DEVELOPING A MODEL FOR THE ANALYSIS OF ORGANIZATIONAL CULTURE: AN APPLICATION TO SAFETY CULTURE IN THREE MUNICIPAL FIRE DEPARTMENT'S

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Developing a model for the analysis of organizational culture: an application to safety culture in three municipal fire departments.

Thesis directed by Professor Peter deLeon.

ABSTRACT

The high level of firefighter injuries and fatalities continues to be a significant problem for local government. The purpose of this dissertation is to determine whether the construct of organizational culture can be applied within the context of municipal fire service organizations in the United States as a means for the assessment and analysis of safety culture. To achieve this purpose, a conceptual model of safety culture is developed along with the variables and instruments necessary to measure safety culture in fire service organizations. Three hypotheses about the nature of the relationships among the variables are tested primarily through multiple regression, factor analysis, and analysis of variance.

Results of the analysis of the data collected from three municipal fire department's supports the proposition that the construct of safety culture can be used to analyze and assess safety culture in fire service organizations. The instruments designed to measure the variables of safety culture are shown to be valid and reliable and the results demonstrate that the three hypotheses that predict the nature and characteristics of the relationship among the variables of safety culture are supported. Specifically, the data support the hypothesis that the two independent variables (Safety Management Systems and Safety Related Behaviors) predict a significant amount of variance in the dependent variable (Organizational Safety Climate). In addition, the data support the hypotheses that the level and strength of scores for all three variables of Safety Culture vary across categories of Job Function and Years of Service.

The form and content of this abstract are approved. I recommend its publication.

Approved: Peter deLeon

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CHAPTER I: INTRODUCTION

More than six times as many firefighters are killed and injured in the United States than in any other industrialized nation. The high rate of firefighter injuries and fatalities has been a significant and costly problem for the fire service and for local government for decades. From 1990 to 2009, more than 1.7 million firefighter injuries occurred and 1950 firefighters were killed in the line of duty. During this same time period, numerous changes have been made in fire service related technology, standards, apparatus, and equipment in an effort to reduce firefighter injury and fatality rates. Despite these efforts, there has been very little change in firefighter injury and fatality rates over the last twenty years. Each year, an average of 87,000 firefighters is injured and 97 die in the line of duty.

Past and present approaches to improving safety performance in the US fire service have not been effective. In comparison, other high-risk occupations and fire service organizations in other counties have been able to dramatically reduced injury and fatality rates by assessing, analyzing, and changing variables of organizational culture relevant to safety. Leaders in the US fire service have just recently recognized that organizational culture may be an important factor that has prevented change and limited improvement in safety performance (FEMA, 2004). It is unclear, however, whether this approach would have the same impact within US fire departments because they operate with lower levels of regulatory control than other high risk occupation, such as chemical manufacturing and nuclear power, and with much higher levels of autonomy and cultural heterogeneity than fire services in other industrialized nations, such as the United Kingdom.

As a consequence, there is a critical need to determine whether this approach to improving safety performance by assessing, analyzing and changing organizational culture will produce the same results in US fire departments. The purpose of this dissertation is to determine whether the construct of organizational culture can be applied within the context of municipal fire service organizations in the United States as a means for the assessment and analysis of safety culture. As such, this dissertation can be considered an exploratory pilot study, since no previous studies have been conducted along this line of research.

In order to determine whether the construct of organizational culture can be applied within the context of the US fire service this study will, first, propose a theoretical framework that explains how organizational culture influences firefighter injury and fatality rates. Second, a conceptual model of organizational culture relevant to safety is developed, including the variables and measures necessary to apply the model within the context of the fire service. Third, the relationship among the variables is explored to determine if the model and measures are a reliable and valid representation of safety culture within this context. Results of this research will be important for future research into the relationship between safety culture and firefighter injury and fatality rates, as well as for the development of intervention programs designed to improve safety culture and reduce injury and fatality rates throughout the fire service.

To determine how organizational culture influences safety performance, however, it is important to understand the nature and characteristics of firefighter injuries and fatalities. This first chapter describes the problem of firefighter injuries and fatalities in the US fire service. Information is presented on the historically high rates of firefighter injuries and fatalities and on the nature and characteristics of firefighter casualties. In addition, a comparison of injury and fatality rates between the United States and the United Kingdom is made for the purpose of highlighting the range of potential improvements that can be made in safety performance in the US fire service. Also, data on the economic impact of firefighter injuries and fatalities on local government is presented to amplify the importance of this problem from a public management perspective. The section on the problem of firefighter injuries and fatalities concludes with a discussion of how organizational culture may be an important factor that has limited the success of previous efforts to improve safety performance in the US fire service and a discussion on the importance of the assessment and analysis of safety culture as a first step in reducing firefighter injuries and fatalities.

The Problem

Firefighter Injury and Fatality Rates

A firefighter is any member of a paid, volunteer, or combination fire department or fire district who responds to fires and other emergencies for the purpose of protecting life and property. While the term usually refers to a specific rank within a fire department, the term is used in this dissertation to refer to all ranks with a fire department, which includes firefighters, company officers, and chief officers.

Firefighter injuries and fatalities have been a significant problem for fire service organizations in the United States for decades. According to the data from the NFPA, during the years from 1990 to 2009, an average of 98 firefighters has died each year in the line of duty. Over the same time period, an average of 87,000 firefighters has been injured every year. Over the last twenty years, the firefighter fatality rate has ranged from a low of less than four firefighter deaths per 100,000 fires in 1992 to almost seven firefighter deaths per 100,000 fires in 2004. In terms of the overall trend over the last twenty years, the firefighter death rate has increased from five firefighters per 100,000 fires in 1990 to over seven firefighters per 100,000 fires in 2008 (NFPA, 2009).

Firefighting is admittedly a hazardous occupation, and some may argue that firefighter injuries and fatalities are simply an inherent part of the work that firefighters perform. However, other industrialized nations have much lower firefighter fatality rates per ten million population. The International Association of Fire and Rescue Service, Center of Fire Statistics, produces annual statistical reports on firefighter fatality rates for countries around the world (CTIF, 2006). These are calculated for member nations based on the firefighter fatality rates per ten million population. A comparison of the US with other nations provides an indication of the magnitude of the difference in firefighter fatality rates. During the period from 1996 to 2002, the US averaged 3.5 firefighter fatalities per ten million population. During that same time period, New Zealand, Italy, Japan, the United Kingdom, Canada and Sweden averaged less than one firefighter fatality per ten million population.

A comparison of the rate of firefighter fatalities per 100,000 firefighters also shows that the US fire service has the highest rate of firefighter losses when compared to other western industrialized nations. Data from the Center for Fire Statistics (CTIF, 2008) indicates that the US fire service suffered an average of 8.5 firefighter fatalities for every 100,000 firefighters from 2002 through 2006. The country with the next highest rate of firefighter fatalities was France with a firefighter fatality rate of 6.4 fatalities per 100,000 firefighters. Other countries included in the study had even lower rates of firefighter fatalities. These included Switzerland (5.0), Russia (3.1), Germany (1.5), and Austria (1.0). Several countries have a fatality rate so low compared to the number of firefighters that the fatality rate was zero. These included the UK, Sweden, and New Zealand.

Some members of the fire service may also argue that although the US fire service has a higher rate of firefighter injuries and fatalities, the higher injury and fatality rates are a reflection of a higher level of risk taking, and that the higher levels of risk taking result in higher levels of operational performance in terms of property and lives saved. A comparison with other industrialized nations indicates that this proposition does not appear to hold up under examination.

Two measures of fire service performance that are commonly used to make international comparisons of fire service performance by the World Fire Statistics Center are direct fire loss as a percentage of the Gross Domestic Product and the civilian fire death rate per 100,000 fires (CTIF, 2006). Examination of the data in direct fire loss for eight countries from 1998 to 2005 indicates that the average direct fire loss as a percentage of GDP for the UK, Germany, France, New Zealand, Australia, Canada and the US was 0.160 percent. If higher levels of firefighter injuries and fatalities are an indication of higher levels of performance, then it would be reasonable to expect that the US would have a lower than average level of direct fire loss. The average direct fire loss in the US was 0.162 percent, indicating that although the US fire service has a high firefighter fatality rate, the operational performance of the US fire service is about average in terms of direct fire loss.

A comparison of the civilian death rate for the same countries indicates that the civilian death rate for the US is the highest of all eight countries at 1.45 deaths per 100,000 fires, significantly above the average of one civilian fire death per 100,000 fires. If higher levels of firefighter injuries and fatalities were an indication of higher levels of performance, then it would be expected that the US would have a low level of civilian fire deaths. The data indicate that although the US fire service has a high firefighter fatality rate, the civilian fire death rate for the US is actually higher than all other nations used in this comparison.

A comparison of the US and UK firefighter fatality rates provides a more detailed example of the differences in safety performance between the US and other industrialized nations. The UK provides a good comparison because the fire service in the UK operates in ways that are similar to US fire departments and collect similar data that can be used for making comparisons. For example, the number of fire fighter deaths in the UK from 1990 to 2006 is less than one fire fighter per 100,000 fires (FBU, 2008). A comparison of the US and UK firefighter death rates for the years from 1990 to 2006 is provided in Figure 1. Based on the calculated trend line, the firefighter death rate for the US is four to six times higher than for the UK. In addition, the firefighter death rate in the US is increasing, while the firefighter death rate in the UK is decreasing. If the US fire service had the same firefighter fatality rate at the UK, then the fatality rate would be reduced from an average of 98 firefighter fatalities per year to 7 firefighter fatalities per year. If the firefighter fatality rate had been reduced to seven per year over the last 20 years, the lives of over 1800 firefighters would have been saved.

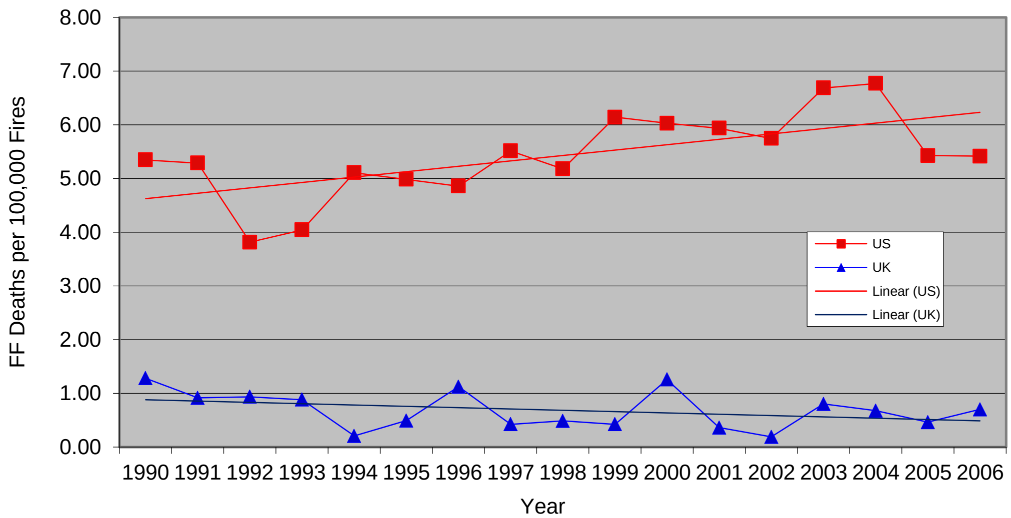

Figure 1. Comparison of US and UK Firefighter Fatality Rates from 1990 to 2006

Injury rates among firefighters in the US have also increased slightly over the time period from 1990 to 2009. Across this time frame, an average of over 87,000 firefighters are injured each year, while the overall trend in firefighter injuries per 100,000 fires has increased from approximately 4,900 injuries per 100,000 fires to slightly over 5,800 injuries per 100,000 fires. The firefighter injury rate in the US is also substantially higher than that of the UK, although it is difficult to make accurate comparisons because of the different methodology used to calculate work-related injuries.

In the US, injury data indicate whether work time was lost, but do not specify how many workdays were lost. According to the Occupational Safety and Health Administration, any injury that requires medical treatment more than simple first aid must be reported whether work time was lost or not. In the UK, only injuries that result in three or more lost workdays are considered a reportable injury. However, in a twelve-year study that examined the correlates of work injury and duration in firefighters in a major Midwestern US city, the average injury duration or work time lost in the sample of firefighters that incurred an injury was approximately ten calendar days, with a standard deviation of fifty-six calendar days (Liao, Arvey, Butler, & Nutting, 2001). Therefore, approximately fifty percent of firefighter injuries resulted in ten or more days of lost work time in this sample. Another research study on the cost and consequences of firefighter injuries and fatalities estimates that thirty five percent of injuries result in lost time from work (NIST, 2004).

The later study indicates that only thirty-five percent of the total number of firefighter injuries result in lost work time. The former study indicates that the average amount of lost work time once an injury occurs is approximately ten days, at least in the one sample. Because the sample has a relatively low mean and a high standard deviation, a standardized score for three days of lost work for the US firefighters in the study is only -0.05 standard deviations below the mean, so the percentage of injuries resulting in three days of lost work time is essentially equivalent to the mean. In other words, slightly over fifty percent of the injuries that involved lost work time result in the loss of three or more days work time.

The US firefighter injury rate for 1995 to 2006 was 4,853 injuries per 100,000 fires. When this figure is reduced by thirty-five percent to account for the percentage of injuries that involve work time lost, the average falls to 1699 injuries resulting in lost workdays. If this figure were reduced by another fifty percent to estimate the number of injuries resulting in at least ten days of lost time, the firefighter injury rate in the US would average 847 injuries per 100,000 fires. Although the number of injuries that result in lost time is significantly lower than the total number of injuries to firefighters in the US, this injury rate is still extremely high in comparison to the UK firefighter injury rates over the years from 1995 to 2006, as shown in Figure 2. Over the years from 1995 to 2006, firefighter injury rates in the UK with at least three days of lost work time averaged 129 injuries per 100,000 fires, while the equivalent injury rate in the US is approximately 847 injuries per 100,000 fires. Although a rough estimate, these figures demonstrate that the US firefighter injury rate is very likely to be over six times higher than the UK injury rate. In addition, Figure 2 shows that the injury rate in the US is increasing while the UK injury rate is decreasing.

