ISSN 1554-3439

International Fire Service Journal of Leadership and Management

Building Theory to Impact Practice

IFSJLM

Volume 4 • Number 1
2010

Journal Team

Editor
Dr. Robert E. England
Political Science Department
Oklahoma State University

Associate Editor
Mike Wieder
Fire Protection Publications
Oklahoma State University

Copy Editor
Barbara Adams
Fire Protection Publications
Oklahoma State University

Production Manager
Ann Moffat
Fire Protection Publications
Oklahoma State University

Layout & Design
Ben Brock
Fire Protection Publications
Oklahoma State University

Journal Webmaster
Desa Kinnamon
Fire Protection Publications
Oklahoma State University

Subscriptions & Permissions Coordinator
Susan F. Walker
Fire Protection Publications
Oklahoma State University

Editorial Board

In this Issue

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

The Dr. Granito Award

Fire Protection Publications (FPP) and the *International Fire Service Journal of Leadership and Management (IFSJLM)* headquartered on the campus of Oklahoma State University (OSU) are proud to announce the creation of the **Dr. John Granito Award for Excellence in Fire Leadership and Management Research (the Dr. Granito Award).** The award will be presented at the *IFSJLM* Research Symposium that supports the Journal held annually in July at the IFSTA Validation Conference. The award honors Dr. John Granito. John is 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* (current). He has participated in more than 400 fire department studies. John also has strong ties to academia. He has served in a number of academic positions for the past 27 years, and for the last 16 years has served 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 will be 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** will present the Keynote Address at the annual *IFSJLM* Research Symposium and will be the Guest of Honor at the reception held on Friday night prior to the Research Symposium.

Nomination Form

Fire Protection Publications (FPP) and the *International Fire Service Journal of Leadership and Management (IFSJLM)* headquartered on the campus of Oklahoma State University (OSU) are accepting nominations for the **Dr. John Granito Award for Excellence in Fire Leadership and Management Research (the Dr. Granito Award).** The award is presented at the Research Symposium that supports the *International Fire Service Journal of Leadership and Management (IFSJLM)* held annually in July at the IFSTA Validation Conference.

The nominee should have made a significant contribution to the advancement of fire leadership and management through his/her scholarly/academic writing. The Dr. Granito Award is not necessarily a life-time achievement award, although such individuals certainly should be in a prominent position to be nominated. The nominee can be a person who, although early in their career as a practitioner/scholar or academic, has made a seminal contribution to the fire leadership and management literature.

To nominate an individual for the Dr. Granito Award, please submit by 15 January of the symposium year: (1) this form (or a copy of it), (2) no more than a one-page single-spaced letter explaining why you believe the person is deserving of the award, and (3) a copy of the nominee's resume or curriculum vitae. Send the materials to: Dr. Granito Award, Dr. Bob England, Editor, *International Fire Service Journal of Leadership and Management,* Department of Political Science, 531 Math Sciences, Oklahoma State University, Stillwater, Oklahoma 74078.

I nominate ____ for the **Dr. John Granito Award for Excellence in Fire Leadership and Management Research.** To support the nomination, I have included a letter of recommendation and a resume or curriculum vitae (CV) of the nominee. (A nomination is not accepted without the supporting letter and resume/CV.)

Nominator Name: ____

Address: ____

____

Zip/Postcode: ____

Contact Information:

Telephone: ____

Email: ____

Message from Dr. Robert England

Editor, *International Fire Service Journal of Leadership and Management (IFSJLM)* and Professor of Political Science at Oklahoma State University

Welcome to Volume 4, Issue 1 of *IFSJLM*. The first article in this issue is a presentation given by Dr. Denis Onieal at the *IFSJLM* Research Symposium held last July in Oklahoma City. Dr. Onieal was the 2009 recipient of the Dr. John Granito Award for Excellence in Fire Leadership and Management Research. We extend our thanks to Dr. Onieal for his excellent keynote address and his many scholarly contributions to fire leadership and management.

We urge readers to nominate others for the award that honors those who advance the **science of fire leadership and management**. A nomination form is found at the bottom of the previous page of this issue of the "*Red Journal*."

Second Annual Dr. John Granito Award for Excellence in Fire Leadership and Management Keynote Address.
Dr. Denis Onieal, Superintendent, National Fire Academy (denis.onieal@dhs.gov)

LODD Reduction: Stories, Science, Statistics, and Solutions

> *…We've arranged a civilization in which most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces ….* Carl Sagan

This presentation about firefighter Line of Duty Deaths (LODDs) will ask and attempt to answer the following four questions surrounding LODDs:

1. We are all great at *Stories*, but how good are we at *Science* and *Statistics*?
2. What is *federalism*; what is *devolution*?
3. What has worked and what never does work?
4. What is the *Solution*; what are we all going to *DO*?

Video presentation by Michael Shermer on what constitutes Science: (**Editor's note: Take the time to find an Internet connection and watch this short video. It provides an excellent context for Dr. Onieal's presentation.**)

http://www.ted.com/talks/michael_shermer_on_believing_strange_things.html

How good are we at science and statistics? Mike Shermer showed you what is and is not science and explains the differences in a pretty funny way. We are not good scientists, and human beings are equally poor as intuitive statisticians. It is hard for us to discover the truth when we just do not ever figure the odds. It is common for someone to believe that they have a good chance of winning the lottery, but at the same time believe they will not get into a vehicle accident because they are a *good driver*. On the face of it, the odds are in favor of the accident and against the lottery, but indeed people do think that way. Hope springs eternal!

In much the same way, people believe fire fighting LODDs occur because fire fighting is dangerous — that is the *story*; but the science and the statistics tell us that roughly 75 percent of the 100 or more annual LODDs are caused by firefighter-controlled behaviors. About 50 percent of the current LODDs are caused by heart-related events and 25 percent by vehicle accidents. Fires and other causes result in about 25 percent of the LODDs.

If you look at the science, the *New England Journal of Medicine* article by Dr. Stephanos Kales, et al. entitled "Emergency Duties and Deaths from Heart Disease Among Firefighters in the United States" identifies the following four personal cardiovascular risk factors in his analysis of LODDs:

1. Poor exercise tolerance
2. High prevalence of obesity and high cholesterol
3. Hypertension (often untreated)
4. Lack of regular periodic examinations

In this and another article in the *American Journal of Cardiology*, Kales identified the odds of a cardiac-related firefighter LODD as follows:

1. 40 percent of LODDs are caused by smokers who have heart attacks.
2. A LODD is:
   - — 35 times greater for those with a known diagnosis of some form of heart disease
   - — 12 times greater for those with hypertension
   - — 6½ times greater for those more than 50 years old

Additional risk factors include obesity, and as a part of society, firefighters are not immune to this alarming trend. Obesity is defined as a Body-Mass Index (BMI) of over 30; a BMI of 25-30 is considered overweight. America's growing obesity problem over the past 18 years is graphically demonstrated on the Centers for Disease Control and Prevention (CDC) web site: www.cdc.gov.

In research tangential to one of the Kales' identified risk factors (regular periodic examinations), Walter Malo and John DeIorio published their findings in the *International Fire Service Journal of Leadership and Management*, "Getting to the Heart of the Matter: Reducing Firefighter Line of Duty Deaths." Their research found the following:

- 64 percent of fire departments who responded to their survey required annual incumbent physicals.
- 22 percent of fire departments responding performed no periodic physicals.
- Of those departments that reported that they conducted physicals:
   - — Half of the physicals were (and the

other half were not) conducted by occupational medicine physicians.

— Only half of those occupational medicine physicians were familiar with NFPA® 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

- 84 percent of the respondents did not include obesity as a determining factor in *fit for duty.*

It is clear from the scientific evidence that previously diagnosed heart disease, age, and obesity are significant contributing factors to heart-related LODDs. While Malo and Delorio's research is probably too small a sample to be definitive, it does identify some opportunities to address the issues through annual medical screening conducted by trained occupational physicians using National Fire Protection Association® (NFPA®) standards. It is a start toward a workable solution to reducing cardiac-related LODDs.

What is federalism, and what is devolution — and how do they relate to efforts to reduce LODDs? In a nutshell, *federalism* defines the role of the federal government versus state government. Unless specifically reserved for the federal government in the U.S. Constitution, most authorities are devolved to reside with the states. The federal government reserves the right to coin or print money, sign treaties with foreign governments, declare war, and regulate interstate commerce. Other authorities like issuing drivers' or medical licenses, regulating voting, issuing marriage licenses and divorce decrees, establishing and sustaining a National Guard, and regulating property transfer rules and requirements belong to the states. Some authorities are shared efforts — family assistance, education, road construction, and road maintenance are but a few. In governance, certain authorities are centralized in the federal government, but most are devolved locally.

An extraordinary example of centralized authority versus devolved authority that this writer once examined is military veterans' benefits. Before discussing this issue any further, I want to state that I have three family members who are disabled veterans — an uncle from World War II, a cousin from Vietnam, and my son from Iraq. Each receives extraordinary treatment from the Veterans Health Administration (VHA) medical system (part of the U.S. Department of Veterans Affairs [VA]); the men and women who work for the VA are remarkable — you will only hear me singing their praises.

After World War II, the Korean War, and the Vietnam War, the government took two distinct approaches to veterans' benefits, and the differences can be used to demonstrate centralized versus devolved services. In one case, the government told the veterans:

Thank you for your service, and the time you took from your life to defend democracy. We want to help you get back with your life by helping you with a college education. You can study whatever you would like, and attend any college or university as long as it is accredited. We will give you funds to pay for your tuition and some living expenses.

And the VA did just that. As a result, we took an entire generation of lower economic status people (which most draftees were) and educated them into the taxpaying middle class. The government devolved the decision, provided general guidance and resources, and let the system work. Our country experienced tremendous economic growth because of the education these veterans received, and we continue to reap the benefits. To the returning veterans who were injured and disabled they also said:

Thank you for your service, and the time you took from your life to defend democracy. We are sorry you were injured, and we will help you get back with your life by treating your medical condition. We will build and manage the hospitals, hire the doctors and the nurses, cook the food, sweep the floors and manage the laboratories.

In the process, the VA built one of the largest healthcare systems in the world.

I happen to think that the VA is very good, but that is my experience; and others have a different opinion. However, I often wonder what the healthcare system in the United States would be today had the VA decided to devolve the health benefits for disabled veterans the same way they devolved the education benefits — that disabled veterans could receive healthcare in their local communities rather than a centralized system. Of course, we will never know, but the question is intriguing.

In the case of LODDs, my concern is that the efforts to reduce LODDs are becoming centralized rather than devolved and that the solutions are too far from the problems.

There are a number of activities associated with the attempt to reduce LODDs. The National Fallen Firefighters Foundation (NFFF) has embarked upon an ambitious program to reduce LODDs. The program was developed during a Firefighter Life Safety Summit held in Tampa, Florida, in March 2004. The Summit produced 16 major initiatives that give the fire service a blueprint for making the necessary organizational changes to reduce LODDs. The work of the NFFF is remarkable — from helping the families of the fallen, to providing scholarships for their survivors, and then conducting the annual Memorial event each October.

While there is widespread recognition of their tremendous efforts, my concern is that the LODD reduction efforts are increasingly viewed as the responsibility of the NFFF rather than the responsibility of the individual or local fire department. In just about every conversation I have on campus (National Fire Academy), the Foundation is mentioned as being the impetus for, or the solution to, the problem. The concern is that the LODD reduction effort is becoming centralized in the NFFF rather than decentralized to the local fire department where the problem is. Solutions there would have a much greater impact.

So, what are we going to DO? I believe that the LODD efforts must be devolved into local fire departments; the solutions must be placed closer to the problem. The NFFF must provide local fire chiefs the tools they need to reduce LODDs — heart attacks and vehicle accidents. NFPA® 1582 should be used and enforced by local fire departments if we are ever going to successfully deal with cardiac and obesity issues. The local fire chief should have model documents at her or his disposal to help enforce NFPA® 1582 along with model programs to help implement the standard. Fire department physicians should be as equally familiar with the standard as the fire chief.

The solution to 25 percent of the LODDs related to vehicle accidents is not rocket science. Mandatory seatbelt use and increased driver qualifications and training are the answers. One of the fire service's best instructors happens to be a retired police officer, Gordon Graham. If you have never heard Gordon speak, do not miss the next opportunity. If you have heard him speak, then you are probably like me — whenever and wherever, I am in the audience.

One of the stories he tells is about truck accidents. He usually asks his audience to raise their hand if they have ever seen a vehicle accident involving a truck. Of course, every hand in the audience goes up. Then he asks if anyone has ever seen a truck accident involving a United Parcel Service (UPS) truck. In all his audiences, very few hands ever go up on that question, and frequently none are raised. Gordon goes into a great explanation as to why UPS is so successful at accident reduction — but there is no magic to it. It is careful screening and training, training, training. There are rules, everyone knows the rules and everyone knows that the rules are enforced. There are consequences for breaking the rules. There is no reason at all that the same cannot be done in the local fire department. What is rewarded is repeated; what is punished does not.

In closing, firefighter LODD reduction is not a gamble with the odds; it is not Las Vegas and it is not the jumbo lottery. It is science; it is data. We have talked it and *PowerPointed* it to death; now is the time for action. The science and the statistics are telling us to work with the best odds. The science and statistics are telling us that it is heart attacks and vehicle accidents that are causing 75 percent of the LODDs. The biggest impact on LODD reduction is in these two areas — *and we control the variables!*

If we are serious about LODD reduction, we must place the solution next to the problem — at the local level. The local fire chief is the most effective change agent and must have the tools, the models, the examples, and the best practices to implement NFPA® 1582 or an equivalent health and fitness program. If we are serious about reducing vehicle-related LODDs, the local fire chief must have model driver training programs, model safe driver and passenger policies, and examples of enforcement. It is time that we expose, rather than comfort and shield, officers who suffer and permit unsafe practices to flourish in their departments.

In closing, I want to once again recognize one of my heroes, Dr. John Granito for whom this award is named for all that he has done for America's Fire and Emergency Services. We are all better because of Dr. Granito's leadership and vision.

B. E. (Bernie) Williams, Ph.D., University of Lethbridge, Canada

Incident Command as a Participative-Management Practice: Dispelling the Myth of Authoritarian Command[1]

Abstract

Using Mintzberg's (1980) concepts of characteristics, roles, variation, and programs, the tasks performed by incident commanders (ICs) were analyzed. Methods included observations at actual incidents, analyses of an incident simulation, and interviews with chief officers in a number of jurisdictions. The results demonstrate similarities between the performance of emergency managers and business managers and highlight the extent to which incident command is a participative-management (PM) practice.

More than 30 years ago, Mintzberg asked the question: *What do managers really do*? (Mintzberg, 1980). In answering this research question, he observed managers at work and exposed a series of management myths. Based on his observations, Mintzberg provided rich descriptions of *what managers really do* and developed a grounded theoretical framework comprised of four basic aspects of managerial work. This paper builds on the work of Mintzberg and applies the basic concepts from his work to the field of emergency incident management. The research reported here is guided by one basic research question: What do emergency incident managers (incident commanders [ICs]) really do?

It is suggested here that, like the practice of business management in pre-Mintzberg times, the practice of emergency management is currently guided by myths. The most prevalent is the myth of the authoritarian IC. While there have been many articles and books written about leadership and management in the fire service, there has been a prevailing assumption, based on situational leadership (Hersey, 1984), that emergency incident management should be approached in an autocratic and authoritarian manner. The literature on incident command focuses primarily on fireground strategy and tactics and what ICs *should do*. However, the literature does not give much attention to what ICs actually do and how they accomplish the myriad tasks that they are faced with.

By examining ICs under both real and simulated conditions, the research reported in this paper provides insight into what ICs do and how they do things. Based on this analysis, conclusions are drawn and recommendations are developed giving particular consideration to the implications for teaching management and leadership in the fire service and developing effective ICs.

Background and Conceptual Overview

Basic Functions and Task Demands of Business Managers

As the fire service has developed and matured as a profession, there has been an increasing adoption of accepted business practices and behaviors. One of the most widely cited sources on the functions and task demands of business managers is Henry Mintzberg (1975; 1980; 1989); his work has been incorporated into the Executive Fire Officer Program at the National Fire Academy (NFA). Mintzberg's ground-breaking book, *The Nature of Managerial Work* (Mintzberg, 1980), and companion article in *Harvard Business Review*, "The Manager's Job: Folklore and Fact" (Mintzberg, 1975), present an insightful theory of managerial work, based on observations of the things that managers actually do. In addition to providing an empirically grounded description and classification of basic managerial tasks, Mintzberg (1980) also provides a concise history of the development of managerial thought and research pertaining to the functions of the manager.

According to Mintzberg (1980), the first classification of managerial functions was developed in 1916, when Henry Fayol (1950) introduced the following five basic managerial functions:

- Planning
- Organizing
- Coordinating
- Commanding
- Controlling

This description of a manager's functions was apparently well received in the early years and was developed further in the 1930s by Luther Gulick who developed the acronym *POSDCORB*, which stands for *Planning, Organizing, Staffing, Directing, Co-ordinating, Reporting, and Budgeting* (Gulick & Urwick, 1937, p. 13, referenced in Mintzberg, 1980, p. 9).

Mintzberg observes that *POSDCORB* prevailed as the most commonly accepted description of managerial functions for more than 50 years, but cautions that it does not *describe the actual work of managers at* *all (but merely) describes certain vague objectives of managerial work* (Mintzberg, 1980, p. 10). In criticizing the *POSDCORB* approach, Mintzberg cites a number of examples of things that managers do such as networking and holding informal discussions, which do not fit into any of the categories of *POSDCORB*. Mintzberg concludes that rather than facilitating our understanding of managerial work, the *POSDCORB* approach *block(s) our search for a deeper understanding of the work of a manager* (Mintzberg, 1980, p. 11). In attempting to build a more accurate description of managerial work, Mintzberg relies on different concepts drawn from various theories and grounds the concepts in the literature as well as evidence from his own systematic observation of managers at work (Mintzberg, 1980, p. 26). The results of his efforts are the following four basic aspects of managerial work:

1. ***Characteristics*** — There are six sets of work characteristics common to all managers' jobs.
2. ***Roles*** — There are ten basic roles which comprise the content of the manager's job.
3. ***Variations*** — Variations in managers' work can be attributed to the job environment, the job itself, the person in the job, and the situation of moment.
4. ***Programs*** — Managers can increase effectiveness by programming some aspects of their job (Mintzberg, 1980, pp 26–27).

Characteristics are the six attributes of managers that Mintzberg (1980) developed from the literature and his own observations. He found them to be common in all managerial work, regardless of individual or setting. The first characteristic of managers is that they *work at an unrelenting pace* (Mintzberg, 1980, p. 29). This situation is due to the open-ended nature of their work and the fact that the manager is the one who is responsible for the success of his or her organization or unit.

The second characteristic is *activity characterized by brevity, variety and fragmentation* (Mintzberg, 1980, p. 31). The breadth and complexity of the manager's responsibilities require that he/she not become too involved in any one issue, and thus the manager is forced to deal superficially with many issues.

