire service vehicle crashes; and 3) prospective focus on operational injuries in regards to improved use of safety officers and possible use of critical controls.

- The evaluations used statistics starting in 2008, as that was the earliest year for which consistent electronic event data were available.
- Interrupted time series analysis was used to evaluate statistically significant changes in injury and crash rates at LFB (Linden, 2015).
- Ordinary least squares regressions were used to estimate changes in level and trend changes in crash and injury rates.
- Newey-West standard errors were used to account for residual autocorrelation and heteroscedasticity in time series data (Newey & West, 1987).
- Denominator data for onsite slips, trips, and falls came from staffing records while emergency calls (i.e., incidents) were used as denominator data for emergency vehicle crash rates.

London Fire Brigade's Accidents Happen Here Safety Campaign. In January 2014, a LFB safety campaign called *Accidents Happen Here* was initiated. This safety campaign focused on reducing slips, trips and falls in fire stations. These accidents are classified as on-site injuries. This campaign included:

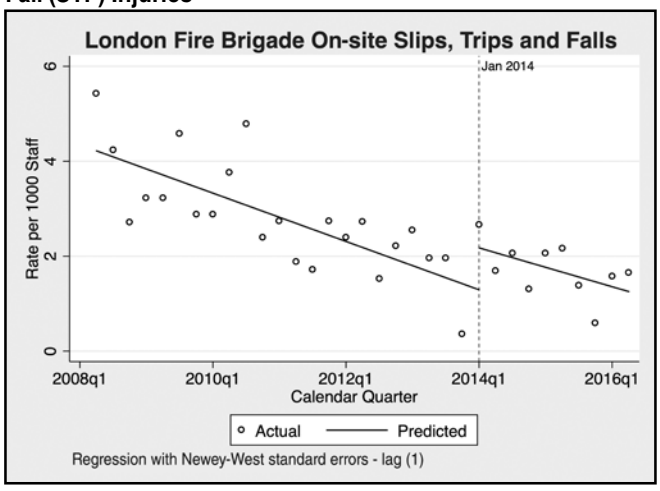
- Auditing the slip, trip, and fall hazards in each fire station.
- Evaluating how slippery each station floor was using instrument measurements, followed by corrective actions.
- Implementing a communication program to increase awareness of the STF hazard in the stations.

For these on-site injuries, there was a decrease from 2008 through the present, consistent with the LFB's overall risk management program (Figure 1). The mean pre-intervention (2008-2013) slips, trips and falls rate was 2.8 per 1,000 staff and mean post-intervention (2014-2016) rate was 1.7. Overall, there

was a reduction of about 3% per quarter between Q1 of 2008 and Q1 of 2016 (P<0.001), and no significant change in slips, trips, and falls rate was observed post-intervention (P=0.62).

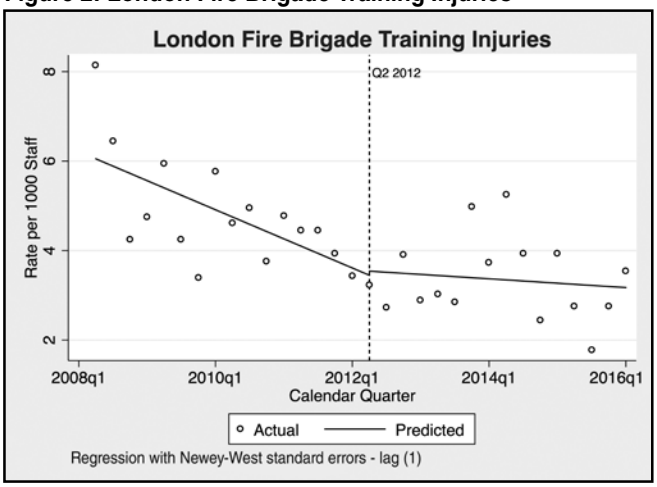
The *Accidents Happen Here* safety campaign did not markedly change the overall trend, with a similar rate of decline before and after January 2014. A potential explanation for the long-term decline in injury rates is the continuing development of a safety culture associated with multiple risk management interventions and increased awareness of and attention to risks. In comparison, non-fire injury rates in the U.S. fire service have trended lower since 1992, albeit slowly (Evarts & Molis, 2018), suggesting that there could also potentially be secular trends operating internationally. An overall trend over time of reduced injuries not consistently associated with particular interventions was also seen in U.S. mines with proactive risk management programs (Griffin et al., 2018). Over time, continued injury reductions were seen in Australian coal mines that were instituting risk management (Poplin et al., 2008).

Figure 1: London Fire Brigade On-site Slip, Trip and Fall (STF) Injuries



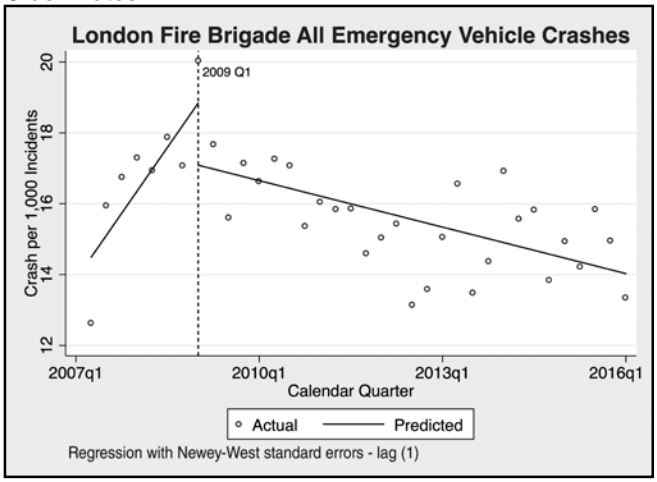
Evaluation of Risk Management Interventions for Training Injuries and Fire Service Vehicle Crashes in the London Fire Brigade. The LFB transitioned to a private contractor for firefighter training in the second quarter of 2012. This transition led to an interest in evaluating training injury rates in association with this change. There was a longitudinal decrease in firefighter training injuries since 2008 (Figure 2). This finding is consistent with the overall LFB's risk management reduction program that put in place multiple safety improvements over time. The quarterly injury rate per 1,000 staff significantly declined by -0.16 per quarter (P=0.003), starting from a mean of 6.1 training injuries per 1,000 in 2008. The move to a private contractor was initially associated with a nonsignificant (P = 0.86) increase in injuries, but the rate appeared to be declining thereafter at about -0.02 per quarter. The reasons for the initial increase in injuries are not clear, but could potentially have involved a disruptive transition phase before the contractor became more familiar with LFB protocols.

Figure 2: London Fire Brigade Training Injuries



The LFB has experienced a marked reduction in the number of fire service vehicle crashes since 2009 (Figure 3). Because the number of vehicle responses directly influences the number of vehicle crashes, the vehicle crash rate per incident was also calculated over the time interval for which the number of incidents was immediately available. This rate also declined over time. Prior to 2009, the quarterly crash rate was increasing by about 2.7% per quarter (or 0.62 per 1,000 incidents) (P=0.02). Beginning in 2009, after the implementation of a formal risk management process, the LFB began to experience steady declines in their quarterly crash rates of about 1.5% per quarter (or -0.3 crashes per 1,000) (P<0.01).

Figure 3: London Fire Brigade All Emergency Vehicle Crash Rates



Since 2008,the following multiple risk management interventions were put in place in the LFB:

- Policy changes to reduce emergency response speeds.

- Revised backing policies.
- Increased driver and officer liability/discipline for preventable incidents.
- New targeted driver training.
- New driver's license database.
- One-way station entrances and exits with bay doors to reduce the need for on-station backing.

As with slips, trips, and falls and training injuries, there was not a single, most effective control identified regarding fire service vehicle crashes. Rather, the reduction appears to be the result of the multiple overlapping interventions. Related to driver training, a civilian fatality occurred in another U.K. fire brigade after a pedestrian stepped out in front of a fire engine and was struck. As a result, fire brigades throughout the U.K., including the LFB, were evaluating their driver training programs both for new drivers and also refresher training for existing drivers.

Prospective Focus on Operational Injuries in Regards to Improved Use of Safety Officers and Possible Use of Critical Controls. One aspect of risk management currently gaining traction, particularly in the mining world, is the identification of *critical controls*, whereby an organization focuses its efforts on ensuring that the most essential controls function effectively for preventing fatal or other catastrophic events. The LFB was interested in identifying enhanced training and on-site activities for its approximately 50 Senior Accident Investigators (SAIs) to increase their potential to act proactively at incidents. Senior Accident Investigators have additional training in health and safety and in accident investigation. Using a critical control approach, they plan to identify the areas with the biggest potential impact (through trend analysis, etc.) and actively target those areas for intervention. Future evaluation of the effectiveness of this intervention is recommended.

In the U.K., health and safety personnel are formally trained in risk management. For example, the LFB requires the following of health and safety advisors:

- Have degree-level qualification in health and safety management.
- Must be Chartered Safety Practitioners (i.e., chartered members of the Institute of Occupational Safety and Health (IOSH). This involves demonstrating professional development over a number of years and includes an exam and interview to demonstrate competence.
- Continue professional development, which must be formally submitted to IOSH.

In addition to working with the LFB**,** meetings were held with a number of individuals to identify opportunities for collaborative work in the U.K. and additional effective risk management processes in the U.K. fire service. There is regional sharing of injury data among fire brigades, which also provides an opportunity for face-to-face sharing of effective risk management processes.

The National Occupational Guidance (NOG) effort was working to standardize standard operating procedures (SOPs) across the U.K., starting with around 8,000 documents with a goal of eventually narrowing them down to 34 (http://www.ukfrs.com/). There are also *coroner's cases* related to a work-related death. In these cases, a coroner has the power to issue a report called a *Prevention of Future Death* when there are key lessons to be learned by an organization in response to the death. Any organization named in the report must respond to the coroner saying how it will address the issues/recommendations if it has not adequately controlled them already. Based on these inquiries, all fire brigade leaders in the U.K. generally implement reviews of their own operations and changes as needed.

In summary, the U.K.'s *best practices* were identified as the following:

- Strong risk management regulations with significant consequences for noncompliance.
- Extensive implementation of risk management in the fire service.
- Formal training of health and safety professionals in risk management.
- Regional sharing of information, including injury rates and effective interventions, by safety and health officers.

The reduced rate of injuries and crashes over time clearly demonstrate the effectiveness of the LFB (and more broadly the U.K.) risk management process.

France/Service de Santé et de Secours Médical du Service Départemental d'Incendie et de Secours Haute-Corse (SSSM/SDIS-2B) (The Health and Medical Rescue Service of the North Corsican Fire and Rescue Service Department)

In France, employers are legally responsible for the health and safety of their employees (Frimat & Fantoni-Quinton, 2014). The French fire service, in the roughly 100 regional departments nationally, has a medical service (SSSM) supporting the fire service (SDIS). This allows the SSSM physicians, nurses, and pharmacists to dedicate their time to the health and safety of their firefighters. The main work of the medical service includes annual evaluations of each firefighter's health and work readiness. The evaluation, standardized by the French government in 2000, includes a vision test,

pulmonary function testing, urinalysis, an electrocardiogram, and a full physical exam (https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000765094&categorieLien=cid).

If a firefighter is unable to return to work, the SDIS is required to find another job for the firefighter. For example, some firefighters are sent for additional training or assigned to vehicle management or pharmacy.

For risk management, the SDIS and all French companies use The Document Unique (Unique Document), following article L4121-1 du code du travail (labor code). This document provides all aspects of organization and work execution risks, which the fire service evaluates and documents along with prevention and/or mitigation plans. The reporting is shared with all SDIS employees. As a result, new risk management actions are frequently established, such as, but not limited to, electrical risk in buildings, hygiene in stations, and driving and parking safety.

The Ecole Nationale Supérieure des Officiers de Sapeurs-pompiers (ENSOSP) (National School for Firefighter Officers) in Aix en Provence is a national school for fire service officers (http://www.ensosp.fr/SP/pages-ENSOSP/accueil-2018). Every year, new officers are trained, and active French officers return to the ENSOSP for continuing education. Furthermore, SDIS directors and the medical chiefs of SSSM go twice a year to the ENSOSP to meet. ENSOSP provides a location where problems can be shared and solutions provided by other officers or instructors with the goal of spreading effective programs back to all fire departments.

Our research focus in France was on a sample of the areas requested by SSSM/SDIS-2B, which included:

- Back injuries.
- Driving (traffic) accidents.
- Operational injuries.
- Training injuries.

Table 1 summarizes the data collected from SSSM/SDIS-2B. The overall rate of annual time-loss injuries, given approximately 1,000 SDIS-2B employees, was lower (1.5-5%) than the French national average of 5.3%.

The majority of time loss was due to illness not caused by work. For example, in the first eight months of 2016, there was one low-back injury among SDIS-2B staff (as compared to five during 2015), but there were an additional nine outside of work. During the first eight months of 2016, there were 787 lost workdays from these lower back injuries. Since most SDIS-2B back injuries occur outside work, specific interventions in the workplace may not be as useful as exercise programs to strengthen the back and thereby prevent injuries.

Most injuries occurred during medical responses (15 total and 6 with time loss). Needle sticks (three) and other blood exposures (five) occurred in eight incidents, none with time loss. The research group recommended to review needle use and disposal policies and follow-up with an evaluation of how well the policies are implemented.

Four injuries occurred from lifting patients. It would be useful to review current lifting policies and training, and to determine how well they are followed. Use of power-assist stretchers would likely reduce the number of back injuries, but they may not help with removing patients from their homes given the local construction with narrow and steep stairwells.

During fire fighting, the following number of firefighter injuries occurred:

- Seven injuries from wildland fire fighting responses.
- Two injuries during structural fires.
- One injury from a dumpster fire.

Injuries may have been prevented if firefighters:

- Avoided overextension. Most injuries were to the lower extremities or back.
- Wore safety glasses, which would have prevented the two eye injuries.
- Carried a light at night. One injury occurred at night when a firefighter did not bring a light.
- Wore adequate gloves to prevent burn injuries. One burn occurred due to inadequate gloves; this resulted in provision of improved gloves for all firefighters.

Table 1. SDIS-2B Injuries from 2012-2015

Year	Operations	Exercise	In station	Training	Driving	Total
2012	13	13	15	3	4	48
2013	12	2	7	3	3	27
2014	4	0	8	1	2	15
2015	23	12	11	4	4	54

Current campaigns were in place for exercise (sports) and in-station and on-road injury prevention. There was a marked reduction in exercise injuries for 2013 and 2014, but the opportunity was not present to collect information on the interventions that led to this decrease. No data were collected on in-station incidents or programs to reduce their occurrence. Two lower extremity injuries (one during operations and one during training) resulted from stepping off a vehicle. Workplace evaluations could help determine if the firefighters are properly dismounting their vehicles.

In France, vehicle crashes are the leading cause of death among firefighters. A recent national program (Plan de Prévention du Risque Routier [PPRR] (Road Hazard Prevention Plan) had been started, but at the time of the study, station interventions were limited to educational posters. In addition to implementing campaigns for other types of injuries and illnesses, the current risk management system could benefit from a continuous review process to determine the effectiveness of program interventions and regular reviews of fatal and serious injuries from other SDIS departments in France. SDIS-2B should adapt interventions to current accidents and those most likely to cause fatal events. It will also be important to track how interventions are implemented and their impact.

SDIS-2B and other French fire departments have also adopted select *critical controls*, which are designed to prevent fatal or other catastrophic events. Since 1996, French wildland fire trucks have an *autoprotection* system that covers the vehicle with a water spray allowing fire to pass over the truck for a few minutes. Firefighters are trained to get inside the vehicle and initiate the autoprotection system. This system both starts the water spray and fills the inside cabin with high pressure air to prevent smoke from entering, without injury to firefighters seeking refuge inside. The system is used every year in France in southern departments and has reportedly saved lives. As part of routine maintenance, it has to be checked daily. A failure of the autoprotection system in a wildland fire service truck caused a fatal burn injury in another SDIS department. To prevent this from occurring, the autoprotection system should be checked at the beginning of each shift to demonstrate that the system functions.

Identified best practices in the French fire service included the intrinsic structure of the SSSM pairing with the SDIS. This allowed physicians, nurses and pharmacists to dedicate their time to the health and safety of their firefighters, including collecting information on illnesses and injuries outside of work, which is essential to addressing this primary cause of absenteeism. The autoprotection system was an example of an effective critical control.

France/Service d'Aide Médicale Urgente (SAMU)/Service Mobile d'Urgence et Reanimation (SMUR) (SAMU/SMUR-92) (The Paris West suburb division of the Urgent Medical Assistance Service and Mobile Emergency and Resuscitation Service)

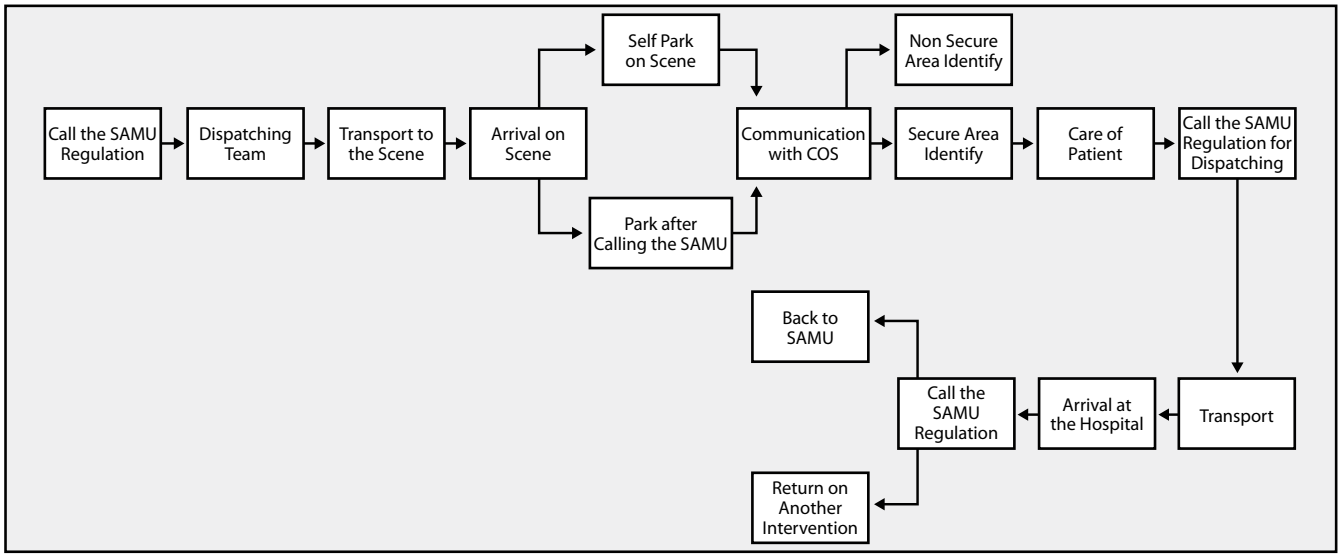
In France, the EMS system involves physicians, nurses, and drivers responding to potentially high acuity patient cases in their homes or in the general community outside of hospitals. In the context of a terrorist threat, first responders may be at significant risk of injury or death, particularly from gunfire. France, like many countries in the world, has faced terrorist attacks, including the Paris attack of Friday, November 13, 2015, when mass shootings occurred at several separate locations (Descatha et al., 2016); (Frattini et al., 2016):

- *Bataclan theatre massacre in Paris*. The attackers killed 90 people. Another 413 were injured, almost 100 seriously.
- *Stade de France in Saint-Denis during a football match.* Emergency teams treated over 60 victims and faced the challenge of overseeing an orderly evacuation of 72,000 spectators. During the night, the emergency teams had to face 129 civilian fatalities on site and more than 300 injuries. The incident ended with a final assault against the terrorists on Wednesday, November 18. Although no first responders were injured, they were potential targets for a secondary attack.
- *Bastille Day, Nice, France.* Another attack occurred in Nice on July 14, 2016. During the fireworks display, a man intentionally drove a truck into the crowd leading to 86 casualties and the injury of 458 others (Quatrehomme et al., 2019). Although first responders were not injured, the potential threat to their safety was evident.