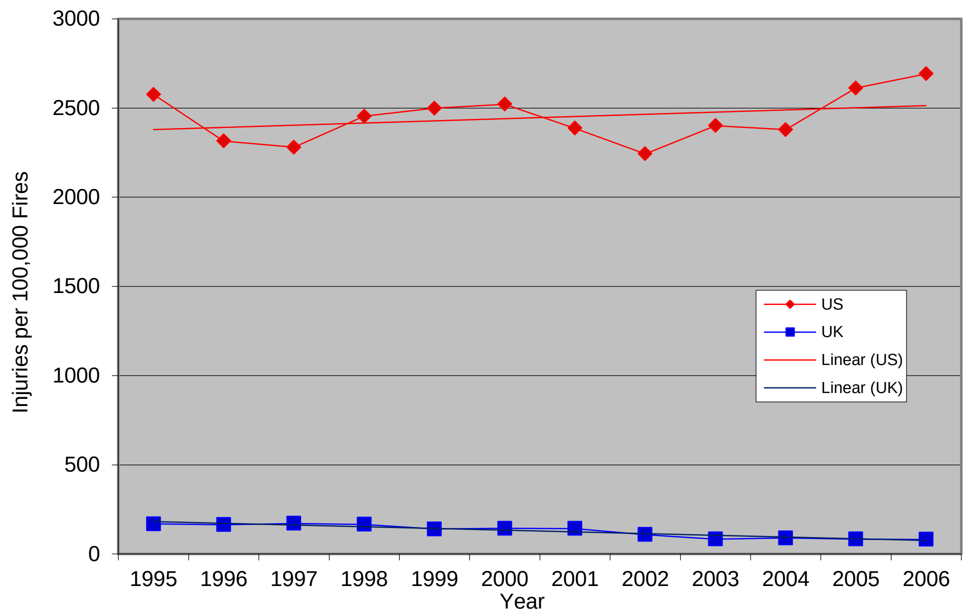

Figure 2. Comparison of US and UK Firefighter Injury Rates from 1995 to 2006

The comparison between the fire services of the US and the UK presents a startling contrast in terms of safety performance, measured by the rates of firefighter injuries and fatalities, and in terms of operational performance, measured by direct fire loss and civilian fire death rates. Both safety performance and operational performance are significantly lower in the US than in the UK fire services. One of the reasons for this difference may be the result of the dramatic shift in culture that has occurred within the UK fire services. Within the last 15 years, the UK fire service has shifted the focus of their operations from an approach based on the type, speed and weight of the response to fires and other emergencies to a focus on a risk assessment approach. Based on a study of the UK fire service conducted in 1998 (FEPD, 1998), the national government found that the approach used at that time was inflexible and inefficient, and that it was not the most effective operational approach to emergency incident operations for the fire service. They recommended that the fire service change their approach going forward and that the approach should be based on the principles of risk assessment as the most flexible, efficient, and effective way to manage fire service resources. The study recommended that additional research be undertaken to complete the necessary took kit that would provide the guidance necessary to implement the transformation of the fire service from a response based approach to a risk based approach for fire service operations.

Guidance for this transformation was provided by the national government and in 2006, a toolkit was developed for the purpose of providing the fire service with the ability to assess service delivery, assist with planning for performance improvement, and to promote sharing of best practices. One of the main themes of the Fire Rescue Operational Assessment Toolkit (DCLG, 2006) was firefighter health and safety. In fact, the entire toolkit was based on the approach used by the Health and Safety Executive office for the management of safety programs throughout the UK, which is based on four key areas. These include Policy, Organizing, Planning and Implementing, and Measuring and Reviewing Performance. These key areas are defined as follows:

- Policy: safety policies are established, they are current, meet legal requirements, and are communicated and implemented.

- Organizing: arrangements are in place to maintain management control of safety and service delivery, to promote cooperation, communications, and the competence of employees

- Planning and Implementing: a planning system is in place to achieve objectives for safety and service delivery, to develop and manage risk control systems and appropriate workplace precautions, to prioritize risk assessment, to balance resources against risks, and to improve and change systems as hazards and risks change

- Measuring and Reviewing Performance: a measuring process is in place to assess the essential elements of safety and service delivery, particularly the effectiveness of plans, procedures and systems of work against performance targets.

This format was used to assess the risk to members of the fire rescue authorities and the risk to communities throughout the UK, which represents an assessment of the safety performance and operational performance of the UK fire services using a risk assessment approach. A transformational change in approach like what has taken place in the UK has never taken place in the US fire service, partly because the national level government does not have the same level of influence on local fire department operations. One of the significant contributions of this dissertation, however, is that the same format used by the UK fire service for their risk-based operational assessment is used to describe and define one of the variables of safety culture. Safety management systems are one of the variables of safety culture that will be described in more detail in the chapter on methodology, but is important to mention here that the same key areas used to assess the entire UK fire service is used to assess a critical element of safety culture in this dissertation, and can be used in future studies to assess safety management systems throughout the US fire service. At some point, it may also be possible to compare at least this variable of safety culture across the UK and US fire services to and how this variable influences safety performance in the fire service organizations of both countries.

Types and Causes of Firefighter Injuries and Fatalities

Data on the types and causes of firefighter casualties can be used to understand the nature and characteristics of the activities firefighters are engaged in when injuries or fatalities occur. The activities and behaviors involved in firefighting and other emergency service operations create hazards that put firefighters at risk. For example, firefighters frequently engage in efforts to ventilate the roof of a building that is on fire in order to allow heat and smoke to escape from the structure. The act of using ladders to put firefighters two or three stories above ground who then use power and hand tools to put a hole in the roof right above the fire creates the potential for firefighters to be injured or killed. Analysis of the injury and fatality data on such activities provides valuable information on the behaviors that should be targeted for change in order to effectively reduce casualty rates.

Several factors have been consistently identified as potential causes of firefighter deaths and injuries. The National Fire Protection Association (NFPA) and the US Fire Administration (USFA) provide annual statistical data on firefighter deaths and injuries. The data are categorized by the type of activity being engaged in at the time of the fatality or injury, which is commonly referred to as the cause of the fatality or injury. These categories include: fatalities and injuries that occur on the fireground during fire suppression operations; those that occur while firefighters are responding to or returning from alarms; those that occur during training exercises; and those that involve other on-duty activity.

The percentage of fatalities that fall within these categories has been relatively consistent. Of the 1950 firefighter fatalities that have occurred between 1990 and 2009, 42 percent occurred on the fire ground, 27 percent of fatalities occurred while responding to or returning from alarms, 9 percent occurred during training, and 22 percent involved other on-duty activity, as shown in Figure 3. In addition to reporting fatalities based on activity at the time of the fatality, the NFPA also reports on fatalities caused by cardiac-related problems, such as heart attacks. According to the NFPA, approximately 44 percent of all US firefighter fatalities are cardiac-related. Cardiac-related deaths are included in the numbers for the various activities used to categorize firefighter fatalities, so these are not shown separately.

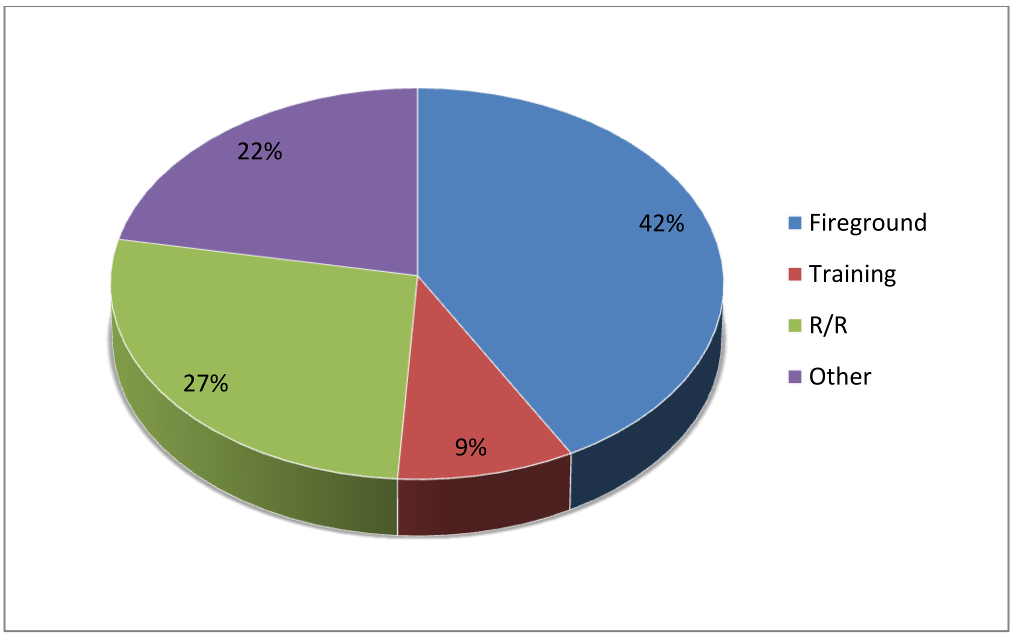

Figure 3. Firefighter Fatality by Type of Activity

Although the comparison of firefighter fatality rates between the US and the UK presents a stark contrast, a comparison of the number of fatalities that occur by type of activity that firefighters are involved in at the time of the fatality is strikingly similar. A report compiled by the Fire Brigades Union (2008) categorizes firefighter fatalities in the UK using the same activities used by the NFPA to categorize firefighter fatalities in the US. These categories include the following: fire deaths, road traffic accidents, training, and other causes. Figure 4 provides a comparison of the percentage of fatalities that fall into each category for each country.

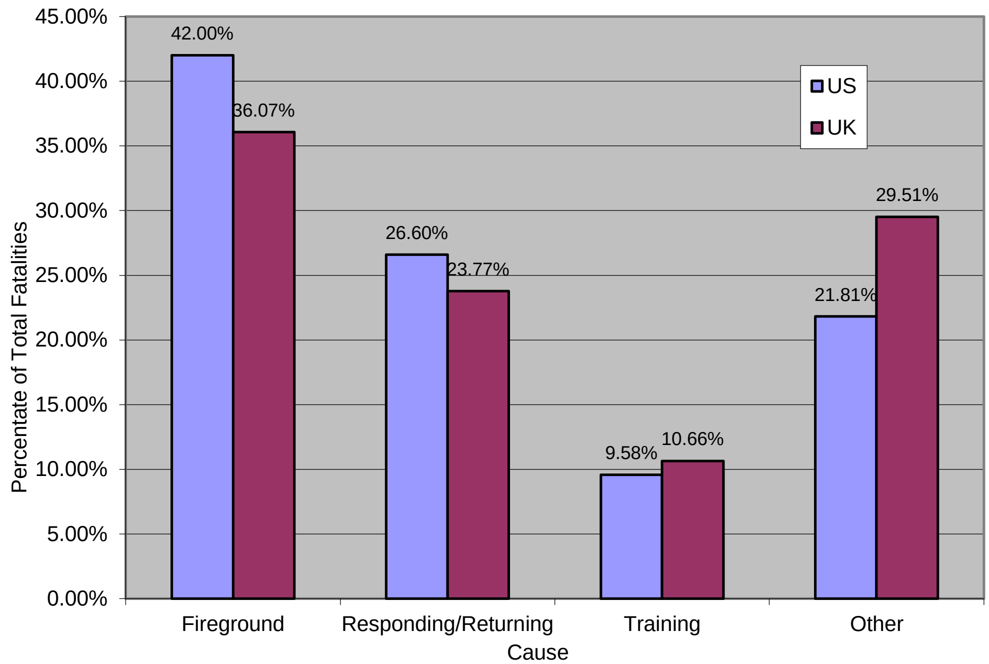

Figure 4. Comparison of US and UK Firefighter Fatality Causes

A comparison of the fatality rate among career and volunteer firefighters in the US shows that the fatality rate among career firefighters is significantly higher than for volunteer firefighters. Data from the National Fire Protection Association (NFPA, 2009) was used to calculate the rate of firefighter fatalities for paid firefighters ad volunteer for the years from 1990 to 2009. The NFPA only uses two categories to track firefighter fatality data in terms of the status of firefighters. The two categories are career and volunteer. The data do not indicate whether the fatality occurred in a combination department that would include both paid and volunteer personnel, but only the status of the individual as a career of volunteer firefighter. During this time period, the fatality rate for paid firefighters was 10.32 fatalities per 100,000 firefighters while rate for volunteer firefighters was 6.97 fatalities per 100,000 firefighters. The fatality rate for career firefighters is 50% higher than for volunteer firefighters. This may be due to the differences in the level of risk inherent in career departments compared to volunteer departments. For example, career departments typically serve larger urban or suburban communities that would have a higher rate of structure fires, creating a higher level of risk to firefighters and, as a result, a higher rate of fatalities. Another possibility is that volunteer firefighters may be more risk averse because they are not paid to risk their lives in the same way as career firefighters, who may either be more risk tolerant or may feel a stronger sense of duty to take higher levels of risk because they are being paid to take those risks, which results in a belief that the community has a higher level of expectations with regard the level or risk taking considered acceptable for career firefighters.

Not only are the rates of fatalities different for career and volunteer firefighters, the causes associated with fatalities for the two categories are also different. An earlier study by the NFPA (2005) shows that while the largest percentage of firefighter fatalities for both categories is fireground activities, more than one third of volunteer fatalities occurred while responding to alarms. Fatalities for career firefighters occurring while responding to alarms accounted for 18.8 percent of all fatalities while accounting for 46.1 percent of volunteer fatalities. The difference in the rate of fatalities that occur while responding to alarms makes up almost the entire difference in the total number of career versus volunteer fatalities over the course of the time period included in the analysis. The difference in the percentage of fatalities resulting from vehicle accidents while responding to alarms may be result of the difference in how volunteer firefighters respond to alarms. Volunteer firefighters frequently respond to the fire station from home or work in their personal vehicle before getting on the emergency vehicle and responding to the emergency incident. Alternatively, they may respond directly to the emergency incident in their personal vehicle rather than respond to the station. In both cases, the number of vehicles responding is increased. In addition, volunteer firefighters respond to the station or to the scene without the same level of warning equipment, such as lights and sirens, compared to emergency vehicles. This may also increase the risk to volunteer firefighters while responding to alarms.