The third characteristic is a *preference for live action* (Mintzberg, 1980, p. 35). The manager works in an environment of stimulus-response, and develops in his or her work a clear preference for live action and specific issues rather than general issues, reflective planning, or abstract discussions (Mintzberg, 1980, p. 37).

The fourth characteristic is an *attraction to verbal media* (Mintzberg, 1980, p. 38). This includes telephone conversations, scheduled and unscheduled meetings. Unlike other workers, the manager does not leave the telephone or the meeting to get back to work; these activities are his or her work (Mintzberg, 1980, p. 44).

The fifth characteristic of managerial work is that the manager is the *link between his/her organization and a network of contacts* (Mintzberg, 1980, p. 44). The manager's position is the *neck of the hour glass* and the manager has the ability to sift and direct information flowing to, from, and within the organization (Mintzberg, 1980, p. 48).

The sixth and final characteristic is that a manager's job is a *blend of rights and duties* (Mintzberg, 1980, p. 48). The manager may initiate programs or establish lines of communication, but once these decisions have been made, the programs will control the manager's time and the information flow will be beyond the manager's control. By virtue of his or her position, the manager has many duties and obligations over which he or she exercises little control.

Roles are described by Mintzberg (1980, p. 54) as the crux of his study and the *theory of what managers do*. According to Mintzberg (1980, p. 54), *a role is defined as a set of behaviors belonging to an identifiable office or position.* In systematically analyzing the literature on managerial work, previous studies, and his own observations, Mintzberg developed a set of ten roles that managers play during the normal conduct of their work. The ten roles are classified into the following three major subsets:

1. Interpersonal roles
2. Informational roles
3. Decisional roles

All of these roles flow from the formal authority and status of the manager. Table 1 is adapted from Mintzberg (1980, pp. 92–93) and provides a summary of the ten roles and examples of each. The ten roles described by Mintzberg (1980) provide a conceptual framework for analyzing the tasks that specific managers perform and can be used as a reference guide for examining the tasks performed by emergency incident managers.

Variations are proposed by Mintzberg (1980) as a means of understanding why it is that specific managers will give different levels of attention to the various roles described previously. Mintzberg (1980) identifies four different types of variables and proposes a contingency theory based on the influence of the four different types of variables. The four types of variables are as follows:

1. ***Environmental*** — Characteristics of the milieu, industry or organization.
2. ***Job*** — Level of job and the function supervised.
3. ***Person*** — Personality and style of person in the job.
4. ***Situational*** — Temporal features of an individual job (Mintzberg, 1980, p. 103).

Table 1: Summary of Ten Roles of Managers

Role		Description	Identifiable Activities from Study of Chief Executives
Interpersonal	Figurehead	Symbolic head; obligated to perform a number of routine duties of a legal or social nature	Ceremony, status requests, solicitations
	Leader	Responsible for the motivation and activation of subordinates; responsible for staffing, training and associated duties	Virtually all managerial activities involving subordinates
	Liaison	Maintains self-developed network of outside contacts and informers who provide favors and information	Acknowledgements of mail; external board work; other activities involving outsiders
Informational	Monitor	Seeks and receives wide variety of special information (much of it current) to develop thorough understanding of organization and environment; emerges as nerve center of internal and external information of the organization	Handling all mail and contacts categorized as concerned primarily with receiving information (e.g., periodical news, observational tours)
	Disseminator	Transmits information received from outsiders or from other subordinates to members of the organization; some information factual, some involving interpretation and integration of diverse value positions of organizational influences	Forwarding mail into organization for informational purposes, verbal contacts involving information flow to subordinates (e.g., review sessions, instant communication flows)
	Spokesman	Transmits information to outsiders on organization's plans, policies, actions, results, etc.; serves as expert on organization's industry	Board meetings; handling mail and contacts involving transmissions of information to outsiders
Decisional	Entrepreneur	Searches organization and its environment for opportunities and initiates "improvement projects" to bring about change; supervises design of certain projects as well	Strategy and review sessions involving initiation or design of improvement projects
	Disturbance Handler	Responsible for corrective action when organization faces important, unexpected disturbances	Strategy and review sessions involving disturbances and crises
	Resource Allocator	Responsible for the allocation of organizational resources of all kinds – in effect, the making or approval of all significant organizational decisions	Scheduling; requests for authorization; any activity involving budgeting and the programming of subordinates' work
	Negotiator	Responsible for representing the organization at major negotiations	Negotiation

Source: Mintzberg, 1980: 92-93.

Depending on the variation in these four different variables, managers will spend more or less time fulfilling the different roles described previously. Based on certain combinations of variables, Mintzberg (1980) proposes eight different managerial job types and theorizes the key roles that would be associated with each. These characterizations as well as the consideration of the four types of variables can be used to understand why emergency incident managers focus more on some roles and less on others.

Programs are the final concepts in Mintzberg's (1980) overall conceptual framework. Programs are basically heuristic devices or mental maps used by managers in the course of their work. Mintzberg (1980) observes that managers have a broad repertoire of programs, including the following:

- General programs
- Task-specific programs
- Scheduling programs
- Special purpose programs

These may be used individually or in different combinations and sequences to deal with the different situations faced by managers each working day (Mintzberg, 1980, p. 143). The concept of programming may be seen as being highly relevant to an analysis of emergency management as no two emergency incidents are exactly alike, but many incidents share many commonalities. Utilizing the concept of programming, we may be able to analyze and understand the way that emergency incident managers react to certain situations and implement specific actions.

Overall, Mintzberg (1980) provides lucid and cogent arguments in support of his approach and is less than bashful in criticizing the weaknesses in previous theories and characterizations of managerial functions and tasks. The *Harvard Business Review* article (Mintzberg, 1975), which is based on his book, provides a concise summary of the major points in the book and makes for enjoyable and entertaining reading. For the purposes of the present research, Mintzberg's classification of six characteristics and ten roles of managerial work provides a useful framework for analyzing the functions and tasks of the IC in order to assess whether there are commonalities with other areas of business management. Further, his concepts of variations and programs provide a vehicle for understanding some of the unique characteristics of emergency management and some of the techniques that managers can use to perform their job effectively.

Similarities Between Business Management and Emergency Management

Over the past 30 or so years, there has been increasing emphasis on training and development of fire service managers and leaders. Formalized training programs, such as the National Fire Academy Executive Fire Officer Program and Management Sciences courses and the *Making a Difference* officer-training program (Coleman, 1988) have been developed in an attempt to standardize and professionalize management and leadership training in the emergency services field. A recurrent theme in the course curricula for these programs is that fire service managers should be collaborative and participative during nonemergency periods at the fire station, but they must be autocratic and authoritative on the fireground. The rationale for this approach is that while a participative approach generally leads to better-quality decisions and engenders the support of employees, there is no time for consultation or collaboration in emergency situations.

Fire service management and leadership training programs typically teach situational leadership, which suggests that no one leadership style is going to be appropriate in all situations (Hersey, 1984). According to this theory, effective leaders must be able to adapt their leadership styles to the demands of a particular situation. It is suggested that the fire station setting is high on relationship building, and therefore a participative style is most effective; while the fireground is high on task demands, and therefore an autocratic style is most effective. This suggestion appears to be a theoretical assumption rather than an empirically supported fact.

Participative management (PM) is a theme that is highly visible in the management literature and has been adopted in many fire service management training programs. PM has been widely studied and researched, and there is a large body of research that provides direction to managers as to how PM techniques may be used to improve performance. A comprehensive analysis and summary of PM techniques is provided by Lawler (1994). He suggests that there are essentially two different approaches to management:

1. Control-oriented approach
2. Involvement-oriented approach

The fundamental difference between the two is the level in the organization at which thinking occurs. In traditional hierarchical control-oriented organizations, employees at the lowest level are given simplistic routine tasks that do not require much thought by employees who perform them. Thinking is the role of the manager, and doing is the role of the employee.

In involvement-oriented organizations, on the other hand, individuals at the lowest level in the organization not only perform work but also are responsible for improving methods and procedures, solving problems on the job, and coordinating their work with others (Lawler, 1994, p. 30). This method is often accomplished with work teams where groups of employees share the responsibility for a certain product, task, or group of tasks. Team members are typically cross-trained to perform all the functions within their work team's area of responsibility and are empowered to make decisions regarding various aspects of their work. Cross-training not only gives the workgroup flexibility in assigning members, but also gives employees a sense of ownership and responsibility within their team's area (Lawler, 1994, p. 90). Specific benefits that are produced through a team approach include greater productivity, higher quality of production, greater speed of production, and greater innovation.

Lawler (1994) suggests that the concept of employee involvement or PM can be adopted in varying degrees within organizations. He observes that advocating a participative supervisory style within a traditional hierarchical organization can be an effective method of engendering a greater sense of responsibility and commitment from employees and, ultimately, obtaining a higher level of organizational performance. This approach, however, is fundamentally different from the creation of a new type of participative organization wherein the work systems, policies, procedures, practices, and organizational design are predicated on the principle of employee involvement and PM.

When considering fire service organizations and, more specifically, the management system utilized in handling emergency incidents (Incident Command System [ICS]), it would appear that the first approach would apply. That is, it is more like a traditional hierarchical structure with a participative supervisory style than a high involvement organization where all of the systems and structures are predicated on the theory of PM. Some of the concepts central to PM, as described by Lawler (1994), may be seen to be highly relevant to the analysis of emergency management systems.

Basic Functions and Task Demands of Fire Service Managers and Leaders

A review of the literature on management and leadership in the fire and emergency services reveals a situation that appears similar to that faced by Mintzberg (1980) when he attempted to study what managers actually do. The literature contains a number of different books and manuals that describe what ICS is, what the objectives of the system are, and what, in general terms, ICs *should* do. With few exceptions (Bigley & Roberts, 2001), there is little or no information available, however, regarding *how* incident command is operationalized or what ICs *actually* do. There is an assumption that emergency incident managers should be directive and authoritarian, but there is not any substantive evidence to support it. In fact, much of what is written about incident command actually suggests that a participative approach is required.

The ICS was first developed in California in the 1970s to deal with large-scale wildland fires (FEMA, 2008). Over the years, a number of different versions of the system have been developed, but following the events of September 11, 2001, a concerted effort was made by the federal government to develop a standardized system that could be used throughout the United States. The ICS was adopted as a key component of the National Incident Management System (NIMS) in 2004, and is also central to NFPA® 1561, *Standard on Emergency Services Incident Management System* (2008), and NFPA® 1600, *Standard on Disaster/Emergency Management and Business Continuity Programs* (2010). According to a National Fire Academy publication (FEMA, 2008):

> *The ICS is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to enable effective and efficient domestic incident management. A basic premise of ICS is that it is widely applicable. It is used to organize both near-term and long-term field-level operations for a broad spectrum of emergencies, from small to complex incidents, both natural and manmade. ICS is used by all levels of government —Federal, State, local, and tribal — as well as by many private-sector and nongovernmental organizations. ICS is also applicable across disciplines. It is normally structured to facilitate activities in five major functional areas: command, operations, planning, logistics, and finance and administration (p. 1).*

While the NIMS program has well-developed course material and a comprehensive training program, concerns have been expressed that the program is too heavily theory-based with not enough emphasis on the *hows* of putting it into practice (Buck, Trainor, & Aguirre, 2006; Cotter, 2007).

In addition to the ICS developed in California, a similar emergency incident management system, known as Fire Ground Command (FGC), was developed in Phoenix (FEMA, 2004, p. 2). Brunacini (2002) describes four major responsibilities for FGC as follows:

1. Provide for firefighter safety and survival.
2. Protect, remove, and provide care for endangered occupants.
3. Stop the fire.
4. Conserve property during and after fire control operations.

Through his discussion of the roles and responsibilities of the FGC, Brunacini (2002) refers several times to the importance of delegation and suggests that a fireground commander who does not delegate effectively will become overwhelmed with tasks and will not receive accurate information and feedback.

Brunacini (2002) breaks fireground operations down into three types: Strategies, Tactics, and Tasks. He proposes that FGC managers should be exclusively concerned with strategy, company officers should be concerned with tactics, and crews of firefighters should be assigned tasks. He further suggests that to be successful, the FGC managers must be familiar not only with strategies, but also with what is involved in conducting a number of different standard tactics and tasks. Thus, much of the book is dedicated to the discussion of specific *nuts and bolts* issues such as rescue, fire control, fire stream management, apparatus placement, and more (Brunacini, 1985/2002).

Overall, Brunacini's (1985/2002) book provides a comprehensive description and analysis of the demands of fireground management and how to approach the management of a fire or emergency incident. By his own admission, however, it is very difficult to describe what fire fighting or fire command actually *feels* like. He likens it to trying to describe what jamoca fudge ice cream tastes like (Brunacini, 1985/2002, p. ix).

Murtagh (1995) in his article "Take Command" describes what he sees as the qualities required by an IC. He outlines four basic tenets of firefighting that should concern the IC. Murtagh suggests that the IC must be concerned with strategy rather than tactics. He further asserts that there are many qualities that a commander must possess in order to effectively perform that function. He suggests that three intertwined qualities stand out: leadership, decision-making ability, and communication skills.

These three qualities may be seen to correspond to the three general types of roles identified by Mintzberg

(1980), namely: interpersonal, decisional, and informational. In addition to these three qualities, Murtagh (1995) suggests that a fireground manager *must be a good judge of reality and be adept at setting priorities* (Murtagh, 1995, p. 91). He argues that *fireground managers must abide with fundamental management principles*, but does not elaborate on what those principles might be. Murtagh also observes that the Oklahoma State University publication on ICS (Murgalis et al., 2002), Brunacini's *Fire Command* (1985/2002), and the Incident Command System manual developed and distributed through the National Fire Academy (FEMA, 2008) all share the same basic assumptions and characteristics.

Overall, the literature on fireground management is somewhat fragmented and sketchy. There are many articles that address the *nuts and bolts* of fireground management and focus primarily on strategy and tactics that will be effective in specific situations. There are also articles dealing with fireground management in a more general sense in which the issue of decision-making processes is most often considered and appears to receive the primary emphasis (Angione, 1995; Anthony, 1994; Huder, 1995; Stukey, 1995).

There are a number of places where the ICS literature appears to contradict the notion that the IC must be autocratic and authoritarian. For example, Brunacini (1985/2002) suggests that to be effective, an IC must be an excellent delegator, coordinator, and communicator. Murtagh (1995) asserts that the IC is highly dependent on the judgment, actions, and status reports provided by different officers who are assigned various duties and responsibilities. Further, Loflin (2009) states that the IC must be concerned with the strategic issues of an incident and not get bogged done in the details of specific tasks. Tasks are assigned and expected to be accomplished without telling the company how the task should be completed (Loflin, 2009).

In one of the few articles that actually examined what incident managers do, Bigley & Roberts (2001) described the ICS as a *highly reliable* organization structure and noted the coexistence of bureaucratic and flexible structural attributes. They found this attribute to be unique and suggested that business organizations could learn from this combination of planned structure and improvisation. Their study involved a series of observations of emergency incidents in a large urban fire department as well as a series of semistructured interviews with personnel at a number of different ranks and positions within the organization (Bigley & Roberts, 2001).

Research Procedures

The literature on emergency management, as reviewed in the previous section, focuses more on the theory of *what to do* rather than describing exactly *how* emergency incident managers perform their jobs. Consequently, it was noted that this gap in the literature could be addressed by research that involves observations and field data in order to develop a characterization of what emergency incident managers actually do. This research was achieved through observations of emergency incident managers under real and simulated emergency conditions and through structured interviews with a convenience sample of chief fire officers and company fire officers (six in total) in different jurisdictions.

Observations of the **characteristics** of emergency incident managers' behaviors were conducted at five multiple-alarm fires that were attended during the research period. Using Mintzberg's (1980) six characteristics as a frame of reference, emergency incident managers were observed while at work, and examples of their actions were recorded on a note pad. The examples were compared to Mintzberg's (1980) description of the characteristics of business managers' work in order to ascertain whether there were similarities.

The roles, responsibilities, functions, and behaviors described in the literature exhibited by the subjects and described by the interviewees were analyzed and classified on the basis of the ten **roles** developed by Mintzberg (1980). First, the responsibilities of the IC described in the *Field Operations Guide section of Incident Command System* (California State Board of Fire Services, 1983, p. 59) were classified on the basis of Mintzberg's (1980) classification scheme pertaining to the ten roles of a manager. Similarly, the description of the emergency incident manager's role as described by Brunacini (1985/2002) was analyzed in terms of the ten roles.

Second, a written incident simulation exercise was designed and administered to 58 battalion chief candidates in a metropolitan fire department. The descriptions of the functions performed by the ICs were compiled into a common list and classified on the basis of Mintzberg's (1980) ten roles. Third, the responses from the interviews were compiled into a list and classified on the basis of Mintzberg's (1980) classification scheme.

Finally, the results of the analysis of the different descriptions were compiled into a summary of the roles performed by emergency incident managers and the frequency with which they were performed. This summary was used as the basis for considering the influence of **variations** and **programs** and analyzing the use of PM techniques in emergency management. Based on the analysis of the four aspects of managerial work proposed by Mintzberg (1980) and the use of PM techniques by emergency incident managers, an analysis was conducted regarding the extent to which the things that emergency incident managers engage in reflect PM techniques used by business managers in nonemergency situations.

Of the 58 battalion chief candidate participants, 13 were chief fire officers, 34 were company fire officers (this rank includes 4 training officers and 4 paramedic supervisors), and the remaining 11 were firefighters. Having this range of ranks provided a number of different perspectives on how the IC performs his or her job. The literature supports the notion that company-level officers and even rank-in-file firefighters must have a good working knowledge of ICS (Hewitt & Landerville, 2007; Christen, 2004; Bigley & Roberts, 2001). This methodology was somewhat restrictive, however, as all participants were from one fire service organization and may not be taken as representative of the fire service in general.

Thus, in order to validate the findings further, a convenience sample was selected in such a way as to represent different geographical regions of North America. This validation was achieved by contacting former classmates from the National Fire Academy located in different geographical regions. A total of six subjects were interviewed by telephone. The sample included five subjects who normally operate at the chief officer level and one subject who operates at the company officer level.

Results

The results are organized around the four aspects of managerial work identified by Mintzberg (1980): **Characteristics, Roles, Variations, and Programs**; and consideration is also given to the principles of **participative management (PM)**, all of which were reviewed in the literature review. For each of these five topics, there is a brief description paraphrased from the literature review, followed by a comparison to the aspects of fireground management as described in the literature, described by the interview subjects, and observed in real and simulated incidents.

Characteristics

The first characteristic observed by Mintzberg (1980) was that managers typically *work at an unrelenting pace*. Quoting Whyte (1954), he observed that managers:

- Have very little idle time
- Handle many pressing problems in rapid-fire order
- Deal with many interruptions
- Retain many problems in their minds simultaneously
- Juggle priorities for action (Mintzberg, 1980, p. 30)

This list is an understatement for the IC. Through the observations performed at five different incidents, emergency incident managers were seen to work at an incredible pace, balancing a myriad of demands and concerns, many of them literally life-threatening. They were in constant communication with various subordinates through radio and face-to-face discussions; they were constantly interrupted by subordinates, peers, superiors, and outsiders; and they continuously attempted to ensure that proper procedures were being followed and their actions were being documented. Many of them worked exceptionally long hours, typically through the night without sleep, rest, or even a break, and they routinely refused to be relieved, even temporarily when the offer was made by a superior officer. As Mintzberg (1980) observed of business managers, the emergency incident managers appeared to feel ultimately responsible for the incident they were managing and worked relentlessly to stay on top of things and remain abreast of all developments.