As prehospital care staff have become potential targets for terrorists, special attention to this threat and consequences by occupational health professionals is essential. In Garches, the SAMU/SMUR-92 wanted to use a risk management approach to evaluate ways of reducing hazards to their first responders during a terrorist incident. The main types of attack are:

- Explosions.
- Shootings.
- Stabbings.
- Chemical, biological, radiological, and nuclear (CBRN) attacks (Thompson, Rehn, Lossius, & Lockey, 2014).

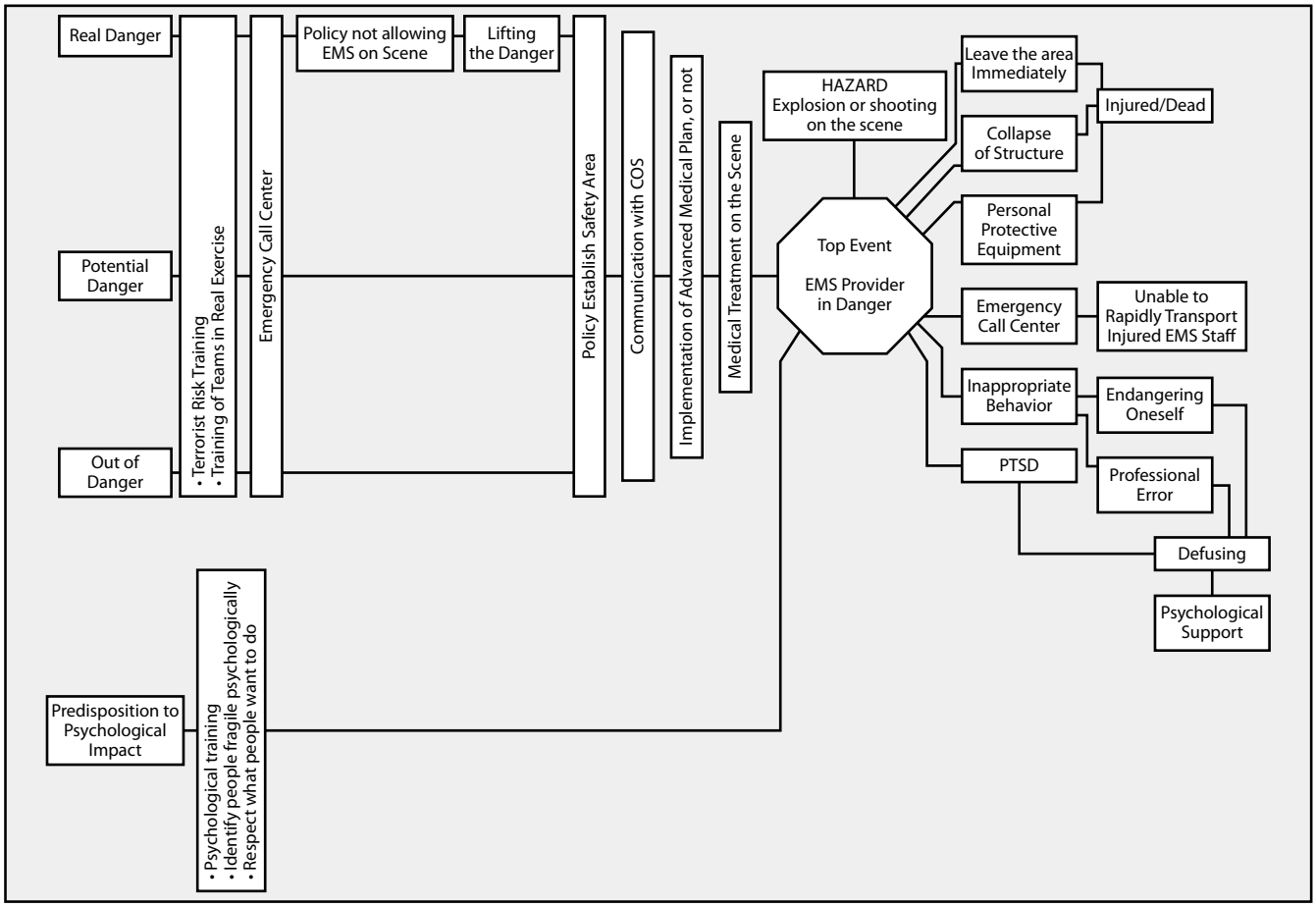
Figure 4: Chronological Flow Diagram of SAMU/SMUR-92 EMS Response to a Potential Terrorist Incident



After frequent planning meetings, a risk management session with the SAMU/SMUR-92 team was held to outline potential interventions to reduce risk. Figures 4 and 5 illustrate their current risk management concepts. One notable finding was the need for greater integration of EMS with police and fire during emergency response training and preparedness exercises, which is a common challenge in many countries (Saber, Strout, Caruso, Ingwell-Spolan, & Koplovsky, 2017), as well as training for responders about self-protection basics when a terrorist attack is suspected. A short acronym, COVER, was developed for the training. In French, COVER stands for Communication, Off (*be quiet*), Vigilance (*awareness*), Equipe (*team work*), and Retour (*feedback*).

Psychological consequences of terrorist attacks included post-traumatic stress disorder, anxiety, and mood disorders. In addition, sleep troubles can arise following any type of attack (Wilson, 2015; Benedek, Fullerton, & Ursano, 2007). Mitigation strategies, to

Figure 5: Bowtie Analysis of EMS Response to a Terrorist Incident



be implemented as early as possible, include regular follow-up with occupational or other appropriately trained physicians.

Meetings were also held with the Brigade de Sapeurs-Pompiers de Paris (BSPP) (Paris Fire Brigade), to discuss its use of the risk management process. One of the BSPP's focus areas, through the help of psychologists, was the prevention of post-traumatic stress disorder (PTSD). The BSPP also had an active program to reduce fire service vehicle crashes, with a focus on motorcycles. Data showed 116 motorcycle accidents in 2013; 75 in 2014; and 73 in 2015, including accidents on the way to and returning home from work. BSPP officials were also looking for effective programs used in other French fire brigades.

Other Site Visits

Zoetermeer. A meeting was held with the Instituut Fysieke Veiligheid (Institute for Safety) in Zoetermeer, Netherlands. The meeting included representatives of the Dutch fire service who were concerned about risks to firefighter health. The representatives' focus was on cardiovascular risks and heat stroke as well as research on reduction of exposure to occupational carcinogens such as from turnout gear contaminated by soot. The Dutch have occupational medicine programs within the fire service. Likewise, Dutch fire departments had extensive risk management practices, but they did not typically follow-up to determine the effectiveness of their risk management interventions.

Copenhagen. A meeting on firefighter cancer was held in Copenhagen, Denmark, with representatives of the Danish fire service as well as members from the international fire service. Health and safety experts also attended the meeting. The objective of the meeting was to collect information to formulate a statement to be considered by the Federation of the European Union Fire Officers Associations (FEU). The Hovedstadens Beredskab (Greater Copenhagen Fire and Rescue) demonstrated its new portable shower decontamination facility intended for hazmat use. For reduction of exposures to carcinogens at the fireground, the firefighters have implemented a procedure that requires the removal of turnout gear immediately after each fire for cleaning and immediately receiving new clean turnout gear. In the Danish fire service, firefighters do not have their own personal turnout gear, allowing a more limited number of extra sets of turnout gear to be rotated among members when their previous set is sent out for cleaning.

Anvers (Antwerp). Government inspectors in Belgium require that fire brigades have risk management processes in place. At a meeting with the Brandweerzone Antwerpen (Antwerp Fire and Rescue Service), brigade officials described their own excellent risk management policies and procedures, such as for responding to pipeline incidents and for the reduction of chemical exposures to firefighters. In addition, the fire brigade was actively working to reduce fire service vehicle crashes.

At the time of the meeting, the Brandweerzone Antwerpen was not actively tracking the effectiveness of its safety and health interventions, partly because its interventions typically focused on severe injuries that were infrequent in nature. Also, historically, the Belgian government has offered only limited national health and safety standards for the fire service. Moreover, there are regional differences among government investigators and rulings, which impedes standardization in risk management processes.

At the time of our research, in the Flanders section of Belgium, fire service leaders were organizing a safety and health meeting on a regular basis for all fire brigades. Fire service officials had also locally developed a *Learning Arena* that brought all first responder partners (fire service, ambulance service, etc.) together to evaluate major incidents and share best practices.

Berlin. Approximately 1.4 million firefighters are within the German fire service. All cities with populations over 100,000 are required to have a career fire brigade, and each village is also required to create its own fire brigade. Industrial facilities of a certain size are required to have a private fire brigade. Within Germany there is a group of all chief fire officers who cover occupational health and safety issues and share information. A severe accident to a firefighter in one fire brigade can lead to changes throughout all fire brigades. The Berliner Feuerwehr (Berlin Fire Brigade) also send their firefighters to other cities in Europe to share and exchange knowledge.

The Berliner Feuerwehr includes EMS, which accounted for roughly 80% of its calls, and all firefighters were trained as emergency medical technicians (EMTs). Thirty-four of the brigade ambulances were staffed by a physician. The fire brigade had an extensive risk management system including hazard assessment (using a risk assessment matrix), SOPs, intranet training systems, and online injury/accident reporting.

Injury reduction efforts included the following:

- Self-rescue equipment that had been designed into turnout gear. The equipment had been developed by a working group, including firefighters.
- All injury reports were investigated by a special group comprised of brigade members.
- Firefighters separated contaminated gear in the equipment bay and used an external company to clean dirty gear for exposure reduction.

The brigade had a designated individual who was responsible for the written health and safety plans. Insurance companies helped the brigade determine which health and safety initiatives should be undertaken. The brigade had an independent team comprised of health and safety experts studying various

health and safety issues for over 10 years. The team met six times a year to evaluate departmental health and safety data. The Berliner Feuerwehr had safety managers for each shift at the station-level that were sent to training school. For occupational health, they had contracts with external physicians for annual medical surveillance examinations. The only risk management gap noted was a general lack of follow-up with data collection to see if risk management interventions were effective.

München (Munich). Fire service leaders from municipalities in the Munich region are required by law to gather and list the potential risks to the safety and health of firefighters. This activity was achieved through the Feuerwehrbedarfsplan, (fire brigade requirement plan), which included both risks and the measures to be taken in order to minimize those risks. As in Berlin, Munich maintained a career fire brigade as well as a volunteer fire brigade. Issues of a certain importance were discussed to ensure an exchange of knowledge and a steady flow of information. In the federal state of Bavaria, there was a platform for the Bavarian Chief Fire Officers to discuss and share experiences regarding prevention of fires and fire protection.

The Munich Fire Brigade used an external government team instead of an internal occupational risk assessment team to identify safety and health risks to their firefighters. Similar to the Berlin Fire Brigade, many of their injuries were from exercise/sports, and they provided training to their firefighters for safe exercise. At the time of the visit, firefighters who contracted cancer believed to be related to occupational exposure did not receive special payment, although reportedly the family of a firefighter in Hamburg that had cancer had brought a complaint to that city. The Munich Fire Brigade was cooperating with other fire brigades in Germany on the issue of cancer risk as part of a comprehensive study conducted by the Klinik Hamburg Eppendorf (Hamburg Eppendorf Clinic).

Barcelona. For the period 2012 to 2015, the Bombers de Barcelona (The Fire Brigade of Barcelona) operational staff of approximately 600 people responded to an average of around 17,000 incidents. Within this period, there were approximately 85 firefighter injuries or illnesses with medical leave and 95 without medical leave. Of the accidents with medical leave, about 60% occurred within the station, with the five leading causes including:

- Handling of material and stepping off their vehicles.
- Descending the fire pole (predominantly sprained ankles).
- Slipping down stairs in the apparatus bay or on the training ground (due to the presence of water).
- Training.
- Physical exercise.

Preventive measures adopted to mitigate these accidents included:

- Specific protocol during driving training for getting off a vehicle.
- Ergonomics of new materials and design of vehicles.
- Installation of 24-hour illumination for the fire pole.
- Improved mats.
- Better signage.
- Planned, specific training for lifting and transport of materials.
- Improvements in exercise equipment in the gymnasium.

Most cities in Spain, including Barcelona, have separate ambulance services. However, Bombers de Barcelona provides an initial response to medical emergencies. Of about 15,000 annual responses, approximately 6,000 involve medical incidents. Before the establishment of separate ambulance services, the brigade responded to about 14,000 medical incidents annually.

The Barcelona Fire Brigade used a risk matrix for routine activities; brigade members identified the procedural risks and documented practices used.

- Annual medical evaluations were voluntary for firefighters. At that time of the visit, 205 out of about 600 firefighters and 30 drivers had received an annual medical evaluation.
- Firefighters washed their fire gear at least twice a year.
- Brigades conducted safety training for their firefighters at the training division in Barcelona.

For advanced or specialized training, brigades sent their officers to other countries, such as the U.K. or the ENSOSP in France, or elsewhere in Spain — such as the Centro de Seguridad Marítima Integral de Jovellanos (Jovellanos Integral Maritime Security Center) in Asturias.

Madrid. Madrid (Madrid Fire Brigade) had many new fire service vehicles and used approximately six shifts, all 24 hours in duration. When brigade members responded to a fire incident, eight personnel (five firefighters, the driver, and two officers) rode in the pumper, as well as three more in a second vehicle. Firefighters did not respond on EMS calls, as there was a SAMU-like system used for those calls. However, all brigade firefighters were trained to the basic level of EMT. Many of the firefighters were also mountain climbers; they had a climbing wall in their gym. Firefighters were required to stay in shape and time was

provided during their shift for them to exercise. Fire brigade officials had previously removed heavy weights and added aerobic workout equipment.

The Bomberos Madrid had some occupational safety and health inspections in the stations, but there was no national legislation for fireground incidents. In 2010, the EU fined Spain for not adequately following EU health and safety laws in regards to risk management. In response, fire brigades started to do risk assessment. However, there has not been follow-up with data to determine the effectiveness of the resulting interventions.

Spain did not have any national guidance for firefighter risk management, nor any formal regional or national sharing of firefighter injury data. A major issue was the lack of data, including data from physician evaluations such as is done in France. Brigade leaders tried to work with insurance companies on this issue, but had not been successful as of the time of the meeting. Brigade officials started to work two to three years previously with workers' compensation/risk management agencies in Madrid, but these agencies did not have firefighter-specific expertise.

Conclusion

Each fire/EMS organization visited had successfully developed risk management practices that would be beneficial to share at an EU or international level. Risk management legislation is most advanced in the U.K. The French have embedded medical programs (SSSM) within their fire brigades that yield multiple benefits, including the ability to holistically address both occupational exposures and adverse lifestyle practices such as, but not limited to, smoking among their firefighters. The SAMU/SMUR system has dedicated drivers for their ambulances. Embedded occupational medicine programs within the fire service were also described in the Netherlands. Regional sharing of risk management best practices is being used in parts of the U.K. and France, and national databases are established in both countries. The U.K. is moving towards using national comparison data to drive change. Examples of regional and/or international sharing of information was also observed or described during the site visits in Denmark, the Netherlands, Belgium, Germany, and Spain.

Other risk management best practices include but are not limited to:

- Documenting and prioritizing risks, best epitomized by the French Document Unique for each SDIS.
- Planning for EMS risks in terrorist situations, as carried out by SAMU/SMUR-92, with training and special follow-up by occupational health professionals.
- Evaluating the effectiveness of interventions, as demonstrated by the LFB.
- Providing risk management specific training for their health and safety personnel in the U.K. and Germany.
- Limiting safety and health personnel turnover through including civilian staff with risk management expertise, as is practiced at some British fire brigades.
- Providing protected time while on-shift for firefighters to stay in shape, as is practiced in some Spanish fire brigades.
- Immediate cleaning of contaminated turnout gear after a fire response in Denmark.

The long-term goal of the study was the formation of a road map for future EU and U.S. fire/EMS safety and health policy and program development. This goal will require creation of health and safety committees within EU multinational fire service organizations, which would need to meet regularly and share effective risk management practices based on documented reductions in their firefighter injury and illness rates. Organizations with broad representation within the EU include the European Fire Service Colleges' Association (EFSCA), the Comité technique international de prévention et d'extinction du feu (CTIF) (International Technical Committee for the Prevention and Extinction of Fire, also known as the International Association of Fire and Rescue Service), and the Federation of the European Union Fire Officer Association (FEU). It may be advantageous to start with a focus area of broad interest to the EU fire service.

References

Benedek D., Fullerton C., & Ursano R. (2007). First responders: Mental health consequences of natural and human-made disasters for public health and public safety workers. *Annual Review of Public Health, 28*, 55-68. doi: 10.1146/annurev.publhealth.28.021406.144037

Bui, D. P., Balland, S., Giblin, C., Jung, A., Kramer, S., Peng, A., Aquino, C., Griffin, S., French, D. D., Porter-Pollack, K., Crother, S., & Burgess, J. L. (2018). Interventions and controls to prevent emergency service vehicle incidents: A mixed method review. *Accident Analysis & Prevention*, *115*, 189-201. doi: 10.1016/j.aap.2018.01.006

Bui, D.P., Pollack-Porter, K., Griffin, S., French, D. D., Jung, A. M., Crothers, S., & Burgess, J. L. (2017). Risk management of emergency service vehicle crashes in the United States fire service: Process, outputs, and recommendations. *BMC Public Health, 17*(1), 885. doi: 10.1186/s12889-017-4894-3

Burgess, J. L., Duncan, M., Mallett. J., LaFleur. B., Littau. S. R., & Shiwaku. K. (2014). International comparison of fire department injuries. *Fire Technology, 50*(5), 1043-1059. doi: 10.1007/s/s10694-013-0340-y

Descatha, A, Huynh Tuong, A., Service Médical Du Raid, Coninx, P., Baer, M., Loeb, T., & Despréauxet, T. (2016). Occupational practitioner's role in the management of a crisis: Lessons learned from the Paris November 2015 terrorist attack. *Front Public Health*, *4*, 203.