Firefighter injuries in the US are classified using the same categories as fatalities. The percentages of injuries by cause that have occurred from 1990 to 2009 are shown in Figure 5. A total of 1,893,240 injuries were estimated to have occurred within this period. Approximately 52 percent of these injuries occurred on the fireground. Responding and returning to alarms caused six percent of the injuries and training activities accounted for another eight percent of the injuries. Other activities accounted for 34 percent of the injuries. There are approximately one million firefighters in the US, according to estimates by the National Fire Protection Association (2008). Approximately twenty-eight percent of the total numbers of firefighters are career and seventy-two percent are volunteers. Despite this difference in the percentage of career and volunteer firefighters, the types of injuries incurred by career and volunteer firefighters are very similar (Rand, 2004).

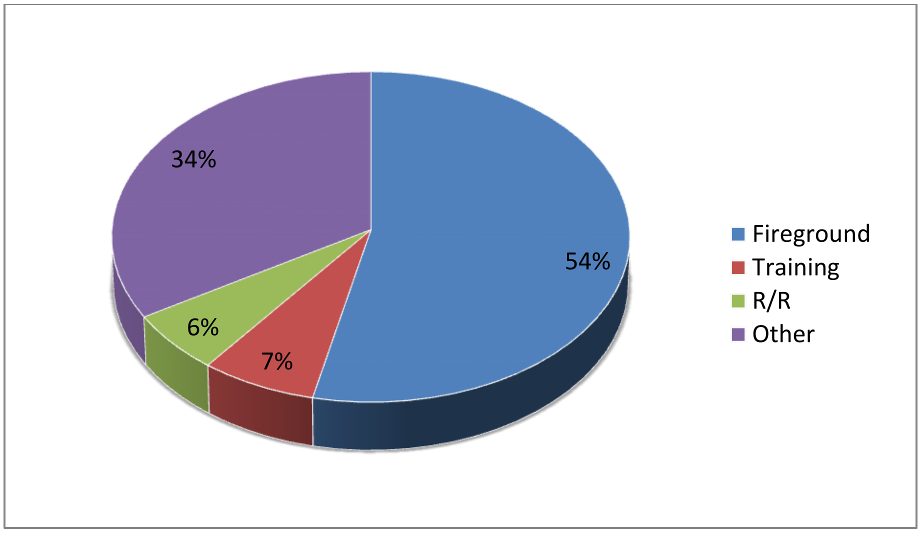

Figure 5. Firefighter Injuries by Type of Activity

Economic Impact

It is important to understand the magnitude of the economic impact of firefighter injuries and fatalities because the results of this study may be used to reduce the cost of firefighter casualties on local government. According to the Bureau of Labor Statistics, nine out of ten firefighters are employed local government (BLS, 2009). Local government, therefore, largely carries the economic burden of injuries and fatalities. If a model of safety culture can be used to reduce firefighter injuries and fatalities, it will also result in significant economic savings for local government.

Four different methods have been used to estimate the economic impact of firefighter injuries and fatalities (Hall, 2009; Meade, 1991; NHTSA, 2000; National Public Services Research Institute, 1990). For the purpose of clarifying the range of estimates for the cost of firefighter injuries, the estimates from these studies have been converted to 2009 dollars based on the Consumer Price Index calculator available at the Bureau of Labor Statistics website (BLS, 2009). Table 1 provides a comparison of the cost estimates converted into 2009 dollars.

Table 1

Comparison of Cost Estimates for Firefighter Injuries

Assessment Model	**Cost per Firefighter Injury (2009 dollars)**
Costs of Cigarette Fires (CPSC/NPSRI)	$43,900
Cost of Fire Safety (Meade)	$54,700
Motor Vehicle Crashes (NHTSA)	$91,400
Total Cost of Fire (NFPA)	$244,400

These estimates of the cost per firefighter injury result in a wide range of estimates for the total annual costs. Three of the four models for estimating the cost of injuries appear to produce reasonable estimates and are considered to be comprehensive approaches to calculating the economic cost of firefighter injuries (NIST, 2004). These include the methods used by Meade, the NHTSA, and the NPSRI studies. The average estimated cost of injuries using these three studies is $63,300 per injury. In 2009, a total of 78,150 firefighter injuries occurred. Therefore, the total cost of firefighter injuries in 2009 was approximately 4.95 billion.

Calculating the cost of injuries is relatively objective and straightforward compared to the issues involved in calculating the cost of a human life. Specification of a dollar value for a human life is a controversial subject (Hall, 2009). Insurance companies, however, have found it necessary to make estimates of the statistical value of life to analyze the financial impact of government regulations, compare risk reduction strategies, and achieve their economic objectives (Viscusi, 2005). In a discussion paper published by the Harvard Law School, Viscusi (2005) asserts that studies utilizing data from the US estimate the statistical value of life to be between $4 million and $10 million, with an average value of approximately $7 million. The study by the NFPA uses $5 million dollars in 1993 values.

As with the cost of injury estimates, the estimates for the cost of firefighter fatalities can be converted into 2009 dollars using the appropriate Consumer Price Index values. Bases on these calculations, the two estimates are relatively close, with the NFPA estimate at $7.3 million and the Harvard estimate at $7.6 million per fatality after conversion to 2009 dollars. The average of these two estimates is $7.55 million for each firefighter fatality. In 2009, a total of 90 firefighter fatalities occurred. Therefore, the total annual economic impact of is over $679 million.

Over the last twenty years, the total economic impact of firefighter injuries and fatalities on local government is estimated to be more than $90 billion. Clearly, the economic impact of firefighter deaths and injuries is an immense problem. As a result, firefighter deaths and injuries have been recognized as one of the most significant national problems in the United States fire service (Frazier, 2005). As a final comparison with the UK, if the firefighter fatality and injury rates in the US had been as low as those in the UK over this time period, the economic impact to local governments would have been reduced by more than $75 billion.

In summary, the rate of firefighter injuries and fatalities in the US is significantly higher than in other industrialized nations. These casualty rates represent an unacceptable level of human loss and suffering, and a significant economic impact on local governments and the nation as a whole. A reduction in firefighter injuries and fatalities is therefore an important goal for local government, fire service organizations, and the public. In addition, although firefighting is a hazardous occupation, the safety performance of other industrialized nations demonstrates that it is possible for the US fire service to reduce firefighter injury and fatality rates, and that such reductions will not necessarily result in lower operational performance. A preliminary examination of data comparing operational performance and safety performance appears to indicate just the opposite: that higher levels of safety performance result in higher levels of operational performance in many countries.

Organizational Culture as a Contributing Factor

An obvious question to ask about the high rates of firefighter injuries and fatalities is: why has this problem been so persistent? Over the last twenty years, the fire service as an industry has constantly worked to improve firefighter safety with improvements in apparatus, tools, personal protective equipment, operational practices, fire codes and fire service related standards. For example, the National Fire Protection Association has developed and published various standards over the last twenty years on respiratory protection, incident management, safety, medical examinations, physical fitness programs, all of which have been intended to some degree to improve firefighter safety. Despite these efforts, very little improvement has been made in overall safety performance within the US fire service, as indicated by the high rates of firefighter injuries and fatalities over the last twenty years.

Numerous factors can contribute to the lack of change or the lack of improvement in performance within organizations. What changes have occurred in the fire service with regard to safety have not been significant enough to result in improvement in safety performance at the national level. One factor that has recently been recognized as having a significant role in organizational change and performance is organizational culture (Marcoulides & Heck, 1993; Rose, 2008; Deshpande, 2007; Moynihan & Pandey, 2006; Moynihan & Pandey, 2003). Organizational culture is a combination of the practices, values and beliefs and underlying assumptions that members within an organization share about appropriate behavior (Rashid, Sambasivan, & Rahman, 2004). Fire service leaders at the local and national level now recognize that one of the fundamental reasons for the relatively low level of safety performance may be the organizational culture of the fire service, and that improvements in safety performance will require a change in organizational culture (FEMA, 2004).

Organizational culture has been recognized as an important factor in the process of planned organizational change (Rashid et al., 2004; Parker & Bradley, 2000), organizational effectiveness (Smircich, 1983), and the success of performance improvement initiatives (Detert, 2000). Organizational culture influences individual behavior, which subsequently determines the level of organizational performance (Yin-Cheong, 1989). The construct of organizational culture, therefore, provides an initial basis for explaining and assessing the outcomes associated with change initiatives and attempts to improve performance.

If management strategies for change and improvement in performance are to be effective, then managers must have a greater knowledge and understanding of the culture within their organization (Parker & Bradley, 2000; Balthazard, Cooke, & Potter, 2006). A limited understanding of organizational culture may be one of the reasons why safety performance improvement initiatives within US fire service organizations have failed in the past. In order to gain greater knowledge and understanding of organizational culture, researchers and managers need a theoretical framework of organizational culture from which a conceptual model of organizational culture can be developed.

Researchers continue to develop various theoretical frameworks that describe and explain the broad concepts and theories of organizational culture and how the variables of organizational culture influence behavior and organizational performance. These frameworks are used to develop more detailed conceptual models that can be used to define the variables, research questions, and methods that should be used to systematically assess organizational culture (Silvester, Anderson, & Patterson, 1999). However, a comprehensive model for defining and measuring organizational culture has yet to be developed (Detert, 2000). As a result, the need continues to exist for research on the development of a specific set of variables and to explore the relationship among the variables in order to develop an effective model of organizational culture (Marcoulides & Heck, 1993).

Research evidence to date not only supports the proposition that organizational culture has a direct impact on organizational performance, but has also found that the norms and expectations created by organizational culture can lead to dysfunctional organizational outcomes (Balthazard et al., 2006). Elements of organizational culture can lead to dysfunctional outcomes and lower levels of performance. For example, with regard to safety, organizational culture may allow for the normalization of high risk or problematic operations, resulting in low levels of safety performance. Making improvements in dysfunctional outcomes involves organizational change. We can posit that organizational change will take place when three conditions are met: a problem is identified and the need to resolve the problem is accepted; people have an awareness and basic understanding of the nature of the problem; and information is available that allows people to define the problem and make appropriate choices between alternative courses of action (Bate, 1983). It is anticipated that results from this dissertation will contribute to organizational change by describing the nature of the problem from an organizational culture perspective and providing an alternative course of action for improving safety performance by changing the variables of organizational culture relevant to safety performance.

Some situations, however, persist despite the acceptance of the people involved that the situation is a problem and is undesirable. People can sometimes become enmeshed in a problem in a persistent and repetitive way, and become unable to solve the problem. What may be happening in these circumstances is that problem solving has become culture bound (Bate, 1983). The problem of safety performance in the US fire service has been persistent over the last twenty years. It appears that although the problem has been recognized and the need for change has been accepted, no significant or meaningful change in safety performance has been achieved. Fire service organizations may be an example of capable and well-intentioned people who are culture bound, and unable to solve the problem of safety performance due to a limited understanding of organizational culture. The fire service appears to need a model of organizational culture that can be applied to the problem of safety performance. This will require the development of variables and measures of safety related organizational culture, and the assessment and analysis of the relationship between these variables. Eventually, this may lead to further research on the relationship between organizational culture and behavior, and between behavior and organizational performance.

Research Questions

This thesis posits that the culture of fire service organizations has a significant influence on firefighter injury and fatality rates because of the way that organizational culture influences the perceptions that firefighters share about appropriate behavior about safety. Safety culture is defined as those elements of organizational culture that are relevant to safety (Clarke, 1999). This dissertation is an attempt to examine the research on organizational culture as a basis for establishing a model of safety culture that can be used within the context of the fire service to a) identify key variables of safety culture, b) develop instruments to measure these variables, and c) to explore the relationships among these variables. This study does not assess the relationship between safety culture and safety performance. Nor does it address the development and implementation of planned interventions that would be used to change the key variables in an attempt to improve safety performance. Rather, this study will lay the foundation for future research in these areas by developing a model of safety culture that can be used to increase our understating of the relationship between the key variables in the model as they are perceived by firefighters in the US fire service. Therefore, the research questions for this study are:

1. Can current models of organizational culture be adapted for the purpose of assessment and analysis of safety culture within the fire service?

Several models of organizational culture have been used to develop models of safety culture in other high-risk occupations for the purpose of assessing and analyzing safety culture. The best model of safety culture for the purpose of this study will be the one that is consistent with the concepts of organizational culture, includes a limited number of variables, has been used in previous studies of high-risk occupations, and has been shown to produce valid and reliable results.

2. What are the key variables in the model of safety culture and how can these variables be operationalized and measured within the context of the fire service?

Variables or variables of safety culture are numerous and vary depending on the purpose of the research and the approach of the researcher. Most models of safety culture include general types of variables or variables that are operationalized in some way for measurement. Different studies, however, use different variables to operationalize the general variables of safety culture. It will be important, therefore, to adapt current measures or create new measures that will be appropriate for use in the assessment and analysis of safety culture within the context of the fire service.

3. What are the characteristics of the relationship and the pattern of the interaction among the variables?

Understanding the nature and characteristics of the relationship among the variables will provide the information necessary to determine whether the model, measures and instruments used in this study are valid and reliable as a means for the assessment and analysis of safety culture in the US fire service.

Significance and Contribution to Knowledge

Research on safety-related issues in other high-risk occupations has found that the concept of safety culture can be a useful construct in the description, explanation, and prediction of safety performance (Mearns, Whitaker, & Flin, 2003; Parker, Lawrie, & Hudson, 2006; Sorensen, 2002). While an extensive body of literature exists on the construct of safety culture involving many high-risk occupations, there is little to no research directed at the application of this knowledge to the problem of safety performance in the fire service. One of the most significant contributions of this thesis is that it extends the application of previous work in the field of safety culture to municipal fire service organizations and the problem of firefighter injuries and fatalities. Because this is first study to apply the construct of organizational culture to the problem of firefighter injuries and fatalities, the findings and results of this dissertation are intended to be considered the seminal pilot study on the subject of safety culture in the US fire service.