The second characteristic, *activity characterized by brevity, variety, and fragmentation,* also provides an accurate depiction of the emergency incident manager's job. ICs were observed to deal with a wide variety of issues including such things as the following and more:

- Reports of firefighters suffering from frostbite and smoke inhalation
- Reports of substandard downwind air quality and the possible need for evacuation of neighborhoods
- Reports of poor radio communication and loss of contact with an interior attack crew
- Requests from the media for a live interview
- Requests from the communications center for updates on conditions and resources
- Requests from the water supply officer for increased hydrant pressure
- Requests from the rehabilitation officer for authorization to purchase food and coffee

Commanders were observed to be constantly interrupted and often several different officers were attempting to contact them at the same time. Phone calls, radio conversations, and face-to-face meetings were all typically brief and to the point, and sometimes cut off part way through.

The third characteristic, *preference for live action* (Mintzberg, 1980, p. 35), was also very apparent in the observations of managers on the job. The emergency incident manager, like the business manager, works in an environment of stimulus-response. However, the stimulus for the emergency incident manager is likely far more pronounced. Radios blaring, telephones ringing, people talking, lights flashing, the smell of smoke, and the visual impact of flames are typical stimuli that the IC is exposed to. As an incident unfolds, there is often incomplete or inaccurate information, and the manager has little time to think or reflect but rather must make decisions and direct activities.

The fourth characteristic is an *attraction to verbal media* (Mintzberg, 1980, p. 38). The IC lives on verbal media, including conversations on cellular telephones, reports via radio, face-to-face meetings, and has minimal involvement with written reports or site tours. The only written communications observed were at an incident involving hazardous materials where some technical information was sent via fax to the command post. The manager asked a subordinate to review the report and provide him with a brief verbal summary. Several managers were observed to have been offered an opportunity to leave the command post temporarily in order that they could perform a *walkabout* or site tour to get a sense of the extent of the incident, the progress being made, and possible hazards still to be overcome. Typically, they refused, and appeared concerned that they may *miss something* if they left the command post. This action is similar to the observation by Mintzberg (1980) that managers were reluctant to leave their offices and take plant tours, even though most managers recognized the value of a tour.

The fifth characteristic of managerial work is that the manager is the link *between his/her organization and a network of contacts* (Mintzberg, 1980, p. 44). Emergency incident managers were observed to be the central clearinghouse for information and maintained direct control over information flowing to, from, and within the incident. The command post (and, as such, the manager) was the single point of contact for all internal communication as well as any information that was to be released to other agencies or to the media and public.

The sixth and final characteristic is that a manager's job is a *blend of rights and duties* (Mintzberg, 1980, p. 48). By virtue of his or her position, the emergency incident manager has many duties and obligations over which he or she exercises little control. He or she is obligated to respond to radio requests for additional resources, acknowledge progress reports from various functional units, and provide updates to the communications center when requested. His or her time and attention are demanded by the media, by subordinates, by peers, by superiors, by outside agencies, and others. Based on the observations of emergency incident managers under actual working conditions, there is no doubt the six characteristics of managerial work described by Mintzberg (1980) accurately depict the characteristics of emergency incident managerial work.

Roles

The ten roles of managers as described by Mintzberg (1980) were used as a guideline to conduct a content analysis of several different descriptions of the tasks and functions that emergency incident managers perform. A summary of the analysis is presented in Table 2. The ten roles are listed on the *y* axis and the different sources are listed on the *x* axis. The numbers shown in the columns represent the frequency that each was described in the particular document.

Each of the roles was identified in some form or another in the documents. The least mentioned were the liaison and negotiator roles. Interestingly, *liaison* is identified in most incident management systems as a command staff function. The standard operating principle in ICS is that the IC shall maintain responsibility for performing any roles that are not delegated to others. Thus, unless the IC delegates another person to act as the liaison officer, that responsibility rests with the commander. Through the observation portion of this research, it was observed that a senior officer was typically assigned as the liaison officer and interacted with outside agencies such as police, utilities, American Red Cross, and others. Perhaps the fact that liaison officer is a preestablished role in ICS automatically precludes those roles from being mentioned as the responsibility of the IC.

The least frequently mentioned role, which was mentioned only once in the descriptions of the things that the emergency incident manager does, was that of the negotiator. This function is another that does not appear in the theory of ICS but was readily observed in the actual incidents. Much of the discussion among senior officers in the command post could be viewed as

Table 2: Summary of Frequencies of Ten Roles in Document Analysis

Role	OSU*	Brunacini	Simulation	Totals
Figurehead	2	0	3	5
Leader	6	5	24	35
Liaison	1	0	3	4
Monitor	1	4	4	9
Disseminator	3	2	6	11
Spokesman	1	0	7	8
Entrepreneur	2	5	18	25
Disturbance Handler	0	5	12	17
Resource Allocator	2	3	11	16
Negotiator	0	1	0	1

*Oklahoma State University

negotiation. Senior officials were observed discussing and in a sense negotiating issues such as the number of additional staff to be recalled, the location of the rehabilitation area, and whether or not to use foam on a fire. Negotiation was also observed with outside agencies at one incident. In the latter stages of a major fire when the incident resources had been scaled down, a local television station requested that the IC allow assembling a mobile studio to transmit live images of the fire. Cognizant of the fact that it would be unwise to give exclusive coverage to one station, the IC negotiated with the media representative and agreed to allow its truck to take a position close to the scene while still leaving sufficient space for the competitor's truck.

Variations

The four types of variables are as follows:

1. ***Environmental*** — Characteristics of the milieu, industry or organization
2. ***Job*** — Level of job and the function supervised
3. ***Person*** — Personality and style of person in the job
4. ***Situational*** — Temporal features of an individual job (Mintzberg, 1980, p. 103)

Depending on the variation in these four different variables, managers will spend more or less time fulfilling the different roles described previously.

Through the observational phase of the research, variation in the manager's work was considered on the basis of the four variables. Variation among incidents was observed within each type, thus validating the applicability of Mintzberg's (1980) work to our understanding of emergency management. Overall, the following four types of variation provide an understanding of the ways that the manager's job can be qualitatively different under different conditions:

1. ***Environmental variation*** — Relates to the characteristics of the milieu, industry, or organization. While the same organization (i.e., department) was involved in all of the incidents observed, there was considerable variation in the type of incidents (i.e., residential occupancy versus industrial occupancy versus industrial with hazardous materials component), and the type of management structure developed by the IC.
2. ***Job variation*** — Pertains to the difference in the level of job and the function supervised. In each situation, observed managers were the senior command staff who basically had the responsibility for all aspects of the incidents. The importance of this position was amplified, however, in one incident that occurred in the daytime (all the others were at night) and resulted in an extremely high dollar loss ($2.2 million).
3. ***Person variation*** — Refers to the personality and style of person in the job. Variations on this factor were observed and involved differences in disposition (i.e., tense and uptight versus laid-back and relaxed).
4. ***Situational variation*** — Relates to temporal features of an individual job. One large fire that was observed involved an IC who had been promoted to battalion chief that morning. The fact that the IC was handling his first large incident made the nature of the manager's job different from other incidents where the IC was more experienced. Mintzberg (1980) theorizes that one of the roles that will be emphasized by the new manager is that of the entrepreneur as he attempts to put his unique stamp on the organization. This was indeed the case in the situation observed as the manager implemented many strategies that had been talked about in the organization but not used to any great extent previously.

Programs

The final aspect of Mintzberg's (1980) description of managerial work is the concept of programs. Mintzberg (1980) observed that managers typically have set ways of doing some things and their actions are guided by their previous experiences. This process involves processing information in the environment and matching it with an appropriate strategy or course of action. In observing the actions of managers under the conditions of real emergency incidents, it was apparent that many of the things that they did followed well-established programs. Indeed, the design and intent of ICS is to have a management structure that is standardized or programmed to the extent that there is a shared understanding of the common purpose, yet which is flexible enough to be adapted to a variety of different emergency situations. Many of the tasks performed by the responding crews followed preestablished programs, but the role of the IC was to identify which concerns were immediate and assign specific crews to specific tasks.

Standardized programs were identified for the IC on incident worksheets that outline, for example, *ventilation, fire attack, search and rescue, exposures,* and more. The role of the manager was to identify which of these standardized procedures were required, decide the sequence in which they should be undertaken, and then decide what resources should be assigned to each function. The manager was also required to identify additional needs or situations that were unique to the incident and required attention. As the incidents progressed, other programs were activated to address needs such as relocation of victims and evacuees, rotation and rehabilitation of crews, and refueling of apparatus.

Many of the commands given in the simulation exercise may be seen as acknowledgement of certain conditions and activation of a particular program. For example, the command to establish a victim collection area is recognition that the incident involves a residential occupancy, it is nighttime, and it is cold outside. The concept of programs may be seen to be extremely relevant to emergency operations and provides excellent insight into the manner by which emergency incident managers accomplish various tasks.

Finally, the concept of programs helps us to understand how managers operate and how they make some of the decisions they do. The concept of programs was found to be highly relevant to emergency management. Several examples of ICs utilizing programs were identified through observations and also were observed in the descriptions provided in the simulation exercise.

The most important aspect of this system is the need for feedback to ICs regarding the tactics being employed, progress being made, and whether or not additional resources are required. Without this type of feedback the IC may not be able to assess the progress being made or assemble the resources required by the different teams. At the incidents that were observed, managers often prompted various teams to provide updates in order that the IC could remain on top of the situation and monitor progress.

Participative Management

It was also noted at the incidents attended that company officers used PM when developing tactics with their crews. The incidents that were attended were typically well into the second-alarm stage when the researcher arrived and major and minor crews were assigned from Level II staging. Company officers would typically receive their assignment from the IC via the Level II staging officer, would report to their crew what their assignment was, and briefly discuss how they would go about it. Crew members often provided suggestions or ideas about how best to tackle the assignment.

It was also observed that ICs routinely solicited advice and recommendations from other officers at the command post and from officers in the field. Typically at major incidents there were at least three senior officers on-scene. Even though one officer was ultimately responsible by virtue of the ICS, that officer routinely relied upon others for input and advice.

Through the interviews, it was identified that collaborative decision-making at the command post and empowering teams to perform tasks were fairly standard methods within ICS. It was common throughout the cities examined that the IC established the strategy and specific teams developed their own tactics to accomplish their assigned tasks. It was generally agreed that PM is extremely relevant to fireground operations and all of the interviewees indicated that their departments utilize PM during emergency operations.

Similarities

On the basis of Mintzberg's (1980) four aspects of managerial work, it would appear that all four aspects are highly relevant to emergency management and demonstrate a vast similarity between business management and emergency management. The similarities are particularly apparent in the analysis of the six characteristics and ten roles identified by Mintzberg (1980). In addition to the six characteristics and ten roles, which help us to understand what managers do and how they do it, the concept of variation helps us to understand why specific managers focus more on some roles than others. This concept was found to be true of emergency incident managers as well as business managers.

Overall, the results overwhelmingly demonstrated distinct commonalities between business management and emergency management. The specific parameters of managerial work described by Mintzberg (1980) were found to apply readily to the characteristics and roles of emergency incident managers. Contrary to beliefs held by some people outside the fire service, and the view found in some fire officer curricula, fireground managers were found to be highly participative in their management style.

Discussion

The results outlined in the previous section clearly indicate that the characteristics of managerial work at an emergency scene closely resemble the characteristics of business management as described by Mintzberg (1980). Each of the six characteristics identified and described by Mintzberg (1980) were found to be readily visible through observations of fire service managers working at emergency incidents. Further, the ten roles described by Mintzberg (1980) were found to be reflected in the document analysis conducted on textbook descriptions of ICS, as well as through observations, a written simulation, and interviews. The roles that were found to be most frequently identified were those of leader, entrepreneur, resource allocator, and disturbance handler. This description is likely of little surprise to any person who has worked at the command level with ICS at a major incident.

One reason that the role of leader was the most frequently identified role is because it is so broadly defined under Mintzberg's (1980) classification system. Dividing this role into subcategories such as directing, ordering, assigning, and delegating may provide a more meaningful level of analysis and allow for a more detailed comparison of the emergency incident manager's job and that of the business manager.

It was also very apparent in the results that emergency incident managers were well aware of the current management theories regarding PM and effectively utilized aspects of these theories when managing major emergency incidents. Contrary to the common myth that ICs must be autocratic and authoritarian on the fireground, much collaboration and PM were observed at the actual incidents and also described by participants in the interviews. Two different possible explanations as to why ICS could be viewed as *paramilitary* or *autocratic* emerged through the course of the research.

One explanation stems from the fact that the IC sits at the apex of the ICS organizational chart and is ultimately responsible for what happens at the scene. This situation could be interpreted by people not familiar with the ICS to mean that the IC will operate as a *one-person show*. Through the observations and interviews, it was very clear that it is generally accepted by experienced emergency incident managers that there is a need for consultation and collaboration, particularly when conducting size-ups and establishing initial strategy. Further, it is recognized that an IC is highly dependent upon the quality and frequency of progress reports provided by other officers on the scene. The officers in the field who are assigned different functions and tasks are an extension of the eyes, ears, and brains of the IC. If these officers are actively managing their assigned area, anticipating additional resource needs, monitoring the effectiveness of the strategy being employed, **and** reporting pertinent information to the IC on a timely basis, the job of the IC is made much easier. The effectiveness of the IC is totally dependent upon the quality of reports being provided by officers in the field. As pointed out by Earl (1995), there is a need for all officers to continually size up the situation at hand, analyze the effectiveness of their tactics, and develop alternative plans should the current one go awry.

A second possible explanation for why ICS may be perceived as being autocratic is provided by the concept of *programs* as proposed by Mintzberg (1980). Programs were described as specific scripts enacted by managers on the basis of their assessment of the existence of certain conditions. This concept as it applies to fire fighting is clearly described in the literature in an article by Huder (1995) entitled "Training Incident Commanders for Decision-Making." The article describes a research study conducted by the U.S. Army Research Institute on the Behavioral and Social Sciences entitled *Rapid Decision-Making on the Fire Ground*. The essence of the article is that fire service managers do not have the luxury of extensive time to weigh possibilities and consider the potential effectiveness of all possible strategies. Instead they make quick decisions based on their previous experiences and the match between the situation and strategy and tactics that have been used successfully in the past. There is, however, also a continuous monitoring process through which the officer will evaluate the effectiveness of the chosen strategy on an ongoing basis.

In many departments there is a deliberate method of establishing programs that responding crews are trained to implement. For example, evaluations involving laying hoselines from a hydrant and stretching attack lines to the front door of a dwelling are standard training protocols in most departments. Similarly, preplans of major target hazards often identify where apparatus will be placed and what tasks first-in companies will perform. To the untrained observer, the utilization of these preestablished programs may appear as the robot-like execution of authoritative commands. What is overlooked, however, is that these programs are typically only the starting point, and there is an essential need for continuous information flow and feedback to the IC as to the progress being made by different teams conducting different programs.

As discussed in the results section, there is also extreme latitude and discretion exercised by the frontline personnel with regards to the way tactics are implemented and the way that tasks are performed. For example, a company assigned to an interior attack on a residential structure fire will be continually monitoring the environment for signs that may suggest that flashover is imminent. In addition, they may be looking for alternative escape routes, signs of victims, and evidence relating to the cause and origin of the fire. In short, even the frontline firefighter must be constantly thinking, observing, and adjusting his or her behavior and activities accordingly. Thus, while the formal structure of incident command may suggest a top-down approach with little opportunity for thought at the lower levels, nothing could be further from the truth.

The analogy that can be made in this regard is to the relationship between formal organizational structure and realized organizational structure. It is generally accepted in business management today that an organizational chart outlines formal lines of authority, and/or reporting relationships, but that the way that an organization *actually* operates may be far different from the formalized chart. It is further recognized that an organizational chart is an inert and static abstraction of what is essentially a fluid and dynamic set of interpersonal relationships. It is a general guide to what the organization does but does not fully reflect how the organization's goals and objectives are achieved. The same applies to the ICS. The formalized roles and responsibilities provide the framework, but there is a dynamic and interactive process by which that framework is enacted.

The fact that PM techniques were observed in the actions of ICs at actual incidents and also reported to be practiced by interviewees from different geographical regions throughout North America strongly suggests a further parallel between business management and emergency management. As Lawler (1994) pointed out, an organization can implement these techniques within a traditional top-down structure or can build these concepts into the way the organization is structured. While a hierarchical structure may not totally facilitate the level of *high involvement* that Lawler advocates, it certainly does not preclude the utilization of PM techniques either. Thus, PM techniques can be implemented under any current organizational structure without necessarily rebuilding the entire organization.

The major finding arising out of this research is that the functions and tasks performed by emergency incident managers are very much similar to those performed by business managers. The key differences identified are that emergency incident managers often operate under much more critical, time-pressured conditions (Huder, 1995). Further, the techniques of PM which have been demonstrated in the literature to enhance the effectiveness of business managers in the performance of their jobs were also found to be utilized by emergency incident managers to enhance the effectiveness of their performance. These findings clearly establish areas of common ground between emergency incident managers and business managers and provide a basis for mutual understanding and respect between fire service managers and other managers (administrators and elected officials) who become involved in the management of emergency incidents from time to time.

One might conclude then that since the characteristics and roles of the two are similar that any manager can move into an emergency management position and perform effectively. Previous research conducted by Kuban (1995) did not support this assertion. When conducting incident simulations with Master of Business Administration (M.B.A.) students and business simulations with emergency incident managers, Kuban (1995) found that emergency incident managers could readily and competently adapt to the demands of business management, but business managers did not perform effectively as emergency incident managers. One possible explanation for this situation, which arises out of the present research, is that business managers lack the experiential knowledge base necessary to effectively implement programs at an emergency incident. This explanation is consistent with the research reported by Huder (1995), wherein he suggests that the decision processes used by emergency incident managers are unique to the critical time pressure environment of emergency management.

A further implication that arises from this analysis pertains to fire service recruiting and promotional practices. There is no doubt that experiential learning is an important part of the fire fighting professional (Huder, 1995). But do fire service organizations always hire people with a propensity to think and learn, or do they simply hire the toughest and the fittest on the assumption that they will work hard and follow orders? The complexity of the equipment, tactics, and types of incidents faced by modern firefighters demands a high standard of intelligence and the ability to think and grow. Further, the firefighters we hire today are the company officers, chief officers and department leaders of tomorrow. To get quality officers at the top there is a need to recruit quality people at the bottom.

Recommendations

The results of this study demonstrate significant similarities between the characteristics and roles of business managers and emergency incident managers. Further, the results indicate that the methods that emergency incident managers utilize to achieve their objectives are similar to and consistent with the concepts of PM that were identified in the literature as currently accepted practices for improving managerial effectiveness. Fire service managers could greatly enhance their profile in the community by publicizing these similarities and helping others outside the fire service to understand how emergency management actually works. Publicizing the similarities could also greatly enhance the recognition and acceptance of fire service managers as professional managers.