Evarts, B., & Molis, J. L. (November-December 2018), United States firefighter injuries – 2017. *National Fire Protection Association Journal*. Retrieved from https://www.nfpa.org/News-and-Research/Publications/NFPA-Journal/2018/November-December-2018/Features/US-Firefighter-Injuries-2017.

Frattini, B., Franchin, M., Travers, S., Jost, D., Alhanati, L., Galinou, N., Tourtier, J. P. (2016). Prehospital rescue organization during the November 2015 Paris terrorist attack. *Journal of Emergency Medical Services*, *41*(5), 24-30.

Frimat, P., & Fantoni-Quinton, S. (2014). Santé travail : Une nouvelle dynamique? [Occuptional health: A new dynamic in France?]. *Archives des Maladies Professionnelles et de l'Environnement*, *75*(5), 469. doi : 10.1016/j.admp.2014.07.003

Griffin, S. C., Bui, D. P., Gowrisankaran, G., Lutz, E. A., He, C., Hu, C., & Burgess, J. L. (2018). Risk management interventions to reduce injuries and maximize economic benefits in U.S. mining. *Journal of Occupational and Environmental Medicine*, *60*(3), 226-233. doi: 10.1097/JOM.0000000000001245

International Organization for Standardization (ISO). (2018). *Risk management – Principles and guidelines*, *ISO 31000: 2018*

Joy, J., & Griffiths, D. (2007). *National minerals industry safety and health risk assessment guideline*, St Lucia, Queensland, Australia. http://www.nost.edu.au/icms_docs/286339_National_Minerals_Industry_Safety_and_Health_Risk_Assessment_Guideline_-_Jim_Joy.pdf

Linden, A. (2015). Conducting interrupted time-series analysis for single-and multiple-group comparisons. *Stata Journal, 15*(2), 480-500.

Newey, W. K., & West, K. D. (1987). A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica, 55*(3), 703-708.

Poplin, G. S., Miller, H. B., Ranger-Moore, J., Bofinger, C. M., Kurzius-Spencer, M., Harris, R. B., & Burgess, J. L. (2008). International evaluation of injury rates in coal mining: A comparison of risk and compliance based regulatory approaches. *Safety Science*, *46*, 1196-1204. doi: 10.1016/j.ssci.2007.06.025

Poplin, G. S., Griffin, S., Pollack Porter, K., Mallett, J., Hu, C., Day-Nash, V., & Burgess, J, L. (2018). Efficacy of a proactive health and safety risk management system in the fire service. *Injury Epidemiology*, *5*(1), 18. doi: 10.1186/s40621-018-0148-9

Quatrehomme, G., Unité Police d'Identification de Victimes de Catastrophes, Toupenay, S., Delabarde, T., Padovani, B., & Alunni, V. (2019). Forensic answers to the 14th of July 2016 terrorist attack in Nice. *International Journal of Legal Medicine*, *133*(1), 277-287.

Robens, A. (1972). Safety and health at work: Report of the Committee 1970-1972. *Cmnd. 5034*, *Her Majesties Stationary Office.* Retrieved from http://www.mineaccidents.com.au/uploads/robens-report-original.pdf

Saber, D. A., Strout, K., Caruso, L. S., Ingwell-Spolan, C., & Koplovsky, A. (2017). An interprofessional approach to continuing education with mass casualty simulation: Planning and execution. *Journal of Continuing Education in Nursing*, *48*(10), 447-453. doi: 10.3928/00220124-20170918-05.

Thompson, J., Rehn, M., Lossius, H. M., & Lockey, D. (2014). Risks to emergency medical responders at terrorist incidents: A narrative review of the medical literature. *Critical Care, 18*(5). doi: 10.1186/s13054-014-0521-1

Wilson, L. C. (2015). A systematic review of probable posttraumatic stress disorder in first responders following man-made mass violence. *Psychiatry Research*, *229*(1-2), 21-26.

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Antecedents of Trust in Leadership: A Multilevel Perspective in the Fire Service

Abstract

*A number of studies have shown that **trust in leadership** improves the attitudes and behaviors of members and contributes to organizational effectiveness. Empirical research is lacking, however, on what factors lead to trust in leadership **within fire departments**. Employing an original survey instrument, this study explores the determinants of trust in leadership within a west coast fire department across two leadership referents (direct versus senior leaders). Findings emerging from this study show that fire departmental personnel trust leaders that (1) form social exchange relationships with members based on emotional support, (2) they perceive as competent, and (3) that demonstrate cooperative behaviors. These findings suggest that training leaders on the importance of relationships can build higher trust levels in fire departments.*

Keywords: trust in leadership, trust in the fire service, trust antecedents, character-based leadership, relationship-based leadership

Introduction

While most existing literature suggests that *trust in leadership* is essential in the fire service, few studies empirically explore this critical topic. Most existing studies focus on leadership qualities and how such qualities influence members' perceptions of organizational commitment (Pillai & Williams, 2004), department performance (Geier, 2016), and job satisfaction (Bartolo & Furlonger, 2000).

When compared to many other types of organizations, one could argue that trust in leadership is perhaps even more important in the fire service. Firefighters are required to perform tasks in complex and unpredictable scenarios where, at times, response operations may involve hazardous, even life-threatening conditions (Colquitt, LePine, Zapata, & Wild, 2011). In this environment, the direct and indirect decisions leaders make influence the level of risk involved in the work that firefighters do daily (Campbell, Hannah, & Matthews, 2010). Given these interdependencies, firefighters are likely to be especially attentive to the behaviors and characteristics of their leaders.

In fact, previous studies have found that trust in leadership does have a positive impact on the success of response operations (e.g., Pillai & Williams, 2004; Geier, 2016). For example, in a survey exploring changes in fire service leadership styles, Geier (2016) found that when leaders are trusted more, members perceive an increase in their unit's performance. In contrast, when fire service leaders lack the trust of their members, they lose the ability to influence them, which degrades operational effectiveness in risk-laden situations (Sweeney, 2010). Considering that members look to leaders to centralize authority and to take action during extreme events (Hannah, Uhl-Bien, Avolio, & Cavarretta, 2009), losing trust in leadership may be detrimental for both the department's performance and the community that depends on the lifesaving services provided by fire departments.

While a number of studies have explored the relationship between leadership qualities and outcome variables, such as trust in teams (Colquitt et al., 2011; Arnold, Kelloway, & Barling, 2001) and trust in organizations (Rezaei, Salehi, Shafiei, & Sabet, 2012; Winston & Joseph, 2005), fewer studies address potential associations between leadership qualities and the development of trust in leaders (Pekerti & Sendjaya, 2010). Dirks and Ferrin (2002) did find, however, that transformational leadership (a leadership style where leaders work with members to determine needed changes, inspire action, and involve members in making those changes) was strongly associated with leader trustworthiness. Studies also show trust developing for leaders that engage in servant leadership (Pekerti & Sendjaya, 2010) and cooperative conflict management (Chan, Huang, & Ng, 2008).

The research presented here adds to the growing empirical literature that examines factors that influence trust in leadership in the fire service. Using character-based and relationship-based theories, research questions are tested that are logically associated

with cognitive and affective dimensions of trust (Dirks & Ferrin, 2002). Data were gathered using a survey designed to measure organizational culture. Building on existing theory, five factors (variables) that the literature suggests build trust in leaders (e.g., Lester, 2007; Sweeney, 2010; Tremblay, 2010) are analyzed using regression analysis. The five variables are: considerate leadership behaviors, cooperative leadership behaviors, leadership competence, value congruence, and perceived fairness.

The present study is organized into the following four additional sections. The first section provides an overview of the literature that focuses on trust in leadership in high-risk organizations such as the military; the theoretical framework used to study the development of trust in fire service leadership; and the literature that assesses trust in leadership by levels of leadership – direct versus senior leaders. The second section presents the data and methods used to empirically assess factors affecting trust in leadership in one U.S. fire department. The third section outlines findings emerging from the survey findings; offers a discussion of these findings; and presents limitations of the research effort. Section four provides a summary and conclusion.

Trust in Leadership: A Review of the Literature

This section is divided into three subsections. First, lessons learned from high-risk organizations, such as the U.S. military, are reviewed as a foundation for understanding factors that may help explain the development of trust in fire service organizations. Second, an integrated framework (based on previous research) is offered for understanding trust in leadership in the fire service. This framework includes a detailed review of the cognitive/character-based theory of leadership and the affective/relationship-based theory of leadership. Third, the literature is reviewed in terms of expected differences of the impact of leadership referents (direct versus senior leadership) on the development of trust in leadership.

Building Trust in Leadership: Lessons Learned from High-Risk Organizations

In studies of organizations outside of the fire service, findings suggest that trust mediates the relationship between leadership behaviors and a number of important outcome variables relating to organizational members' attitudes and performance (Goodwin, Whittington, Murray, & Nichols, 2011). For example, studies show that trust in leadership explains the impact that transformational leaders have on organizational members' perceptions of job satisfaction, work stress, stress symptoms (Liu, Siu, & Shi, 2010), psychological well-being (Kelloway, Turner, Barling, & Loughlin, 2012), and increased performance (Schaubroeck, Lam, & Peng, 2011).

Research focusing on high-risk organizations also provides insights about the determinants of trust in leadership. As noted in the previous section of this article, while empirical research is scant on the factors explaining trust in fire service organizations, findings emerging from studies of factors influencing trust in leadership in other high-risk organizations is much more abundant. Research on the military, for example, has shown that both character-based (perceptions of who the leader is) and relationship-based (how the leader interacts with individuals) aspects of leadership are important for the development of trust in military leaders (Hyllengren et al., 2011).

When considering *character-based* aspects of leadership, previous military-based studies have found that the following factors influence trust development:

- Credibility (Sweeney, Thompson, & Blanton, 2009).
- Confidence (Hyllengren et al., 2011).
- Competence (Sweeney, 2010).
- Emotional stability (Hyllengren et al., 2011).
- Common interests (Sweeney et al., 2009).
- Fairness (Tremblay, 2010) of military leaders.

In addition, *relationship-based* factors that influence trust development include:

- How much leaders encourage involvement in decision-making processes (Hyllengren et al., 2011).
- The establishment of cooperative independence (Sweeney et al., 2009).
- How much leaders foster creativity (Hyllengren et al., 2011).
- Whether leaders emphasize individualized consideration (Lester, 2007).

Sweeney et al. (2009) note that with higher levels of trust in leadership, soldiers are more willing to risk injury or death to contribute to organizational goals. Firefighters often face similar vulnerabilities in their work environment. Research emerging from studies on building trust in military leaders is foundational to the integrated framework for trust-building in the fire service, which will be discussed next.

Building Trust in Leadership: Toward an Integrated Framework for the Fire Service

According to Rousseau, Sitkin, Burt, and Camerer (1998), "Trust is a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another" (p. 395). Trust in leadership, then, is the willingness of an organizational member to be vulnerable to the actions and behaviors of his or her leader. These

actions and behaviors are beyond the subordinate's control (Mayer, Davis, & Schoorman, 1995).

Scholars, such as McAllister (1995), suggest that interpersonal trust stems from two different dimensions: cognitive and affective. The cognitive dimension, often associated with character-based theories of trust in leadership, emphasizes the vulnerability component of the definition of trust provided by Rousseau et al. (1998) and posits that individuals develop trust by using a rational logic that assesses the degree to which others may be relied and depended upon and their ensuing willingness to accept vulnerability. The model proposes that three broad factors, perceptions of leader ability, integrity, and benevolence, account for the majority of leader trustworthiness.

In comparison, the affective dimension, often associated with relationship-based theories of trust in leadership, suggests that individuals use an emotional logic based on perceptions of care, concern, and goodwill to determine trustworthiness of leaders (McAllister, 1995; Colquitt et al., 2011). Focusing on just one of the cognitive or affective perspectives or treating the two perspectives as equivalents does little for the development of theory (Dirks & Ferrin, 2002).

The next two subsections develop more fully the theoretical foundations of first the cognitive/character-based approach and the affective/relationship-based approach to understanding trust in leadership.

Cognitive/Character-Based Approach to Understanding Trust in Leadership. Research argues that how members appraise the ability of leaders influences how much they trust leaders (Lapidot, Kark, & Shamir, 2007; Sweeney, 2010). Discussed in terms of its influence on organizational members' willingness to accept vulnerability, Mayer, Davis, and Schoorman (1995) suggest that ability is *the amount of influence a leader has gained over some particular domain, specifically certain skills and competencies*.

Scholars, such as Schaubroeck et al. (2011), highlight the importance of leadership ability in developing trust among organizational members. In fact, these scholars claim that leader competence (ability) is the primary element of the cognitive approach to trust in leadership. This perspective implies that members rationally assess the competency of leadership based on their previous behavior in order to create their perception of leadership trustworthiness. If leaders lack competency in some area, their inability to perform related tasks may create concern among members and may ultimately lead to the loss of trust in the leader.

Incompetent leaders may also be unable to adequately allocate resources, provide work performance expectations, or simply remain organized, which also can lead to members seeing these leaders as ineffective and untrustworthy (Burke, Sims, Lazzara, & Salas, 2007). In either case, the lack of trust stems from incompetent leaders making decisions that damage their reputation, which reduces the likelihood that individuals will be willing to accept risks in extreme contexts. Sweeney's (2010) study on the U.S. Army found that leader competence was the most important factor in determining the trustworthiness of leaders.

In addition to ability/competency, previous studies also suggest that perceptions of leader integrity have an important influence on trust in leaders (Engelbrecht, Mahembe, & Heine, 2015; Palanski & Yammarino, 2011). Integrity is defined, according to Mayer et al. (1995), as "the trustor's perception that the trustee adheres to a set of principles that the trustor finds acceptable" (p. 719). This definition suggests that the extent to which members morally accept and follow a leader's set of principles are both important aspects of integrity (Engelbrecht, Heine, & Mahembe, 2017). Organizational members use their internal beliefs to assess:

- The behaviors of their leaders.
- The consistency of their leaders' words and actions.
- The leaders' reputations to form a judgment of integrity and corresponding trustworthiness (Mayer et al., 1995).

In effect, members are less likely to trust leaders who they believe lack integrity and are less willing to put themselves in dangerous positions under their command. The literature also suggests that value congruence and perceptions of organizational fairness are important concepts associated with leader integrity.

Value congruence is an important component of integrity and, correspondingly, trust in leadership (Moorman, Blakely, & Darnold, 2018; Mayer et al., 1995). Value congruence is defined as *the degree to which there is commonality among organizational members*, particularly in terms of ethics, morals, and how members view the relative importance of these ideas (Lau, Liu, & Fu, 2007). Meglino, Ravlin, and Adkins (1989) show that when personal values of members are compatible with the values of leadership, positive outcomes are seen via member satisfaction and commitment. Thus, it is no surprise to see that the extent of leader-member value congruence determines the likelihood of leaders being seen as trustworthy (Moorman et al., 2018; Gillespie & Mann, 2004; Jung & Avolio, 2000), since such congruence results in fewer concerns about the actions or decisions of leadership.

In addition to value congruence, researchers have studied integrity by assessing perceptions of organizational fairness or justice, which has also been shown to be important for the development of trust in leaders (Dirks & Ferrin, 2002; Ambrose & Schminke, 2003). Dirks and Ferrin (2002) note that perceived fairness in the practices or decisions of an organization will influence the level of trust in leadership since members associate these practices with their leaders.

Three components of organizational fairness or justice — distributive, procedural, and interactional — drive the perception of leader fairness among members in slightly different ways.

- Distributive justice involves the fairness of outcomes such as pay or promotion (Folger & Konovsky, 1989).
- Procedural justice refers to the consistent application of policies and procedures (Konovsky & Pugh, 1994).
- Interactional justice captures how fairly members are treated at an interpersonal level (Bies & Moag, 1986).

Interactional and procedural justice, however, are the dimensions most commonly associated with trust in leaders (Dirks & Ferrin, 2002; DeConinck, 2010; Stinglhamber, Cremer, & Mercken, 2006). On the one hand, organizational justice may explain how fair a leader is (character-based). On the other hand, it may explain the degree to which leaders respect members through an exchange (relationship-based). Following DeConinck (2010), the expectation in this article is that social exchange and the role of reciprocity best explain the development of trust via fairness, especially due to the emphasis on interactive relationships when considering interactional justice. This topic is developed more fully in the relationship-based approach to understanding trust in leadership discussed in the following subsection.

In summary, according to the cognitive/character-based approach, trust operates through rational concerns of vulnerability that are based on perceptions of a leaders' ability and integrity. From the ability perspective, the literature suggests that leader competence captures trust (Sweeney, 2010), while from the integrity perspective, the same is true for value congruence (Gillespie & Mann, 2004) and perceived fairness (DeConinck, 2010). Therefore, the expectation is that leaders who are perceived by survey respondents to possess these characteristics and behaviors will receive more trust. As such, three hypotheses of this study associated with the cognitive/character-based approach to understanding trust in leadership are:

Hypothesis 1: Leaders who are perceived to be more competent will be perceived as more trustworthy.

Hypothesis 2: The perception of higher value congruence will result in more trust in leadership.

Hypothesis 3: The perception of greater fairness will result in more trust in leadership.

Affective/Relationship-based Approach to Understanding Trust in Leadership. The relationship-based approach to understanding trust in leadership suggests that the development of trust operates through leaders creating relationships with members that demonstrate care and concern. First proposed by Blau (1964), social exchange theory suggests that trust in leaders develops through "the voluntary actions of individuals that are motivated by the returns they are expected to bring and typically do in fact bring from others" (p. 91). This theory is based on the norm of reciprocity, or that an individual providing benefits to another trusts the receiving party to reciprocate (DeConinck, 2010). These reciprocal interactions build trust over time with members developing positive future expectations, which lead to more positive attitudes and behaviors (Homans, 1958; DeConinck, 2010).

Social exchange theory details processes of benevolence — organizational members consider their relationships with leaders beyond the standard economic contract and instead believe that both sides operate on a basis of goodwill and the perception of mutual obligations (Blau, 1964). Dirks & Ferrin (2002) suggest this benevolent treatment produces a high-quality relationship where organizational members are more willing to reciprocate considerate behavior.