While extending previous research in the field of organizational culture, this study also makes several important new contributions to current theories about organizational culture. First, this study proposes a theoretical framework regarding the relationship between organizational culture and performance. Second, a conceptual model of safety culture is proposed that can be adapted for research into other areas of organizational culture. Third, specific variables and measures are developed and adapted for the purpose of assessing and analyzing safety culture in the US fire service.

Although extensive research has been conducted in regard to the influence of safety culture on safety performance, one important gap is the lack of an integrated approach to understanding the effect of safety culture on safety performance. Several studies have examined the effect of changes in safety management systems on safety performance (Mearns et al., 2003; Yule & Flin, 2007; Hoffman & Stetzer, 2006), while other studies have examined the effect of changes in safety related behaviors on safety performance (Cooper & Phillips, 2004; DeJoy, 2005). These studies have examined the impact of safety management systems and safety behaviors on safety performance independently of one another. Other studies have examined how individual values and beliefs about safety influence safety performance (Clarke, 2000). Few research studies have used an integrated model that includes all three of these elements as variables of safety culture (Cooper, 2000b). This study makes a significant contribution to the research on organizational culture by developing and testing an integrated model of safety culture using all three of these variables.

Results of this research also make a practical contribution toward ameliorating the problem of firefighter injuries and fatalities. As stated earlier, high rates of firefighter injuries and fatalities have been problematic within the US fire service for decades, despite significant efforts at the local and national level to reduce firefighter casualties. Reducing injuries and fatalities is an important goal for fire departments and for local government because of the human and economic cost of firefighter casualties. The federal government has also recognized the importance of finding an effective strategy for reducing firefighter casualties. In 2004, the United States Fire Administration established a goal to reduce firefighter fatalities by 25% within 5 years, and 50% within 10 years. In terms of the total number of firefighter fatalities, however, there has been no significant change over the last six years. Results from this study have the potential to help make a major contribution toward these national policy goals.

Many in the fire service are beginning to recognize that the reason for the ongoing and increasing problem of firefighter injuries and fatalities may be the result of the influence of safety culture on individual behaviors and organizational safety performance. For example, the National Fallen Firefighters Foundation developed sixteen firefighter life safety initiatives. The first and most important initiative listed as a means for reducing injuries and fatalities is to change the safety culture within the fire service (NFFF, 2004). Results from this study will make an important contribution toward understanding the relationship among the variables of safety culture in the US fire service, and eventually, toward reducing firefighter injuries and fatalities.

Overview

The first chapter of this dissertation has described the problem of firefighter casualties in terms of the human and economic impact to firefighters, fire departments, and local communities. Based on a comparison of firefighter casualties between the US and other industrialized nations, the argument is posed that safety performance of US fire services is relatively low, and that significant improvement is possible by improving the safety culture of the US fire service. Fire service organizations in other countries and other high-risk industries have used the construct of safety culture to substantially improve safety performance, but this approach has not been applied to the problem of injuries and fatalities in the US fire service. A rationale for exploring the concept of safety culture within the context for the fire service has been developed, leading to three research questions that are used as a guide to the topics included in the literature review.

The second chapter of the dissertation explores the literature relevant to the construct of safety culture. The areas of research included in this chapter begin with the construct of organizational culture that lays the foundation for the development of the concept of sub-cultures. One such sub-culture in high-risk occupations is safety culture. Several frameworks and models of safety culture are explored to determine which model of safety culture is best for the purpose of assessment and analysis of safety culture in the fire service. The literature on safety culture is also used to develop variables that can be operationalized and measured in order to examine the nature of the relationship between these variables. An overview of the theoretical approach used in the study provides a framework for the methodology used in the collection and analysis of data used to assess safety culture in the fire service.

The third chapter describes the theoretical framework and conceptual model of safety culture as well as the methodological approach taken in the dissertation, which includes the basic design of the study, the study population, and sample population. Details of the survey instruments are provided along with a description of the data collection process and the data analysis plan. Five sets of data analyses are described, each of which is intended to demonstrate how the three hypotheses developed in the thesis will be examined. Several limitations of the methodological approach of the study are discussed, in addition to the measures taken to insure the protection of human subjects.

The fourth chapter presents the results from the statistical analysis of the data. This includes descriptive statistics for demographic data and for questions in the survey instruments used to operationalize the variables. Results from analysis of the reliability and validity of the survey instruments are presented. In addition, findings about the relationship among the variables are presented. This includes presentation of data from multiple regression analysis of the variables and elements of the variables and the presentation of data from confirmatory factor analysis to determine whether the model used in the study fits the data. The chapter concludes with the presentation of result from the aggregation of individual data to the organizational level and the presentation of organizational level results.

The fifth and last chapter discusses the results in relation to the research questions and hypotheses that form the basis for the study. Implications of the results with regard to the framework and model used in the study are discussed. An extensive discussion examines the results in terms of what they indicate about the relationship among the variables and how demographic factors influence the results. The strengths and limitations of the study are also discussed. The chapter concludes with a discussion about the implications of the study for future research.

CHAPTER II: LITERATURE REVIEW

The literature review is divided into three main sections on organizational culture, sub-cultures, and safety culture. The section on organizational culture discusses the definition of the construct, the approaches used by researchers to study the relationship among the variables of organizational culture, and the impact that organizational culture has on individual behavior and organizational performance. This is followed by a discussion of the similarities and differences between the concept of organizational culture and organizational climate and whether these are two distinct concepts or just different research approaches to the same underlying phenomenon. The variables used in studies of organizational culture are then discussed, which is followed by a discussion of how researchers have developed theoretical frameworks to explain how the variables of organizational culture influence individual behavior and organizational performance.

The section on organizational sub-cultures presents a discussion of the argument made by some scholars that organizations have multiple sub-cultures rather than a single global culture. Sub-cultures, they argue, are smaller segments of the organization that provide a more accurate and useful representation of modern organizations. The study of organizational sub-cultures provides more detail about the social functioning in organizations and better explains the differences among organizations. This section concludes with a discussion of the interaction of sub-cultures in organizations and the impact of sub-culture dominance.

The section on safety culture is structured in a way this is similar to the structure of the section on organizational culture. This section begins with a discussion of the definition of safety culture and the approaches used to study the construct in high-risk occupations. A discussion of the literature on safety climate and safety culture is presented next, which follows along the same argument as scholars have made about organizational culture and climate. This is followed by a discussion of the variables used to operationalize the construct of safety culture. One of the important issues involved with safety culture is the potential conflict between safety and organizational performance. A discussion of the literature on this conflict is presented, followed by a discussion of the findings in the literature on the relationship between safety culture and safety performance. This section concludes with a summary of the important points from the literature on safety culture.

The entire literature review chapter concludes with a discussion of the need for a comprehensive theoretical framework that explains the relationship between safety culture and safety performance, and the need for a conceptual model that integrates the conflicting approaches to the study and analysis of safety culture in high-risk occupations.

Organizational Culture

Organizational culture has been identified as one of the most powerful and stable forces operating in organizations (Schein, 1996). Change and improvement in public sector organizations have been pursued with a limited understanding of organizational culture, even though culture is recognized as central to the development of effective change strategies (Parker et al., 2006). A better understanding of organizational culture is important because it provides a basis for making more accurate and useful assessments of the social context of organizations. A deeper understanding of how the social context in public organizations influences behaviors can help to improve performance in public sector organizations (Glisson & James, 2002). Managers who have a greater knowledge and awareness of existing organizational culture are able to develop more effective strategies for change that will lead to more successful and more sustainable performance improvement (Balthazard et al., 2006).

Definition and Approaches

The study of organizational culture is fundamentally a continuation of organizational sociology that is focused on the normative bases and shared understandings of individuals that influence the development of the social context of organizations (Ouchi & Wilkins, 1985). Scholars do not agree on the definition of organizational culture, but there are several common elements that are used to describe the construct in general terms. Organizational culture is viewed in this thesis as a socially constructed system of shared practices and values that have a significant influence on individual behavior, as well as the level of organizational performance, and are difficult to change (Bloor & Dawson, 1994, Marcoulides & Heck, 1993; Schraeder, Tears, & Jordon, 2005,). Organizational culture is transmitted through a process of socialization and distinguishes members of one organization from another (Hofstede, 1998). Studies of organizational culture focus on how individuals in organizations perceive, interpret and understand their work environment and how these perceptions, interpretations and understanding influence individual behavior and organizational outcomes (Bloor & Dawson, 1994; van Muijen, Koopman, & Witte, 1999; Silvester et al., 1999).

Scholars have frequently taken one of two fundamentally different conceptual approaches to the study of organizational culture. Some scholars approach culture from the *functional* perspective, while other approach culture from the *interpretive* perspective. Some researchers refer to these approaches as the objectivist and subjectivist perspectives toward the analysis of organizational phenomena (Morgan & Smircich, 1980). Others describe the functional approach as a perspective that views the organization as system and the interpretive approach as a perspective that views the organization as a process (Linstead & Grafton-Small, 1992). The two approaches are based on fundamentally different assumptions related to ontology, epistemology, human nature, and methodology (Hassard, 1991). Researchers approach the study of organizations from one or the other of these two approaches depending on their conceptualization of the problem of interest, the research questions that have been formed, and the purpose of the study (Smircish, 1983; Tierney, 1988).

From the functional perspective, organizations are objective and concrete, and have a systematic character in terms of the relationship among constituent elements of the organization that result in observable activity and behavior (Morgan & Smircich, 1980). Researchers using this perspective view organizational culture as a distinct set of variables that together create a composite of culture (Tierney, 1980). In addition, the organizational elements of culture are viewed as something that exists apart from the individual members but that have a significant influence on member behaviors (Gioia & Pitre, 1990). People are considered to be products of their organizational environment in that they respond to their perceptions of organizational events and activities in relatively predictable ways. Based on the assumption that member behavior is linked to organizational variables through causal relationships, researchers have attempted to discover which organizational elements have the strongest influence on behaviors, to operationalize these elements into variables that can be measured, and to utilize these variables to change behavior and to increase organizational effectiveness (Tierney, 1980). Typically, quantitative methods are used for the analysis of data to explore the relationship between the variables and the influence of these variables on member behavior and organizational outcomes (Smircich, 1983).

The interpretive perspective is at the opposite end of the ontological spectrum. Organizational reality is viewed as subjective and socially constructed. Objective reality is less important than the process through which people create their relationship with their organizational environment; objective knowledge does not exist because it is influenced by the arbitrary references and constructions of the researcher (Morgan & Smircich, 1980). Organizations are formed through inter-subjective experience into patterns of interpretations and meaning rather than patterns of behaviors (Hassard, 1991). Because reality is defined through a process of social exchange, the organization only exists through the interpretation and meaning that members share about organizational events and activities (Tierney, 1988). The purpose of organizational studies from this perspective is to understand the process of interpretation and the construction of meaning (Smircich, 1983). Organizational culture then is viewed as a process of interaction rather than a set of variables, and the intent of interpretive research is to understand how members of an organization interpret reality and how shared realities are created, sustained and changed (Hassard, 1991).

Specific applications of the functionalist approach to studies of organizational culture have been described as a systems perspective on organizational culture. A systems perspective is defined as an attempt to explain the systematic influence of organizational factors on individual behaviors (van Muijen et al., 1999). It consists of cognitive systems of shared explanations of the social context within an organization in terms of how people think, reason, and act (Bloor & Dawson, 1994; Denison, 1996; Wallace, Hunt, & Richards, 1999). This approach is based on the assumption that the social context of an organization can be characterized by a limited number of variables that accurately represent the work environment (Jones & James, 1979).

These variables are typically divided into two categories: practices and values (Hofstede, 1998). Individual behaviors are influenced by perceptions of shared practices and shared values that collectively define the social context that exists in an organization. Perceptions of practices are extrinsic and objective organizational factors, while values are intrinsic and subjective individual factors (Hofstede, 1998). As a result, some researchers have defined organizational culture as the perceptions of behavioral expectations and normative values that are shared by members of the organization (Bloor & Dawson, 1994; Glisson & James, 2002; van den Berg & Wilderom, 2004). The system of practices and values are defined through variables that are considered to be relevant to understanding the practices and values that frame the social context of the organization (Bloor & Dawson, 1994; Balthazard et al., 2006).

The interpretive perspective has also been applied to studies that have a specific focus on organizational culture. These studies have been described as a process approach, which is defined as a process of individual perception, interpretation, and meaning associated with organizational activity (Hatch, 1993; Ouchi & Wilkins, 1985; Bloor & Dawson, 1994). Much of this process is learned through socialization (Bate, 1984; Ouchi & Wilkins, 1985). Current organizational members hold certain assumptions that establish expectations and influence perceptions about organizational activity. Perceptions are developed into mental representations of how the organization works. These mental representations provide a guide for how individual members work within the organization (Hemmelgarn, Glisson, & James, 2006). Socialization occurs as new members are taught that these assumptions are the correct way to perceive, think and feel about organizational functions, attributes, and activities (Schein, 2004). As a result, members are acculturated to a set of organizational assumptions, values and beliefs, and behavioral expectations that guide the interpretation of organizational stimuli, influence the development of meaning associated with organizational stimuli, and act to constrain or enable individual decision making and action (Hemmelgarn et al., 2006; Bloor & Dawson, 1994).

The process of acculturation can have negative effects on problem solving by constraining self-efficacy and outcome expectancy (Bate, 1984). For example, with regard to this dissertation, organizational culture in the fire service may nourish the assumption that members are not able to improve safety performance or that it is not desirable to improve safety performance. In other words, the assumptions embedded in the organizational culture may create a state of socialized helplessness. Members believe that there is no point in trying to improve safety performance or believe that it is not in their best interest to do so. As a result, no attempt is made to assess and disconfirm these assumptions, which continue to be reinforced.