Thus, the primary recommendation arising from this study is that fire service managers attempt to create a better understanding of fire service operations by highlighting the similarities with business management and dispelling myths that incident command is inflexible, autocratic, and paramilitary. The findings from this study may be used as a reference or resource to provide fire service managers with the information base necessary to effectively communicate with municipal administrators and elected officials.

A further recommendation of this study is that consideration of task demands of emergency management be considered when identifying the knowledge skills and abilities required at both the entry level and promotional level in the fire service. Human resource policies relating to recruitment and staff development should take into account the thinking and decision-making requirements involved in performing as a chief officer, company officer, or firefighter. As discussed in the previous section, all members of the department are required under ICS to have the ability to analyze situations, make decisions, and communicate with other members.

An additional recommendation is that the basic conceptual framework identified in this study be used as the basis to examine fire service emergency operations in other jurisdictions. While an attempt was made to validate the findings by conducting interviews with members of other fire service organizations, this process was severely restricted by time constraints and limited resources. In order to draw more substantiated and generalizable results, it would be highly desirable to replicate the observation and simulation portions of this study in other jurisdictions.

Finally, there have been recent concerns expressed regarding the level of stress experienced by ICs and the potential for high-stress conditions to influence decision-making (Brunacini, 2009; Kowalski-Trakfler, Vaught, & Scharf, 2003). While this issue was beyond the scope of the current study, it appears to be an important consideration when attempting to analyze how emergency incident managers complete their required tasks. Further research on the role of stress and mechanisms for managing stress would appear to be a related stream of research that could be insightful to pursue in attempt to gain insight into what emergency incident managers do and how they effectively fulfill the many demands of the position.

References

Angione, C. R. (1995). "The dilemmas of fireground command." *Fire Chief*, March, 39–42.

Anthony, D. F. (1994). "Managing a disaster." *Fire Engineering*, August, 22–40.

Bigley, G., & Roberts, K. (2001). The incident command system: High-reliability organizing for complex and volatile task environments. *Academy of Management Journal*, *44*(6), 1281–1299.

Brunacini, A. V. (2002). *Fire command* (2nd ed.). Quincy, MA: National Fire Protection Association.

Brunacini, A. V. (2009). More cool school: The IC's need to disconnect. *Fire Engineering*, *162*(1), 176.

Buck, D. A., Trainor, J. E., & Aguirre, B. E. (2006). A critical evaluation of the Incident Command System and NIMS. *Journal of Homeland Security and Emergency Management, 3*(3), 1–27.

California State Board of Fire Services (1983). *Incident command system*. Stillwater, OK: Fire Protection Publications

Christen, R. (2004). Incident command from a firefighter's perspective. *Firehouse*, *29*(7), 94+.

Cole, D. (2000). The Incident Command System: A 25-year evaluation by California practitioners. A research paper submitted to the National Fire Academy, Executive Fire Officer Program.

Coleman, R. (1988). *Making a difference: The fire officer's role.* Fort Collins, CO: Emergency Resource.

Cotter, M. (2007). Incident command the Washington way. *Fire Engineering*, December, 10–11.

Earl, S. E. (1995). The fireground officer: Just a backup system? *Fire Engineering*. January: 89-92.

Fayol, H. (1950). *Administration industrielle et generale*. Paris: Dunod (first published 1916).

Federal Emergency Management Agency (FEMA) (2004). *NIMS and the Incident Command System*. Retrieved December 15, 2009, from http://www.fema.gov/txt/nims/nims_ics_position_paper.txt

Federal Emergency Management Agency (FEMA). (2008). *Incident Command System training: Review material*. Retrieved December 15, 2009, from http://training.fema.gov/EMIWeb/IS/ICSResource/assets/reviewMaterials.pdf

Gulick, L. H., & Urwick L. F. (1937). *Papers on the science of administration*. New York: Columbia University Press.

Hersey, P. (1984). *The situational leader*. Escondido, California: Center for Leadership Studies.

Hewitt, J., & Landreville, P. (2007). Volunteer firefighter as incident commander. *Fire Engineering*, *160*(5), 18+.

Huder, R. C. (1995). "Training incident commanders for decision-making." *Fire Engineering*. March, 16.

Kowalski-Trakfler, K. M., Vaught, C., & Scharf, T. (2003). Judgment and decision making under stress: An overview for emergency managers. *International Journal of Emergency Management*, *1*(3), 278–289.

Kuban, R. (1995). *Crisis management in Canada: A study of its practice*. Calgary, AB: Pendragon Publishing Ltd.

Lawler, E. E., III. (1994). *The ultimate advantage: Creating the high involvement organization*. San Francisco: Jossey-Bass.

Loflin, M. (2009). Incident commander checklist: A quick reference guide. *Fire Engineering*. *162*(8), 65–66+.

Mintzberg, H. (1975). "The manager's job: Folklore and fact." *Harvard Business Review*, *53*(4), 49-61.

Mintzberg, H. (1980). *The nature of managerial work*. Englewood Cliffs, NJ: Prentice-Hall.

Mintzberg, H. (1989). *Mintzberg on management: Inside our strange world of organizations*. New York: Free Press.

Murgallis, R., Phelps, B, and John Joershke (editor) (2002). *Command and control: ICS, strategy development and tactical selections*. Stillwater OK: Fire Protection Publications, Oklahoma State University.

Murtagh, M. (1995). "Take command." *Fire Engineering*, April, 90–100.

National Fire Protection Association (NFPA). (2008). NFPA® 1561: Standard on Emergency Services Incident Management System. Quincy, MA: Author.

National Fire Protection Association (NFPA). (2010). NFPA® 1600: Standard on Disaster/Emergency Management and Business Continuity Programs. Quincy, MA: Author.

Smith, W., & Dowell, J. (2000). A case study of co-ordinative decision-making in disaster management. *Ergonomics*, *43*(8), 1153–1166.

Stukey, D. (1995). "Shifting gears to defensive mode." *Fire Engineering*, *148*(8), p. 50+

Whyte, W. H., Jr. (1954). How hard do executives work? *Fortune*, January, 108–11, 148, 150–152.

Endnotes

[1] This paper is based on research conducted through the National Fire Academy as part of the Executive Fire Officer Program. A previous version of this paper was presented to the 2005 *IFSJLM* Research Symposium held in Tulsa, Oklahoma.

About the Author

B. E. (Bernie) Williams, Ph.D., earned his Bachelor's and Master's Degrees from the University of Alberta and his Doctorate Degree from the Faculty of Management, University of Toronto. He presently holds an academic appointment at the University of Lethbridge, where he teaches Business Policy and Strategy and Organization Theory. Prior to joining the university, Williams enjoyed a 20-year career in the fire service and completed the Executive Fire Officer Program at the U.S. National Fire Academy (NFA). He has served as an adjunct faculty member at the NFA since 1994. His research has been published in *Fire Engineering*, *Fire Chief*, and the *Academy of Management Journal*. Bernie can be contacted at **b.williams@uleth.ca**.

Dr. Robert Nolan, Department of Educational Leadership, Oklahoma State University
Thomas Hughes, Fire Protection Publications, Oklahoma State University
Dr. Lihua Xu, University Assessment and Testing, Oklahoma State University
Anand Lakshmanan, MS, Electrical Engineering, Oklahoma State University
Olivia Meeker, Doctoral candidate, Counseling Psychology, Oklahoma State University.

The Effectiveness of Self-Instruction to Improve Firefighter Health and Safety

Abstract

The purpose of this research was to investigate the effectiveness of self-directed learning (SDL) as an educational method to improve the health and safety of volunteer firefighters. Over a period of 18 months, researchers created a valid and reliable test of firefighter health and safety that they pilot-tested on three different groups of volunteer firefighters. Part I of the test measured knowledge of safety measures at the fireground. Part II measured attitudes toward health and safety. After two pilot tests, which established the validity and reliability of the instrument, the test was administered to volunteer firefighters from five states selected from the South, Northeast, Midwest, Mountain, and Pacific regions of the country. The design of the study was pretest and posttest, with random assignment to treatment and control. Returns were analyzed using a T-test of the difference in posttest mean scores. It was determined that self-study was an effective means to improve the knowledge of firefighter health and safety. However, improvements in scores of attitudes toward health and safety did not improve significantly.

Introduction

The purpose of this research was to determine whether self-directed learning, a central concept in the practice and study of adults and continuing education according to Garrison (1997), could be used to improve the health and safety of volunteer firefighters in the United States. Most of the research in self-directed learning has focused on the external management of the learning process (Garrison, 1997). Little has been studied as to the contextual contingencies of self-directed learning other than the work of Spear and Mocker (1984) who maintained that such learning was often triggered and shaped by environmental conditions. In the current study, we were interested not only in the learners' motivation to enter the learning task but also to monitor their own progress and control the pressures of time. In this sense, we proposed to follow a theoretical model developed by Garrison (1997). Our research interest was to investigate what might be accomplished to change the culture of volunteer firefighters, their knowledge of health and safety, and their attitudes toward risk-taking.

Some have argued that health and safety have traditionally focused on possible harms rather than on the culture of safety, in which possible risks are framed (Dake, 1992). Also, it is common knowledge that risky behavior is inversely related to one's level of knowledge (Sjoberg & Drottz-Sjoberg, 1991; Simonet & Wilde, 1997). For these reasons, this research proposed to determine whether volunteer firefighters would engage in self-directed learning or self-study to improve their knowledge of health and safety if they were provided with all of the resources for self-study with the promise of a small incentive.

Problem Addressed and the Need for Research

Although the firefighter fatality rate of 171 recorded in 1978 has diminished due to better fire-fighting equipment and improved training and guidelines, an average of 106 firefighters have perished while in the line of duty each year from 1995 to 2004 (http://www.usfa.dha.gov/about/media/2002releases/02-00t.shtm).[1] Many of those fatalities were preventable, had those firefighters followed the guidelines published in National Fire Protection Association® (NFPA®) 1500, *Standard on Fire Department Occupational Safety and Health Program* (2007).

The fatality statistics given in the previous paragraph include both career and volunteer firefighters. This study, however, focused exclusively on volunteer firefighter health and safety. Why volunteer firefighters? In 2007, 51.3 percent of all firefighter fatalities were among volunteer firefighters (U.S. Fire Administration [USFA], 2007). For fatalities due to sudden cardiac arrest, the percent is even higher as a summary of firefighter fatalities from 1995 to 2004 indicates (Fahy & LeBlanc, 2006). This study also addressed the recommendations of the Firefighter Life Safety Initiatives (Everyone Goes Home, 2007) whose 16 Initiatives included the following:

- No. 1: Define and advocate the need for a cultural change within the fire service relating to safety; incorporating leadership, management, supervision, accountability, and personal responsibility.
- No. 2: Enhance the personal and organizational accountability for health and safety throughout the fire service.

- No. 4: All firefighters must be empowered to stop unsafe practices.
- No. 7: Create a national research agenda and data collection system that relates to the initiatives.

Theoretical Model

First, we examine the construct of self-directed learning. Where and when did this concept arise? Although human beings have probably always engaged in self-directed learning, research into the theory began with the work of Allen Tough (1967, 1971) on self-instruction. Early research on self-instruction, or as Knowles (1970) later coined the term *self-directed learning*, was purely descriptive. Following those descriptive studies, the research became more analytical (Brockett & Hiemstra, 1991; Candy, 1991; Garrison, 1997).

According to adult learning theory, individuals engage in self-directed learning (henceforth, SDL) in order to achieve practical goals that they can apply immediately to their lives. In addition, SDL theory maintains that adults engage in SDL when the content of their learning relates closely to what is important at a given time in their lives. Following the SDL theoretical framework, the National Health and Safety Assessment Project is intended to help volunteer firefighters reduce the level of injuries and fatalities related to their work.

This project proposed to determine whether SDL can be conducted on a national scale by creating a test that would diagnose the learning needs of volunteer firefighters. Once diagnosed, the study aimed to provide learning goals identified by NFPA® (NFPA®, 2007) and provide the material sources for learning. Rather than have the volunteer firefighters evaluate their own learning, a commonly accepted practice in SDL, this research adhered to the empirical canon of objective measures obtained by means of a posttest.

Garrison (1997) maintained that SDL has three important components that provide the theoretical frame for our study: (1) SDL requires motivation to enter the task and to persevere in the task. (2) Beyond initial motivation, SDL requires self-management on the part of the adult learner, and (3) self-monitoring of one's own progress. We assumed for this study that our participants would have various degrees of self-management and self-monitoring. As for motivation, we assumed that all volunteer participants would be highly motivated, not only by the promised reward, but by the fact that health and safety is a life and death issue in their work as volunteer firefighters.

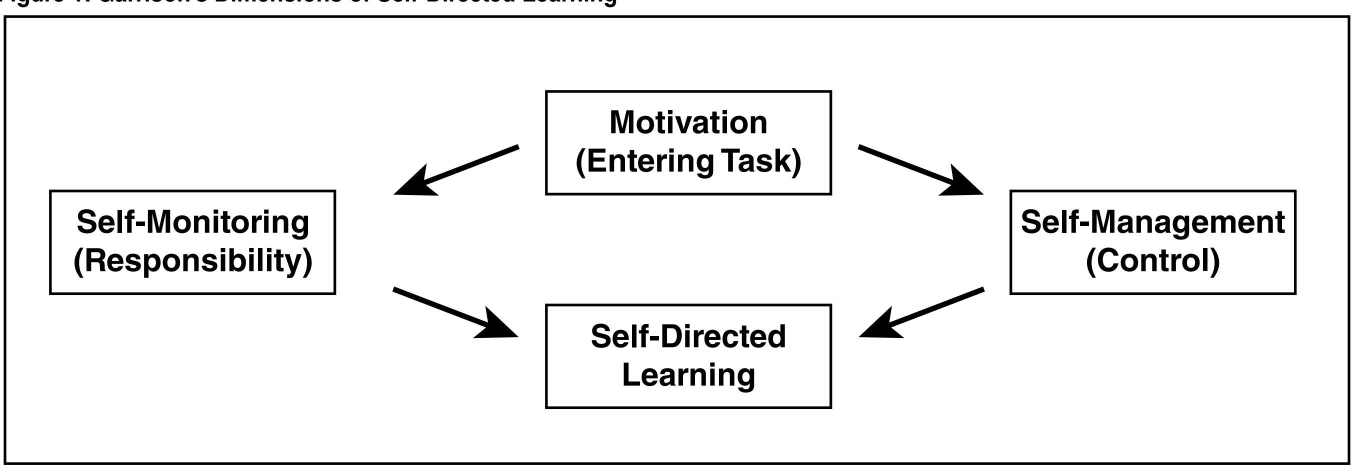
Figure 1 shows an illustration of the components of SDL and a discussion of how those components fit into the decision to participate and the successful completion of a self-study project. We selected this model with the full awareness of all the demands placed on volunteer firefighters' time, knowing that nearly all of them work fulltime in something other than firefighting and have family and other community commitments (e.g., church leadership, fraternal organizations, youth sports, or scouting). We thought Garrison's (1997) model fit this research better than other models and theories of SDL because, due to time limitations, volunteer firefighters would have to carefully monitor their time and their obligations to be able to finish the study.

Research Question and Hypotheses

We wanted to know if self-study or SDL would be an effective way to improve volunteers' practices of improving their health and safety given the dangers of their missions. We hypothesized that self-study would improve their knowledge of health and safety strategies and thus reduce their risk-taking following the research of Sjoberg and Drottz-Sjoberg (1991). We were also interested in finding out whether self-study would have any effect on attitudes towards health and safety. Thus our hypotheses could be stated as follows:

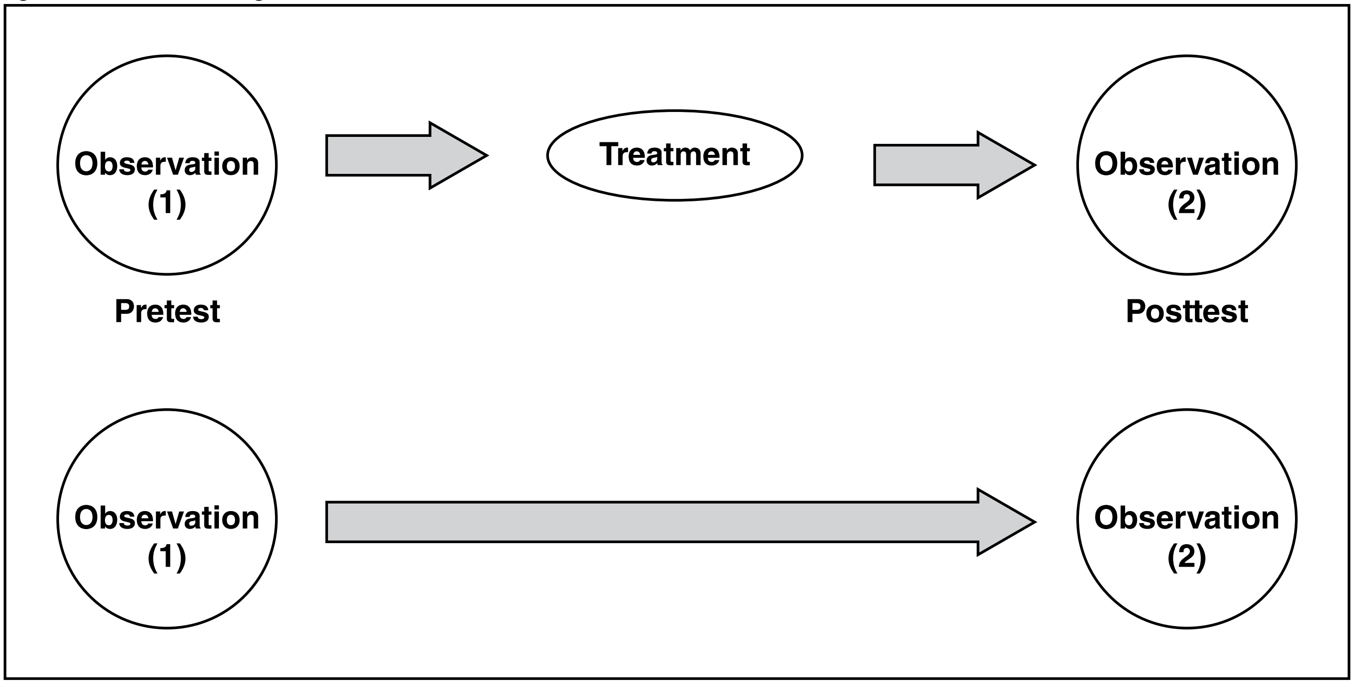
1. ***Hypothesis 1***: Self-study has an effect on health and safety knowledge scores or H^1: There is no difference between posttest scores of treatment and control groups on knowledge of firefighter health and safety.

Figure 1: Garrison's Dimensions of Self-Directed Learning



Adapted with permission from Garrison, R. (1997). Self-directed learning: Toward a comperhensive model. *Adult Education Quarterly, 48* (1), pp.18-33.