Studies also show that leaders engaging in benevolent behaviors influence the extent to which leaders are trusted (Whitener, Brodt, Korsgaard, & Werner, 1998; Brower, Schoorman, & Tan, 2000). As defined by Mayer et al. (1995), "benevolence is the extent to which a trustee is believed to want to do good to the trustor" (p. 718). Benevolence commonly refers to the degree to which members consider a leader to demonstrate genuine care and authentic concern (Burke et al., 2007).

Benevolence consists of three general actions: (1) displaying consideration and sensitivity for members' needs and interests; (2) acting to protect members' interests; and (3) refraining from exploiting members for the benefit of personal interests (Mayer et al., 1995; Whitener et al., 1998). Benevolent leaders benefit individuals around them with these genuine actions, which members reciprocate over time, resulting in an exchange or relationship-based perspective that develops trust.

Benevolent leaders engage in numerous behaviors, such as support, assistance, and role modeling, that resemble other leadership styles, particularly those which influence the emotions of members through increased consideration. For example, benevolent leaders often engage in transformational behaviors (Burke et al., 2007), which are also thought to build higher levels of trust by capturing the emotional involvement of members and raising their responsiveness to higher ideals and values (Jung & Avolio, 2000).

Transformational behaviors involve the use of charisma, inspirational motivation, individualized consideration, and intellectual stimulation to aid in the formation of trust (Bass, 1985). Using these mechanisms,

leaders are able to establish exchange relationships that demonstrate their care and concern for members to the extent that members are motivated to perform beyond initial expectations (Dirks & Ferrin, 2002; Jung & Avolio, 2000; Gillepsie & Mann, 2004). Leaders also build trust, respect, and admiration by encouraging and empowering members and by serving as role models for appropriate behavior (Podsakoff, Mackenzie, Moorman, & Fetter, 1990; Bass & Avolio, 1990).[1]

A meta-analysis by Dirks and Ferrin (2002) shows that among numerous other antecedents, transformational leadership has the strongest relationship with perceptions of trust in leadership. Dirks and Ferrin (2002) state, however, that the exact causal mechanism for this result is unclear. Overall, transformational leadership has substantial overlap with considerate leadership behaviors (Rowold & Borgmann, 2014).

Benevolent leaders also engage in cooperative behaviors to demonstrate their care and concern. Such leaders, for example, often use actions resembling those of cooperative conflict managers, which research shows to have an influence on the development of trust in leadership (Chan et al., 2008). The cooperative conflict management style also emphasizes goodwill in relationships, but in contrast to transformational styles, it focuses on how leaders address needs and resolve differences (Chan et al., 2008). More specifically, rather than emphasizing strategies of encouragement and motivation, the cooperative conflict management style refers to the idea that when there are numerous concerns to satisfy for organizational members, the use of integrating, obliging, and compromising conflict resolution tactics are thought to best achieve positive outcomes for members. The cooperative conflict management style places an emphasis on finding the best solution for both parties (Rahim & Magner, 1995). Other leadership styles and behaviors, such as consultative leadership and participative decision-making, follow a similar logic of cooperation and the norm of reciprocity. Department members respond to leaders that provide these socioeconomic benefits with an increase in open communication and trust.

Taken together, the affective/relationship-based approach to understanding trust in leadership implies that trust operates through the norm of reciprocity, where perceptions of interpersonal trust are based on the emotional impact of benevolent actions. The literature shows numerous leadership styles and behaviors that are logically associated with benevolent actions, which research suggests leads to trust in leadership. In line with Mayer et al.'s (1995) description of benevolent actions, the expectation in this study is that leaders demonstrating more consideration and cooperativeness will be perceived as more trustworthy by survey participants. As such, this review of the affective/relationship-based approach to understanding trust in leadership resulted in two additional hypotheses:

Hypothesis 4: Leaders who are perceived to demonstrate increased consideration will be perceived as more trustworthy.

Hypothesis 5: Leaders who are perceived to demonstrate increased cooperativeness will be perceived as more trustworthy.

Leadership Referents (Direct Versus Senior Leaders)

As Dirks and Ferrin (2002) note, it is important to take different leadership referents, direct (also called supervisory in this article) versus senior leaders, into account when determining trust in leadership. While the research in this area is sparse, limited studies do suggest that trust in leadership may have distinct drivers across different levels of leadership because leaders at different hierarchical levels perform different tasks (Bass & Stogdill, 1990; Kannan-Narasimhan & Lawrence, 2012). Senior leaders, for example, are often tasked with strategic decision-making, while direct leaders perform supervisory roles. In effect, senior leadership develops rules, regulations, standard operating procedures, policies, procedures, etc., which in turn reflect and define organizational values. Supervisory leaders are the primary judge of departmental members' behavior, providing praise, punishment, and rewards (Mayer, Kuenzi, Greenbaum, Bardes, & Salvador, 2009).

Given that direct leaders are often considered more effective at influencing the day-to-day behavior of organizational members (Mayer et al., 2009; Meglino et al., 1989), cooperative leadership is likely associated with trust in direct leaders rather than in senior leaders. Additionally, Dirks and Ferrin (2002) argue that members attribute interactional justice behaviors to the referent in control of interpersonal treatment and to the referent implementing organizational procedures, which in both cases are direct leaders. Dirks and Ferrin's argument is supported by the findings of DeConinck (2010); his research shows that interactional and procedural justice are more associated with trust in direct supervisors. Based on the observations of Dirks and Ferrin (2002), the anticipation in this study is that direct leaders will be trusted more than senior leaders. As such, hypotheses 6 and 7 are:

Hypothesis 6: Cooperative leadership will be a predictor of trust in direct leaders, rather than senior leaders.

Hypothesis 7: Perceived fairness will be a predictor of trust in direct leaders, rather than senior leaders.

Data and Methods

This section presents the data and methods used to empirically determine factors associated with trust in leadership in one U.S. fire department. The section is comprised of four subsections — participants, survey instrument, variables, and analysis.

Participants

The sample was drawn from a single fire department located on the west coast of the U.S. Of the 500 members in the department, 333 (67%) completed the survey. **Table 1** provides an overview of the characteristics of the sample.

Table 1. Background Characteristics

	n	%
Rank		
Probationary Firefighters/Recruits	6	2
Single Role Paramedics	15	4
Administrative Staff	62	19
Firefighters	83	25
Engineers/AO/DO's	59	18
Captains	94	28
Battalion Chiefs	11	3
Deputy/Assistant Chiefs	4	1
Age		
<= 35 years	109	35
>= 36 years	204	65
Gender		
Women	44	14
Men	267	86
Education		
High school graduate only	4	1
Some college/vocational school	106	34
College graduate	191	61
Graduate school	14	4
Years in Service		
<= 10 years	108	34
>= 11 years	208	66
Yearly Salary		
<= $79,999	65	22
>= $80,000	237	78

As Table 1 shows, 90% (298) of the respondents identified with the ranks of captain, firefighter, administrative staff, or engineer. Eighty-six percent of the sample participants were men. Sixty-one percent of the survey respondents were college graduates, and another 34% had some college or vocational training. About two-thirds (65%) of the sample were 36 years of age or older. Similarly, 66% of the participants had been in his or her position for 11 years or longer, and 78% of the sample earned $80,000 or more a year.

Survey Instrument

The survey questionnaire was developed by the authors and administered online in March 2018. The survey instrument was first sent to the fire chief of the department as a link. The authors subsequently sent the link in an email three different times to all department members. All participants were informed that their responses would remain anonymous and that their participation in the survey was voluntary.

The survey incorporated indices, which the authors created, from the Fire Industry Organizational Culture Survey (FIOCS) to measure a number of important organizational culture dimensions specifically found in the fire service. The FIOCS was constructed primarily from reliable and valid indices used in previous organizational research. Based on feedback from an initial round of pilot testing in a different fire department, survey items were modified to fit the context of the fire service. A few original survey items were also created to measure concepts not captured in existing studies. The validity of the survey's indices was confirmed using Exploratory and Confirmatory Factor Analysis. Reliability was assessed using Cronbach's alpha reliability test. Coefficients of reliability ranged from .74 to .95, showing that the instrument was reliable (Santos, 1999; Croasmun & Ostrom, 2011).

Given that this survey instrument and many of the measures employed had never been used in a fire department setting, an effort was made to ensure that questions included in the survey captured the meaning of the concept *organizational culture* from the perspective of the firefighters included in the study. To gather survey respondents' perspectives on this concern, four in-person focus groups were conducted with fire personnel who were separated into groups based on departmental rank. Focus group findings and resulting modifications made to the survey instrument supported the FIOCS's reliability and validity.

Variables Used in the Study

Independent Variables. Each index was computed by using a Cronbach alpha test that generates the summative score (mean) from all items in the index (Gliem & Gliem, 2003). Because the independent variables are measured on different scales, all predictor

variables were standardized prior to analysis. This standardization process provided greater interpretative ability of the coefficients (Kim & Ferree, 1981). As noted in the last subsection, Cronbach's alpha coefficients for each index fall between acceptable levels of .78 and .94 (Santos, 1999).

With the exception of the study's fairness index, each index is measured on the same 7-point Likert scale ranging from completely disagree (1) to completely agree (7). The fairness index uses a 5-point scale that asks the extent to which the statements represent their department, ranging from to a very small extent (1) to a very large extent (5). There were no open-ended questions on the survey instrument.

Considerate leadership behaviors were measured using three items originally from van der Post, Coning, and Smit's (1997) Management Style Index and two items from the FIOCS. Study procedures required the design of mirrors for each of these questions to capture both leadership referents of supervisory and senior management. So, in total there are ten items that constitute the two leadership referent indices. An example item reads, "Senior leadership sets a good example for others to follow." The mirror of the question for the direct leadership referent reads, "My immediate supervisor sets a good example for others to follow." To measure if competent leaders are seen as more trustworthy, two items from the FIOCS' Leadership Competency Index and mirrors were used to capture each referent. An example item reads, "The senior leaders are competent" and its mirror question for the direct leadership referent is, "My immediate supervisor is competent."

Cooperative leadership was measured using five items that were originally from van der Post et al.'s (1997) Conflict Resolution Index. An example item reads, "Differences of opinion are welcomed in this department." Value Congruence was measured using five items that originated from Culture Management, another index created by van der Post et al. (1997). An example item reads, "This department has strong values, which are widely shared by its employees." Finally, to measure if fairness serves as an indicator for trust in leadership, four items that originated from the Copenhagen Psychological Questionnaire's (COPSOQ) Justice and Recognition indices were combined with another three items that the authors created. Example survey questions read, "I am treated fairly at my workplace," and "Promotional opportunities are provided fairly."

Dependent Variables. A single item that originated from van der Post et al.'s (1997) Management Style Index was extracted and used to measure trust in leadership, which was also mirrored to capture different leadership position referents. The items read, "I have a low level of trust with senior leadership," and "I have a low level of trust with immediate supervisors." Responses to these items were measured on a 7-point Likert scale, ranging from completely disagree (1) to completely agree (7).

Analysis Method

The ordinal nature of the study's outcome variable best fits the assumptions of an ordered logistic regression model (Long & Freese, 2014), which is conducted for all hypotheses.[2] Regression models are also performed separately for each leadership referent (direct versus senior leader). The standard $p < .05$ approach for the significance cutoff is utilized. The primary emphasis in this study will be the significance and direction of the predictor with the dependent variables.

Findings, Discussion, and Limitations

This section is divided into three sections. First, the findings emerging from the data analysis are summarized. Next, findings are discussed in terms of their statistical and theoretical significance. Finally, the limitations associated with the study are outlined.

Findings

Tables 2 and 3 show the correlation matrices for each leadership referent (Table 2 for senior leaders and Table 3 for direct leaders). The data in the tables include *all survey participants*. Data show that considerate (r = .79), and competent (r = .68) leadership are both positively and strongly correlated with trust in senior leadership, while value congruence (r = .58), and fairness (r = .50) follow at lower levels.

Table 2. Correlation Matrix: Trust in Senior Leadership Is Dependent Variable

Variable	Trust (SR)	Competence	Considerate	Cooperative	Values	Fairness
Trust (SR)	1					
Competence	0.6771	1				
Considerate	0.7903	0.7887	1			
Cooperative	0.3702	0.3295	0.4391	1		
Values	0.5833	0.5769	0.7012	0.4175	1	
Fairness	0.5046	0.5023	0.6016	0.5757	0.5607	1

Note: Correlations are from averages of all ranks combined. All correlations are significant at the p<.01 level.

Table 3. Correlation Matrix: Trust in Direct Leaders Is Dependent Variable

Variable	Trust (DCT)	Competence	Considerate	Cooperative	Values	Fairness
Trust (DCT)	1					
Competence	0.6007	1				
Considerate	0.6861	0.8412	1			
Cooperative	0.4858	0.4198	0.5299	1		
Values	0.2620	0.2185	0.3126	0.4175	1	
Fairness	0.4216	0.4295	0.5322	0.5757	0.5607	1

Note: Correlations are from averages of all ranks combined. All correlations are significant at the p<.01 level.

Cooperative leadership does not correlate with senior leadership trustworthiness to any meaningful extent.

Table 3 shows that considerate (r = .69) and competent (r = .60) leadership are also correlated with trust in direct leaders, but slightly less so than their correlations with senior leadership. Similar for senior leaders, cooperative leadership again lacks a strong correlation (r = .49) with trust in direct leaders, while fairness (r = .42) and value congruence (r = .26) have even weaker coefficients than seen in the previous matrix for senior leaders. These data lead to the expectation that competent and considerate leadership, even when controlling for all variables simultaneously, may be strong predictors of trust in leadership in the regression models that follow for both leadership referents.

Tables 2 and 3 also show that some of the predictors were correlated with each other, which suggests the possibility of multicollinearity issues. Multicollinearity is the existence of such a high degree of correlation between supposedly independent variables being used to estimate a dependent variable that the contribution of each independent variable to variation in the dependent variable cannot be determined. To assess the extent of this potential statistical problem, the data were furthered analyzed using the Variation Inflation Factor (VIF) test. The VIF score for both models was lower than 5.0, which suggests multicollinearity is not an issue in the data (Hair, Ringle, & Sarstedt, 2011). Attention now turns to the regression analyses.

Table 4 shows the results from the ordered logistic regression analyses *for all survey respondents* by leadership referent (direct and senior leaders) ($x^2(5)$ = 355.55, p < .01). The data in the left-hand side of the table for senior leaders (Model 1) show that Hypotheses 1 and 4 are supported. Hypothesis 1 and 4 stated:

Hypothesis 1: Leaders who are perceived to be more competent will be perceived as more trustworthy.

Hypothesis 4: Leaders who are perceived to demonstrate increased consideration will be perceived as more trustworthy.

As hypothesized, both competent and considerate leadership have positive and significant (p < .01) relationships with trust in senior leadership. No support is found, however, that cooperative, value congruence, or fairness are significantly associated with trust in senior leaders.

Table 4. Ordered Logistic Regression: Results from All Survey Respondents by Leadership Referent

	Model 1	Model 2
Variable	Senior Leaders	Direct Leaders
Competence	**.580** (.182)**	**.245** (1.98)
Considerate	**2.32** (.260)**	**1.79** (.253)**
Cooperative	**.215** (.176)	**.556** (.192)**
Values	**.185** (.191)	**.053** (.161)
Fairness	**.032** (.204)	**.011** (.212)
Obs	328	333
LR chi2(5)	355.5**	244.29**
log likelihood	-444.44412	-410.43896

Note: Trust in leadership is DV. Includes all survey participants. Standardized regression coefficients (β) are in bold and standard errors are in parentheses. (p< .05 *, p< .01 **).

In comparison, data in the right-hand side of Table 4 (Model 2) show the results for trust in direct (supervisory) leaders ($x^2(5)$ = 244.29, p < .01). In Model 2, unlike for senior leaders, leadership competence lacks statistical significance. However, similar to senior leaders, considerate leadership is again positively and significantly p < .01 associated with trust for direct leaders.

Table 4 also reveals that Hypotheses 5 and 6 are supported by the ordered logistic regression analysis for direct leaders. Hypotheses 5 and 6 said:

Hypothesis 5: Leaders who are perceived to demonstrate increased cooperativeness will be perceived as more trustworthy.

Hypothesis 6: Cooperative leadership will be a predictor of trust in direct leaders, rather than senior leaders.

The cooperative leadership variable is positive and significant p < .01. As compared to the regression coefficient for considerate leadership in Model 2 (β = 1.79), the regression coefficient for cooperative leadership (β = .556) is much smaller. While Hypothesis 6 is supported, this finding also suggests that considerate leadership is a stronger predictor of trust in direct leaders, specifically. The leadership variables value congruence and fairness again lack statistical significance.

In Table 4, regression analyses show that Models 1 and Model 2 fail to reject the null Hypotheses 2, 3, 7. These Hypothesis stated:

Hypothesis 2: The perception of higher value congruence will result in more trust in leadership.

Hypothesis 3: The perception of greater fairness will result in more trust in leadership.

Hypothesis 7: Perceived fairness will be a predictor of trust in direct leaders, rather than senior leaders.

In other words, higher value congruence and perceived greater fairness were NOT significantly associated with all survey participants' attitudes about variables that enhance trust in leadership. Similarly, greater perceived fairness among all survey respondents was not a statistically significant predictor of trust in direct/supervisory leaders.

In order to make the analysis more robust, additional regressions were performed based on respondents' rank in the department. The two regression models (1 and 2) tested in Table 4 included ALL survey participants. Perhaps respondent's view the importance of factors that affect trust in leadership differently based on their rank or hierarchical level in the department. If so, perhaps the findings based on all survey participants shown in Table 4 were spurious. Senior leadership, for example, might engage in more exchange relationships with middle-level ranks since senior leaders interact more often with middle-level officers than they do with lower ranks.

To test the impact of departmental rank on respondents' attitudes toward what factors increase trust in leadership in this fire department, the participants were split into three hierarchical groups:

- "Support Staff (Group A)" (82 members), which consisted of Administrative Staff, Single Role Paramedics, Probationary Firefighters, and Recruits.
- "Firefighters and Engineers (Group B)" (142 members), which included Firefighters and Engineers/ AO/DO's.
- "Middle-to Upper-Leadership (Group C)" (104 members), comprised of Captains, Battalion Chiefs, Assistant Chiefs, and Deputy Chiefs (AC/ DC's).

Tables 5, 6, and **7** display the ordered logistic regression results for the three levels in the department's rank hierarchy.[3]

Table 5, Model 3 ($x^2(5)$ = 121.88, p < .01) and Model 4 ($x^2(5)$ = 94.92, p < .01) show the results for Support Staff (Group A). Considerate leadership is the only significant (p < .01) predictor; support staff survey participants perceive leaders who demonstrate increased consideration as more trustworthy. This finding applies to support staff attitudes toward BOTH direct and senior leaders. Competence, cooperative leadership, value congruence, and fairness are not significant predictors of trust in leadership.