Culture and Climate

Differences in the functional and interpretive perspectives may be a significant factor in the disagreement that continues in organizational culture research over the distinction between organizational culture and organizational climate. Some scholars view culture and climate as distinct phenomena while others view them as very similar constructs that are approached from different perspectives.

The concept of organizational culture is used to describe attributes of individuals (Deshpande & Farley, 2004). Organizational culture is described as a subjective construct that is approached in most research studies from an idiographic perspective (Denison, 1996). An idiographic approach is very similar to the interpretive perspective in that the focus of this approach is to understand the process of how meaning is created in organizations involving subjective phenomenon using qualitative methods (Luthans & Davis, 1982). The main purpose of these studies is to increase understanding of human dynamics in organizations over time and the effect of these dynamics on behavior and organizational effectiveness (Wallace, 1989; van Muijen et al., 1999).

In organizational culture studies, it is assumed that the meaning individuals attach to organizational functions directs perceptions and interpretation by members and defines what is important. "Meaning" is created through a process of perception, interpretation, and evaluation, and is manifest in the patterns of normative beliefs and behavioral expectations that are shared by members of the organization, as well as the assumptions upon which values and behaviors are based (Glisson & James, 2002; Yin-Cheong, 1989). Assumptions, values and beliefs, and behavioral norms are described as the principal components of culture, although assumptions are generally viewed as the most important component in terms of the influence that assumptions have on the development of meaning in organizations (Schein, 2004).

The concept of organizational climate is used to describe attributes of organizations (Deshpande & Farley, 2004). Organizational climate is described as an objective construct that is approached from a nomothetic perspective (Denison, 1996). A nomothetic approach is more closely aligned with the functionalist perspective using quantitative methodologies to study organizational systems and individual behaviors (Luthans & Davis, 1982). Climate studies examine the influence of individual perceptions of organizational attributes on actual behavior and organizational effectiveness (Yin-Cheong, 1989). Organizational attributes include perceptions of behavioral norms and perceptions of common organizational activities (Moran & Fredericks, 1992). These are categorized into variables that represent the characteristics of the organization and include not only behavioral characteristics, but also include perceptions of values and attitudes.

In contrast to the studies on organizational culture, studies on organizational climate do not include assumptions as one of the attributes of analysis (Wallace et al., 1999). Climate studies measure individual perceptions of organizational attributes based on the theory that the way individuals perceive their work environment is largely shared by members of the organization and are interpreted in similar ways so that they reflect the shared norms, attitudes and values that shape organizational behavior (Moran & Fredericks, 1992).

Culture and climate studies appear to use the same theoretical framework to describe how organizations function but use slightly different elements to operationalize the constructs (Hemmelgarn et al., 2006; Glendon & Stanton, 2000; HSE, 2005; Zhang, Wiegmann, Thaden, Sharma, & Mitchell, 2002; Wiegmann, Zhang, Thaden, Sharma, & Gibbons, 2004; Guldenmund, 2000). These are two slightly different approaches to the study of the same phenomenon: the social context of organizations. Both approaches assert that the social context of organizations can be measured through the perceptions of individual members; that perceptions of individual members influence actual behaviors; and that behaviors influence organizational performance. They differ in how the social context of organizations is operationalized. Culture studies use measures of assumptions, values and beliefs, and behavioral norms. Climate studies use measures of organizational activities, values and beliefs, and behavioral norms.

Similarities between the constructs of culture and climate have been recognized in the literature, resulting in an effort by some scholars to develop integrative frameworks for exploring the social context of organizations. Both of these concepts are important to understanding how organizations function and how organizations influence individual behavior and organizational effectiveness (Glisson & James, 2002). An integrative approach assumes that both culture and climate studies are exploring the same phenomenon but from different perspectives resulting in different interpretations (Denison, 1996). Both constructs examine the social context of organizations and use similar variables to define that context. In addition, both constructs are based on perceptual measures and manifestations of those variables.

Although the variables used to describe the attributes of organizations vary from one study to another, research approaches that integrate the two constructs generally use the same three variables, which include: 1) assumptions, 2) values and beliefs, and 3) behavioral norms (van den Berg & Wilderom, 2004). Assumptions are the critical dimension of culture studies. Practices and values are the critical variables of climate studies, although these variables are also included in culture studies.

Most culture studies focus on understanding the relationship among variables using qualitative methods. Climate studies focus on the influence of organizational systems on individual behavior and organizational outcomes using quantitative methods (Luthans & Davis, 1982). A shift in the methodological approach to culture studies has resulted in some culture studies using methods normally used in climate studies, such as survey methods and quantitative analysis of data. In addition, some climate studies have shifted their approach from a purely functional perspective to a more interpretive perspective, recognizing that individual behaviors are influenced by meaning, and that meaning in organizations is constructed through the interaction of objective organizational conditions and subjective individual perceptions (Moran & Fredericks, 1992).

Clearly, there are some similarities between the two approaches, and some movement from both ends of the functional-interpretive scale toward the middle ground in an attempt to integrate these perspectives. Although there remain two very distinct perspectives and approaches to the study of the social context of organizations, scholars recognize that both perspectives are important for understanding how organizations function and how characteristics of organizations influence individual behavior (Wiegmann et al., 2004; Glendon & Stanton, 2000).

Elements of Organizational Culture

Many of the studies that examine organizational culture attempt to develop a universal set of elements that allow for comparative generalizations regarding perceptions of the social context of organizations and their impact on individual behavior (Denison, 1986). Other studies attempt to explain the influence of organizational culture on organizational functions in terms of how organizational functioning can be changed and improved, and how those changes can be sustained (Scott, Mannion, Davies, & Marshall, 2003). Another use of the construct of organizational culture is to interpret how organizational members understand their work experiences and how interpretations and understanding are related to action (van Muijen et al., 1999). For each of these uses of the construct of organizational culture, there is a need to identify and define the elements by which organizational culture can be meaningfully assessed (Silvester et al., 1999). This next section will examine of the models and measures that have been used in organizational culture research.

While scholars have yet to agree on a precise definition of organizational culture, many researchers define the construct using very similar measures (Scott et al., 2003). For example, Rashid et al. (2004) defines the construct as the practices, values and beliefs, and underlying assumptions that are shared by members of an organization and serve to shape behavior and attitudes toward change. Individual behaviors are determined by the pattern of interaction of these three measures of organizational culture (Bloor & Dawson, 1994; Naidoo, 2002). This definition is used as the basis of a functionalist approach to the study of organizational culture. Based on a review of comparative studies of organizational culture, van den Berg & Wilderom (2004) defines the construct as the shared perceptions of organizational work functions. Organizational functions are operationalized as the values, practices and organizational systems that operate within the organization. From this perspective, the same variables of organizational culture are used to form the basis for an interpretive approach for the purpose of making systematic comparisons of organizational culture in order to develop more comprehensive theory.

The instruments used to measure the variables of culture are either typological or dimensional depending on the purpose of the study (Scott et al., 2003). Typological measures assess one or more cultures classified by criteria defined by the researcher. Dimensional measures describes culture by its position on one or more continuous variables, commonly using Likert scales and predefined statements formed into questionnaires.

Typological measures.

Two of the most commonly used typological models to the analysis of organizational culture are the Organizational Culture Inventory (Cooke & Szamal, 1993) and the Competing Values Framework (Quinn & Rohrbaugh, 1981; Parker & Bradley, 2000). In both of these approaches, four cultural types are formed from the intersection of two variables of organizational culture.

The Organizational Culture Inventory (OCI) model was developed for the purpose of measuring perceptions and expectation regarding behavioral norms in organizations (Cooke & Szamal, 1993; Denison, 2006). The two variables used in the OCI are concern for people or tasks, and the need for satisfaction or security. These two variables are then formed into twelve normative beliefs and behavioral expectations that are then categorized into three culture types: constructive, passive-defensive, and aggressive-defensive.

The Competing Values Framework (CVF) was initially developed by Quinn & Rohrbaugh (1981) as a model of organizational effectiveness, and has since been modified to measure characteristics of organizational values (van Muijen et al., 1999). The CVF uses two different value variables with contrasting poles to form four different culture types. The variables used in this approach are structure and focus. Structure is defined as a range from flexibility to control while focus is defined as a range from being directed internally to externally. The four culture types resulting from these two variables are: the human relations type (flexible structure and internal focus); the open systems type (flexible structure and external focus); the rational goal type (controlling structure and externally focused); and the internal process type (controlling structure and internally focused).

In a study of the relationship between organizational culture and attitudes toward change, Rashid et al. (2004) used a model consisting of four cultures based on two variables: sociability and solidarity. The four culture types used in this study were networked, communal, fragmented and mercenary. A networked culture has high sociability and low solidarity. A communal culture has high sociability and high solidarity. The Mercenary culture has low sociability but high solidarity. Organizations with a fragmented culture have low levels of both and are considered to be dysfunctional.

Dimensional measures.

Another group of studies uses a dimensional model of organizational culture in which practices and values are the two primary variables of culture (Denison, 1996; Hofstede, 1998; Ouchi & Wilkins, 1985; van den Berg & Wilderom, 2004; Wallace et al., 1999). In these studies, the principle approach to organizational culture is to measure values and behavioral norms (Denison, 2006) and to analyze the relationship between these key variables (Karahanna, Evaristo, & Srite, 2005). Practices can be altered more easily than values, which are very difficult to change but can be affected by changing practices (Karahanna et al., 2005). These two factors are often described as having a unitary or global impact on organizations based on the assumption that organizations have only one certain type of organizational culture (Hatch, 1993).

Practices are the shared perceptions of expected behaviors that regulate individual action (Bate, 1984; Hofstede, 1998). Organizational members learn what are considered to be appropriate practices through the process of socialization (van Muijen et al., 1999). The level of normative pressure to perform or not perform certain critical behaviors predicts individual action. Perceptions of behavioral norms are, therefore, antecedents of actual behavior (Karahanna et al., 2005).

Practices are categorized as organizational management practices or individual work practices (Marcoulides & Heck, 1993; Bloor & Dawson, 1994; Denison, 1996; Hofstede, 1998; Ouchi & Wilkins, 1985; van den Berg & Wilderom, 2004; Wallace et al., 1999). These two practices are different factors in that management practices are focused on managing or controlling the work in an organization, while individual practices are focused on doing the work in an organization.

Instruments used to measure practices are developed from a broad scope of common organizational work practices (van den Berg & Wilderom, 2004). For example, Hofstede (1998) differentiates the concepts of practices and values by defining practices as a set of six dimensional scales, which include the following: process/results, employee/job, parochial/professional, open/closed, loose/tight, and normative/pragmatic. In a study by van den Berg & Wilderom (2004), five different variables were proposed as a common set of practices for future studies that include autonomy, external orientation, interdepartmental coordination, human resource orientation, and improvement orientation. It seems apparent that the variables used to describe practices depend heavily on the purpose of the study and vary considerably from one study to the next.

Values define what is considered right or wrong, desirable or undesirable, rational or irrational, legitimate or illegitimate within the work environment (Bate, 1984). They are enduring beliefs that a specific mode of conduct or end state of existence is preferred to an opposite or converse mode (Karahanna et al., 2005). Values are shared between organizational members and are deeply embedded (Denison, 1996; Hofstede, 1998; Ouchi &

Wilkins, 1985; Schein, 2004; Wallace et al., 1999). They are also considered to be invisible affective factors that are difficult to change (Hofstede, 1998; Wallace et al., 1999). Because values are considered to be implicit and cannot be observed directly, they are often inferred from their visible manifestations in alternatives of behavior (Hofstede, Neuijen, Ohayv, & Sanders, 1990).

The variables used to operationalize values in organizational culture studies have varied widely. Some studies have used power, reward, effectiveness, efficiency, fairness, teamwork, competitiveness, and opportunity as variables (Wallace et al., 1999). Others have used the variables developed by Hofstede (1990) in a cross-national study of culture, which include authority, power distance, security, collectivism, and results orientation. In a study of how organizational culture influences managerial behavior in organizations, Karahanna (2005) used what he defined as instrumental and terminal values. Instrumental values are associated with desirable modes of conduct and where subdivided into moral and competence related values. Terminal values are associated with desirable end-states and were subdivided into personal and social values.

A key issue in organizational studies using these two variables is the nature of the relationship between practices and values (Yin-Cheong, 1989; van den Berg & Wilderom, 2004; Hofstede et al., 1990; van Muijen et al., 1999). Researchers are interested in different occupations, organizations, and behaviors. A fundamental assertion these researchers make is that any culture of interest can be broken down into component practices and values. Once the variables are operationalized, researchers can then test predictions about how the combination of variables influences behavior.

Another assertion that is critical to studies that use practices and values as variables is that practices are part of the organizational environment and that values are part of the person (Denison, 1996). Some studies explore the proposition that values moderate the relationship between the organizational variables and individual behaviors (Karahanna et al., 2005). This moderating effect occurs because values have a strong affective component and imply a preference for a certain type of behavior, which influences behavioral choices. Others explore the proposition that practices and values have an equal level of influence on behavior (Denison, 1996). Still other researchers examine the possibility that practices have a stronger influence on behavior (Hofstede, 1998). The characteristics of the relationship among the variables and the way in which the variables are operationalized appears to vary depending on the layer of culture of interest (national, occupational, or organizational) and on the specific referent culture of interest.

Multiple variables.

Other studies take a different approach to organizational culture based on a model that assumes that organizations have only one type of culture that can be assessed using multiple variables. These variables may or may not explicitly include practices and values. A typical approach to the study of organizational culture using multiple variables includes the development of an overall framework that provides the basis for a more specific model of culture defined by the variables and measures used in the study (Denison, 2006).

Different variables are selected and defined for different studies depending on the research agenda of the study and the specific line of inquiry that is being examined (Denison, 2006). Some studies examine the influence of the variables of organizational culture on individual behavior (Lok & Crawford, 1999; Wallace et al., 1999) while others examine their influence on organizational effectiveness (Denison, 2006; Rad, 2006). Other studies attempt to establish sets of variables that can be used for comparative studies of culture between organizations, or for the purpose of making comparisons of culture within organizations by hierarchical level or organizational functions (Berg & Wilderom, 2004; Hofstede, 1998). The variables used in these studies are created for the purpose of the study after a review of relevant literature, or are selected from the limited number of instruments that are used most frequently in previous studies.