Figure 2: Research Design



2. ***Hypothesis 2***: Self-study has an effect on attitudes toward firefighter health and safety or H^2: There is no difference between posttest scores of treatment and control groups on attitudes toward firefighter health and safety.

This research study used a pretest/posttest design, with random assignment to treatment and control groups. The pretest as well as the posttest assessed the knowledge and attitudes of the volunteer firefighters who volunteered to participate in the study. Figure 2 illustrates the design used in this study.

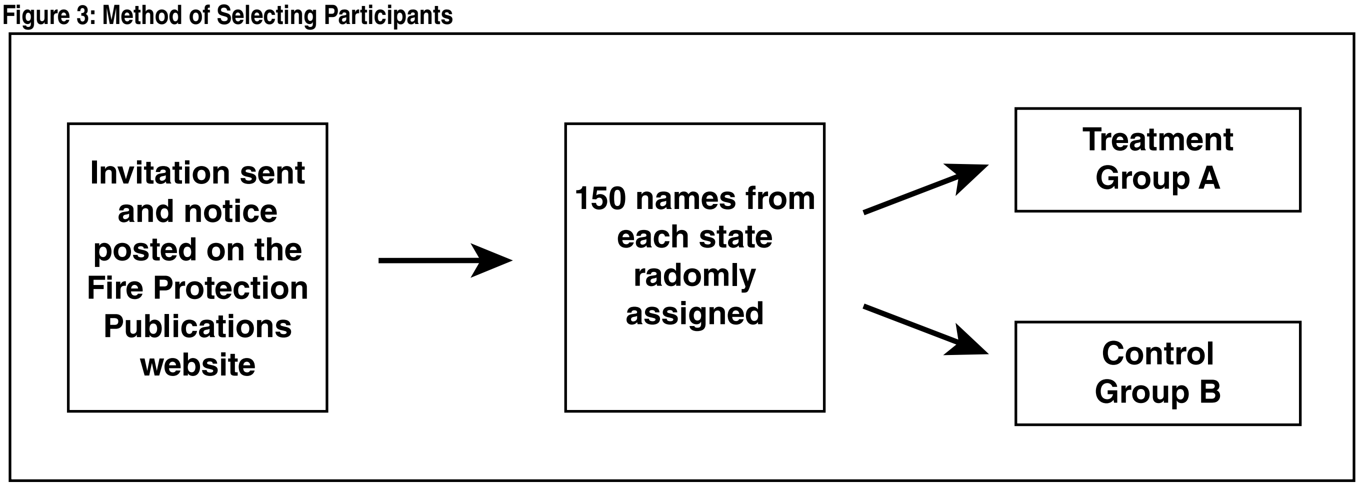
Population and Sample

Volunteer participants were recruited by means of an announcement posted on the official web site of Fire Protection Publications (FPP) located at Oklahoma State University (OSU). The invitation was posted on a nationally recognized web site; however, it specified that the invitation was open exclusively to volunteer firefighters from Pennsylvania, Alabama, Indiana, New Mexico, and Oregon. Those particular states were chosen to represent the South, East, Midwest, Mountain, and Pacific regions of the United States in an effort to gather a sample that, although not random and strictly representative, could claim to reflect the entire United States rather than any one region of the country.

Paper and electronic invitations were also sent to every volunteer fire department in these states as well as to the offices of the state fire marshals. Interested firefighters from each of these states were asked to submit names, addresses, companies, and email addresses. Once 150 names and addresses were received, the names were printed on slips of paper and put into a hat. They were then mixed thoroughly and drawn one by one, with the first slip of paper assigned to treatment and the second to control until all 150 had been drawn and assigned (see Figure 3).

The initial response to the web site was very encouraging — 529 individual volunteer firefighters from only

Figure 3: Method of Selecting Participants



two states responded to the first invitation posted on the web site and from the initial mailing. Included with some of the responses were comments written in a dialog box such as *I look forward to participating in this survey and This is a great idea.*

Data Collection Instrument

The crucial step in the project was to develop an assessment instrument designed to measure the knowledge and attitude levels for the sample of volunteer firefighters selected from the five states listed earlier. The assessment instrument was constructed from a training manual on firefighter health and safety (Stowell, Brakhage, & Smith, 2001) and firefighter web sites that track incidents of death and injury. The content of the first part of this assessment instrument was from the training manual.

Part I assessed firefighters' knowledge of fire-fighting safety and health. Answers were forced choice using four-point foils with only one response being the best choice. Correct choice answers were scored as one point. No penalties were scored for wrong choices or items left unanswered.

Part II of the instrument assessed attitudes towards fire-fighting safety and health. Items in Part II were selected from a web site that tracked fatalities and near misses and suggested corrective actions that would have prevented the deaths or near-miss incidents (see http://www.everyonegoeshome.com/initiatives.html). The following is an example of our attempt to measure attitudes. The question and response categories are taken directly from the instrument used in this study:

> ***All firefighters riding in fire apparatus should be seated and belted securely by seat belts in approved riding positions prior to the vehicle's being placed in motion.***
>
> ***Strongly agree…Agree…Disagree…Strongly Disagree…No opinion***

The instrument was pilot-tested on three different groups of volunteer firefighters. The first pilot test was conducted in September, 2006, in which we analyzed the responses of 62 volunteer firefighters from Oklahoma. Reliability coefficients for the first pilot study were unacceptable: 0.279 for Part I of the instrument and 0.87 for Part II. Consequently, the instrument was thoroughly revised, using statistical item analysis that revealed the poor items. For the second edition of the instrument, we dropped many items, added new ones, transferred items from Part I to Part II, and reduced the instrument from 63 items to 60.

For the second pilot test, we sent the instrument to volunteer fire departments in New Jersey and Kansas. Of the 50 sent, 32 completed instruments were returned. The second pilot test resulted in Alpha coefficients of 0.853 for Part I and 0.896 for Part II. Reliability coefficients improved to 0.866 for Part I and 0.862 for Part II, using the Spearman Brown correction formula on a test of split half reliability. After the two pilot tests, we considered the instrument sufficiently valid and reliable to conduct the data collection.

Initial survey instruments (the pretest) were printed and mailed to the list of volunteers from Indiana and Pennsylvania beginning June, 2007. Alabama surveys were mailed in July, and Oregon and New Mexico surveys were mailed in September and October. Both Groups A and B of each state received their surveys at approximately the same time.

Upon receipt of a completed pretest survey from a given participant of Group A (experimental group) of each state, two self-study materials were mailed first class. The materials included **Fire Department Safety Officer** by Stowell, Brakhage, and Smith (2001) and **Study Guide for Fire Department Safety Officer** by Joerschke and Adams (2001). The experimental group was asked to read the book and complete the questions in the study guide in 4 weeks. Six weeks after the initial surveys were returned, they were sent a second survey (posttest) with instructions to complete it and return it in a self-addressed, postage-paid envelope. The same procedure was repeated with Alabama, New Mexico, and Oregon some weeks later.

As stated earlier, both A (experimental) and B (control) groups received their respective second surveys (posttests) at approximately the same time. Content of the two surveys was essentially the same. However, in place of the demographic questions of the first survey, five questions were added to the second survey, two of which were open-ended. One of the five questions inquired whether future study materials should be online or printed; another asked about formats for future training. The most important of the added items for this study was the open-ended question about the impact of the surveys and study materials.

Results

As detailed earlier, each state was mailed 150 survey forms, 75 randomly assigned to what we called Group A and 75 to Group B. At each of the two mailings, experimental mortality occurred; that is, not all 75 volunteers actually completed and returned the surveys. Return rates are shown in Table 1.

It is interesting to note that Pennsylvania and Indiana had the highest response rates at the initial invitation and higher response rates at each of the succeeding mailings. The first step in Garrison's (1997) theoretical model of SDL perhaps explains why the initial response to the invitation was very good. The next two stages of self-monitoring and self-management may explain why the response rates decreased at each of the two mailings. Reminders were sent both electronically and by postal service to individual participants in both treatment and control groups.

The posttest responses between the experimental and the control groups were analyzed using a simple

Table 1: Response Rates for the Pretest and Posttest from Five States

Group	Test	State				
		Pennsylvinia	Indiana	New Mexico	Oregon	Alabama
A - Treatment	Pretest	56 out of 75 = 74%	56 out of 75 = 74%	22 out of 43 = 51%	20 out of 34 = 58%	48 out of 72 = 66%
	Posttest	42 out of 56 = 75%	43 out of 56 = 78%	11 out of 22 = 50%	15 out of 20 = 75%	27 out of 48 = 56%
B - Control	Pretest	45 out of 75 = 60%	50 out of 75 = 67%	27 out of 43 = 63%	25 out of 34 = 74%	41 out of 73 = 56%
	Posttest	33 out of 45 = 73%	42 out of 50 = 84%	19 out of 27 = 70%	14 out of 25 = 56%	30 out of 41 = 73%

T-test of the means between independent samples. A T-test was used to compare the posttest responses between the two groups to see whether it was likely that the mean differences were due to chance. Researchers expected that the self-study of firefighting health and safety material would make a difference in improving participating firefighters' knowledge and attitudes. Therefore, it was the researchers' hypothesis that the experimental group would have statistically significantly different scores in both knowledge and attitudes than the control group.

The experimental hypothesis could be stated this way: *There is no difference between posttest scores of Group A (treatment) and Group B (control)*. Table 2 shows the descriptive statistics of the posttest scores. Group A is the treatment group and Group B is the control group. Table 3 shows results of the T-test analysis.

At the $\alpha = 0.05$ level, there was no statistical difference between the treatment group and the control group on the posttest for Alabama, neither in the knowledge of firefighter safety and health nor of the attitudes toward firefighter safety and health. For Indiana, our analysis showed a statistically significant gain in knowledge. The attitude scores showed no statistically significant difference. There was no statistically significant difference between treatment and control groups in New Mexico. The difference in mean scores might have been related to the very small *N* from that state. For the Oregon group, the analysis demonstrates that there was no statistical difference between the groups. Perhaps this was because of the low number of participants in Oregon.

Comparison of the posttest scores of the treatment and control groups in Pennsylvania demonstrates a statistically significant gain of the knowledge scores, but not for the attitudinal scores. The T-test of the difference of the means between the treatment and the control samples of the survey indicate that not much change occurred in terms of attitude when the quantitative measures alone are considered. However, Indiana and Pennsylvania had relatively high response rates and demonstrated a statistically significant gain in knowledge of firefighter health and safety.

It may have been that the long drawn-out process of using the postal service and mailing the survey forms at irregular intervals affected the response rates and the motivation of the participants in states with smaller populations. For example, soon after the web site invitation was posted, survey tests were mailed to Pennsylvania and Indiana concurrently. Both states had relatively high response rates as did the Alabama sample. Alabama also received their pretest surveys soon after the recruitment period. An alternate hypothesis would suggest that the state population differentials came into play both in terms of response rates and increased scores on the surveys.

New Mexico and Oregon are relatively less populated states. High response rates increased the sample size, which in turn increased the degrees of freedom in the statistical analysis used in this study. The bigger the sample size of each group means a smaller sampling error, which allows for a greater probability of statistical significance. For example, Oregon showed an average mean of 2 points gain in content knowledge (see Table 2); a number that was comparatively high. However, the smaller sample meant fewer degrees of freedom and the large error term obviated any statistical significance. Indeed, the comments to the open-ended questions on the posttest pointed to a more practical significance of the study.

Finally, we combined the posttest scores of all five states to attempt to gain a broader picture of the effect of a self-directed study project on posttest scores of knowledge of firefighter health and safety. To ensure that our control and treatment samples were comparable in their knowledge and attitudes of firefighter health and

Table 2: Posttest Scores of Treatment and Control for Five States for Attitude and Content

State		Group	N	Mean	Standard Deviation	Standard Error Mean
Alabama	SumCont Control	A - Treatment	23	22.87	3.95	0.87
		B - Control	25	22.48	1.83	0.35
	SumAtt Control	A - Treatment	23	133.09	18.98	3.96
		B - Control	25	127.93	16.67	3.15
Indiana	SumCont Control	A - Treatment	43	23.35	2.52	0.38
		B - Control	42	21.93	2.91	0.44
	SumAtt Control	A - Treatment	42	125.81	19.22	3.11
		B - Control	42	129.43	18.89	1.85
New Mexico	SumCont Control	A - Treatment	11	22.60	2.68	0.87
		B - Control	19	20.67	3.66	0.84
	SumAtt Control	A - Treatment	11	125.40	20.85	6.61
		B - Control	19	132.17	19.10	4.28
Oregon	SumCont Control	A - Treatment	14	22.80	3.03	0.84
		B - Control	12	20.50	2.32	0.73
	SumAtt Control	A - Treatment	15	138.07	11.94	3.08
		B - Control	12	135.83	17.29	4.60
Pennsylvania	SumCont Control	A - Treatment	41	23.25	2.05	0.34
		B - Control	31	21.42	3.53	0.63
	SumAtt Control	A - Treatment	39	127.95	19.65	3.03
		B - Control	31	133.52	15.33	2.71

Note: SumCont = Knowledge of content; SumAtt = Attitudinal scores

Table 3: T-test of Means between the Posttest Scores of the Treatment and Control Groups for Five States Separately

State	Section	T	df	Sig. (2-tailed)	Mean difference	Std. error Difference
Alabama	Content	0.445	46	0.659	0.39	0.876
	Attitude	1.033	46	0.307	5.158	4.993
Indiana	Content	2.41	83	0.018*	1.42	0.589
	Attitude	-0.87	82	0.387	-3.619	4.158
New Mexico	Content	1.325	28	0.196	1.708	1.29
	Attitude	-0.639	28	0.528	-4.761	7.446
Oregon	Content	1.794	26	0.063	2.031	1.048
	Attitude	0.467	26	0.644	2.528	5.409
Pennsylvania	Content	2.387	71	0.02*	1.628	0.682
	Attitude	-1.202	71	0.233	-5.00	4.16

$^*p < 0.05$ (2-tailed)

safety, we compared treatment and control groups of all five states combined on their pretest scores. Tables 4 and 5 show this analysis.

One can readily see in Table 4 a large decrease in participation between posttest and pretest participation rates. The reduction in *Ns* is a measure of the successive experimental mortality from all five states that participated in the study.

Analyzing our posttest scores between the treatment samples and the control samples in all five states using the T-test of means between independent samples, we found that the self-study project was an effective procedure for enhancing the knowledge of firefighter health and safety, at least among those firefighters who persevered in this relatively long, drawn-out quasi-experimental study. There were many reasons why firefighters might have dropped out of the study before its completion. We might surmise that the third step in Garrison's model — ability to control one's time — was the main reason for noncompletion of the self-directed study and testing. Indeed, some completed posttests were returned a year after the scheduled due dates.

As with many quantitative studies, a small slice of qualitative data gathered by means of open-ended questions occasionally completes the picture. Changes in attitude, for example, that showed no statistical improvement in the quantitative analysis seem to have had a practical value if we were to take into account the approximately 12 percent of the respondents who responded to the open-ended question about the impact of the study. The question asked ***Please describe any impact that participation in this research project has had on you or your fire department.***

Comments indicated that respondents were at least gaining in awareness of the issues. From the wording of the comments, they might have represented volunteer department chiefs or firefighters with oversight responsibilities. The qualitative data gathered from the open-ended question on the surveys was analyzed into three categories: (1) Awareness to improve safety, (2) Implementation of health and safety knowledge, and (3) The plan to implement changes in the future. What seemed to be the dominant theme was the *awareness for the need to improve safety.* The following statements exemplify this theme:

- *This project has brought to light several issues on safety that we do not spend much time on while training.*
- *This has made me realize we have work to do to improve our fire department.*
- *The study has really made me think more closely about our operations on the fireground and station and realize that we're not as safe as we all thought.*
- *It made me more aware of how to properly avoid any type of safety issues in the future.*
- *I realized how important a safety officer is and how my department is in need of one.*
- *This has been very instrumental in raising awareness.*
- *It has made me realize the need to implement more of a physical fitness program.*
- *This research project made me more aware of the safety officer's responsibility.*

A second theme we coded as *implementation of health and safety knowledge.* The following quotes are examples of this theme:

- *We are ramping up the training and safety programs in our department.*
- *We have used the course as a review of our departments [sic] SOPs [standard operating procedures] and firefighter health and safety.*
- *We have used this evaluation to begin round-table discussions among all members.*
- *My department has developed several SOPs and SOGs [standard operating guidelines] from questions I answered on this survey.*
- *I promote seatbelt use stronger. I focus [sic] training myself and others better.*
- *We have looked at and are progressing upon the implementation of a risk analysis/management program.*

Table 4: Comparison of Pretest and Posttest Mean Scores of All Five States

Pretest/Posttest Scores	Group	N	Mean	Standard Deviation	Standard Error Mean
Pretest Content	A - Treatment	203	21.134	2.456	0.17235
	B - Control	186	21.197	3.854	0.20932
Posttest Content	A - Treatment	136	22.963	2.899	0.24861
	B - Control	135	21.518	2.999	0.25817

Table 5: T-test Comparison of the Pretest and Posttest Mean Scores of Treatment and Control Groups for Five States Combined

Independent T-test	Group	T	df	Sig. (2-tailed)
Pretest Scores	A – Treatment B – Control	1.857	387	0.064
Posttest Scores	A – Treatment B – Control	3.992	262	0.000*

**p < .05 (2-tailed)*

- *It did get us to get at our SOP and go over a few issues we had.*
- *After completing the safety officer book, I had opened up several conversations with members of my fire department regarding safety.*
- *My department has now added the position of safety officer.*
- *We are in the process of updating our SOPs.*

Finally, the only other theme that seemed important enough to report was the *plan to implement changes sometime in the future*. The following quotes support this theme:

- *… we will work to improve based on this information.*
- *We are trying to implement a health and safety program.*
- *I am currently reviewing my departments [sic] SOG and we are planning on beginning semiannual firefighter proficiency evaluations.*
- *Will review SOPs/SOGs (standard operating procedures/standard operating guidelines) and bylaws.*
- *I will be addressing these (safety) issues in the upcoming months during training.*
- *I'm … going to give the chief the book to read; this could help improve the department.*

Conclusion

When taken as a national sample, the combined five states we had selected benefited from the self-study activities we invited them to engage in. Their posttests of technical knowledge related to health and safety showed an improvement, and that improvement was not due to history or chance, but can be attributed to their efforts to complete the self-study materials. On the other hand, there was no improvement in attitudes as indicated by comparing the pretests with the posttests by individual states and all five states taken as an aggregate. Yet, the answers to open-ended questions made by a small segment of the participants indicated that there were some volunteer firefighters who had gained heightened awareness and intended to make changes in their modi operandi.

There were limitations to the study. The most glaring limitation was the low return rate from western states, especially at the posttest stage of the project. Due to the limitations of staffing among the research team, the survey tests had to be sent in waves that stretched over 4 months. A better strategy would have been to send all 750 pretests on the same date. Both Indiana and Pennsylvania showed significant improvement on the test of knowledge. These states also had the highest return rates.