Table 5. Ordered Logistic Regression: Results from Support Staff Only (Group A) by Leadership Referent

	Model 3	Model 4
Variable	Senior Leaders	Direct Leaders
Competence	**.285** (.410)	**.036** (.439)
Considerate	**3.48** (.667)**	**2.92** (.639)**
Cooperative	**.239** (.374)	**.556** (.385)
Values	**.195** (.467)	**.282** (.406)
Fairness	**.054** (.511)	**.031** (.546)
Obs	82	82
LR chi2(5)	121.88**	94.92**
log likelihood	-90.803347	-82.220473

Note: Trust in leadership is DV. Support Staff (Group A) consists of Administrative Staff, Single Role Paramedics, Probationary Firefighters, and Recruits. Standardized regression coefficients (β) are in bold and standard errors are in parentheses. (p< .05 *, p< .01 **).

Table 6 displays results for only those survey respondents that are Firefighters and Engineers (Group B). Model 5 ($x^2(5)$ = 107.00, p < .01) shows that for this group of departmental members, considerate leadership (p < .01) produces a strong and positive relationship with trust in senior leadership. The remaining four variables — competence, cooperative, value congruence, and fairness — are not significantly related to trust in leadership for senior leaders among firefighters and engineers.

Model 6 ($x^2(5)$ = 61.62, p < .01) in Table 6, on the other hand, shows that both considerate and cooperative leadership are positive and significant predictors of trust in direct leaders at the p < .01 level. Additionally, fairness becomes significant at the p < .05 level, although fairness is *negatively* associated with trust in direct leaders. This finding runs counterintuitive to Hypothesis 7 that held:

Hypothesis 7: Perceived fairness will be a predictor of trust in direct leaders, rather than senior leaders.

This anomaly will be discussed more fully later in this study.

Table 6. Ordered Logistic Regression: Results for Firefighters and Engineers Only (Group B) by Leadership Referent

	Model 5	Model 6
Variable	Senior Leaders	Direct Leaders
Competence	**.524** (.284)	**.049** (.253)
Considerate	**1.39** (.366)**	**1.18** (.325)**
Cooperative	**.077** (.274)	**1.00** (.318)**
Values	.**446** (.293)	.**127** (.246)
Fairness	**.148** (.305)	**-.641** (.211)*
Obs	142	142
LR chi2(5)	107.00**	61.62**
log likelihood	-196.4307	-175.08893

Note: Trust in leadership is DV. Firefighters and Engineers (Group B) consists only of Firefighters and Engineers/AO/DO's. Standardized regression coefficients (β) are in bold and standard errors are in parentheses. (p< .05 *, p< .01 **).

Table 7 displays the results for the perceptions on leadership from Middle- to Upper-Leadership (Group C) in the fire department. Model 7 ($x^2(5)$ = 120.62 p < .01) shows that competent and considerate leadership are positive and significant predictors of trust in senior leaders at the p < .01 level. The remaining four variables in the model are not significant predictors of trust in senior leadership among fire department members who hold middle- to upper-ranks in the department.

Table 7. Ordered Logistic Regression: Results from Middle- to Upper-Leadership (Group C) by Leadership Referent

	Model 7	Model 8
Variable	(7) Senior Leaders	(8) Direct Leaders
Competence	**.822** (.309)**	.**172** (.372)
Considerate	**2.66** (.463)**	**2.25** (.485)**
Cooperative	**.489** (.325)	**.160** (.339)
Values	**-.333** (.319)	**-.581** (.289)*
Fairness	.**189** (.388)	**1.15** (.435)**
Obs	104	104
LR chi2(5)	120.62**	99.36**
log likelihood	-133.23813	-133.47489

Note: Trust in leadership is DV. Middle– to Upper–Leadership (Group C) consists of Captains, Battalion Chiefs, Assistant Chiefs, and Deputy Chiefs. Standardized regression coefficients (β) are in bold and standard errors are in parentheses. (p< .05 *, p< .01 **).

Model 8 ($x^2(5)$ = 99.36, p < .01) shows that while competence lacks significance, considerate leadership, similar to senior leaders in Model 7, also predicts trust in direct leaders (p < .01) among those survey respondents who hold middle- to upper-leadership positions in the department. Perceived fairness also shows a positive and significant relationship at the p < .01 level. Finally, value congruence is significant at the p < .05 level. But, instead of positively related to increased trust in direct leaders as posited in Hypothesis 6, value congruence is inversely related to greater trust in direct leaders among middle- to upper-leaders in the survey. This is an unexpected finding; and it is discussed further in the next subsection.

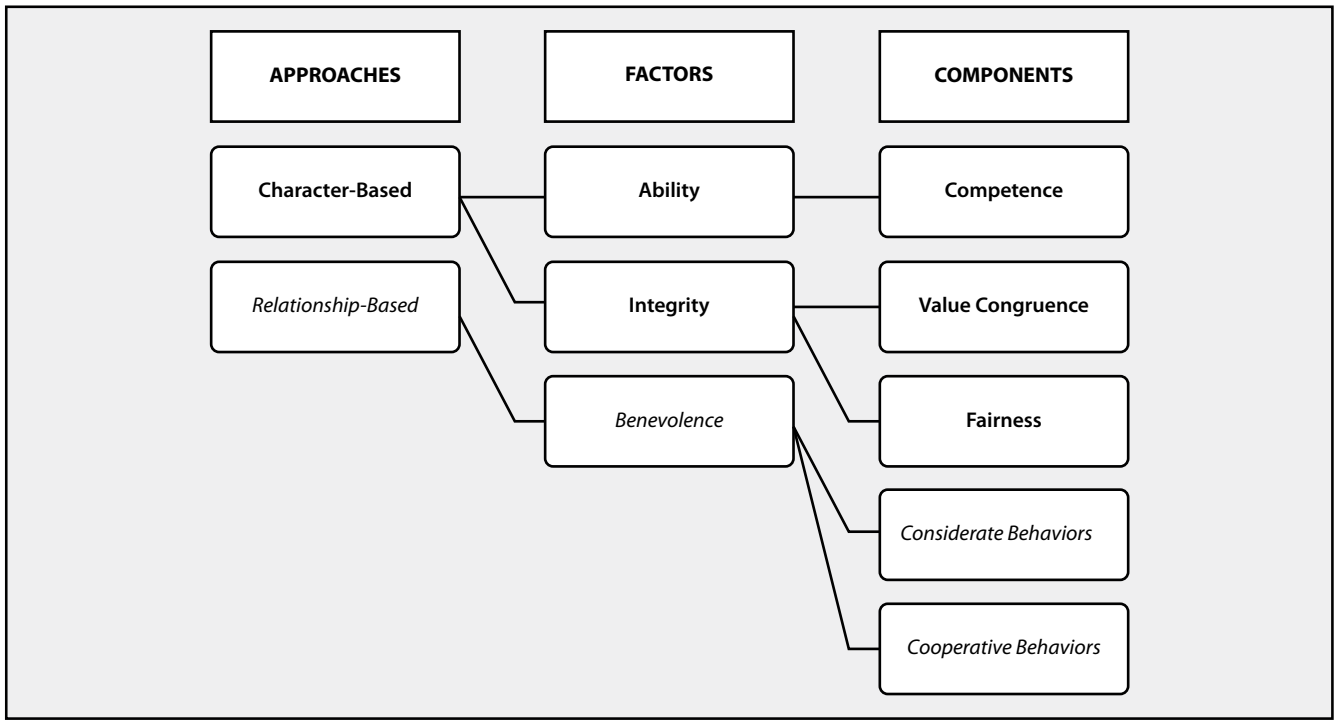
Discussion

Based on the existing literature, **Figure 1** provides a schematic representation of how trust in leadership was conceptualized. Data findings presented in this study support previous studies, with some notable departures and some added nuance in regards to leadership referents.

Based on the analysis of all survey respondents, results suggest that fire department members, regardless of the rank they hold, primarily assess both senior and direct leaders' trustworthiness based on their consideration for others. This finding reinforces similar results presented in the literature that come from studies of other types of organizations (Dirks & Ferrin, 2002; Whitener et al., 1998; Brower et al., 2000). Additionally, more competent senior leaders also appear to be trusted more, a finding similar to that found by Sweeney (2010). Data analyses also show that direct leaders are also judged by how cooperative their behaviors are, which lends support to findings by Chan et al. (2008). The relationship is likely seen with direct leaders since they possess the most authority in handling day-to-day conflicts and concerns (see Mayer et al., 2009) and are thus seen as the leaders operating in an exchange-based relationship where cooperative styles are employed. Overall, findings posited in this research find more support for the relationship-based perspective for direct leaders, but members do seem to assess leadership trustworthiness based on the character of senior leaders as well.

The results from the ordered logistic regression for Support Staff (Group A) were the only survey respondents (see Table 5) who align with findings from the similar analysis of all survey participants' perceptions. Considerate leaders are perceived to be the most trustworthy. Among support staff respondents, value congruence and fairness were not found to be significant predictors of trust in leadership. Perhaps these predictors are not important since most of the members in this rank (62 out of 75%) are administrative staff and not firefighters per se. As such, they might not share the same value system or adhere to the same organizational culture as firefighters do. Similarly, 15 of

Figure 1. Proposed Trust in Leadership Framework



the 82 members in this group are single-role paramedics and not firefighters. Finally, the remaining six survey respondents in this group are probationary firefighters/recruits and are not fully acculturated into the norms and values of the department.

Findings from Firefighters and Engineers (Group B) reinforce the positive trend of considerate leadership being strongly associated with trust for both direct and senior leadership referents. That said, cooperative leadership only positively and significantly influences trust in direct leaders. Regression Model 6 shown in Table 6 also shows that fairness as a leadership trait was significant and *negatively* associated with trust in direct leaders. This finding was unexpected and runs counter to Hypothesis 7 that states:

> **Hypothesis 7:** Perceived fairness will be a predictor of trust in direct leaders, rather than senior leaders.

Some research has shown that higher perceptions of procedural fairness can result in negative outcomes, but typically leaders are not poorly judged when procedures are fair. For example, those in inferior positions may envy the success of others, but if outcomes were achieved via fair procedures, blame is likely to be attributed internally instead of externally (Khan, Quratulain, & Bell, 2013). It is possible that the unexpected finding is a product of the organizational justice measure combining all aspects of distributive, procedural, and interactional justice. For example, each justice dimension has been found to produce different effects on trust in leadership (DeConinck, 2010). In addition, some research shows that members may not attribute their perceptions of injustice to lower-power authorities such as direct leaders (Van Dijke, De Cremer, & Mayer, 2010). This would not apply to the Middle– to Upper-Leadership (Group C), however, which is comprised of high-authority ranks. This significant ($p < .05$) finding, nonetheless, suggest further research is in order.

Models 7 and 8 in Table 7 illustrate that middle- to upper-level departmental ranks, such as captains, battalion chiefs, assistant chiefs, and deputy chiefs, also follow the trend of assessing the trustworthiness of both direct and senior leaders based on their considerate behaviors. For senior leaders, trust in leadership also increased positively and significantly for those leaders who were judged as competent. Additionally, Group C members look to perceptions of fairness to determine how trustworthy direct leaders are. DeConinck (2010) also finds that interactional and procedural justice are associated with trust in direct leaders.

Cooperative leadership fails to produce a significant relationship with trust in either leader referent, an unsurprising result considering that cooperative leadership is likely not as relevant to Group C members. Many individuals in these ranks are those who, in fact, manage conflict.

Finally, Model 8 in Table 7 surprisingly shows a negative and significant relationship between value congruence and trust in direct leaders. This finding contradicts previous findings in the literature (e.g., Gillespie & Mann, 2004; Jung & Avolio, 2000). This anomaly may be explained by theories of social distance; Group C members are closer in social distance to their leaders in terms of status and authority. Decreased social distance can actually diminish the influence and respect of leaders, as the weaknesses of a leader

become more visible to those who are socially similar (Antonakis & Atwater, 2002). In other words, the personal and psychological familiarity among individuals in the upper ranks in the fire department may actually result in too much information about leaders and their shortcomings. Clearly, once again, further research about building trust in fire departments as organizations is needed.

Limitations

Research presented here is limited in several important ways. First, the sample came from a single fire department. In contrast, the U.S. fire service is huge, with more than 30,000 fire departments and over 1 million firefighters. Perceptions about trust in leadership are likely to vary along several dimensions, including the type (volunteer, career, or combination), size, and region of a department. In short, this study is exploratory in nature. Findings cannot be generalized beyond this single survey study.

Second, while great care was taken to establish the validity and reliability of the survey instrument used in the study, additional experience with the survey will allow the authors to fine tune both the questionnaire and construct measures.

Third, as compared to what is commonly seen in the literature, this study took a slightly different approach in how variables were measured. For example, antecedents to trust in leadership are often discussed via transformational leadership, transactional leadership, and other leadership styles that are commonly measured with particular indices (e.g., Podsakoff et al., 1990; Podsakoff, MacKenzie, & Bommer, 1996). Our instrument was designed to capture more general facets of organizational culture in the fire service, which, in turn, only allowed us to capture leadership concepts that reside at the core of styles that are a product of social exchange relationships. Similarly, fairness is often explored through specific facets of procedural, distributive, and interactional justice, which are often studied as individual concepts that may vary in how individuals predict trust in leadership (DeConinck, 2010). The fairness measure used in this study combined aspects from all three components. Finally, this study only explored some of the possible antecedents to trust in leadership in the fire service.

Despite these limitations and the exploratory nature of research presented here, the study contributes to the trust literature by testing alternative measures and mapping a path for future research on trust in leadership in the fire service.

Conclusion

This study tested five leadership-related factors to determine how members in one west coast fire department perceived leadership trustworthiness at both the direct (supervisory) and senior leader levels. The research was grounded in two theoretical perspectives. The first theory suggests that trust develops as a product of the willingness to accept risk under the character of leaders and the decisions they make, which can often put firefighters at risk. This theory is referred to as the cognitive or character-based approach to leadership. The second theory maintains that leadership occurs at an emotional level as a product of quality relationships. Under this theory, considerate leaders see their goodwill reciprocated in the form of care and support. This approach is often called the affective or relationship-based approach to leadership.

Based on the cognitive/character-based approach to leadership theory, three hypotheses were formulated around the ability and integrity of leaders. The hypotheses predicted that leaders who were perceived by fire department personnel to possess certain qualities, such as being competent, having principles, and being fair-minded, would receive more trust.

Using the affective/relationship-based approach to leadership theory, two hypotheses were formulated around the benevolence of leaders. These hypotheses predicted that more considerate and cooperative leaders would be trusted more by fire department survey respondents. Finally, two hypotheses were given to explore trust in distinct leadership referents — direct (supervisory) and senior leaders. Using new measures from an original survey instrument designed to capture organizational culture in the fire service, these seven hypotheses were tested using ordered logistic regression with data garnered from a single west coast fire department.

Taken together, findings presented here suggest that leaders who engage in considerate behaviors, executed by forming social exchange relationships with members based on emotional support, assistance, role modeling, and goodwill, produce the most trust among both direct and senior leaders in the fire department. Considerate leadership was the most significant predictor of trust in leadership, but findings also show that senior leaders are trusted more when survey respondents perceive them as competent decision-makers. In contrast, direct leaders demonstrating cooperative behaviors receive more trust.

These findings about the importance of considerate and cooperative leadership factors as predictors of trust in leadership persisted across nearly all model specifications, regardless of whether the analysis was for all survey participants or for perceptions emerging for specific ranks – Support Staff (Group A), Firefighters and Engineers (Group B), or Middle– and Upper–Leaders (Group C). This finding runs contrary to existing research on leader distance. For example, Shamir (1995) found that leaders who are close in proximity with members are thought to provide more opportunities to show care, concern, and support for their members. Physically close leaders are also more approachable to members and are more capable of engaging in effective role model behaviors (Yagil, 1998). Thus,

leaders of closer proximity to members might be better equipped to build quality social exchange relationships, whereas senior leaders with less contact with members would have more challenges building these relationships.

Perhaps the nature of the rank hierarchy of fire departments impacts the usefulness of the leader distance theory offered in the general literature since each fire service rank interacts both directly and frequently with both supervisory and senior leadership. For example, Battalion Chiefs are considered to be senior leadership, and they are in close proximity to captains, firefighters, and other lower ranks. Assistant/deputy chiefs and the fire chief are in close proximity to battalion chiefs. Each rank should be able to gather enough information about the expertise of both leadership referents and engage in exchange-based relationships.

Value congruence as a leadership factor was significantly related to trust in senior leadership among middle-and upper-ranks, although the negative correlation contradicted existing literature. This finding may be attributed to decreased social distance among these ranks, as weaknesses become more visible to those of similar status and authority. Lastly, fairness was significantly associated with trust in direct leaders in two models. The relationship was positive, as predicted, with middle-to upper-leadership ranks of captains, battalion chiefs, and assistant and deputy chiefs. Fairness was negative associated, however, with firefighters and engineers. This significant relationship was not in the hypothesized direction.

Future studies examining trust in leadership in the fire service should further explore the causal logic of considerate, competent, and cooperative leaders to better understand how trust develops. This research could include, for example, determining which aspects of competence, such as technical and resourceful, are most important to members. Future studies should also distinguish among forms of fairness — distributive, procedural, and interactional.

Research presented here shows that considerate, competent, and cooperative leaders are trusted more in the west coast fire department that served as the sample of this exploratory study. While results are not generalizable to all fire departments based on this single survey study, evidence suggests, at least for the fire department studied, that training leaders on the importance of relationships based on goodwill, technical aspects of the job, and being receptive to members (e.g., allowing input, satisfying all parties when possible) can build higher trust levels in leaders and consequently more positive outcomes (performance, commitment, satisfaction etc.). Because firefighters already perform highly stressful jobs, it is important to avoid leader-member disconnects that may easily exacerbate effects from stress-related issues in departments (Reichel, 1996). While research here does not aim to generalize to all fire departments, the information may serve as a useful starting point for departments seeking to build trust in their leaders.

References

Ambrose, M. L., & Schminke, M. (2003). Organization structure as a moderator of the relationship between procedural justice, interactional justice, perceived organizational support, and supervisory trust. *Journal of Applied Psychology*, *88*(2), 295-305.

Antonakis, J., & Atwater, L. (2002). Leader distance: A review and a proposed theory. *The Leadership Quarterly*, *13*(6), 673-704.

Arnold, K. A., Kevin Kelloway, E., & Barling, J. (2001). Transformational leadership or the iron cage: Which predicts trust, commitment and team efficacy? *Leadership & Organization Development Journal*, *22*(7), 315-320.

Bartolo, K., & Furlonger, B. (2000). Leadership and job satisfaction among aviation fire fighters in Australia. *Journal of Managerial Psychology*, *15*(1), 87-93.