For example, Lok & Crawford (1999) used three variables of culture in a study of the influence of organizational culture on job satisfaction and commitment. These included bureaucratic, innovative and supportive variables. Wallace (1999) used four variables of culture to examine the relationship between culture and managerial values. The variables used in his study were individualism, uncertainty avoidance, power distance, and masculinity. In a study that examined the impact of culture on the implementation of TQM initiatives, Rad (2006) used seven variables of cultural values: entrepreneurship, risk taking, uncertainty avoidance, power distance, individualism versus collectivism, masculinity or femininity, and mechanistic versus organic structure. In other studies, best practices are described and used as cultural variables. For example, van den Berg & Wilderom (2004) used five variables and Hofstede (1998) used six variables of practices to define and measure culture for the purpose of making comparative studies within and between organizations. An exploratory study of the Organizational Culture Profile by Sarros, Gray, Densten, & Cooper (2005) included eight variables of culture. The variables included in this instrument are: innovation, attention to detail, outcome orientation, aggressiveness, supportiveness, decisiveness, team orientation, and the emphasis on rewards.

A study by Denison (2006) provides an example of how variables of organizational culture are measured through several sub-elements or indexes of each dimension. In this study, four variables of cultural values and behavioral norms are developed into a conceptual framework for the purpose of understanding organizational culture to help explain differences in organizational performance. These four variables are involvement, consistency, adaptability, and mission. Each of the four variables is measured with three component indexes, each of which is measured with a number of survey items. For example, involvement is measured with the following three indexes: empowerment, team orientation, and capability development. Five survey items are used to measure each of the three indexes.

Measures of the interaction between variables of culture are an important aspect of the multi-dimensional approach. It is the patterns of interaction between variables of organizational culture that provides the basis for explaining and predicting individual behaviors (Karahanna et al., 2005; Bloor & Dawson, 1994; van den Berg & Wilderom, 2004). It is also important to point out that it is not the objective and explicit occurrence of these variables that are measured. It is the subjective perception of the variables that are measured in the vast majority of these studies (Bloor & Dawson, 1994; van den Berg & Wilderom, 2004). Although it has been recognized that a comprehensive approach to the study of organizational culture would include measures of both the objective occurrence and the perception of cultural variables, none of the studies that surfaced in this literature review included such comparisons.

Levels of culture as variables.

Many of the studies that take a dimensional approach to the study of organizational culture use the model developed by Schein (2004). As one of the few conceptual models of organizational culture, Schein's construct has been used extensively in other research for analysis of organizational culture, for exploring the relationship between organizational culture and performance, and in the development of approaches for effectively changing organizational culture (Hatch, 1993; Jones, Jimmieson, & Griffiths, 2005; Rashid et al., 2004; Parker & Bradley, 2000; Marcoulides & Heck, 1993).

Organizational culture is defined by Schein as "a pattern of shared basic assumptions that was learned by a group as is solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems" (Schein, 2004, pg. 17). The variables of organizational culture are differentiated into three levels based on the degree to which each dimension can be explicitly observed. The three levels include practices, values and beliefs, and underlying assumptions.

Practices are the routine behaviors that are shared by members of an organization and are the most visible and overt dimension of organizational culture. Values and beliefs are considered to be a deeper dimension of culture that provide members of the group with a sense of what is important, what is right or wrong, and of how things work. Shared values and beliefs become shared assumptions when they become taken for granted. If practices, values and beliefs repeatedly work to solve problems of external adaptation and internal integration, then eventually they are no longer confronted, contested, or debated. As a result, they become underlying assumptions. Underlying assumptions are the most implicit and least visible dimension of culture. The relationship between these variables is proposed to be a linear one where assumptions interact with values and beliefs, and values and beliefs interact with practices, but practices do not interact with underlying assumptions.

One of the defining characteristics of organizational culture is that it consists of a shared pattern of perceptions among members of an organization. According to Schein, values usually become shared in organizations through a process of social validation. Social validation occurs when values are confirmed by the shared social experience of the group. Values that are not tested, or cannot be tested, are validated on the basis of how comfortable and anxiety-free members are when they abide by them. As values become shared, members become more and more comfortable with them, and less and less conscious of them, so that they eventually become underlying assumptions. According to Schein (2004), the fundamental characteristic of organizational culture is the pattern of shared assumptions in a group. Shared assumptions form the conceptual framework that a group uses to deal with problems of external adaptation and internal integration.

The ability to deal effectively with problems of adaptation to the external environment depends on several management elements (Schein, 2004). These include the organization's mission and strategy, service goals, the means to accomplish those goals, and a system for measuring performance and taking corrective action. Mission and strategy describe the primary tasks, core competencies, and basic functions of the organization. Goals are more specific and concrete statements about what the organization intends to deliver in terms of products or services.

The means by which an organization accomplishes its goals include the structure, authority, processes, and control systems that are developed within an organization (Schein, 2004). Consensus on the means for achieving goals results in regular patterns of behaviors or behavioral norms. Measuring performance and developing corrective strategies involves consensus within an organization about what to measure and how to measure it. Cultural assumptions are used as the basis for determining how to measure success and what criteria and information are gathered for that purpose. After problems of external adaptation are identified, corrective strategies are developed based on consensus about how the problem has been defined, what needs to be done to remedy the problem, and how to determine if the desired changes have occurred.

The ability to deal effectively with internal issues requires a different set of management elements focused on maintaining relationships among members of the organization (Schein, 2004). These include the development of common conceptual categories, the criteria for group inclusion or exclusion, the distribution of authority and influence, and the allocation of incentives and constraints. Conceptual categories are formed from the shared perceptions and understandings of members and are used to prioritize and communicate about problems. Criteria for inclusion in groups are usually based on involvement in common tasks or functions or by the hierarchical structure of the organization. Norms of authority and influence are important elements accomplishing tasks and in reducing the level of anxiety in organizational members by clarifying roles and responsibilities. The allocation of incentives and constraints acts to control behaviors so that they remain within established norms. The system of rewards and punishments reveal important behavioral norms and cultural assumptions in an organization by identifying those behaviors that are valued and those that are not valued.

Because underlying assumptions are the deepest and least visible dimension of organizational culture, they are also the most difficult to define and measure. Based on how assumptions are used to solve problems of external adaptation and internal integration, however, it is possible to construct a logical argument for the use of organizational management systems as the manifestation of underlying assumptions. Assumptions are formed as members of an organization learn to solve problems of external adaptation and internal integration. Various management elements are important factors in the development of solutions to these problems, and over time, these become institutionalized as the organization's management system. Organizational management systems are, therefore, the explicit and overt manifestation of underlying assumptions used by members of an organization to solve problems of external adaptation and internal integration. Underlying assumptions are made manifest through the organizational management systems derived from the mission and goals of the organization and the operational means to achieve those goals (Schein, 2004).

Although used extensively as a framework for organizational culture studies, several limitations of the model proposed by Schein have been identified in the literature (Denison, 2001). These include the fact that the model does not explain the link between assumptions and behaviors, since the model is linear in that assumptions interact with values and beliefs, values and beliefs interact with behaviors, but behaviors do not interact with assumptions. In addition, the model proposed by Schein places a high degree of emphasis on the cognitive level of the model and de-emphasizes the more visible levels. It has been suggested that a more powerful approach to understanding organizational culture would be created if all three levels of culture were linked. Such a model would provide more useful insights through analysis of the relationships between the levels and would provide greater capacity for change (Denison, 2001).

Culture, Behavior and Performance

A theoretical understanding of the relationship between organizational culture and performance is important in terms of the value and significance of this thesis. It is important because it helps to place organizational culture into perspective as a critical component of an overall framework that can be used to make changes and improvements in organizational performance. The purpose of this dissertation is to develop a greater understanding of organizational culture that can be used as the basis for future research on how culture can be changed to improve performance. The value of this research is enhanced when the construct of organizational culture is developed with an understanding of how culture influences individual behavior and organizational performance.

Culture and control.

Culture acts on individuals as a mechanism for controlling individual behavior and organizational performance (Ouchi & Wilkins, 1985). Several different types of organizational control systems are described in the literature. In a study on organizational culture and change in local government, Kloot & Martin (2007) defines two different control systems: one is a values-based control system based on the shared values and beliefs of members of the organization; the other is a management-based control system that consists of the formal rules, structures and processes of the organization.

Karreman & Alvesson (2004) explored the relationship between social identity and organizational control systems and argues that two types of control systems influence individual behaviors. Management control systems similar to that described by Kloot &

Martin (2007) that influences individual behavior by operating through formal structures and processes of control that target specific behaviors directly and explicitly. The other is a normative control system that influences individual behaviors by operating through a process of socialization regarding the informal rules of the organization. This system creates a social identity within groups, which apply social pressure on individuals indirectly and implicitly to conform to the behavioral norms of the group. Group norms are a powerful and important control mechanism because individuals respond to the expectations of fellow employees, particularly in cohesive groups such as the fire service (Daft & Macintosh, 1984).

The three different control systems described in the literature can be labeled as the *management-based* control system, the *normative-based* control system, and the *values-based* control system. Management-based control systems are consistent with Schein's description of underlying assumptions in organizations, which are made manifest through the management systems associated with external adaptation and internal integration. These two functions are described as the essential elements of organizational culture. The values-based and normative-based control systems are consistent with Schein's assertion that values and behavioral norms make up the other two levels of organizational culture. Organizational subunits or workgroups do not necessarily agree on goals, on what behavior is desirable, or on which approach works best to control behavior (Goddard, 1999). Higher levels of management tend to rely more on the management-based control system with its emphasis on formal rules to control behavior directly. Work groups tend to rely more on the normative-based control system, which emphasizes the informal, indirect, social control of behavior.

Management-based and normative-based systems regulate behavior by initiating and maintaining contingencies external to the person. Individuals behave in certain ways to either obtain desired consequences or avoid undesired consequences (Gagne & Deci, 2005). Values-based systems regulate behavior because the individual takes on certain values such that external contingencies are no longer required to regulate behavior (Gagne & Deci, 2005). Perceptions about whether controls are extrinsic or intrinsic is an important issue in organizational studies because they are associated with a variety of affective, cognitive, and behavioral outcomes (Ng, Sorensen, & Eby, 2006). For example, extrinsic control mechanisms, such as the management or normative based systems, have generally been demonstrated to result in lower levels of self-efficacy and outcome expectancy, while intrinsic control mechanisms, such as the values based system, result in higher levels of self-efficacy and outcome expectancy, as well as higher levels of motivation and performance on core tasks (Ng et al., 2006).

Organizational culture and behavior.

A common approach in the research on organizational culture is focused on attempts to explain the relationship between organizational culture and individual behavior in the work environment. The importance of this relationship is based on the assumption that a better understanding of how organizational culture influences individual behavior provides managers with better predictive and prescriptive power (Karahanna et al., 2005). A number of studies have attempted to develop theoretical frameworks to explain how changes in organizational culture result in changes in behavior. A common framework use in several of these studies is the conceptual equation developed by Lewin (1951) that explains the relationship between individuals and their social environment. This equation states that behavior (B) is a function of the person (P) and the environment (E).

Culture and climate researchers have both used this framework in more recent organizational studies as a useful way to integrate the culture and climate perspectives into a single conceptualization of the influence that social contexts have on human behavior (Denison, 1996; Karahanna et al., 2005; van Muijen et al., 1999). It also provides a means for integrating the general concepts and specific definitions of organizational culture that have previously been discussed.

If individual behavior is a function of the interaction of the person and his or her environment, then it is important to have a more specific definition of what is meant by person and environment. Within the construct of organizational culture, a social system includes an external organizational dimension and an internal individual dimension (Sarros et al., 2005; Yin-Cheong, 1989). These two variables parallel Lewin's environmental and personal variables. Applying Lewins' framework using these variables, the nature of the relationship can be stated as follows: behavior is a function of the interaction of the organization characteristics and individual characteristics. These variables also parallel the conceptualization of culture as consisting of practices and values, where practices are the organizational characteristics and values are the individual characteristics.

Practices have been previously defined as including both organizational management practices and behavioral norms within organizations. If these two variables are taken together with values as the three variables of organizational culture, then they are consistent with the more specific definitions of organizational culture as a construct composed of assumptions, values, and practices (Schein, 2004).

Assumptions have been previously described as being made manifest in organizational management systems and comprise one part of the eternal organizational dimension of culture. Individuals in different organizations make different assumptions about the human nature, motivation, and social relationships. Based on the assumptions made in these areas, organizations will develop different approaches to management practices (Yin-Cheong, 1989).

Values and beliefs comprise the internal individual dimension of culture (Schein, 2004). These elements are also used in the definitions of climate (Denison, 1996). Values and beliefs involve the preferences for certain actions over others, the positive or negative affect that an individual has towards those actions, and beliefs about the consequences associated with those actions.

Practices have been previously described as the behavioral norms within an organization, and comprise another element of the external organizational dimension of culture. The creation and enforcement of behavioral norms is one of the most powerful ways to influence individual behavior (Yin-Cheong, 1989). Norms reinforce desired behavior and inhibit undesirable behavior because they put pressure on members to comply with those behaviors that are considered desirable and legitimate. If a member deviates from the behavioral norm, then other members will put pressure on that member to conform.

Based on this more detailed description of the person and the environment, Lewin's equation can be modified to state that behavior (B) is a function of the interaction of management systems (MS), behavioral norms (BN), and individual values and beliefs (VB) as follows: B=f(MS, BN, VB). Management systems and behavioral norms constitute the external or environmental dimension of culture. Values and beliefs constitute the internal or personal dimension of culture.