One of the anonymous reviewers of this article pointed out another weakness in the study. Perhaps we were naïve in assuming that increased knowledge would lead to attitude change. Perhaps changes in attitude involve more complexity as identified by Sager (1989). Future research needs to include risk-taking because it interacts with organizational structure and organizational culture.

The most powerful outcome of this study was in its practical significance. It provided a first strong step in implementing the seventh recommendation of the Firefighter Life Safety Initiatives to *create a national research agenda ....* (Everyone Goes Home, 2007). It also heightened the awareness of some volunteer firefighters of the need to follow recommendations for firefighter health and safety that were the result of many years of research into the causes and conditions of firefighter fatalities and injuries.

References

Brockett, R. G., & Hiemstra, R. (1991). *Self-direction in adult learning: Perspectives on theory, research, and practice*. New York: Routledge.

Candy, P. C. (1991). *Self-direction for lifelong learning*. San Francisco: Jossey-Bass.

Dake, K. (1992). Myths of nature: Culture and the social construction of risk. *Journal of Social Issues, 48*(4), 21–37.

Everyone Goes Home (2007). *Firefighter life safety initiatives*. Retrieved May 23, 2007, from http://www.everyonegoeshome.com/initiatives.html

Fahy, R., & LeBlanc, P. (June, 2006). *Firefighter fatalities in the United States—2005*. Quincy, MA: National Fire Protection Association. Retrieved May 23, 2007, from http://:www.nfpa.org

Garrison, R. (1997). Self-directed learning: Toward a comprehensive model. *Adult Education Quarterly*, *48*(1), 18–33.

Joerschke, J. & Adams, B. (2001). *Study guide for the first edition of fire department safety officer*. Stillwater, OK: Fire Protection Publications, Oklahoma State University.

Knowles, M. (1970). *The modern practice of adult education: Andragogy versus pedagogy*. New York: Cambridge Books.

Knowles, M. (1975). *Self-directed learning: A guide for learners and teachers*. New York: Association Press.

Knowles, M., Holton, E., & Swanson, R. (1998). *The adult learner* (5th ed.). Houston, TX: Gulf Publishing Company.

National Fire Protection Association. (2007). NFPA® 1500, *Standard on fire department occupational safety and health program*. Quincy, MA: NFPA.

Sager, J. S. (May, 1989). Fire fighting experiences and the perception of danger. *Fire Engineering*, 47-50.

Simonet, S., & Wilde, G. (July, 1997). Risk: Perception, acceptance and homeostasis. *Applied Psychology: An International Review*, *46*(3), 235–252.

Sjoberg, L., & Drottz-Sjoberg, B. (December 1991). Knowledge and risk perception among nuclear power plant employees. *Risk Analysis, 11*(4), 607–618.

Spear, G., & Mocker, D. (1984). The organizing circumstance: Environmental determinants in self-directed learning. *Adult Education Quarterly, 35*(1), 1–10.

Stowell, F., Brakhage, C., & Smith, C. (2001). *Fire department safety officer*. Stillwater, OK: Fire Protection Publications, Oklahoma State University.

Tough, A. M. (1967). *Learning without a teacher*. Toronto: Ontario Institute for Studies in Education.

Tough, A. M. (1971). *The adult's learning Projects: A fresh approach to theory and practice of adult learning*. Toronto: Ontario Institute for Studies in Education.

U. S. Fire Administration (2007). *USFA firefighter fatality provisional report*. Retrieved November 7, 2007, from http://www.firerescue1.com/fire-products/Administration Billing/articles/331673-U-S-Fire-Administration-Firefighter-Fatality-Provisional-2007-Report

Endnote

[1] These numbers do not include the 343 Fire Department of New York (FDNY) deaths on September 11, 2001.

About the Authors

Dr. Robert E. Nolan is Professor Emeritus of the School of Educational Studies at Oklahoma State University. He served on the faculty of the OSU College of Education from 1986 to 2008. Dr. Nolan, who serves as corresponding author, was the PI of this project funded by the Federal Emergency Management Agency. He can be reached at: **bob.nolan@okstate.edu**.

Thomas Hughes holds a Master of Public Administration degree and two undergraduate degrees in Fire Science from the University of New Haven. He is also currently working on a Ph.D. in Disaster & Emergency Management at Oklahoma State University. Thomas works as a Research Coordinator at Fire Protection Publications in Stillwater. He has been a firefighter for 12 years and holds the rank of Captain and Training Officer with the Ingalls Fire Department in Payne County, Oklahoma.

Dr. Lihua Xu obtained her Ph.D. in Educational Psychology with a specialty in Research, Evaluation, Measurement, and Statistics from Oklahoma State University.

Anand Lakshmanan received his MS in Electrical Engineering from Oklahoma State University. He currently works for a french oil exploration company.

Olivia Leeker is a doctoral candidate in the Counseling Psychology Ph.D. Program at Oklahoma State University.

Greg A. Wyant, Division Chief of Training and Safety, Noblesville (Indiana) Fire Department

An Analysis of Air Quality after a Fire

Abstract

This research evaluates the quality of air after a fire. This evaluative research involved the collection and analysis of data on air quality after a fire to determine what particulate matter, vapors, and gases are present and their corresponding danger to firefighters. It also examines how fire department leaders should safely manage personnel operating in these environments. The presence of numerous compounds was found at every testing site and in numerous categories. In the context of postfire operations, firefighters operating without the benefit of respiratory protection could risk exposure to dangerous airborne compounds, regardless of the levels of typical indicator gases.

Introduction

The list of hazardous injuries that occur in the workplace for firefighters is extensive and growing with the introduction of new industrial processes and the expansion of industrialization in the United States. According to Robert Friis (2007), exposures to workplace hazards are closely associated with traumatic injuries and death. Friis contends that a range of conditions such as hearing loss, respiratory diseases, and adverse birth outcomes have been inflicted on firefighters (2007).

The human respiratory tract is one of the few direct routes into the human body. Humans inhale and exhale massive volumes of air each day, but natural protective measures, such as mucus, render the air relatively clean for use by the human body. There are, however, some vapors, gases, and particulate matter that are not filtered and, if inhaled, can cause both acute and chronic health issues. Firefighters, as part of the job, routinely enter environments that can contain many of the aforementioned vapors, gases, and particulate matter. If a firefighter were to enter an atmosphere thought to be void of harmful airborne products without respiratory protection, the consequences could be severe if that atmosphere was in fact contaminated.

The problem is that the smoke and other unburned products of combustion are fast becoming, if they are not already, more dangerous than the fire that spawned them. Historically, if all units marked *in service* from a fire left the scene relatively unscathed, the efforts of those units was a success. That situation is still true today; however, there is more to the success equation. The relative success should not be judged only in the short-term or acute sense, but it should also be judged over the long-term or chronic sense.

Unfortunately, it may take years to realize the damage that inhaled unburned products of combustion have caused. Death, as most people know, does not always appear during an incident or even shortly after an incident for that matter. There is the issue of chronic illness that can result from the inspiration of unburned products of combustion. Certainly, the acute or immediate health issue or death captures headlines as it should. What of those who die a slow death from an illness such as cancer? The questions about that type of death are many, but the one question that is often impossible to determine is what caused the cancer?

Firefighters are developing certain types of malignancies at an alarming rate. LeMasters et al. (2006) conducted a meta-analysis of cancer risk among firefighters and found significantly increased cancer probabilities for multiple myeloma, non-Hodgkin's lymphoma, and prostate cancer and twice the cancer rate of the general population for testicular cancer.

This study evaluates the quality of the air after a fire. The research involves collecting and analyzing data on air quality after a fire to determine what particulate matter, vapors, and gases are present. Air samples were tested for the following broad categories of compounds:

- Polynuclear aromatic hydrocarbons (PNAHs)
- Aldehydes
- Acids
- Volatile organic compounds (VOCs)
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Hydrogen cyanide (HCN)

This paper argues that in the context of postfire operations, firefighters should anticipate that when operating near the testing site without the benefit of respiratory protection, they are risking exposures to a varying and unpredictable cocktail of airborne compounds, regardless of the levels of typical indicator gases.

Conceptual Framework

The ecological theory postulates that the factors that influence environmental health behavior occur at several levels (Murphy, 2005; Skolnik, 2008). These levels include public policy factors, individual factors, intrapersonal factors, interpersonal factors, and institutional factors. The theory also contends that behavior both influences and is influenced by the social environments in which it occurs (Murphy, 2005). The health belief model, on the other hand, suggests that people's health behaviors depend on their perception of the likelihood of getting the illness, the severity of the illness if they get it, the barriers to engaging in preventive behavior, and the benefits of engaging in behavior that will prevent the illness. According to Murphy (2005), people's health behavior also depends on whether or not they feel that it is possible to perform the appropriate behavior. Ultimately, people's health behavior is dependent on their self-efficacy (Skolnik, 2008).

Literature Review

"Carbon Monoxide is the most common cause of poisoning in industrialized countries," and this fact alone speaks to the deceptive nature of CO (Bledsoe, 2008, p. 6). According to Bledsoe, CO is an odorless, colorless, and tasteless gas that results from the incomplete combustion of carbon-containing fuels (2008). Firefighters, as a natural part of the profession, are at an increased risk of exposure to CO since their *working environment* often is inside a structure that has burned. This information is provided to students in a student manual as part of a new initiative sponsored by the International Association of Fire Fighters (IAFF) to educate firefighters about many of the acute and chronic signs and symptoms of CO poisoning. H. A. Schaitberger, General President of the IAFF, wrote in a letter to all IAFF local Presidents (personal communication, November 2007): "We believe that many of the cardiac arrests firefighters are experiencing may well be attributable to CO exposure." This statement is important when one considers that the leading cause of death among firefighters is cardiac arrests. In fact, a total of 49 (46.2 percent) of the firefighter line-of-duty-deaths that occurred in 2006 were ruled to be cardiac arrest (United States Fire Administration [USFA], 2007). In a National Institute of Occupational Safety and Health (NIOSH) publication, the organization recommends, among other things, that "fire departments control exposure to carbon monoxide and other fire contaminants with proper fire scene management and respiratory protection" (NIOSH, 2007, introduction section, 4).

The smoke from residential fires can contain any number of compounds. These compounds are not only based on the fuel source or what was burning but also on fire conditions (NIOSH, 2007). CO is only one byproduct of the combustion process. Hydrogen cyanide (HCN), for example, is also frequently detected in structure fires as is a plethora of other particulate matter and gases (NIOSH, 2007). According to Michael Lee (2007), there is a strong possibility that cyanide poisoning is responsible for some portion of the cardiac arrests experienced by firefighters. As is evident, much time and effort has been spent studying the effects of these products on the cardiovascular system.

Previous Studies

In April 2003, the National Institute of Science and Technology (NIST) sponsored *Smoke Component Yields from Room-scale Fire Tests* (Gann, Averill, Johnsson, Nyden, & Peacock, 2003). While the structure of the NIST tests was not an exact match to the testing conducted as a part of this research, the results do add credibility to some of the research questions raised in this article. Gann et al. (2003) conducted measurements of CO, CO_2, oxygen, HCN, hydrogen chloride, hydrogen fluoride, hydrogen bromide, nitric oxide, nitrogen dioxide, formaldehyde, and acrolein. The purpose of the NIST testing was to "… establish a technically sound basis for assessing the accuracy of the bench-scale device(s) that will be generating smoke yield data for fire hazard and risk evaluation" (Gann et al., 2003, p. xi). The testing measured preflashover and postflashover levels of the aforementioned compounds in a controlled setting using a sofa, a particleboard bookcase, a polyvinyl chloride sheet, and a household electric cable. The results indicated the yields of CO, CO_2, HCN, hydrogen chloride, and carbonaceous soot was determinable and measurable. Nitrogen dioxide, formaldehyde, and acrolein were not found above the detection limits.

Another study requested by the Bureau of Alcohol, Tobacco, and Firearms (ATF) and conducted by a branch of NIOSH occurred in 1997, hereafter referred to as the *ATF study*. "A fire scene usually happens in three distinct phases; suppression, overhaul, and investigation" (Kinnes & Hine, 1997, p. 2). The ATF study focus was specifically directed to the timeframe of the investigation. The catalyst for the ATF study was a concern by ATF special agents and fire investigators in northern Virginia about potential respiratory health effects from conducting fire scene examinations and the adequacy of their respiratory protection (Kinnes & Hine, 1997). The results indicated the presence of various concentrations of the tested analytes. The tested analytes included respirable dust, metals, HCN, inorganic acids, aldehydes, polycyclic aromatic hydrocarbons, volatile organic compounds (VOCs), and elemental carbon (Kinnes & Hine, 1997).

A similar study conducted by Bolstad-Johnson et al. (2000) focused on firefighter exposures during fire overhaul. Sampling was conducted for aldehydes, benzene, toluene, ethyl benzene, xylene, hydrochloric acid, polynuclear aromatic hydrocarbons (PNAHs), respirable dust, hydrogen cyanide, carbon monoxide, nitrogen dioxide, sulfur dioxide, asbestos, metals, and total dust (Bolstad-Johnson et al., 2000). This research was conducted in Phoenix, Arizona, and included air monitoring during overhaul in 25 different structures (Bolstad-Johnson et al., 2000). Testing media varied for the different analytes tested. The results indicated that the following analytes exceeded published ceiling values: acrolein, CO, formaldehyde, glutaraldehyde, benzene, nitrogen dioxide, sulfur dioxide, and PNAHs (Bolstad-Johnson et al., 2000). The results exceeded ceiling values of different organizations (e.g., NIOSH, Occupational Safety and Health Administration [OSHA], etc.) to varying degrees and not at every fire. Secondarily, the Bolstad-Johnson et al. (2000) study concluded that CO should not be used as an indicator gas for other contaminants found in these atmospheres because there was no correlation found between CO levels and the relative safety of the environment.

The effects of breathing any one of the compounds by itself are, to varying degrees, predictable assuming exposure levels are known. However, determining exposure levels and limiting inclusion of other compounds are virtually impossible in the postfire setting. A study conducted by LeMasters et al. (2006) broached the subject of firefighter cancer rates, which has shed some light on trends within the fire service resulting from possible exposure. The study was a qualitative three-criterion assessment and a quantitative meta-analysis of cancer risk among firefighters. This study rendered potential cancer rate results for firefighters ranging from probable (high likelihood), possible (more than average), to unlikely (equal to general population). A summary of the LeMasters et al. (20006) study is found in Table 1.

Table 1: Summary of Likelihood of Cancer Risk

Cancer Type	Likelihood of Cancer Risk by Criteria
Multiple Myeloma	Probable
Non-Hodgkin Lymphoma	Probable
Prostate	Probable
Testis	Probable
Skin	Possible
Malignant Melanoma	Possible
Brain	Possible
Rectum	Possible
Buccal Cavity and Pharynx	Possible
Stomach	Possible
Colon	Possible
Leukemia	Possible
Larynx	Unlikely
Bladder	Unlikely
Esophagus	Unlikely
Pancreas	Unlikely
Kidney	Unlikely
Hodgkin's Disease	Unlikely
Liver	Unlikely
Lung	Unlikely

This study confirmed previous findings of an elevated metarelative risk for multiple myeloma among firefighters. LeMasters et al. (2006, p. 1200) further concluded that "… firefighter risk for these four cancers may be related to the direct effect associated with exposures to complex mixtures, the routes of delivery to target organs, and the indirect effects associated with modulation of biochemical or physiologic pathways."

A roundtable discussion in the September 2007 issue of *Fire Engineering* centered on the following question: "Self contained breathing apparatus (SCBA) policies define the required use of SCBAs at fires. During the overhaul phase, when, if at all, are your firefighters allowed to remove their SCBA protection?" (Coleman et al., 2007, p. 34). Representatives from 24 different fire departments (22 U.S. cities and 2 international entities) responded to the question. The summary results indicated that 21 of the respondents do not currently mandate SCBA usage during overhaul, but instead have varying degrees of respiratory protection criteria. Examples of those criteria include immediately dangerous to life or health (IDLH) restrictions, CO levels, low oxygen levels, and lower explosive limits (LELs). Three respondents do have SCBA usage requirements in place. Much of the time, the decision concerning the IDLH atmosphere is left to a monitoring instrument and/or the incident commander (IC) or safety officer. At other times, the decision considers what has burned, visible particulate matter, absence of visible smoke, etc. Most of the responses indicated positive short-term results in that no injuries were reported during or after the incident.

Exposure Values

In terms of human exposure to the multitude of different compounds in the field, different organizations have studied and published different definitions of values and limits of exposure. Miller (2004), in a hazardous materials book, defines many of these terms. The three organizations that are used most frequently are NIOSH, Occupational Safety and Health Association (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH).

NIOSH defines an IDLH atmosphere as "an atmospheric concentration of any toxic, corrosive, or asphyxiating substance that poses an immediate threat to life. It can cause irreversible or delayed adverse health effects and interfere with the individual's ability to escape from a dangerous atmosphere" (2004, p. 78). OSHA defines an IDLH atmosphere as "an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere" (2004, p. 78). OSHA has also defined a limit known as a permissible exposure limit (PEL). A PEL, as defined by OSHA, is "the maximum concentration to which the majority of healthy adults can be exposed over a 40-hour work week without suffering adverse effects" (2004, p. 78). An OSHA PEL (C) is a PEL ceiling limit and is "the maximum concentration that a person can be exposed to at any time, even for an instant" (2004, p. 78). The ACGIH has established a threshold limit value (TLV). The TLV, as defined by ACGIH, "is an occupational exposure value recommendation which it is believed nearly all workers can be exposed day after day for a working lifetime without ill effect" (2004, p. 78). There are a variety of other limits and values, but those referenced constitute the majority of the measures necessary for this research.

OSHA Regulation 29 *CFR* 1910.134 (2007) reads much the same as NIOSH with minor exceptions. One such exception is listed in the general requirements section and is identified as 29 CFR 1910.134 (d)(1)(iii). This section states the following:

> *The employer shall identify and evaluate the respiratory hazard(s) in the workplace; this evaluation shall include a reasonable estimate of employee exposures to respiratory hazard(s) and an identification of the contaminant's chemical state and physical form. Where the employer cannot identify or reasonably estimate the employee exposure, the employer shall consider the atmosphere to be IDLH.* (OSHA, 2007, p. 5)

National Fire Protection Association® (NFPA®) 1981 (2007), A.1.1.1 proposes that "… there is no way to predetermine hazardous conditions, concentrations of toxic materials, or percentages of oxygen in air in a fire environment, during overhaul operations." There is a recommendation in the same location that "SCBA are required at all times during any fire-fighting, hazardous materials, or overhaul operations" (2007, A.1.1.1). This information is important to consider when implementing a process for identifying the most appropriate respirator for the task.

Study Procedures

The identification of the different compounds that are actually present in the air after a residential fire required the professional guidance of an American Industrial Hygiene Association (AIHA) certified laboratory. In conjunction with a laboratory representative, it was determined that air testing would be conducted for the following broad categories: aldehydes, acids, CO_2, CO, HCN, PNAHs, and VOCs.

Site Control

There are three very distinct criteria sections to this air-testing process. The first is related to the specifics of the burnt structure. Criteria for a structure to be considered included the following:

a. The structure must have been a wood frame residential structure.

b. The structure must have been occupied and contained furnishings and floor and window coverings.

c. The structure must have suffered damage significant enough to have rendered at least one room at least 75 percent fire damaged.

d. Air currents within the structure must have been controllable.