Bass, B. M. (1985). *Leadership and performance beyond expectations*. New York, N.Y.: Collier Macmillan.

Bass, B. M., & Avolio, B. J. (1990). Developing transformational leadership: 1992 and beyond. *Journal of European Industrial Training*, *14*(5), 21-27.

Bass, B. M., & Stogdill, R. M. (1990). *Bass & Stogdill's handbook of leadership: Theory, research, and managerial applications*. New York, N.Y.: Simon and Schuster.

Bies, R. J., & Moag, J. F. (1986). Interactional justice: Communication criteria of fairness. In R. J. Lewicki, B. H. Sheppard, & M. H. Bazerman (Eds.), *Research on negotiations in organizations* (Vol. 1, pp. 43-55). Greenwich, CT: JAI Press.

Blau, P. (1964). *Power and exchange in social Life* (2nd ed.). New York, N.Y.: J. Wiley & Sons.

Brower, H. H., Schoorman, F. D., & Tan, H. H. (2000). A model of relational leadership: The integration of trust and leader–member exchange. *The Leadership Quarterly*, *11*(2), 227-250.

Burke, C. S., Sims, D. E., Lazzara, E. H., & Salas, E. (2007). Trust in leadership: A multi-level review and integration. *The Leadership Quarterly*, *18*(6), 606-632.

Campbell, D. J., Hannah, S. T., & Matthews, M. D. (2010). Leadership in military and other dangerous contexts: Introduction to the special topic issue. *Military Psychology*, *22*(sup1), S1-S14.

Chan, K. W., Huang, X., & Ng, P. M. (2008). Managers' conflict management styles and employee attitudinal outcomes: The mediating role of trust. *Asia Pacific Journal of Management*, *25*(2), 277-295.

Colquitt, J. A., LePine, J. A., Zapata, C. P., & Wild, R. E. (2011). Trust in typical and high-reliability contexts: Building and reacting to trust among firefighters. *Academy of Management Journal*, *54*(5), 999-1015.

Croasmun, J. T., & Ostrom, L. (2011). Using Likert-type scales in the social sciences. *Journal of Adult Education*, *40*(1), 19-22.

DeConinck, J. B. (2010). The effect of organizational justice, perceived organizational support, and perceived supervisor support on marketing employees' level of trust. *Journal of Business Research*, *63*(12), 1349-1355.

Dirks, K. T., & Ferrin, D. L. (2002). Trust in leadership: Meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, *87*(4), 611-628.

Engelbrecht, A. S., Heine, G., & Mahembe, B. (2017). Integrity, ethical leadership, trust and work engagement. *Leadership & Organization Development Journal*, *38*(3), 368-379.

Engelbrecht, A. S., Mahembe, B., & Heine, G. (2015). The influence of integrity and ethical leadership on trust in the leader. *Management Dynamics: Journal of the Southern African Institute for Management Scientists*, *24*(1), 2-10.

Folger, R., & Konovsky, M. A. (1989). Effects of procedural and distributive justice on reactions to pay raise decisions. *Academy of Management Journal*, *32*(1), 115-130.

Geier, M. T. (2016). Leadership in extreme contexts: transformational leadership, performance beyond expectations? *Journal of Leadership & Organizational Studies*, *23*(3), 234-247.

Gillespie, N. A., & Mann, L. (2004). Transformational leadership and shared values: The building blocks of trust. *Journal of Managerial Psychology*, *19*(6), 588-607.

Gliem, J. A., & Gliem, R. R. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for likert-type scales. Paper presented at the Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education, The Ohio State University, Columbus, OH, October 8-10, 2003. Retrieved from https://scholarworks.iupui.edu/handle/1805/344

Goodwin, V. L., Whittington, J. L., Murray, B., & Nichols, T. (2011). Moderator or mediator? Examining the role of trust in the transformational leadership paradigm. *Journal of Managerial Issues*, *23*(4), 409-425.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, *19*(2), 139-152.

Hannah, S. T., Uhl-Bien, M., Avolio, B. J., & Cavarretta, F. L. (2009). A framework for examining leadership in extreme contexts. *The Leadership Quarterly*, *20*(6), 897-919.

Homans, G. C. (1958). Social behavior as exchange. *American Journal of Sociology*, *63*(6), 597-606.

Hyllengren, P., Larsson, G., Fors, M., Sjöberg, M., Eid, J., & Kjellevold Olsen, O. (2011). Swift trust in leaders in temporary military groups. *Team Performance Management: An International Journal*, *17*(7/8), 354-368.

Jung, D. I., & Avolio, B. J. (2000). Opening the black box: an experimental investigation of the mediating effects of trust and value congruence on transformational and transactional leadership. *Journal of Organizational Behavior*, *21*(8), 949-964.

Kannan-Narasimhan, R., & Lawrence, B. S. (2012). Behavioral integrity: How leader referents and trust matter to workplace outcomes. *Journal of Business Ethics*, *111*(2), 165-178.

Kelloway, E. K., Turner, N., Barling, J., & Loughlin, C. (2012). Transformational leadership and employee psychological well-being: The mediating role of employee trust in leadership. *Work & Stress*, *26*(1), 39-55.

Khan, A. K., Quratulain, S., & Bell, C. M. (2013). Episodic envy and counterproductive work behaviors: is more justice always good? *Journal of Organizational Behavior*, *35*(1), 128-144.

Kim, J.-O., & Ferree, G. D. (1981). Standardization in causal analysis. *Sociological Methods & Research*, *10*(2), 187-210.

Konovsky, M. A., & Pugh, S. D. (1994). Citizenship behavior and social exchange. *Academy of Management Journal*, *37*(3), 656-669.

Lapidot, Y., Kark, R., & Shamir, B. (2007). The impact of situational vulnerability on the development and erosion of followers' trust in their leader. *The Leadership Quarterly*, *18*(1), 16-34.

Lau, D. C., Liu, J., & Fu, P. P. (2007). Feeling trusted by business leaders in China: Antecedents and the mediating role of value congruence. *Asia Pacific Journal of Management*, *24*(3), 321-340.

Lester, P. B. (2007). *Swift trust: Examining the development and acceleration of follower trust in leaders in a temporary group context*. ETD collection for University of Nebraska - Lincoln. AAI3242158. http://digitalcommons.unl.edu/dissertations/AAI3242158

Liu, J., Siu, O.-L., & Shi, K. (2010). Transformational leadership and employee well-being: The mediating role of trust in the leader and self-efficacy. *Applied Psychology*, *59*(3), 454-479.

Long, S., & Freese, J. (2014). *Regression models for categorical dependent variables using Stata,* (3rd ed.). College Station, TX: Stata Press.

Mayer, D. M., Kuenzi, M., Greenbaum, R., Bardes, M., & Salvador, R. (2009). How low does ethical leadership flow? Test of a trickle-down model. *Organizational Behavior and Human Decision Processes*, *108*(1), 1-13.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review*, *20*(3), 709-734.

McAllister, D. J. (1995). Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal*, *38*, 24-59.

Meglino, B., Ravlin, E., & Adkins, C. (1989). A work values approach to corporate culture: A field test of the value congruence process and its relationship to individual outcomes. *Journal of Applied Psychology*, *74*(3), 424-432.

Moorman, R. H., Blakely, G. L., & Darnold, T. C. (2018). Understanding how perceived leader integrity affects follower trust: Lessons from the use of multidimensional measures of integrity and trust. *Journal of Leadership & Organizational Studies*, *25*(3), 277-289.

Palanski, M. E., & Yammarino, F. J. (2011). Impact of behavioral integrity on follower job performance: A three-study examination. *The Leadership Quarterly*, *22*(4), 765-786.

Pekerti, A., & Sendjaya, S. (2010). Servant leadership as antecedent of trust in organizations. *Leadership & Organization Development Journal*, *31*(7), 643-663.

Pillai, R., & Williams, E. (2004). Transformational leadership, self-efficacy, group cohesiveness, commitment, and performance. *Journal of Organizational Change Management*, *17*(2), 144-159.

Podsakoff, P. M., MacKenzie, S. B., & Bommer, W. H. (1996). Transformational leader behaviors and substitutes for leadership as determinants of employee satisfaction, commitment, trust, and organizational citizenship behaviors. *Journal of Management*, *22*(2), 259-298.

Podsakoff, P. M., MacKenzie, S. B., Moorman, R. H., & Fetter, R. (1990). Transformational leader behaviors and their effects on followers' trust in leader, satisfaction, and organizational citizenship behaviors. *The Leadership Quarterly*, *1*(2), 107-142.

Rahim, M. A., & Magner, N. R. (1995). Confirmatory factor analysis of the styles of handling interpersonal conflict: first-order factor model and its invariance across groups. *Journal of Applied Psychology*, *80*(1), 122-132.

Reichel, D. (1996). The roots of burnout. *Emergency*, *28*, 30-33.

Rezaei, M., Salehi, S., Shafiei, M., & Sabet, S. (2012). Servant leadership and organizational trust: the mediating effect of the leader trust and organizational communication. *EMAJ: Emerging Markets Journal*, *2*(1), 70-78.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Review*, *23*, 393-404.

Rowold, J., & Borgmann, L. (2014). Interpersonal affect and the assessment of and interrelationship between leadership constructs. *Leadership*, *10*(3), 308-325.

Santos, R. (1999). Cronbach's alpha: a tool for assessing the reliability of scales. *Journal of Extension*, *37*(2), 1-5.

Schaubroeck, J., Lam, S. S. K., & Peng, A. C. (2011). Cognition-based and affect-based trust as mediators of leader behavior influences on team performance. *Journal of Applied Psychology*, *96*(4), 863-871.

Shamir, B. (1995). Social distance and charisma: theoretical notes and an exploratory study. *The Leadership Quarterly*, *6*(1), 19-47.

Stinglhamber, F., Cremer, D. D., & Mercken, L. (2006). Perceived support as a mediator of the relationship between justice and trust: A multiple foci approach. *Group & Organization Management*, *31*(4), 442-468.

Sweeney, P. J. (2010). Do soldiers reevaluate trust in their leaders prior to combat operations? *Military Psychology*, *22*(sup1), S70-S88.

Sweeney, P.J., Thompson, V. D., & Blanton, H. (2009). Trust and influence in combat: An interdependence model. *Journal of Applied Social Psychology*, *39*(1), 235-264.

Tremblay, M. A. (2010). Fairness perceptions and trust as mediators on the relationship between leadership style, unit commitment, and turnover intentions of Canadian forces personnel. *Military Psychology*, *22*(4), 510-523.

Van Dijke, M., De Cremer, D., & Mayer, D. M. (2010). The role of authority power in explaining procedural fairness effects. *Journal of Applied Psychology*, *95*(3), 488-502.

van der Post, W. Z., de Coning, T. J., & Smit, E.vd M. (1997). An instrument to measure organizational culture. *South African Journal of Business Management*, *28*(4), 147-161.

Whitener, E., Brodt, S., Korsgaard, A., & Werner, J. (1998). Managers as initiators of trust: an exchange relationship framework for understanding managerial trustworthy behavior. *Academy of Management Review*, *3*(23), 513-530.

Winston, B. E., & Joseph, E. E. (2005). A correlation of servant leadership, leader trust, and organizational trust. *Leadership & Organization Development Journal*, *26*(1), 6-22.

Yagil, D. (1998). Charismatic leadership and organizational hierarchy: Attribution of charisma to close and distant leaders. *The Leadership Quarterly*, *9*(2), 161-176.

Endnotes

[1] This is in comparison with other leadership styles, such as transactional leadership, which is less associated with trust in leadership (Dirks & Ferrin, 2002) and focuses more on an economic exchange with members based on rewards and punishments (Jung & Avolio, 2000). Also, consultative leadership style is another approach that is thought to develop trust in leaders. Consultative leaders build trust by considering the input of members for important decisions and by showing members that their opinions are used in the organization and valued (Podsakoff et al., 1990). Since members have more influence in organizations led by consultative leaders, their perceptions of risk and vulnerability decline — which leads to greater trust in leadership (Gillespie & Mann, 2004). Consultative leadership, however, is often combined with transformational leadership (Burke et. al, 2007).

[2] Ordered logistic regression is a specified regression model designed for ordinal dependent variables (DVs) such as Likert scales. The model works similarly to multiple regression, which is a statistical technique used to analyze the impact that several independent variables (IVs) have on the DV, or outcome variable. Put differently, multiple regression predicts the value of an outcome variable based on the values of the IVs. With multiple regression, the independent impact of each IV on the DV can be determined. Thus, multiple regression tests the ability of the IVs to explain, or predict a change in the outcome variable.

[3] Like the analyses performed to test for multicollinerity for the correlation matrices shown in Table 3 and Table 4 that included all survey respondents, correlation matrices for survey respondents for each rank ((i.e., Support Staff (Group A); Firefighters and Engineers (Group B); and Middle- to Upper-Leadership (Group C)), were examined. Results suggested the possibility of multicollinearity. Matrices were then investigated using the Variation Inflation Factor (VIF) test. VIFs never exceeded the 5.0 threshold level. Thus, the assumption was that multicollinearity was not affecting data groupings (Hair et al., 2011).

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Fireground Cue Recognition: Effects on Firefighter Situational Awareness When Facing High-Risk Situations in Virtual Reality

Abstract

While there is significant information linking cue recognition to enhanced situational awareness on the fireground, most studies focusing on this topic are qualitative in nature. Few studies have attempted quantitative research to determine how cue recognition impacts awareness of fire behavior. In this study, 62 firefighters were immersed in a virtual reality environment that simulated a high-risk fire fighting scenario. Logistic regression analysis results showed that cue recognition is significantly related to firefighters' ability to predict structure occupancy and that previous exposure to similar fire conditions is significantly related to the inability of firefighters to identify critical fire behavior scenarios. This enhanced situational awareness found in a virtual reality environment has potential to reduce real risk for firefighters and victims on the fireground.

Keywords: fireground cue recognition, firefighter situational awareness, firefighter virtual reality training, high-risk decision-making

Introduction

Each year, the fire service in the United States typically experiences between 80 to 100 fatalities and 55,000 to 85,000 injuries, proving that fire fighting is an inherently dangerous occupation (NFPA, 2018). Poor decision-making is frequently cited as a major contributing factor to firefighter injuries and fatalities (NIST, 1998; NFFA, 2005; City of Charleston, 2008; NIOSH, 2009). Studying emergency responders' decision-making process is challenging because firefighters are often engaged in internal cognitive struggles that are highly complex and difficult to measure and quantify.

Researchers from both the National Institute of Standards and Technology (NIST, 1998) and the National Fallen Firefighters Foundation (NFFF, 2005) suggest that firefighters can keep themselves out of harm's way by making good decisions. Moreover, research also suggests that "suboptimal decisions by fire leaders" may be contributing to negative outcomes for people (Useem**,** Cook, & Sutton, 2005, p. 462).

While the circumstances surrounding firefighter injuries are sometimes beyond human control, a study by the Federal Emergency Management Agency (FEMA, 2002) found that many fatalities "are the result of a chain of events, which, if detected early, has the potential to be broken and prevent many, or even most, fatalities" (p. 3). In short, given the life and death consequences both for themselves and the citizens they serve, it is critical to understand how and why firefighters, specifically Incident Commanders, make decisions.

This study, using quantitative methods (binary logistic regression analysis), examines the experiences of 62 firefighters who were immersed in a virtual reality environment that simulated a high-risk fire fighting scenario. The purpose of this research is to determine if situational awareness achieved via cue recognition and prior exposure to similar fireground conditions reduce the potential risk for firefighters and victims in high-risk environments.

The study is organized into five additional sections. The first section provides a review of the literature examining the key concepts underlying the study: (1) high-risk decision making, (2) cue recognition, (3) situational awareness, and (4) virtual reality training. Section two outlines the research questions and hypotheses. Section three reviews the study methodology. Section four presents the results of the virtual reality experiences of the 62 study participants. The concluding section presents a summary of key findings emerging from the research.

High-Risk Decision-Making, Cue Recognition, Situational Awareness, and Virtual Reality Training: A Review of the Literature

High-Risk Decision-Making

To make crucial decisions in high-risk environments, Incident Commanders are expected to understand and grasp the components of severe fire behavior, such as when encountering pre-backdraft (prior to the occurrence of a backdraft) conditions. However, decision-making research in real-time and unsafe environments has been challenging, specifically in high-risk scenarios,

such as fire fighting, where individuals enter a situation and must cognitively process information quite quickly (Okoli, Watt, & Weller, 2016).

Since the 1980s, when the Naturalistic Decision Making (NDM) field of study emerged, the goal of decision study theorists has been to identify factors that predict accurate outcomes in the most efficient manner (Klein, 2008). Studies within the NDM framework have typically examined how experts make complex decisions in real (naturalistic) settings, rather than in laboratory or controlled environments (Zsambok, 1997; Wong, 2000). These studies are also more concerned with how people make decisions using their experience and domain knowledge, as opposed to how decisions *should* be made. The NDM theory has now afforded researchers the ability to better explain decision-making in uncertain, dynamic, ill-structured, and time-pressured environments (Orasanu & Connolly, 1993).

Early studies reported how decision-making might occur under changing conditions in certain occupational fields (e.g., airline pilots, see Orasanu & Connelly, 1993). Shortly thereafter, Klein (1993) conducted research on fireground decision-making and used verbal protocol to analyze and identify decision strategy. In their qualitative study on firefighter decision-making, Okoli et al. (2016) showed that the information gathering process for Incident Commanders may occur "sometimes amidst incomplete, confusing and conflicting information, (e.g., a decision to employ offensive or direct fire fighting in a workshop garage containing combustible acetylene cylinders, even when the standard operational procedure required adopting a more defensive strategy)" (p.98). While instructive, this method of retroactive qualitative research was limited in its application. Moreover, the models developed in many of these studies did little to help explain *how* decision makers could comprehend, integrate, and implement the vast amounts of information with which they were inundated.

Where there are multiple courses of action that may help an individual with decision choice, humans typically select strategies associated with the least cognitive effort (Johnson & Payne, 1985; Kool, W., McGuire, J., Rosen, Z., & Botvinick, M., 2010). Shepard (1964) suggested that when facing a decision task where alternatives have both advantages and disadvantages, the immediate subgoal becomes reducing the emotional discomfort associated with the state of the conflict induced by the decision problem. Ariely (2009) pointed out that when the decision task is difficult, decision-makers may resort to default decisions. Keeney & Raiffa (1993) described the concept of tradeoffs in decision-making as "a problem of trading off the achievement of one objective against another objective" (p. 66). Hogarth (1987) proposed that decision-makers tend to avoid strategies that explicitly require difficult tradeoffs, yet firefighters may often find themselves engaged in decision tasks with extremely difficult tradeoffs — decision dilemmas where there are limited safe alternatives. There is still a great need to provide useful information on how these cognitive strategies could potentially assist firefighters who routinely operate in high-risk environments.