Organizational culture develops and changes over time. As a result, some researchers have asserted that the relationship between the variables of the system is recursive rather than a simultaneous interaction (Denison, 1996). Changes in the social system or culture of an organization evolve over time in successive stages of interaction rather than through the simultaneous interaction of the variables. While it is recognized that the person and the environment are both the product of this interaction and influence the interaction, there is a time lag between environmental stimulus and individual response (Denison, 1996). As the variables of the social system interact over time, behaviors begin to change in response to changes in the social system or culture of the organization.

In this theoretical framework, the Organizational variable is comprised of Management Systems and Behavioral Norms. The Individual variable is comprised of Values and Beliefs. These variables interact with each other to motivate and shape individual behavior in organizations (Denison, 1996; Yin-Cheong, 1989). This framework would predict that changes in these elements of organizational culture would result in changes in the behaviors of individual members.

Organizational variables are under a relatively higher level of management control compared to the individual dimension (Denison, 1996), and are easier to change than individual values and beliefs (Karahanna et al., 2005). Therefore, making changes in these two variables of organizational culture would be a logical starting point for managers attempting to change behavior and improve organizational performance.

Organizational culture and performance.

Organizational culture is often studied for the purpose of understanding the connection between the organizational culture and organizational performance, and how organizational performance can be improved by changing the variables of organizational culture. Although many studies explore the link between organizational culture and organizational performance, no common framework, model or variables have been established for use in studies of the influence of organizational culture on performance (Detert, 2000; Jones et al., 2005). Despite this problem, there does appear to be a consensus among many researchers about the important influence that organizational culture has on organizational performance, and that changes in organizational culture are essential for changes and improvements in organizational performance (Sarros et al., 2005; Schraeder et al., 2005; Rad, 2006). At the same time, however, Wallace (1999) asserts that the connection between organizational culture and performance has not been sufficiently tested empirically.

Organizational culture is recognized in the literature as having considerable influence on organizational performance (Cooper, 2001; Lok & Crawford, 1999; Schraeder et al., 2005) and that organizational performance cannot be adequately or accurately understood without a comprehension of organizational culture (Wilkins & Ouchi, 1983). Although a number of other factors can make a difference in performance, such as the personal, leadership, team, system, and contextual factors described by Mwita (2000), cultural factors have been recognized as having a key role in determining levels of organizational effectiveness and performance (Smircich, 1983; Marcoulides & Heck, 1993). The influence of organizational culture on performance is viewed by some researchers as being mediated by individual behavior in that culture influences individual behavior and it is behavior that influences organizational performance (Yin-Cheong, 1989). From this perspective, the interactions of the variables of culture form the basis for individual action (Bloor & Dawson, 1994). Understanding the effect that culture has on individual behavior and the subsequent effect of individual behavior on organizational performance provides a framework for development of appropriate interventions for the improvement of performance, more effective management of resistance to change, and a higher level of acceptance of change (Karahanna et al., 2005; Schraeder et al., 2005).

Improvement in organizational performance obviously requires change. Culture is a key variable in the success or failure of change and performance improvement initiatives (Detert, 2000; Naidoo, 2002; Smircish, 1993; van den Berg & Wilderom, 2004). Planned organizational change must be developed with an awareness of existing culture in an organization to be successful (Parker et al., 2006). A common feature of the failure of change and performance improvement initiatives is a failure to understand organizational culture and the way that culture interacts with change strategies (Naidoo, 2002; Balthazard et al., 2006). Efforts to change and improve organizational performance that are not reflected in a change in the variables of organizational culture will not be translated into action (Cooper, 2001). It is critical, therefore, to make organizational culture explicit (Balthazard et al., 2006) so that specific variables of organizational culture can be examined and assessed in order to successfully implement change and to sustain change over time (Jones et al., 2005).

While most of the research on the influence of organizational culture on performance is focused on the positive effects that culture has on performance, it follows that culture can also have negative effects. Culture can distort perceptions (Hatch, 1993) or act to limit the alternatives that are considered legitimate and effective for solving problems (Bate, 1984; Naidoo, 2002). In addition, certain types and levels of culture are considered positive or functional, while other types and levels of culture are considered dysfunctional (Balthazard et al., 2006). Dysfunctional outcomes can occur when individual perceptions of behavioral norms and management systems result in a decision process that normalizes indications of problems, leading to poor decision making. Bad or poor decisions lead to lower effectiveness, lower efficiency and lower performance (Balthazard et al., 2006).

Managers and executives in organizations generally pay particular attention to organizational change that leads to improved performance. The construct of organizational culture, therefore, needs to be framed in a way that is useful for mangers to understand and monitor culture (Schraeder et al., 2005) and in bringing about successful change and performance improvement (Cooper, 2001). The construct of organizational culture can be most useful for managers if it is used to help them understand the connections between the social context of the organization, individual behavior, and organizational performance (Cooper, 2001).

Management behavior has been found to have a profound impact on organizational activity and performance outcomes (Coggburn & Schneider, 2000; Fernandez-Muniz, Montes-Peon, & Vazquez-Ordas, 2007). In addition, management processes and capabilities are necessary for sustaining levels of higher performance (Jones et al., 2005). Because managers have a critical role in bringing about and sustaining organizational change, organizational culture needs to be defined and operationalized so that important variables are under the control of organizational managers (Marcoulides & Heck, 1993).

Organizational culture is important as a practical construct for managers seeking to initiate change and performance improvement initiatives. It is also an important construct for researchers attempting to develop a universal set of variables that can be used in comparative studies across organizations to explore the influence of social context on individual behavior and organizational performance (Denison, 1996). Several studies have operationalized culture using the three variables previously described: behavioral norms, values and beliefs, and underlying assumptions (Henri, 2006; Jones et al., 2005; Yin-Cheong, 1989; Karahanna et al., 2005). As discussed earlier, these variables of organizational culture influence individual behavior. However, researchers continue to struggle to develop a comprehensive framework that explains the relationship between changes in culture, changes in behavior, and changes in performance (Yin-Cheong, 1989; Linstead & Grafton-Small, 1992).

A number of different theoretical frameworks have been proposed for the purpose of describing the relationship between organizational culture and performance. For example, a study by Rad (2006) on the impact of organizational culture on the implementation of TQM used a framework with 14 variables that influence organizational performance. These were categorized into five domains, including human resources, performance appraisal, strategic planning, structural management, and process management. In a similar study, Marcoulides & Heck (1993) proposed a model of the important criteria and variables of organizational culture that influence organizational performance, as shown in Figure 6. These included five variables: organizational structure and purpose; organizational values; task orientation; organizational climate, and worker attitudes.

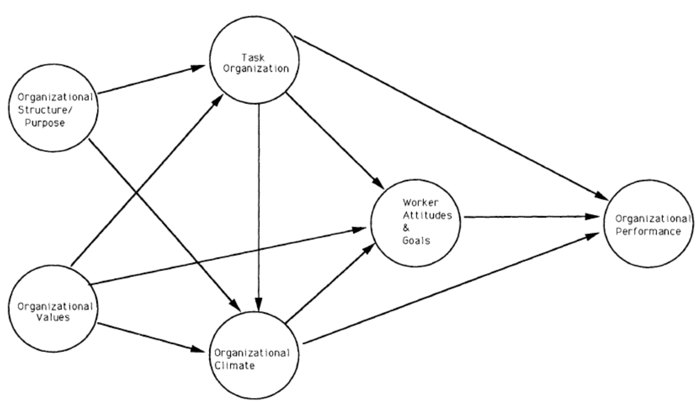

Figure 6. Organizational Culture/Performance Framework: Marcoulides & Heck

As part of his study of dysfunctional cultures, Balthazard et al. (2006) developed a framework that includes antecedents, behavioral norms associated with culture, and outcomes. In this framework, antecedents are the structures, systems, technology and skills of the organization and members. The behavioral norms associated with culture are adapted from the Organizational Culture Inventory and include constructive, passive/defensive, and aggressive/defensive cultural norms. Outcomes include organizational outcomes such as quality of services, adaptability, and turnover, as well as individual outcomes such as role clarity, behavioral conformity, and job satisfaction. The model is shown below in Figure 7.

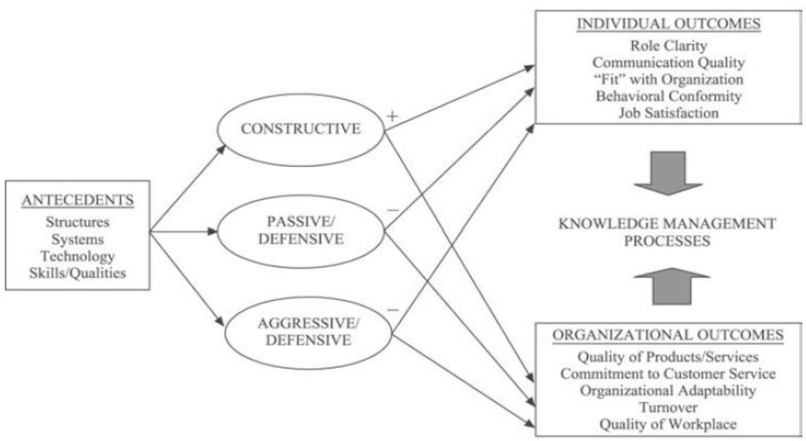

Figure 7. Organizational Culture/Performance Framework: Balthazard

Several researchers have developed frameworks for the relationship between organizational culture and performance that are also consistent with the previously described frameworks for the relationship between organizational culture and behavior. A framework developed by Yin-Cheong (1989), for example, proposed the following relationships: organizational culture is a critical source of influence on individual behavior; pre-existing personal characteristics also influence behavior; personal attributes and capabilities determine individual effectiveness; other contextual factors also influence individual effectiveness; individual effectiveness determines organizational effectiveness.

In a study that examines the theoretical relationship between culture, behavior, and performance, Mwita (2000) proposed a conceptual framework that helps to explain the relationship among these variables. In this framework, the links between culture, behavior, and performance are based on the ABC (Antecedents, Behaviors, and Consequences) model of behavior change. Antecedents set the stage for behavior by encouraging individuals to behave in certain ways. Behaviors are the actions taken by individuals that produce outcomes. Consequences include the individual and organizational outcomes that follow behaviors. Individual perceptions of the variables of organizational culture make up the antecedents of actual behavior. Individual and group behavior results in certain consequences for the individual and for the organization. Organizational consequences include an increase or decrease in organizational performance.

Building on the previous discussion about Lewin's (1951) model of the relationship between individuals and their social context, it is possible to develop a more comprehensive theoretical framework that links organizational culture, behavior, and performance. Lewin's model proposed that behavior is a function of the person and the environment. Applying this concept to the ABC model of behavior change, the interaction between the person and the environment are the antecedents of individual behavior. The person and the environment are the individual and organizational variables that make up the social context of an organization, which defines the concept of organizational culture. Organizational variables include management systems and behavioral norms. The individual variables include the cognitive values and beliefs of individuals. The interaction of these variables results in the social construction of meaning that influences actual behavior. Behaviors result in positive or negative consequences for the individual and the organization. Consequences are the performance outcomes for the organization. This framework for the relationship between culture, behavior and performance is represented in Figure 8.

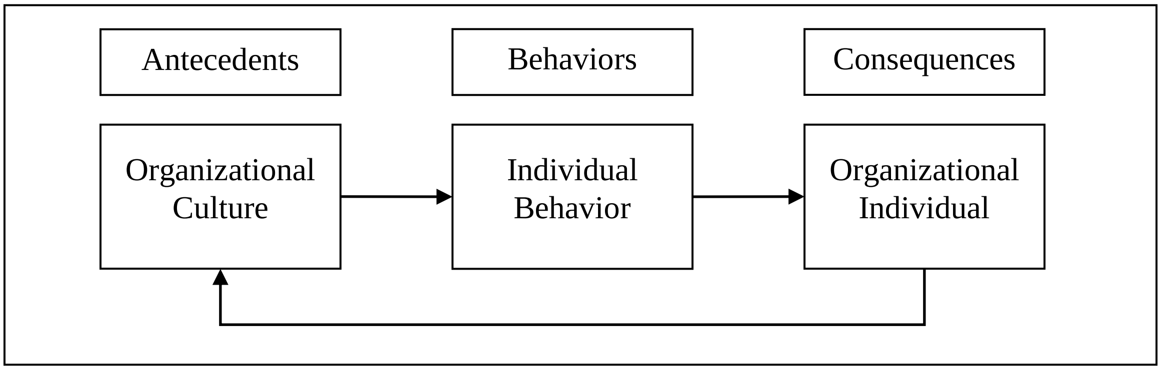

Figure 8. ABC Framework of Culture and Performance

The ABC model links the concepts of organizational culture, individual behavior and organizational performance into a comprehensive theoretical framework. In comparison with other frameworks, the ABC framework is much more consistent with the research on the relationship between organizational culture and behavior and fits well with the models of organizational culture that use a limited number of variables to define the construct, such as management practices, work practices, and individual values and beliefs.

Layers of Culture

Culture is not just an organizational phenomenon. The research on organizational culture consistently identifies at least three layers of organizational culture for the purpose of theory building: national, occupational, and organizational (Karahanna et al., 2005; Hofstede et al., 1990; Wallace et al., 1999). The national level culture influences the formation of culture within occupations, which subsequently influences the culture formed within organizations. The differences in national level culture may help to explain the differences in safety performance between the US and UK fire service. In the UK, for example, safety may be a higher priority and valued more at the national level than it is for organizations in the US, resulting in a different set of priorities and values for members of the fire service that is consistent with the nationally held priorities and values.

At the organizational level, members of an organization develop socially constructed perceptions, interpretations, and meaning associated with organizational activity. If these are shared widely enough throughout the organization, they constitute the organizational level of culture. The occupational level of culture develops as organizations operating within a profession share similar perceptions, interpretations and meaning regarding their work (Karahanna et al., 2005; Sarros et al., 2005).

Each layer of culture influences individual behavior in organizations. The national level culture forms, shapes and influences entire occupations within a particular society. The organizational level factors that form within occupations have a direct influence on individual behaviors that are also indirectly influenced by the occupational and national level culture.