The second criteria section describes the parameters that are established for the actual field testing. The following criteria apply:

a. All work within the structure, destructive or otherwise, must cease while testing is in progress.

b. Artificial air circulation must cease while testing is in progress.

c. Every effort must be made to establish a sampling site with low air circulation.

d. The sampling site should be established as near to the area of fire involvement as possible.

e. In the suppression continuum, the fire should be in the postoverhaul, preinvestigation phase.

f. Air testing should commence for a period lasting no less than 10 minutes.

g. The sampling must be started within 4 hours of the fire being extinguished and overhauled.

h. Records must be kept relating the time that the fire was out and sampling was started and ended.

i. A schematic drawing must be made noting the sampling location, fire location, etc.

The third criteria section is contained under the broad category of field sampling and is typically dictated by the laboratory receiving the samples. Specific instructions for sample collection were obtained from the contracted laboratory. For any sampling that is to be done and for all of the samples described, a complete and thorough set of sampling instructions can and should be obtained from the laboratory conducting the analysis. An overview of the general guidelines used for this research is as follows:

a. All air handling pumps were calibrated prior to usage to ensure proper air flow settings.

b. The pumps for hydrogen cyanide (HCN), acids, polynuclear aromatic hydrocarbons (PNAHs), and aldehydes were located at a height of 5 feet 10 inches above the floor.

c. The carbon monoxide (CO), carbon dioxide (CO_2), relative humidity, and temperature monitor, known as an IAQRAE™ (indoor air quality monitor), was placed in operation 4 to 6 feet from the floor as soon as the sampling location was determined.

As mentioned, the sample collection procedures are largely dictated by the laboratory. For accuracy, the actual procedures used as a part of this research are included for each tested component.

Sampling Protocol

The PNAH profile included testing for the following five compounds: anthracene, benzo (a) pyrene, chrysen, phenanthrene, and pyrene. The testing method number is the OSHA 58 method (OSHA, 1986), which utilizes cassettes containing glass fiber filters (GFFs), air tubing, and an air pump set at 2.0 liters per minute (lpm). The basic steps in the field include connecting an Aircheck® 52 pump to 3/8 inch Tygon® air tubing that is outfitted with a plastic luer lock adapter and an air flow regulator, checking the air flow rate by attaching an air flow rotameter, and attaching the pump and tubing onto the tripod in preparation for insertion of the testing cassette. The testing cassette was inserted onto the tubing and the pump was started for a minimum of 10 minutes. When the appropriate time had elapsed, the pump was turned off, and the cassette was removed from the tubing. The GFF was removed from the cassette and placed in a glass vial, which was sealed with a cap containing a polytetrafluoroethylene (PTFE) liner. The sample was then refrigerated, kept out of sunlight, and shipped cold within 24 hours of collection to the laboratory.

The aldehyde profile included testing for benzaldehyde, veleraldehyde, propionaldehyde, butyraldehyde, crotonaldehyde, formaldehyde, isovaleraldehyde, and acetaldehyde. The testing method used was the NIOSH 2016 method (Schlecht & O'Connor, 2003), which utilizes a sorbent tube containing silica gel, air tubing, and an air pump set at 0.4 liters per minute (lpm). The basic steps in the field include connecting an Aircheck® 52 pump to ¼ inch Tygon® air tubing which is outfitted with a plastic luer lock adapter and air flow regulator, checking the air flow rate by attaching an air flow rotameter, and attaching the pump and tubing onto the tripod in preparation for insertion of the testing ampule. The testing ampule ends are broken with a tube breaker and the sorbent tube is inserted onto the tubing and the pump is started for a minimum of 10 minutes. When the appropriate time has elapsed, the pump is turned off, and the sorbent tube is removed from the tubing. The sorbent tube ends are capped and the tube is refrigerated, kept out of sunlight, and shipped to the laboratory cold within 24 hours of collection.

The acid profile included testing for sulfuric acid, phosphoric acid, hydrogen bromide, hydrochloric acid, hydrofluoric acid, and nitric acid. The testing method number is the NIOSH 7903 method (Schlech & O'Connor, 2003), which utilizes sorbent tubes, air tubing, and an air pump set at 0.5 lpm. The basic steps in the field are identical to those described for the aldehyde sample collection. The only exception is that refrigeration is not important for the acid sorbent tube.

HCN, because of its unique properties, required testing by itself. The testing method number is the NIOSH 6010 method (Schlecht & O'Connor, 2003), which utilizes sorbent tubes, air tubing, and an air pump set at 0.2 lpm. The basic steps in the field are identical to those described for the aldehyde sample collection. The only exception is that refrigeration is not important for the HCN sorbent tube.

The VOC profile tested for the 63 most prevalent compounds found in the sample by using a library search of thousands of VOC signatures. The testing method number is the OSHA TO15 method (OSHA, 2003a). The actual device used to collect an air sample is an evacuated air cylinder (mini can) and a quick grab regulator. The mini can holds 400 cubic centimeters (cc) of air and is outfitted with a quick grab regulator, which regulates the flow of air to a constant rate from vacuum pressure. Sampling in the field is accomplished by the following:

a. Positioning the sampler and the mini can in the atmosphere to be sampled

b. Attaching the quick grab regulator to the mini can

c. Allowing the mini can to draw air for the predetermined time (10 minutes in this case)

d. Removing the quick grab regulator

The sample is contained within the mini can and shipped to the laboratory within 24 hours.

CO and CO_2 along with incidentals such as relative humidity and temperature were recorded by an IAQRAE™ air sampling monitor. The IAQRAE™ draws an air sample and analyzes it at 60-second intervals. All of this information is downloaded into a computer for interpretation.

The ability to replicate this step is of very high importance. It is important to replicate the actual criteria described, but not important that there is an exact match of contents burned. The only feasible way to replicate the exact products that burned would be in a laboratory setting, which would allow the researcher to decide what products to burn.

Limitations of Procedures

Two factors conspired to create a sample size limitation. First, there was an uncharacteristic lack of fires during the timeframe of this study (August 2007 to January 2008) in the area of the research. Four samples were ultimately retrieved. Secondly, the financial impact of each sample set was sufficient to limit the number of allowable sample sets to five. Another limitation associated with this research was determining what analytes to test. This proved to be a decision that was not anticipated. Therefore, it stands to reason that certain compounds could have been present but were not tested due to the constraints of finances and resources. Every effort was made to include the most likely and damaging compounds in this research.

The amount of time that passed from the time that overhaul was completed and the samples were drawn varied from sample set to sample set. This time potentially allowed for the air quality to improve through both natural and artificial (*man-made*) air currents. This limitation is interrelated to the limitation caused by the lack of fires and the need to travel great distances for fires that met the research criteria.

Air currents within a structure that has burned are almost always present to some degree. On occasion, it was difficult to control natural air currents. This situation may have negatively impacted the results of some sample sets. The limitation would have allowed for the air within the burnt structure to dilute or clear at an accelerated rate, causing the sample result to indicate a low reading. All artificial air currents were stopped prior to sampling.

Finally, there was a limit to the amount of time that a sample could be drawn. Typically, investigators were waiting to conduct an investigation while the samples were being drawn. Every effort was made to allow the incident to progress at a normal pace; extending the sample time would have negatively impacted the incident and possibly the responding department. Therefore, some samples could have indicated higher readings if there would have been more time available for air collection. As it was, the 10-minute criterion, as described in the procedures, was the absolute minimum time that samples were drawn.

Research Findings and Discussion

The purpose of this evaluative research was to collect and analyze data on air quality after a fire to determine what particulate matter, vapors, and gases are present and how fire department leadership should safely manage their personnel operating in these environments. To answer the question of what particulate matter, vapor, and/or gas is/are in the air during the testing timeframe, it was necessary to compile and render the laboratory analysis results. All four sample sets indicated varying degrees of particulate matter, vapor, and gas. The most significant of which are indicated in Table 2.

The significant results listed in Table 2 indicate the presence of formaldehyde, acetaldehyde, and acetone to some degree at every fire sampled, while benzene, styrene, toluene, propylene, and propionaldehyde were present at three of the four fires. The detected levels were below the OSHA PEL or ACGIH TLV as applicable. As Table 2 indicates, a variety of compounds were discovered at some fires, but not necessarily at all fires. Air monitoring of these four sample sets indicated negligible levels of CO and CO_2. A surprising and completely relevant finding is that many fire departments utilize CO as the only indicator gas for determining the safety of SCBA removal. This situation could still allow for exposure of firefighters to many of the compounds that are indicated in this research.

The Literature Review (Previous Studies) section of this paper describes three separate but similar studies of air quality. The NIST testing, which was conducted during the suppression phase, revealed high yields of CO, CO_2, hydrogen chloride, and HCN (Gann et al., 2003). The ATF study, which was done during the investigation phase, revealed varying concentrations of HCN, inorganic acids, aldehydes, polycyclic aromatic hydrocarbons, and VOCs (Kinnes & Hine, 1997). The Phoenix research, which was conducted during the overhaul phase, indicated high yields of acrolein, CO, formaldehyde, glutaraldehyde, benzene, nitrogen dioxide, sulfur dioxide, and PNAHs (Bolstad-Johnson et al., 2000).

As described by the ATF study (Gann et al., 2003), the fire scene occurs in three distinct phases: suppression, overhaul, and investigation. This research combines results from all three of these phases as well as the timeframe or gap that exists between overhaul and investigation. In the case of all phases, toxic compounds were present during every timeframe that was tested. These results indicate just how difficult it is to predict all of the potential compounds that can be found in a burnt structure. Therefore, the answer to the research question is impossible to answer exactly but can be answered in the general sense as follows: Any number or combination of harmful/toxic compounds can be present at every phase of fire and at every fire.

Implications for Intervention

The potential health risks to personnel who inhale these products should be considered. The health risks, potential or actual, are proving to be very diverse. As the literature suggest, CO is garnering much attention from the IAFF as being a contributing factor to cardiac arrests. Likewise, Michael Lee (2007) indicated a strong

Table 2: Sample Set Significant Results

Compound	LOQ ug	ppm Range	Sample Set Exhibiting Results
Propionaldehyde	0.1	0.011 to 0.028	1, 3, 4
Crotonaldehyde	0.1	0.013	1
Formaldehyde	0.04	0.0076 to 0.15	1, 2, 3, 4
Acetaldehyde	0.04	.022 to .064	1, 2, 3, 4
Benzaldehyde	0.1	0.016	3
Butyraldehyde	0.1	0.013 to 0.020	3, 4
Compound	**LOQ ppbv**	**ppbv Range**	**Sample Set Exhibiting Results**
Propylene	5	6 to 8	1, 2, 4
Acetone	5	24 to 64	1, 2, 3, 4
Compound	**LOQ ppbv**	**ppbv Range**	**Sample Set Exhibiting Results**
Isopropyl Alcohol	5	17	1
Benzene	5	15 to 132	1, 3, 4
Toluene	5	8 to 40	1, 3, 4
Styrene	5	5 to 85	1, 3, 4
Acetaldehyde	5	8.1 to 11	2, 4
Ethanol	5	15 to 27	2, 3
Decane	5	13	2
Compound	**LOQ ppbv**	**ppbv Range**	**Sample Set Exhibiting Results**
Undecane	5	7.4	2
Naphthalene	5	7.4	2
Propane	5	15	3
2-Propenoic acid, 2-methyl, methylester	5	16	3
Phenylethyne	5	14	3
Indene	5	25	3
Naphthalene	5	22	3
Tetrahydrofuran	5	11	4

Note: ug = micrograms, LOQ = level of Quantitation, ppbv = parts per billion by volume, ppm = parts per million

possibility that HCN poisoning is responsible for some portion of the cardiac arrests experienced by firefighters. These two compounds are getting national attention from organizations such as the IAFF and International Association of Fire Chiefs (IAFC), and steps are being taken to attempt to reduce the risks to firefighters from these compounds.

The results of this research indicated that aldehydes were present at every fire sampled. An article in *Burning Issues*, “Health Effects of Wood Smoke Pollutants” (2001), listed some of the health effects of the aldehyde group as toxic and carcinogenic, which can cause liver lesions, nasal cancer, and growth retardation.

The VOCs that were found at three of the four fires were benzene, toluene, propylene, and styrene. The adverse health characteristics associated with benzene include acute toxicity, mucous membrane irritation, neurological symptoms, and acute myeloid leukemia (“Health Effects,” 2001). Toluene exposure can cause dizziness, headache, confusion, and impaired coordination. Toluene is neurotoxic and causes neurobehavioral changes and liver, kidney, and nose erosion. Chronic toluene exposure causes permanent damage to the brain ("Health Effects," 2001). Propylene is a Group C carcinogen, which classifies it as possibly a human carcinogen (Environmental Protection Agency [EPA], 2007). Styrene exposure affects the central nervous system. Effects of styrene exposure include subjective complaints of headache, fatigue, dizziness, confusion, drowsiness, malaise, difficulty in concentrating, and a feeling of intoxication. Styrene is classified as a potential human carcinogen (OSHA, 2003b).

There are roughly 15 other compounds listed in Table 2 that were identified as present in at least one sample set. The majority of these compounds are classified as VOCs and can generally be characterized, from a health-effects standpoint, as causing irritation, headache, loss of coordination, nausea, cancer, and damage to the liver, kidney and central nervous system. Many other VOCs still have unknown health effects and carcinogenic values (EPA, 2007). The effects of these products on humans greatly depend on the quantity of the compound inhaled and the duration associated with the inhalation event. The health risks described vary from situation to situation. It was also discovered that some of these compounds accumulate in the body. Therefore, it is possible that a person could accumulate many of these compounds over several events, creating a reactionary dose much higher than any single, original exposure dose. The results in Table 2 also indicate that a single exposure event can result in exposure to multiple compounds at once. The health effects of this phenomenon were unattainable, but it is highly doubtful that the outcome would improve.

Protection Considerations

The level of protection afforded fire personnel operating in these environments should be considered. In fact, the guiding information may well already rest in two documents. As described in the literature review, OSHA 29 CFR 1910.134 (d)(1)(iii) "….Where the employer cannot identify or reasonably estimate the employee exposure, the employer shall consider the atmosphere to be IDLH" (OSHA, 2007). NIOSH recommends that users entering an IDLH atmosphere utilize only an SCBA or supplied-air respirator (SAR) (NIOSH, 2004). This research has proven unequivocally that firefighters are incapable of determining exactly what substances are in the air after a fire and therefore must consider the environment IDLH and wear an SCBA whenever entering that environment.

This study indicates several noteworthy findings that apply directly to the fire service and the respiratory protection policies currently being used. The air monitors that are currently in use to determine CO, oxygen, and LELs are not capable of identifying all of the other toxic compounds that may be in the air, thus allowing an IC or safety officer to allow removal of SCBAs and expose their members to unknown compounds. There is not a correlation between CO levels and toxic compound levels. This situation indicates that a gap in respiratory protection could exist if CO is used as an SCBA-removal indicator gas. Toxic compounds were discovered at every fire that was sampled as part of this research as well as in all three research studies (NIST, ATF, and Phoenix) cited in the literature. Many of the toxic compounds that were studied can cause the exposed to exhibit confusion, headaches, and dizziness. These signs can be mistaken for normal fatigue or exertion, which could add to the lack of detection. The research further indicates that there can be a cumulative effect of these compounds, which could result in higher retained levels than any single original exposure level.

Data Synthesis

The conclusions of this research clearly indicate that (a) there are toxic compounds in the air for extended periods of time after extinguishment, (b) the health risks associated with exposure to these toxic compounds could be significant, and (c) an SCBA or SAR is the only appropriate respiratory protection for the postfire incident scene.

The study indicated results that were consistent with similar research conducted by other entities. There was limited, if any, prior research that exactly matched this study, but there were three studies that were similar and aided this researcher immensely. The findings of other researchers indicated patterns that were similar to the findings reported here.

The NIST study, conducted during the suppression phase, revealed high levels of CO, CO_2, hydrogen chloride, and HCN, but did not reveal any substantial VOC or aldehyde compounds (Gann et al., 2003). The Phoenix study, conducted during overhaul, revealed high levels of CO, aldehydes, VOCs, PNAHs, and acids (Bolstad-Johnson et al., 2000). This study, conducted between the overhaul phase and the investigation phase, revealed levels of aldehydes, and VOCs. Finally the ATF study, conducted during the investigation phase, revealed high levels of HCN, acids, aldehydes, polycyclic aromatic hydrocarbons, and VOCs (Kinnes & Hine, 1997).

All of the prior studies when compared to the present study yielded very similar results. The one noted difference between the prior studies and this current study rests in the activity level within the structure. The three prior studies had no work-level restrictions and allowed normal fireground functions to continue, whereas this study restricted the activity level within the structure. The implications of this situation are that the various toxic compounds are ever-present, but some compounds may require a degree of agitation to become airborne and ultimately detectable by researchers.

Any number of toxic compounds is present in a burnt structure in every timeframe tested. The current practice of removing SCBAs based on acceptable CO, oxygen, and LEL levels is not an indicator of a safe environment and should be discontinued. While a clear linkage was not drawn and may never be drawn between the increased cancer rates among firefighters and the exposure to toxic compounds, the prudent leader should anticipate this linkage and take all steps to reduce the risk.

The fire service, along with supporting agencies such as OSHA, NIOSH, and NFPA®, is working diligently to provide firefighters with the best protective equipment possible. The unfortunate result is that there is an added physical burden placed on the wearer of an SCBA. The results of this study indicate that wearing this equipment at all times is prudent. Many fire departments currently utilize an SCBA during suppression activities, but neglect to do so, by policy, during the remaining phases of the fire scene. In terms of the fire scene continuum, it is apparent that the majority of loss stoppage occurs during the suppression phase. This situation allows the fire scene to proceed at a more controlled pace through the remaining phases of the incident. Perhaps by conducting deliberate rehabilitation of firefighters, rotating personnel properly, and slowing the pace of the scene, the added burden of SCBA usage can be decreased sufficiently.

The implications of this study for the members of the fire service are not easily measured but could be very significant. Cancer and other malignant ailments are often difficult to trace to their cause. All indications from this research consistently suggest that breathing toxic compounds will increase an individual's risk of cancer. Proactively restricting the amount of time that fire service members are allowed to operate at structure fires without SCBAs should significantly reduce the projected health risk in terms of both the acute and chronic sense.

Organizationally, the fire service led by the IAFC, USFA, the IAFF, and others have diligently worked to identify and steer the fire service clear of pitfalls that act as impediments to forward progress with regards to safety. The IAFF is now mounting a strong campaign aimed at reducing the acute problem of CO poisoning of firefighters. This research indicates that the respiratory protection problem is not limited to CO poisoning. This research suggests that coupling the CO poisoning efforts of the IAFF with the results of this research could, in fact, save just as many lives in the chronic sense as the IAFF CO initiative will in the acute sense.