Cue Recognition

Wong (2004) defines *cue* as any stimuli with implications for action. Okali et al. (2016) elaborate on the concept and regard cues as features of the task environment. Cues are a process by which knowledge and experience enable an individual to recall something back from memory. Even today, research is divided over whether cues increase cognitive efforts (Okoli et al., 2016) or reduce the demands on cognitive resources (Brouwers, Wiggins, Helton, O'Hare, & Griffin, 2016). What is agreed upon is that cues play a crucial role with decision-making by activating pattern recognition processes. Research has also shown that a greater level of cue utilization resulted in consistent decision strategies. The primary goal of the Naturalistic Decision Making field of study (Kahneman and Klein, 2009) is to maintain accuracy and identify the cues that experts use to make their judgments.

Identifying relevant cues can lead to extremely expedient decision-making (Warwick, McIlwaine, Hutton, & McDemott, 2001). In environments where it is essential to rapidly and accurately extract meaningful information, cue recognition has been found to be *essential* for developing accurate mental models of cognitively demanding tasks (Bellenkes, Wickens, & Kramer, 1997). Likewise, research of sports with quick ball movements, such as cricket and tennis (Müller et al., 2006; Jackson and Mogan, 2007), has found that the utilization of cues is fundamental to reactionary responses. In these instances, individuals who have a relatively higher capacity for cue utilization are able to more quickly identify important features of task performance, which, in turn, reduces cognitive load (Wiggins, 2015).

Firefighters are trained to be highly cognizant in searching for external cues and are tasked with sourcing through vast amounts of incoming information at fire scenes (Okoli et al., 2016). In their research, Okoli et al. (2016) attempted to create a model conceptualizing how experienced firefighters scan through multiple information sources to select the most relevant cues. Incident Commanders are required to identify vital cues, either through information received or from features of the environment, both of which can drastically affect fireground performance. Even amidst rapidly evolving conditions, cues are important precursors to successful, accurate, and workable action plans (Morrison et al., 2013; Okoli et al., 2016). These cues might come in the form of information derived when observing the following:

- Fireground environment relative to the color, texture, and movement of smoke.

- Existence or absence of flames.
- Size or location of the fire.
- Presence of items located around the fire structure.

The ability to read cues can be affected by situational awareness; and thus, situational awareness plays a key role in the decision-making process.

Situational Awareness

Endsley (1997) suggests that it is necessary to comprehend the construct of situational awareness to fully understand its impact on decision-making. Situational awareness is not a new concept for the fire service. More than two decades ago it was determined that firefighters relied on situational awareness to make their decisions. In 1995, Endsley found that higher levels of situational awareness enable decision makers to function in a timely and efficient manner. She concluded that firefighters "must ascertain the critical features in widely varying situations to determine the best course of action" (p. 32).

In the last 25 years, interest in modeling situational awareness as a critical component of complex, dynamic decision-making has dramatically increased (e.g., Fracker, 1991; Artman, 1999; Durso & Sethumadhavan, 2008). Bomhof (2017) suggests that situational awareness involves a gathering of information to build a good understanding of the situation. Applying this definition directly to fireground commanders, Okali et al. (2016) proposes that situational awareness is "information obtained through observation and size-up" (p.100). As an example, firefighters scan the environment to help them ascertain distinguishing environmental characteristics such as "smoke escaping from under the eaves, melting rubber between clip-lock walls, cracks on the walls, the colour, texture and density of smoke, victims' physical and psychological state" (Okali et al., 2016, p.100).

Studies have shown that firefighters are often faced with the challenge of "making sense of the unfolding events [upon] immediately arriving at the scene of an incident" (Okoli et al., 2016, p. 98). Making optimal fireground decisions can be a "decision-making burden on fire leaders," but is nonetheless vital for successful front-line fire suppression (Useem, et al, 2005, p. 467). Failure to maintain an appropriate level of situational awareness can have devastating results. Previous research suggests that inaccurate or incomplete situational awareness on the fireground can lead to the disorientation of firefighters, potentially resulting in injuries or even death (Endsley, 1995; Brennan, n.d.). To avoid such a horrific event, firefighters *must* maintain situational awareness on the fireground (Brennan, n.d.).

Virtual Reality Training

Virtual reality "is an advanced form of human-computer interface that allows the user to interact with and become immersed in a computer-generated environment in a naturalistic fashion" (Eichenberg, 2012, p. 3). Over the last decade, virtual reality has been repeatedly shown to be an effective training tool in diverse fields such as surgery, combat, and the treatment of various psychological conditions (Shin & Kim, 2015; Gallagher, et al, 2013). Recent technological developments have allowed the utilization of human-computer interactions through virtual reality technology in conjunction with decision-tracing technology to examine firefighters' decision-making through simulations (e.g., Bayouth, 2011; Bayouth, Keren, Franke, & Godby, 2013; Keren, Bayouth, Godby, & Franke, 2013; Keren, Franke, Bayouth, Godby, & Harvey, 2013).

Virtual reality has the capability to bring dangerous situations to life for firefighters without putting them at any physical risk. As such, virtual reality expands opportunities for fire departments to access cost-effective and safe ways to evaluate the decision-making and psychological readiness of firefighters. Virtual reality safely and relatively inexpensively immerses firefighters in real-world experiences, thus expanding the breadth and depth of scenarios to which they are exposed. The use of virtual reality training allows for realistic and reproducible environments that can be manipulated to meet the needs of the experiment. Virtual reality also has the distinct advantage over retroactive interviews by isolating and enabling a focus on firefighter judgment, decision-making, and other responses in *real time*.

Virtual reality technology in the present study was utilized to assess decision-making and evaluate firefighters' ability to identify cue recognition and acquire the appropriate level of situational awareness and cognitive readiness in high-risk fire situations.

Research Question and Hypotheses

As noted previously, typically scholars have used *qualitative* research to describe how firefighters are able to obtain enhanced situational awareness — to process a wide range of informational cues on the fireground and make optimal decisions (Okoli et al., 2016). In contrast, this study seeks to *quantitatively* answer the question: Can aspects of cue recognition and prior risk exposure lead to enhanced situational awareness within a virtual reality environment? To answer that question, the following two hypotheses have been tested in two virtual reality exercises.

H1: Within a virtual reality environment, firefighter cue recognition is related to situational awareness.

H2: Within a virtual reality environment, firefighters' previous risk exposure to backdraft is related to situational awareness.

Methodology

This section is divided into three subsections. First, the study participants are identified. Second, the virtual reality training environment is discussed. Third, the testing procedure is outlined.

Participants

A convenience sample of 62 full-time career firefighters (61 males, 1 female) ranging in age between 21-60 years old (Mean = 39.3, *SD* = 10.0) were recruited from fire departments throughout central Iowa. While instructive, this study is limited in terms of the quantitative generalizability of findings. The research is based on the experiences of only 62 firefighters from a limited number of fire departments. The small sample size was due in part to the multistep, complex, and time-consuming process.

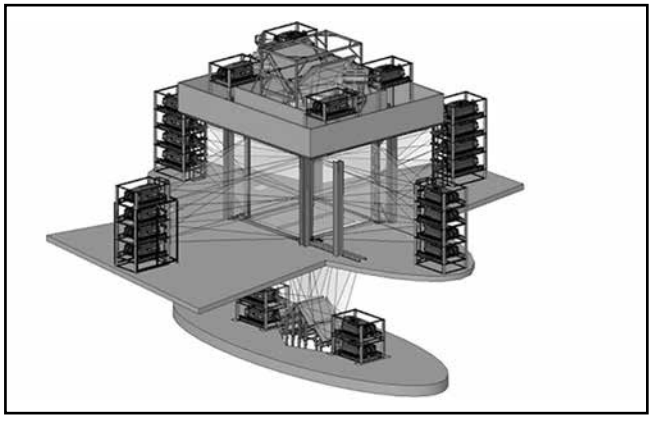
No participants were excluded from the study, nor did any receive compensation in return for their participation. Participants' years of experience ranged from less than a year (*n* = 2) to 35 years (*n* = 1), with the mode being five years and a mean of 13.8 years (*SD* = 8.4). Participants' rank included 16 chief officers (i.e., fire chief, deputy chief, battalion chief, assistant chief, and captain), eight company officers (i.e., lieutenants), and 38 firefighters.

Virtual Reality Training Environment

The research study was conducted in a full-scale virtual reality environment providing a naturalistic-like setting, while at the same time preserving the quality of a controlled laboratory setting and a safe environment. Located on the campus of Iowa State University, the virtual reality simulations utilized the C6, which consists of a 10- by 10- by 10-foot virtual reality room where all four walls, the ceiling, and the floor are projection screens (**Figure 1**). The screens respond in real time to the movements of the user, thereby providing a real-world experience.

The authors developed a simulation engine, titled VirtuTrace, which was used to render the stereoscopic, 3-D fire scene scenario projected onto the screens. This scene generated a visually immersive environment with resolution at the limit of human eyes. A 3-D eight-channel surround sound system reinforced the immersive experience. A position-to-velocity system was programmed for the C6 where subject movement in a certain direction would result in the virtual reality environment moving toward the subject. Thus, participants could explore the entire virtual reality environment in much the same way as they would in real life.

Figure 1: The C6 Uses Six Banks of Four Projectors: One Bank for Each Wall, Ceiling, and Floor.



Testing Procedure

Following approval by the Iowa State University Institutional Review Board, participants were recruited and tested individually in approximately 60- to 90-minute sessions. Prior to moving onto the actual experimental protocol, participants acknowledged they understood how to move through the virtual reality environment and how to interact with the decision matrices. For the purposes of this research, each participant started in a blank-walled C6 virtual reality environment. Participants were subsequently informed, via the C6 speaker system, that they should assume the role of an Incident Commander after the scenario begins. This protocol parallels dispatcher radio traffic commonly received en route to an incident scene.

Participants then progressed to the fire fighting pre-backdraft scenario. Backdraft has been defined as an explosion of greater or lesser degree in which inflowing air into a burning structure may ignite a mix of unburned combustible gases, which result in a fireball and explosion with extreme hazardous potential (see Gorbett & Hopkins, 2007; Quintere & Karlsson, 1999). For example, backdraft catches or traps as many as 45% of the firefighters killed by smoke inhalation or secondary burns received from structure fires (Foley, 2003).

Participants began their scenario in the front yard of a single-family residential house with cues, such as an airtight structure, smoke-stained windows, smoke escaping from gaps around windows or doors, and the absence of flame, which are indicative of pre-backdraft conditions (**Figure 2**).

Figure 2: Puffing Smoke and Smoke-Stained Windows.

After arriving on scene for the typical fireground incident, firefighters are taught to do a 360-degree walk-around the house, commonly referred to as a 360°. The firefighter performs a 360° to obtain knowledge that facilitates understanding and comprehension of the situation; s/he acquires cues that suggest the type and progression of fire and the potential for rescuable victims (**Figure 3**). This process helps to ensure optimal situational awareness of the overall incident.

Figure 3: Cues Regarding Occupancy and Potential Victim(s) Included an Empty Driveway, Overflowing Mailbox, Garbage in Yard, and Newspapers Piled by the Front Door.

In the simulation, participants could move through the scene as if they were actually on the fireground to assess the situation both visually and audibly. In lieu of interacting with other firefighters to obtain more information relevant to the situation, participants could acquire desired data through interaction with a decision matrix of information bins (**Figure 4**). The bins in the matrix provided information audibly, mimicking radio communication with the participant's dispatcher, the fire chief, or the engine operator. Participants could review as much, or as little, of the information in the information bins as they desired. After reviewing this data, each participant (i.e., firefighter) made a decision as to how he/she would respond to the situation.

Figure 4: Participant Interacting with the Decision Matrix in the Virtual Reality Environment.

Firefighters in the virtual reality environment made decision choices that were later analyzed using binary logistic regression analysis.[1]

Upon completion, participants were provided with a short paper questionnaire regarding the experiment and their ability to analyze the situation (i.e., scenario, risk, and cue identification). Participants were then given a 26-question online survey consisting of several demographic questions. This survey also included scenario-specific questions, evaluated on a five-point Likert scale, with respect to their experiences in the virtual reality simulations. The participant's virtual reality scenario measured his/her response to that specific scenario only. This virtual reality scenario cannot be generalized to other situations and circumstances encountered in the fire service.

Results

This section shows the results of the firefighters' decisions in the virtual reality environment for the research question underlying this study.

Scenario 1 — Cue Recognition

To answer the research question involving assessment of situational awareness in virtual reality environments, the first hypothesis regarding cue recognition was evaluated. In this scenario, situational awareness is defined as correctly predicting the occupancy of the structure. To help evaluate the concept of situational awareness, visual cues, such as toys in the yard, a vehicle in the driveway, and an empty mailbox, were presented in the virtual reality environment prognosticating the likelihood that individuals (potential victims) were inside a burning building. Correctly perceiving this scenario required the need for firefighters to enter the structure to perform search and rescue. Conversely, cues, such as an overflowing mailbox, a pile of newspapers on the front porch, lack of vehicles in the driveway, and an empty pool in the backyard, suggested that no occupants were inside the residence on fire; thus, eliminating the need for firefighters to enter a vacant residence fire. Participants identifying relevant cues as to the occupancy of the structure should be able to develop the best workable action plans (Okoli et al., 2016), leading to the correct identification of structure occupancy and potential victim risk.

The independent variable for this study is whether a participant identified one or more of the cues associated with the actual occupancy outcome. To offer a quantitative-based test of the hypothesis associated with the research question, *cue recognition* was coded 1 (one) if the firefighter participant was successfully able to identify one or more of the provided cues, such as newspapers, vehicles, mail in mailbox, etc., relating to occupancy. *Cue recognition* was coded 0 (zero) if the participant was unable to identify any of the provided cues, such as newspapers, mail in mailbox,

etc., relating to occupancy. *Structure occupancy* was given the code 1 when a participant in the virtual reality environment correctly assessed the corresponding cues associated with the *likelihood* or *unlikelihood* that victims in need of rescue were inside the residence on fire. *Structure Occupancy* was given the code 0 when a participant incorrectly assessed the likelihood/unlikelihood that victims in need of rescue were inside the residence on fire.

A Chi-square Test of Independence was conducted to examine whether *cue recognition* and *structure occupancy* were independent of each other. The results of the Chi-square test were significant, $\chi^2(1) = 12.08$, $p < .001$, meaning that we are able to reject the null hypothesis that the two variables are unrelated. Instead, we find support for the alternative hypothesis that *cue recognition* and *structure occupancy* are related. However, the chi-square test results may be unreliable due to cell counts less than 5, so a Fisher exact test was also performed (**Table 1**). The results of the Fisher exact test were also significantly different, $p = .001$, reinforcing that *cue recognition* and *structure occupancy* are related to one another. Because the Fisher's exact test was conducted for a 2 by 2 contingency table, the odds ratio was calculated, OR = 8.18. This statistic indicates that the odds of observing the 0-0 and 1-1 categories is 8.18 times as likely as observing the 0-1 and 1-0 categories.

Further, a binary logistic regression (**Table 2**) was conducted to examine whether *cue recognition* had a significant effect on accurately identifying the likelihood of *structure occupancy.* The regression coefficient for *cue recognition* (1) was significant, $B = 2.15$, $p = .001$, suggesting that *cue recognition* had a significant effect on the likelihood of correctly observing *structure occupancy*. The associated odds ratio (OR) was 8.57. For respondents able to recognize at least one *cue*, the odds of accurately observing *structure occupancy* would increase by approximately 757%. The overall model was significant, $\chi^2(1) = 11.06$, $p < .001$. McFadden's R-squared was calculated to examine the model fit, where values greater than 0.20 are indicative of models with excellent fit (Louviere, Hensher, & Swait, 2000). The McFadden R-squared value calculated for this model was 0.16, showing measures of robustness.

The research results presented here show that cue recognition within the virtual reality environment can lead to situational awareness. When faced with a high-risk pre-backdraft virtual reality environment, Incident Commanders in this study were able to successfully extrapolate enough relevant cues to accurately identify potential victim(s) at risk. The outcomes of this study may have some similarities with findings reported by Weiss and Shanteau (2003). They found that Incident Commanders are able to successfully discriminate relevant from less relevant cues.

Scenario 2 — Previous Risk Exposure

To further evaluate the research question about creation of situational awareness within a virtual reality environment, we tested the second hypothesis regarding backdraft events. In this test, situational awareness is defined as correctly identifying the scenario presented as pre-backdraft or backdraft conditions. The independent variable for this test is whether a participant had previous experience with pre-backdraft or backdraft conditions.

To test the hypothesis associated with the research question, a participant was coded as a 1 (one) when indicating she or he had *Previous Exposure to Backdraft* conditions. Conversely, a participant was coded as a 0 (zero) when indicating she or he had no *Previous Exposure to Backdraft* conditions. *Scenario* was coded as a 1 when a participant correctly identified the scenario presented as pre-backdraft or backdraft conditions. *Scenario* was coded as a 0 when a participant incorrectly identified the scenario presented as any conditions, such as incipient fire, pre-flashover, flashover, and post-flashover, other than pre-backdraft or backdraft.

A Chi-square Test of Independence (**Table 3**) was conducted to examine whether *Previous Exposure to Backdraft* and *Scenario* recognition were independent. The results of the Chi-square test were significant, $\chi^2(1) = 3.85$, $p = .05$, suggesting that *Previous Exposure to Backdraft* and *Scenario* were related to one another at the 95% confidence interval.

Table 1: Cross Tabulation of Cue Recognition and Occupancy

	Occupancy			
Cue	Incorrect Occupancy	Correct Occupancy	OR	*p*
No Cue	9	7	8.18	.001
At Least One	6	40		

Table 2: Logistic Regression of the Likelihood of Predicting Occupancy

Variable	B	SE	95% CI	χ^2	*p*	OR
(Intercept)	-0.25	0.50	[-1.24, 0.74]	0.25	.62	
Cue (1)	2.15	0.67	[0.84, 3.46]	10.36	.001	8.57

Note. $\chi^2(1) = 11.06$, $p < .001$, McFadden $R^2 = 0.16$.

Table 3: Cross Tabulation of Previous Exposure to Backdraft and Scenario Identification

	Scenario				
Previous Exposure to Backdraft	Incorrect Scenario	Correct Scenario	χ^2	*df*	*p*
No	24	28	3.85	1	.05
Yes	8	2			

Table 4: Logistic Regression of the Likelihood of Predicting Backdraft

Variable	B	SE	95% CI	χ^2	*p*	OR
(Intercept)	0.47	0.29	[-0.09, 1.03]	2.72	.10	
Previous Exposure to Backdraft (1)	-1.86	0.84	[-3.50, -0.21]	4.88	.03	0.16

Note. $\chi^2(1) = 6.07$, p = .014, McFadden $R^2 = 0.07$.