Policy Recommendations

This research revealed that the members of the fire service, operating in the current fashion, are being exposed to potentially harmful compounds. Therefore, it is recommended that the fire service leadership stop allowing members to conduct overhaul and postfire functions in and around burnt structures without the respiratory benefit of an SCBA. Technically, this can easily be accomplished by adjusting fire department policies to reflect these changes as the draft policy in the Appendix indicates. The incident command system should be in place and remain so throughout the overhaul process to ensure that firefighter rehabilitation is conducted, accountability is maintained, and respiratory policies are being followed.

It is also very important for all fire departments to secure surveillance systems for monitoring occupational illness and supply personal protective equipment (PPE) to employees with the realistic goal of minimizing the occurrence of adverse health outcomes associated with the work. All PPE, especially SCBA masks, should be fit-tested per applicable standards and manufacturers' recommendations. All firefighters should be encouraged to partake in prevention training programs. The training programs should be directed at eliminating adverse health outcomes before they occur.

Conclusion

The firefighter's workplace is intimately connected with his or her health, wellness, and mortality. Firefighters are often affected in some way by exposure to poor air quality and environmental hazards that are associated with their work. Further research should be conducted on a much larger scale to determine why firefighters are experiencing an increased rate of cancer. Cancer is an unacceptable and unjust end to one of the noblest of careers, especially if the cause of the cancer rests within the career. It is the hope of this researcher that a more focused research effort be placed on the topic of chronic health issues as they pertain to firefighters.

The implications of this study should be communicated to other stakeholders, including, but not limited to USFA, IAFF, IAFC, and others that may benefit from the knowledge of these results. The increased potential for harm to firefighters that would result from not dispersing this information could be substantial.

References

Bledsoe, B. E. (2008). *Carbon Monoxide Poisoning: Implications for the Fire Service*. Midlothian, TX: Cielo Azul Publications.

Bolstad-Johnson, D. M., Burgess, J. L., Crutchfield, C. D., Storment, S., Gerkin, R., & Wilson, J. R. (2000). Characterization of firefighter exposures during fire overhaul [Abstract]. *American Industrial Hygiene Association Journal, 61*(5), 636–641.

Coleman, J., Hiraki, R., Weir, C. J., Seidel, G., Schwering, J., Dunne, T., … Bucy, M (2007). SCBA use during overhaul. *Fire Engineering*, *160*(8), 34–44.

Environmental Protection Agency (EPA). (2007). *Basic information: Organic gases.* Retrieved February 10, 2008, from http://www.epa.gov/iaq/voc.html

Friis, R. (2007). *Essentials of environmental health*. Sudbury, MA: Jones and Bartlett Press.

Gann, R. G., Averill, J. D., Johnsson, E. L., Nyden, M. R., & Peacock, R. D. (2003). *Smoke component yields from room-scale fire tests* (NIST Technical Note 1453). Washington, DC: U.S. Government Printing Office.

Health effects of wood smoke pollutants. (2001). *Burning Issues*. Retrieved January 14, 2008, from http://burningissues.org/www-old/tables/health-effects-table.html

Kinnes, G. M., & Hine, G. A. (1997). *Health hazard evaluation report* (HETA 96-0171). Cincinnati, OH: National Institute of Occupational Safety and Health (NIOSH) Publications Office.

Lee, M. (2007). *Cyanide poisoning poses hidden threat*. Retrieved 1-29-2008 from http://www.firerehab.com/cyanide/news/283219

LeMasters, G. K., Genaidy, A. M., Succop, P., Deddens, J., Sobeih, T., Barriera-Viruet, H., . . . Lockey, J. (2006). Cancer Risk Among Firefighters: A Review and meta-analysis of 32 studies. *Journal of Occupational and Environmental Medicine, 48*, 1189–1202.

Miller, L. A. (2004). *Hazardous Materials for First Responders* (3rd ed.). Stillwater, OK: Oklahoma State University, International Fire Service Training Association (IFSTA).

Murphy, E. (2005). *Promoting healthy behavior* (Health Bulletin 2). Washington, DC: Population Reference Bureau.

National Fire Protection Association® (NFPA®). (2007). NFPA 1981: *Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services. Avon*, MA: NFPA® Publications.

National Institute of Occupational Safety and Health (NIOSH). (2004). *Respirator selection logic sequence* (NIOSH Publication No. 2005-100). Retrieved February 7, 2008, from http://www.cdc.gov/niosh/docs/2005-100/chapter3.html

National Institute of Occupational Safety and Health (NIOSH). (2007). *Preventing fire fighter fatalities due to heart attacks and other sudden cardiovascular events* (U.S. Department of Health and Human Services [DHHS] Publication No. 2007-133). Cincinnati, OH: NIOSH-Publications Dissemination.

Occupational Safety and Health Association (OSHA). (1986). *Selected Polynuclear Aromatic Hydrocarbons (PNAHs)*. Retrieved January 25, 2008, from http://www.osha.gov/dts/sltc/methods/organic/org058/org058.html.

Occupational Safety and Health Association (OSHA). (2003a). *Volatile organic compounds in air*. Retrieved February 3, 2008, from http://www.osha.gov/dts/sltc/methods/partial/pv2120/pv2120.html

Occupational Safety and Health Association (OSHA). (2003b). *Styrene*. Retrieved February 8, 2008, from http://www.osha.gov/SLTC/styrene/index.html

Occupational Safety and Health Association (OSHA). (2007). "Respiratory protection." *Occupational Safety and Health Standards, 29* CFR 1910.134. Retrieved February 7, 2008, from http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table

Schlecht, P. C., & O'Connor, P. F. (Eds.). (2003). *NIOSH Manual of Analytical Methods* (*NMAM*) (4th ed.). (U.S. Department of Health and Human Services [DHHS] Publication 2003-154). Washington, D.C.

Skolnick, R. (2008). *Essentials of Global Health*. Sudbury, MA: Jones and Bartlett Press.

United States Fire Administration (USFA). (2007). *Firefighter fatalities in the United States in 2006*. U. S. Department of Homeland Security. Retrieved January 28, 2008, from http://www.usfa.dhs.gov/downloads/pdf/publications/ff_fat06.pdf

Appendix

Required Use of SCBA and PPE

Purpose

Enhance the safety of line personnel by requiring the use of SCBA during specific emergency operations and training exercises.

Objectives

The intent of the SCBA policy is to avoid any respiratory contact with products of combustion, superheated gases, toxic products, or other hazardous contaminants at any time that these products are present or suspected to be present.

Responsibility

All personnel expected to respond and function in areas of atmospheric contamination shall be equipped with SCBA and trained in its proper use and maintenance.

Procedures

1. The ______ Fire Department shall provide an SCBA mask, regulator, voice amplifier, and harness with tank to each interior qualified firefighter. Equipment is positioned on Fire Department apparatus. Each firefighter will be responsible for the proper use and function of the equipment.

2. SCBA shall be worn and used by all personnel operating:

   a. Inside of structures that have had or are experiencing a fire. The SCBA shall be worn during all phases of the operation up to and including suppression, overhaul, and the investigation (with exceptions as noted in Section c).

   b. Outside of structures that have experienced a fire. The SCBA shall be worn when outside the structure if the firefighter is in close proximity to or breathing/smelling smoke or burnt material from the structure.

   c. For various investigative functions. Fire investigation personnel will occasionally enter a fire structure before overhaul and shall wear an SCBA during these times. Once overhaul is completed and the scene is relinquished to the investigation team, every effort will be made to wear an SCBA when practical. It is understood that some investigative functions require unobstructed vision. The decision of when and what type of respiratory protection will be worn for investigations ultimately rests with the lead investigator by permission of the Fire Chief.

   d. Above an active fire area.

   e. In an atmosphere that is oxygen deficient.

   f. During vehicle fires and dumpster fires.

   g. When $C0_2$ levels are between 20 and 23 percent.

   h. When LEL levels are below 10 percent.

The use of full turnout gear is required during all fireground and rescue operations. This gear includes coat, bunker pants, Nomex® hood, boots, gloves, helmet, goggles or appropriate approved eye protection, and SCBA when required. This requirement does not include situations involving water rescue, confined space, hazardous materials, or emergency medical service (EMS). In these incidents, responders follow their respective standard operating procedures (SOPs).

About the Author

Greg Wyant currently serves as the Division Chief of Training and Safety at the Noblesville Fire Department in Noblesville, Indiana. He holds a B.S. degree and a Master of Public Management (MPM) degree from Indiana University at Kokomo. He is a graduate of the Executive Fire Officer Program at the National Fire Academy and has obtained his Certified Fire Officer Designation (CFOD) from the Center for Public Safety Excellence. Greg is a 16-year veteran of the Noblesville Fire Department. Greg can be contacted at: **gwyant@noblesville.in.us.**

Book Review

Review of:

Johnson, W. B., & Harper, G. P. (2005). *Becoming a leader the Annapolis way: 12 combat lessons from the Navy's leadership laboratory.* New York: McGraw-Hill. 257 pp. ($21.95 hardback).

Not unlike our nation's sailors and marines, firefighters are often called to place themselves in harm's way with little notice. As in the naval service, poor leadership in the fire service can have devastating consequences. While the U.S. Navy realized the need to formally prepare its leaders in 1845 with the admission of the first cadets to the U.S. Naval Academy, the fire service has been slower to embrace formalized leadership training. While the Executive Fire Officer Program at the National Fire Academy and management programs offered via various academic institutions have improved the situation dramatically in recent years, it remains clear that formalized leadership training remains out of the grasp of many fire officers. For these officers, Johnson and Harper have managed to offer a succinct treatise on the subject.

The authors are certainly qualified to speak on the subject of leadership development as it is practiced at the U.S. Naval Academy. Professor Johnson is an associate professor of psychology at the Academy while Harper is a retired Navy captain and aviator. It appears that both men understand the gravity of the academy's mission well:

> *To develop midshipmen morally, mentally, and physically, and to imbue them with the highest ideals of duty, honor, and loyalty in order to provide graduates who are dedicated to a career of naval service and have potential for future development in mind and character to assume the highest responsibilities of command, citizenship, and government.*

If we merely substitute the words fire officer for midshipmen and fire service for naval service we can see how readily applicable the lessons offered by Johnson and Harper are to the fire service.

To this end, the authors offer a series of 12 lessons (which on their face seem relatively self-explanatory, but upon deeper reflection become increasingly sophisticated and difficult to put into practice). Their recommendations include the suggestions to *take oaths and make commitments, follow first, character counts, and IQ is not enough.* The book illustrates each of the twelve lessons via a series of anecdotes. For example, in their chapter "IQ is not Enough," the reader is provided the example of a fictional composite officer, Lt. Commander Barney *the Bull* Kaufman, whose micromanagement and poor interpersonal skills lead to his downfall. I will not spoil the reader's anticipation by elaborating further. Instead, I will leave the development of their thesis to the authors who are far more capable than me.

The time has long since passed when firefighters should be promoted to leadership positions based solely upon their technical prowess. The ability to force a tough door or *make* a long hall, while necessary, are not sufficient conditions to ensure effective leadership. Professor Johnson and Captain Harper have provided aspiring fire service leaders with a valuable tool they can use as they prepare themselves to lead firefighters into harm's way.

Lance C. Peeples
Firefighter in St. Louis County, Missouri

Journal Information

The *International Fire Service Journal of Leadership and Management* is a refereed or peer-reviewed journal published biannually. It is published by Oklahoma State University (OSU), International Fire Service Training Association (IFSTA), and Fire Protection Publications (FPP). Detailed information about the journal is provided below.

Preparing an Article for Publication in IFSJLM

Articles submitted for review should be in general conformance with the guidelines outlined below. If the manuscript is accepted for publication it is the responsibility of the author(s) to prepare a final manuscript that conforms to *IFSJLM* style requirements and to submit to the editor one hard copy of the final paper and one electronic copy of the paper as a Microsoft Word© file.

Articles should be no longer than 30 pages in length (including tables, figures, references, and notes). Research notes should not exceed 18 total pages. Manuscripts must be typed, double-spaced, on paper sized 8.5 by 11 inches, and use standard margins.

Given the readership of the journal, articles should avoid technical jargon, mathematical modeling, etc. and be of interest to both academics and practitioners. Articles using survey and statistical data are encouraged, but information and findings should be communicated clearly and concisely.

Tables and figures should not be placed in the text. Each table or figure should appear on a separate piece of paper and placed at the end of the manuscript. In the text of the manuscript, indicate approximate placement of tables and figures by using inserts – [e.g., Table 1 About Here].

On a detachable first page of the manuscript include the title of the manuscript and all identifying material for each author – i.e., names, affiliations, mailing addresses, telephones numbers, and email addresses. If the article is co-authored, place an asterisk by the name of the person who will serve as a point of contact. Also on this page provide a short 75 to 100-word biographical sketch that includes information about each author, their positions, their organizations, and previous publications and/or professional interests.

A 50 to 75-word article abstract should accompany an article. The abstract should concisely identify the research question studied, theoretical framework employed, methods used, and major findings of the research.

IFSJLM uses the American Psychological Association (APA) reference style to cite literature used in the article. This author-date method of citation requires that you cite the author's surname and date of publication (e.g., Neal, 2000). To cite a specific part of a source, such as a quote from an article, provide the author's surname, date of publication, p. for page and page number (e.g., Neal, 2000, p. 42). For complete information on using the APA style see the 6th edition of the Publication Manual of the American Psychological Association. This manual can be found at your local bookstore, research library, or can be purchased on-line at: http://www.apastyle.org/. Sources cited in the text should be listed in a references list following the style also outlined in the APA Manual.

Submission Requirements and Information

All manuscripts submitted to *IFSJLM*: (1) must be original (not previously published in whole or part in either print or electronic format) and (2) must not be under review for publication elsewhere. Upon acceptance and publication, the Board of Regents for the State of Oklahoma retain the exclusive rights to publication. Journal articles and book reviews are copyrighted by the Oklahoma State University Board of Regents, with all rights reserved. Copyright assignment is a condition of publication. Authors will be provided and will be asked to sign a copyright assignment. Crown manuscripts are exempt from the copyright requirement. Articles submitted for review are not returned. Electronic submissions are NOT accepted.

Please submit four hard (4) copies and one electronic copy in Microsoft Word© format of an article or three hard (3) copies and one electronic copy in Microsoft Word© format of a book review to: Robert E. England, Editor, *International Fire Service Journal of Leadership and Management*, Fire Protection Publications, Oklahoma State University, 930 N. Willis St., Stillwater, Oklahoma 74078-8045.

Article Review Process

All articles, unless otherwise noted upon publication, submitted to *IFSJLM* are peer reviewed. *IFSJLM* uses a double-blind review process: The author does not know who reviewed the article and the reviewers do not know who wrote the article. Thus, it is important that the author only be identified on the cover page. The editor will remove the cover page before the article is sent out for review. Avoid making references to previous research by referring to oneself in the third person and referencing such work. The review version of the article should not thank colleagues for reviewing a draft of the manuscript or state that an earlier version of the paper was presented at a conference. If accepted for publication, the final version of the article can contain such information. As they read an article, peer reviewers are trying to answer the following questions. Is the material in the article accurate and relevant? Is the article grounded in theory? Are the methods used in the study appropriate and appropriately used? Does the article significantly add to our understanding of fire leadership and management? If not, the article may merit publication, but not in *IFSJLM*.

Reviewers are asked to evaluate articles within a 30- to 45-day time frame. If they cannot meet this parameter, they are instructed to inform the editor as soon as possible so that a new reviewer can be selected. After the editor receives all peer reviews, a decision is made to (1) accept the article for publication (subject to preparation guidelines and editing by journal staff), (2) accept the article pending specific revisions required by the peer reviewers, (3) allow the author to "revise and resubmit" the article for review based on general guidelines suggested by the reviewers, or (4) reject the article. Articles accepted under the "revise and resubmit" category are sent out for a second round of reviewers with no implied guarantee of acceptance The editor of *IFSJLM* decides which articles will appear in the journal based on the peer review process. Decisions made by the editor are final. Reviewers' comments are made available to manuscript authors. Book reviews are NOT peer reviewed. The journal editor is responsible for deciding which book reviews to include in *IFSJLM*.

Journal Information

Book Reviews

Book reviews can be of a single book or several books that are tied together by a common theme (e.g., four different books on the topic of terrorism). Book reviews should not exceed five (5) double spaced 8.5" by 11" pages using standard margins. Book reviews are not peer reviewed and are published at the discretion of the editor.

Book reviews should provide thoughtful analyses of the importance, utility, and/or meaning of a single book or several books to the development of the international fire service. In other words, the review should not focus on the merits and demerits of the book itself, but rather should focus on the nexus between the message of the book(s) and the development of fire leadership and management. Book reviews must focus on leadership and management issues, topics, and themes.

Electronic Access

Electronic access to the journal is not available at this time.

Permissions:

Contact: Susan F. Walker, Fire Protection Publications, Oklahoma State University, 930 N. Willis St., Stillwater, Oklahoma 74078-8045; E-mail: Royals@osufpp.org, 405-744-7046

Subscriptions

IFSJLM is published biannually (usually, but not necessarily in January and July). Subscriptions prices are: $20 per year for students and $50 for all other individuals and institutions. A flat fee of $10 per year is added to all international subscriptions. Proof of student status is not required; we rely on professional ethics.

Please complete this page and submit to:

IFSJLM-Subscriptions
C/O Susan F. Walker
Fire Protection Publications
Oklahoma State University
930 North Willis St.
Stillwater, Oklahoma 74078

Name: ____

Address: ____

____

Zip/Postcode: ____

Phone Number: ____

Email: ____

Payment: If paying by credit card, please call 1-800-654-4055. We accept Visa and Mastercard. Please have your card number and card expiration date handy. If paying by check: Make payable to Fire Protection Publications. Remember to add $10 per year if the journal is being delivered outside of the United States.

DISCLAIMER

The International Fire Service Journal of Leadership and Management is an academic journal. As such, articles that appear in the journal are "approved" for publication by two to four anonymous members of the Journal's Editorial Board and/or ad hoc peer reviewers. As editor I do not choose the articles that appear in the journal nor do I edit the content or message of an article once accepted. The copy editor and I only edit for style and readability.

The ideas and comments expressed in an article are those of the author(s) and should not be attributed to members of the Journal's production team, Editorial Board, or to the sponsors of the journal--which are Oklahoma State University (OSU), the International Fire Service Training Association (IFSTA), and Fire Protection Publications (FPP). We simply publish that which has been peer approved. If for some reason an article causes consternation, you, the reader, are urged to contact the author directly to engage in a dialogue; that is how academic journals work. An author's e-mail is provided with each article. Or, if you wish, you can submit a three to five page "response" to an article in which you outline significant theoretical and or methodological objections to an article. The response may be accepted for publication. If so, the author will be allowed to offer a three to five page "rejoinder" to the response. This is how academic journals work. For the most part, however, you should direct your comments directly to the author. Responses and corresponding rejoinders will be rare and will be published at the discretion of the Journal editor. Journals are intended to stimulate debate and conversation. If you do not like what you read, contact the author or write an article for peer review that offers an alternative perspective.

Dr. Robert E. England
Editor

Published in cooperation with Oklahoma State University, Fire Protection Publications, and the International Fire Service Training Association.

Fire Protection Publications

International Fire Service Training Association