Further, a binary logistic regression (**Table 4**) was conducted to examine whether *Previous Exposure to Backdraft* had a significant effect on the likelihood of identifying the backdraft situation (i.e., *Scenario* = 1). The regression coefficient was significant, B = -1.86, p = 0.03, indicating that participants with previous exposure to backdrafts were significantly less likely to identify the potential threat in the virtual reality environment. The odds ratio (OR) of 0.16 suggests that the odds of observing the correct *Scenario* would decrease by approximately 84% with past exposure to one of these events. The overall model was significant, $\chi^2(1) = 6.07$, p = .014. McFadden's R-squared was calculated to examine the model fit, where values greater than 0.2 are indicative of models with excellent fit (Louviere et al., 2000). The McFadden R-squared value calculated for this model was 0.07.

This finding carries significant implications for the health and safety of firefighters. Previous research by Wickens and Hollands (2000) found that cue selection involves the activation of some association from past memories, found both in the cue of some environmental feature, and some concept stored in memory. Similarly, Wiggins (2015) found that the development of cue-based associations in memory is largely dependent on the accumulation of experience in an environment, while Warwick et al. (2001) proposed that situation recognition can come from either prior knowledge or expertise. However, the results herein are inconsistent with the past research, in that participants with previous experience in similar fire conditions did not necessarily translate to a better ability to identify high-risk environments. Participants were unable to translate their cue-based associations in memory into correct scenario identification.

The inability to accurately predict backdraft scenarios could be critical given that some in the fire fighting occupation may believe that experience is the best teacher. Likewise, the severe consequences associated with the potentially catastrophic event of a backdraft make it imperative that firefighters cognitively recognize and correctly interpret the indicative cues implying a pre-backdraft condition (Gorbett & Hopkins, 2007; Norman, 1991). Cues, such as the presence (or absence) of smoke-stained windows, puffing smoke through small openings in the house, and the non-presence of flames, can inform the firefighter as to whether the fire scene is consistent with pre-backdraft. When encountering pre-backdraft conditions such as these, choosing the wrong line of action has the potential to kill firefighters.

Conclusion

The goal of this study was to answer the question: Can aspects of cue recognition and prior risk exposure lead to situational awareness within a virtual reality environment? To answer that question, experiments were conducted in a fully immersive virtual reality environment with 62 firefighters. Based on the statistical analyses reported in Tables 1 and 2, the null hypothesis for Scenario 1 is *rejected*: Cue recognition gained in a virtual reality simulation *is related* to the enhanced situational awareness of firefighters by significantly predicting ($p < .001$) the likelihood that study participants could tell a potential victim was inside a burning house. Because results confirmed that *cue recognition does lead to enhanced fireground situational awareness,* the ability for firefighters to ascertain the potential for victim rescue was increased.

Based on the statistical analyses reported in Tables 3 and 4, the null hypothesis for Scenario 2 is rejected: *Previous Exposure to a Backdraft experience is significantly related to situational awareness, though it did not improve firefighters' ability to predict the correct Scenario in virtual reality as a pre-backdraft situation.* Participants that had previously been exposed to backdrafts were more likely to *incorrectly* identify that fire scenario in the virtual reality environment.

Research shows that prior knowledge of an event or situation enhances situational awareness (Warwick, et al, 2001). As such, prior experience with backdraft situations could significantly affect how firefighters

process information at a fire scene (or in a virtual reality environment) (see Alba & Hutchinson, 1987; Shanteau, 1988). As Payne, Bettman, and Johnson (1993) remind us, prior knowledge "obtained either through *experience or training* [emphasis added] will determine which strategies are available to a decision maker in his or her memory" (p. 4). Regardless of the scenario, the results potentially suggest that cues play a crucial role in decision-making by activating pattern recognition processes, which can result in more consistent decision strategies (Okoli et al., 2016; Brouwers et al., 2016).

This study suggests that virtual reality environments, such as that used in this study, can be a highly effective tool to assess high-risk scenarios. Post-study debriefings of the firefighter participants indicated that they were all suitably immersed in the fire fighting scenario. Training in virtual environments is safer than live fire environments; they also allow for the assessment of subtle differences in decision-making processes.

Future research should explore further the utility of virtual reality simulations in the training of firefighters, as well as those in occupations who are exposed to high-risk, potentially dangerous situations. For example, volunteer firefighters are more likely to be injured on the fireground than are career firefighters despite having typically fewer callouts (Karter, 2012). Having less fireground experience may be the underlying cause for these injuries. As such, virtual reality training holds the promise of increasing cue recognition that, in turn, leads to greater situational awareness for ALL firefighters. Enhanced decision-making gained through greater situational awareness, in turn, can lead to fewer firefighter injuries and help ensure that everyone goes home.

References

Alba, J. W., & Hutchinson, J. W. (1987). Dimensions of consumer expertise*. Journal of Consumer Research, 13,* 411-445*.*

Ariely, D. (2009). Accepting the default, *NH Record*, *LXI*(2), Retrieved March 20, 2019 from https://nihrecord.nih.gov/newsletters/2009/01_23_2009/story3.htm

Artman, H. (1999). Situation awareness and cooperation within and between hierarchical units in dynamic decision making. *Journal of Ergonomics, 42*(11), 1404-417.

Bayouth, S. T. (2011). *Examining firefighters' decision making in virtual reality.* (Doctoral Dissertation), Ames, Iowa: Iowa State University.

Bayouth, S. T., Keren, N., Franke, W. D., & Godby, K. (2013). Examining firefighter decision-making: How experience influences speed in process and choice. *International Journal of Fire Service Leadership and Management, 7*, 51-60.

Bellenkes, A. H., Wickens, C. D., & Kramer, A. F. (1997). Visual scanning and pilot expertise: The role of attentional flexibility and mental model development. *Aviation Space Environmental Medicine, 68*, 569-579.

Bomhof, L. (2017, August). *Experience says it all! Or not…? Situation awareness on the fire ground*. (Doctoral Dissertation), Enschede, Netherlands: University of Twente.

Brennan, C. (n.d.). *The Link between disorientation and situational awareness*. Retrieved March 9, 2019, from http://www.fireengineeringuniversity.com

Brouwers, S., Wiggins, M. W., Helton, W., O'Hare, D., & Griffin, B. (2016, March). Cue utilization and cognitive load in novel task performance. *Frontiers in Psychology*, *7*, 1-12. Retrieved March 8, 2019 from www.frontiersin.org

City of Charleston. (2008). *Post incident assessment and review team phase II report.* Retrieved March 2, 2019, from http://downloads.pennet.com/fe/misc/20080515charlestonreoirt.pdf

Durso, F. T., Sethumadhavan, A. (2008, June). Situation awareness: Understanding dynamic environments. *Human Factors, 50*(3), 442-448. Retrieved March 3, 2019 from https://journals.sagepub.com/doi/pdf/10.1518/001872008X288448

Eichenberg, C., (Ed.) (2012). *Virtual reality in psychological, medical and pedagogical applications*. London, England: InTech Open Limited Publishing. doi: 10.5772/2607

Endsley, M. R. (1988). Design and evaluation for situation awareness enhancement, *Proceedings of the Human Factors Society 32nd Annual Meeting*, Santa Monica, CA.

Endsley, M. R. (1995). Towards a theory of situational awareness in dynamic systems. *Human Factors, 37*(1), 32-64.

Endsley, M. R. (1996). Situation awareness in dynamic human decision making: Measurement. In R. D. Gilson, D. J. Garland, & J. M. Koonce (Eds.), *Situational awareness in complex systems* (pp. 79-97). Daytona Beach, FL: Embry-Riddle Aeronautical University Press.

Endsley, M. R. (1997). The Role of situation awareness in naturalistic decision making. In C. Zsambok, & G. Klein (Eds.), *Naturalistic Decision Making* (pp. 269-284). Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.

Ericsson, K., & Charness, N. (1994). Expert performance: Its structure and acquisition. *American Psychology, 49*(8), 725-747.

Federal Emergency Management Agency (FEMA). (2002). *Firefighter fatality retrospective study*, Retrieved December 23, 2018, from https://www.usfa.fema.gov/downloads/pdf/publications/fa-220.pdf

Foley, S. N. (2003). *Resources for fire department occupational safety and health.* Quincy, MA: National Fire Protection Association, Inc.

Fracker, M. L. (1991). *Measures of situation awareness: Review and future directions*. Wright-Patterson Air Force Base, OH: Air Force Systems Command. Retrieved March 15, 2019, from https://apps.dtic.mil/dtic/tr/fulltext/u2/a262672.pdf

Gallagher, A. G., Seymour, N. E., Jordan-Black, J-A., Bunting, B. P., McGlade, K., & Satava, R. M. (2013). Prospective, randomized assessment of transfer of training (ToT) and Transfer Effectiveness Ratio (TER) of virtual reality simulation training for Laparoscopic skill acquisition. *Annals of Surgery*, *257*(6), 1025-1031.

Gorbett, G., & Hopkins, R. (2007). *The current knowledge and training regarding backdraft, flashover, progression phenomena*. World Safety Conference (pp. 1-25). Quincy, MA: National Fire Protection Association.

Hartin, E. (2008) *Fire development and fire behavior indicators*. Retrieved March 18, 2019, from www.firehouse.com

Hogarth, R. (1987). *Judgment and choice: The psychology of decision (2nd ed).* New York, NY: John Wiley & Sons, Inc.

Hutton, R., & Klein, G. (1999). Expert decision making. *System Engineering, 2*, 32-45.

International Association of Fire Chiefs (2014). *Fundamentals of Fire Fighter Skills* (3rd ed.). Burlington, MA: Jones & Bartlett Learning.

Jackson, R. C., & Mogan, P. (2007). Advance visual information, awareness, and anticipation skill. *Journal of Motor Behavior, 39*, 341–351. doi:10.3200/JMBR.39.5.341-352

Johnson, E. J., & Payne, J. W. (1985). Efforts and accuracy in choice. *Management Science*, *31*(4), 395-414.

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: A failure to disagree, *American Psychologist*, *64(6)*, 515-526.

Karter, M. J. (2012). *An analysis of volunteer firefighter injuries, 2008-2012*. Quincy, MA: National Fire Protection Agency.

Karter, M. J., & Molis, J. L. (2013). *U.S. Firefighters injuries – 2013.* Quincy, MA: National Fire Protection Association. Retrieved December 3, 2018, from: https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/Old-FFF-and-FF-Injuries/FirefighterInjuries2014.ashx?as=1&iar=1&la=en&hash=D01B95B172C0FA23C5A4AF68AFA14E3CE479CE74

Keeney, R. L., & Raiffa, H. (1993). *Decisions with multiple objectives: Preferences and value trade-offs*. Cambridge, UK: Cambridge University Press.

Keren, N., Bayouth, S. T., Godby, K. M., & Franke, W. D. (2013, October). Examining the effect of stress and firefighters' experience level on time-to-decision in virtual reality. In *Proceedings of the 2013 International Meeting of the Human Factors and Ergonomics Society,* September 30 - October 4, 2013, San Diego, CA.

Keren, N., Franke, W. D., Bayouth, S. T., Godby, K. M., & Harvey, M. E. (2013, December). VirtuTrace: Training for making decisions under stress in virtual environments. In *Proceedings of the I/ITSEC Interservice/Industry Training Simulation & Education Conference*, December 2-5, 2013, Orlando, FL.

Klein, G. (1993). A Recognition-primed decision (RPD) model of rapid decision-making. In G.A. Klein, J. Orasanu, R. Calderwood, & C.E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 138-147). Norwood CT: Ablex Publishing Co.

Klein, G. (2008). Naturalistic decision-making. *Human Factors, 59*(3), 456-460.

Klein, G., Calderwood, R., & Clinton-Cirocco, A. (2010, September). Rapid decision making on the fire ground: The original study plus a postscript. *Journal of Cognitive Engineering and Decision Making*, *4*(3), 186-209.

Kool, W., McGuire, J., Rosen, Z., & Botvinick, M. (2010). Decision making and the avoidance of cognitive demand. *Journal of Experimental Psychology*, *139*, 665-682.

Kunreuther, H., Meyer, R., Zeckhauser, R., Slovic, P., Schwartz, B., Schade, C., … Hogarth, R. (2002). High stakes decision making: Normative, descriptive and prescriptive considerations, *Marketing Letters*, *13*(3), 259-268.

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods*. New York, NY.: Cambridge University Press. Retrieved March, 21, 2019, from https://www.researchgate.net/publication/215666083_Stated_choice_methods_analysis_and_application

McHugh, M. L. (2013). The chi-square test of independence. *Biochemia Medica, 23*(2), 143-149.

Menard, S. (2009). *Logistic regression: From introductory to advanced concepts and applications.* Thousand Oaks, CA.: Sage Publications.

Morrison, B. W., Wiggins, M. W., Bond, N. W., & Tyler, M. D. (2013, June). Measuring relative cue strength as a means of validating an inventory of expert offended profiling cues. *Journal of Cognitive Engineering and Decision Making, 7(2)*, 211-226.

Müller, S., Abernethy, B., & Farrow, D. (2006). How do world-class cricket batsmen anticipate a bowler's intention? *Quarterly Journal of Experimental Psychology, 59*, 2162-2186. doi: 10.1080/02643290600576595

NFPA. (2018). *U.S. Firefighter injuries in 2017*, Retrieved December 23, 2018, from https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/osffinjuries.pdf

National Fallen Firefighter Foundation (NFFF). (2005, June). *National Fire Service Research Agenda Symposium* (pp, 1-50). Emmitsburg, MD.: National Institute of Standards and Technology (NIST), Center for Fire Research.

National Institute of Standards and Technology (NIST). (1998). *Appendix C: Decision skills training*. Washington, D.C.: United States Government Printing Office.

National Institute for Occupational Safety and Health (NIOSH). (2009). *Death in the line of duty*. Retrieved March 21, 2013 from http://www.cdc.gov/niosh/fire/reports/face200718.html

Norman, J. (1991). *Fire officer's handbook of tactics*. Saddlebrook, NJ: Fire Engineering.

Okoli, J., Watt, J., & Weller, G. (2016, August). Towards the classification of fireground cues: A qualitative analysis of expert reports. *Journal of Contingencies and Crisis Management*. Retrieved March 10, 2019, from https://www.researchgate.net/publication/306136419. doi: 10.1111/1468-5973.12129

Orasanu, J., & Connolly, T. (1993). The reinvention of decision-making: In G. Klein, J. Orasanu, C. Zsambok (Eds.). *Decision making in action*. Norwood, NJ: Ablex (pp. 3-20). doi: 10.1002/bdm.3960080307

Payne, J., Bettman, J. R., & Johnson, E. J. (1993). *The Adaptive decision maker*. New York: NY: Cambridge University Press.

Perry, N. C., Wiggins, M. W., Childs, M., & Fogarty, G. (2013). The application of reduced-processing decision support systems to facilitate the acquisition of decision-makings kills. *Human Factors, 55*, 535-544. doi: 10.1177/0018720812467367

Pfaff, M. S., Klein, G. L., Drury, J. L., Moon, S. P., Liu, Y., & Entezari, S. O. (2012). Supporting complex decision making through optional awareness, *Journal of Cognitive Engineering and Decision Making*. doi: 10.1177/1555343412455799

Quintiere, J., & Karlsson, B. (1999). *Enclosure fire dynamics*. Albany, NY: Delmar.

Shanteau, J. (1988). Psychological characteristics and strategies of expert decision makers. *Acta Psychologica*, *68*, 203-215.

Shepard, R. N. (1964). Circularity in judgements of relative pitch. *Journal of the Acoustical Society of America, 36*, 2346-2353.

Shin, HyeonHui, & Kim, KyeongMi (2015). Virtual reality for cognitive rehabilitation after brain injury: A systematic review. *Journal of Physical Therapy Science*, *27*(9), 2999-3002.

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). Mahwah, NJ: Routledge Academic.

Useem, M., Cook, J., & Sutton, L. (2005). Developing leaders for decision making under stress: Wildland firefighters in the South Canyon fire and its aftermath. *Academy of Management Learning & Education*, *4*(4)*,* 461-485.

Warwick, W., McIlwaine, S., Hutton, R. J., & McDemott, P. (2001). Developing computational models of recognition-primed decision making. *Proceedings of the 10th Conference on Computer Generated Forces.* Fairborn, OH: Klein Associates, Inc.

Weiss, D. J., & Shanteau, J. (2003). Empirical assessment of expertise. *Human Factors, 45*, 104-116.doi:10.1518/hfes.45.1.104.27233

Wickens, C. D., & Hollands, J. (2000). *Engineering psychology and human performance* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Wiggins, M. W. (2015). *Diagnostic expertise in organizational environments*. Surrey: Ashgate Publishing.

Wong, B. L. W. (2000). The integrated decision model in emergency dispatch management and its implications for design. *Australian Journal of Information Systems, 7*(2) 95-101. Retrieved March 18, 2019 from http://eprints.mdx.ac.uk/2221/1/Wong_Intergrated_Decision_Model.pdf

Wong, B.L.W. (2004). Critical decision method data analysis. In D. Diaper, N. Stanton, (Eds.), *The Handbook of task analysis for human-computer interaction* (pp. 327-346). Mahwah, NJ: Erlbaum.

Zsambok, C. (1997). Naturalistic decision-making: Where are we now? In C. Zsambok, G. Klein (Eds.), *Naturalistic decision-making* (pp. 3-16). Mahwah, NJ: Erlbaum.

Endnote

[1]To test both research questions, a binary logistic regression was conducted. The binary logistic regression is an appropriate statistical analysis when the purpose of research is to assess if a set of nominal, ordinal, or interval/ratio predictor variables predict a dichotomous dependent variable (Stevens, 2009). This analysis permits the evaluation of the odds of membership in one of the two outcome groups based on the combination of predictor variable values.

Binary logistic regression analysis, by design, overcomes many of the restrictive assumptions of linear regression. For example, normality and homoscedasticity of the residuals are not assumed. The overall model significance for the binary logistic regression was examined using the χ^2omnibus test of model coefficients. McFadden's R^2 was examined to estimate the percent of variance accounted for by the independent variables. Predicted probabilities of an event occurring were determined by Exp(β), also known as the odds ratio.

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Dr. Shawn Bayouth is the Chair of Arkansas State University's Department of Disaster Preparedness and Emergency Management. Shawn received his Ph.D. from Iowa State University and continues his research in decision making utilizing virtual reality. He retired in 2018 from a 29-year career in the fire service as a nationally certified paramedic, Fire Officer IV, a graduate of the Executive Fire Officer (EFO) Program, as well as a five-time designated Chief Fire Officer (CFO). He has served on several of IFSTA's validation committees and is currently on the Editorial Board of the *International Fire Service Journal of Leadership and Management*.

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