The idea that culture has layers is important for two reasons. First, culture is defined by the concept of shared perceptions, so it should be possible to aggregate individual perceptions to the organizational level. If perceptions are not shared across the organization, then no organizational culture exists. Second, this study involved three geographically separate organizations. If culture is shared at the occupational level, then the results of the study should demonstrate some similarities across the three participating organizations.

The variables used to operationalize culture in studies that have made cross-national comparisons at the various layers include values and practices (Hofstede et al., 1990; Hofstede, 1998; Karahana, 2005). Researchers have explored the relationship between culture and behavior as well as the characteristics of the relationship between values and practices at the different layers of culture. There is disagreement among researchers about which variable of culture has the strongest influence on individual behavior. Some researchers assert that while values have a stronger influence over behavior at the national level, practices are more important and have a stronger influence over individual behavior at the organizational level (Hofstede et al., 1990). Others assert that values have a stronger influence over individual behavior at the organizational level because they moderate the relationship between organizational practices and individual behavior (Karahanna et al., 2005).

Although researchers disagree about which variables are more important at which layer of culture, they appear to agree that both the occupational and organizational level of culture influence individual behaviors. While the occupational level of culture has a direct influence on individual action, the occupational level of has an indirect influence. As a result, organizations in the same occupation should have similar cultures (Wallace et al., 1999; Ouchi & Wilkins, 1985).

Perception in the Study of Culture

Perceptions are an important aspect of organizational studies. Organizational studies typically focus on the properties of the organizational system, the interaction of the variables that are used to operationalize the system, and how changes in the variables influence individual behaviors and organizational outcomes (Parker, Baltes, Young, Huff, Altmann, Lacost, & Roberts, 2003). Perceptions are important because they mediate the relationship between objective characteristics of the work environment and individual behavior. Rather than respond directly to objective characteristics of the work environment, individuals first perceive and interpret that environment. These perceptions and interpretations create cognitive and affective states within the individual that combine with personal values and beliefs to become the antecedents of actual behavior (Carr, Schmidt, Ford, & DeShon, 2003). Perceptions are useful for predicting behavior because the perceptions associated with previous behavior are used to gauge the appropriateness of subsequent behavior (Hofstede, 1998).

A number of researchers have examined the mechanism by which perceptions influence behaviors. Individuals interpret events, conditions and experiences that occur in the work environment through a process of psychological abstraction and concept formation that is based on their perceptions. Perceptions of important attributes of the work environment are formed into cognitive representations. Individuals organize these representations into cognitive maps that describe the social context of the work environment (James, 1982, James 1989). These maps are used to understand and predict outcomes and to gauge the appropriateness of behavior (Jones & James, 1979).

While individual perceptions are important for predicting behavior, shared perceptions are an important element in the formation of organizational culture. The concept of shared perceptions and interpretations is an important element in the definition of organizational culture (Hofstede, 1998). If perceptions of the work environment are not shared by individual members of the organization, then no meaningful organizational culture exists. When perceptions are shared by members of the organization, perceptual measures of organizational culture can be aggregated to the organizational level. Aggregated measures of organizational culture can then be used to predict organizational outcomes (Parker et al., 2003).

The concept of organizational culture can be focused on a specific referent. For example, this study is focused on those aspects of organizational culture relevant to safety, so the specific referent is safety culture. Studies have found that specific cultures predict specific outcomes (Carr et al., 2003). This finding allows researchers interested in specific outcomes, such as safety performance, to focus on measuring specific perceptions relevant to safety, which should be predictive of safety performance. This is consistent with the research findings that organizational culture influences organizational performance (Balthazard et al., 2006; van Muijen et al., 1999; Dickson, Hanges, & Resick, 2006).

Perceptual measures of relevant attributes of the work environment have been used in culture and climate studies for some time (Jones & James, 1979; Hofstede, Bond, & Luk, 1993; Neal, Griffin, & Hart, 2000). These studies typically measure perceptions of work-related practices and personal values as a means for predicting individual behavior (Hofstede et al., 1993). Perceptual measures of work related practices and personal values are based on the attribution of meaning (James & James, 1989).

The meaning of work related practices are formed from the perception of the presence or absence of important attributes of the work environment. Practices are made explicit through cognitive descriptions of the referent specific attributes of the work environment. Measures of practices describe the degree to which attributes of the work environment are present or absent.

The meaning associated with personal values are formed from the internal psychological evaluations that individual make about their work environment. Values are made explicit by affective descriptions of referent specific attributes of the work environment. Measures of values describe either the preference for or the importance of referent specific attributes of the work environment.

The distinction between practices and values is important because studies have found that perceptions of organizational practices act as normative influences by shaping values and beliefs and that both practices and values are predictive of behaviors and organizational outcomes (Carr et al., 2003, Hofstede, 1998). Questionnaires are commonly used to measure perceptions of relevant organizational practices and personal values (Hofstede, 1998b). Questionnaires use a different format depending on whether the questions are asking about practices or values. Questions about practices typically ask the respondent to rate the degree to which the practice is present or absent from the work environment. Questions about values will typically ask the respondent to rate the degree to which they agree or disagree with statements about referent specific situations in the work environment. Demographic variables are included in these studies based on the expectation that people in different roles and organizational positions are subject to different experiences resulting in different perceptions and interpretations (Jones & James, 1979; Williamson, Feyer, Cairns, & Biancotti, 1997).

While many researchers use perceptual measures of organizational culture, others argue that organizational culture is better described as an objective set of conditions. They argue that while perceptions provide important information about how organizations function, direct observation provides a more objective measurement of organizational culture and may result in a very different understanding how organizations function (Glisson & James, 2002). One of the shortcomings of measuring perceptions is that these measures may not reflect objective descriptions of the organizational work environment (James & James, 1989). In either case, it is argued that a comprehensive approach to understanding organizational culture would require the measurement of both objective organizational conditions and individual perceptions of conditions (Denison, 1996).

Summary

Organizational culture is a socially constructed system of shared practices and values that influence individual behavior and organizational outcomes. Social construction of the system occurs through a process of perception and interpretation from which individual create meaning about their work environment. The meaning associated with the work environment is then transmitted through a process of socialization that distinguishes one organization from another.

Researchers take either a functional or interpretive approach to the study of organizational culture. The functionalist approach views organizations as an objective system. The elements of the system are separate from the individual members of the organization, but interact in predictable ways to influence the behavior of those members. The purpose of organizational studies using this approach is to discover which organizational elements have the strongest influence on behaviors, to operationalize these elements into variables that can be measured, and to utilize these variables to change behavior and to increase organizational effectiveness. The interpretive approach views organizations as a subjective process. Organizational culture is viewed as a process of interaction rather than a set of variables. The purpose of organizational studies from this approach is to discover how individuals create meaning through the subjective interpretation of the organizational environment.

The functional and interpretive perspective to organizational studies has likely been a significant factor in the distinction that is made between culture and climate studies. Studies that examine organizational culture are based on the interpretive approach and explore the dynamics of how meaning is created from subjective phenomenon using qualitative measures. Assumptions, values and beliefs, and behavioral norms are the variables used to operationalize organizational culture. The meaning that members attach to these elements influences individual behavior and organizational performance. Studies that examine organizational climate are based on the functional approach and explore the influence of objective organizational attributes on individual behavior and organizational performance. Organizational elements are typically categorized into quantitative variables that represent organizational activities, behavioral norms, as well as values and beliefs.

Some researchers argue that the distinction between culture and climate is a false dichotomy and that these are really the same phenomenon that is studied from slightly different perspectives. Integrated approaches to organizational studies include variables from both perspectives. These studies typically include assumptions, values and beliefs, and behavioral norms as variables and use both qualitative and quantitative methods. Researchers using an integrated approach to explore the social context of organizations generally refer to these as organizational culture studies. Similar to both approaches, these studies are focused on the characteristics of the organization that influence individual behavior and organizational performance.

Organizational culture acts as a control system on individual behavior. Three types of control systems have been identified in the literature, which correspond to the three main types of variables used in organizational culture studies. These include the management, values and normative based control systems. Management systems are described in the literature as reflective of the organizational assumptions about human nature, motivation and social relationships. Organizational culture studies use assumptions as one of the three common variables used to operationalize the construct. Therefore, the management control system corresponds to the assumptions as a variable in organizational culture studies. The other two control systems and variables correspond as a matter of definition: the values based control system corresponds to the variable of values and beliefs, while the normative control system corresponds to the variable of behavioral norms. It is interesting that the research on culture as a control mechanism corresponds to the variables used in other organizational culture studies. The correspondence between organizational culture as a control mechanism and organizational culture variables in an indication that these variables are consistently used in organizational culture studies that examine the influence of organizational culture on individual behavior.

A number of studies have examined the relationship between organizational culture and performance. Some of these do not explicitly include individual behavior as a functional element of the theoretical framework. Other researchers include individual behavior as a critical component of the theoretical framework for their study based on the assertion that organizational performance is mediated by individual behavior. These studies recognize the result of individual behavior has consequences for the organization and for the individual and that these consequences or outcomes may be positive or negative. Changes in organizational culture that generate a change in individual behavior may result in positive or negative outcomes for the organization as well as for the individual members.

Many of the studies that explore the construct of organizational culture assume that organizations have one overarching culture. Some scholars have challenged this conceptual framework and have argued that a more realistic and productive approach is to assume that organizations have several different sub-cultures operating at the same time. Organizational operations include a number of different goals, functions, systems and processes that may be better understood by exploring the social context of the organization on a smaller scale and in more detail. They argue that this approach to the study of organizational culture may improve our understanding of organizational culture and may advance the theoretical development of the relationship between the social context of organizations and individual behavior by narrowing the number and types of variables that are explored at one time. The concept of organizational sub-cultures is particularly important for this study, since the construct of culture in organizations is applied to the specific problem of firefighter injuries and fatalities, which is a more narrowly focused approach to the study of organizational culture. As a result, the next section is a discussion of the literature on organizational sub-cultures, followed by a discussion of the literature on safety culture as a sub- culture in high-risk occupations.

Subcultures

Organizational culture is a conceptual framework used for the analysis of the social context of organizations. Because the concept of organizational culture has been formed in large part from an anthropological approach to social systems, the construct has generally been regarded as unitary, meaning that organizations have only one culture. Some researchers challenge this approach and dispute the assumption that organizational culture is unitary (Hatch, 1993, Naidoo, 2002; Huang, Newell, & Galliers, 2002; Denison, 1996).

While researchers assert that the social context of organizations is composed of various subcultures rather than one global culture, subcultures are conceptualized as structurally and functionally equivalent to organizational culture (Lok, Westwood, & Crawford, 2005). The principal difference is that subculture research focuses attention on a smaller segment of the social context of organizations. In addition, researchers argue that while the unitary perspective of culture provides a basis for explaining differences among organization, it does not provide enough detail about the social functioning within organizations to guide the development of effective interventions for changing behavior and improving performance (Lok et al., 2005; Scott et al., 2003). In addition, because the subculture perspective on organizations is smaller in scope, subcultures are viewed as more malleable and responsive to change (Boisnier & Chatman, 2003).

Conceptual Perspectives on Sub-Cultures

Subcultures are generally viewed from two different perspectives. Some researchers argue that organizations are constituted of one main culture in which subcultures are embedded. Subcultures share some elements of the main culture and the other subcultures that exist in the organization (Naidoo, 2002). Others argue that organizations do not have one main culture but consist of different subcultures that exist because of the different hierarchical levels and functional divisions that form the structure of organizations, and the different activities and tasks that organizational members perform. From this perspective, there is nothing necessarily in common between subcultures and nothing about subcultures that can be applied across an entire organization (Huang et al., 2002).

Regardless of whether organizational culture is viewed as an aggregation of subcultures or not, subculture researchers argue that a multi-cultural model is a more accurate and useful representation of modern organizations. A multi-cultural approach to the study of organizational functioning provides a more complex conceptualization of organizational culture by recognizing the existence of different sub-cultural perspectives (Karahanna, 2002). At the same time, this approach provides the means for a deeper understanding of how and why organizations function by focusing on a specific piece of the social context of the organization. Researchers have anticipated that this approach will provide more explanatory and predictive power than the global or unitary approach to organizational culture (Karahanna, 2002).

Formation of Sub-Cultures

Formation of subcultures is driven by a variety of organizational, social, and individual characteristics, which have been described by Boisnier (2003). Subcultures can be formed around characteristics associated with the structure, functions, and tasks within an organization. Subcultures may also emerge around different groups of organizational members who interact to accomplish specific tasks. Certain values are developed and associated with these tasks, which are then adopted by the group as task specific norms and values. The subculture is formed on the basis of the behavioral norms and values associated with the tasks. Individual characteristics that influence the formation of subcultures include the degree to which the subculture is perceived to be positively associated with self-esteem, social esteem, and self-efficacy. Individuals join subcultures because they identify with the values that are explicitly or implicitly associated with the subculture. For example, individuals join the local fire department because they identify with the values of service, courage, bravery, and risk-taking that they perceive are part of the culture of the fire service.

Individual members internalize the values of the subculture, which then become part of the individual's self-view.

The organizational, social and individual characteristics used to describe the formation of subcultures are also used to characterize the differences between subcultures. Organizational subcultures are characterized by differences between groups, functions, activities and tasks that result in a set of norms and values different from those associated with other subcultures. Different groups exist in organizations based on the vertical or horizontal relationship defined by the organization's structure (Ouchi & Wilkins, 1985). Different groups exist as part of the hierarchical and divisional structure of the organization (Denison, 1996: Naidoo, 2002). Organizations are also structured by functions that operate across vertical and horizontal relationships. These subcultures form around the site of activities of people who perform similar tasks (Linstead & Grafton-Small, 1992; Naidoo, 2002).

Substantive organizational functions that have been identified in previous research include safety and service (Denison, 1996; Neal & Griffin, 2002). Research based on this approach is focused on a specific function of interest and the work practices and behaviors associated with that function (Karahanna et al., 2005). Because different groups perform different tasks, sub-cultural differences are created between groups and functions (Huang et al., 2002). The differentiation of groups and functions within organizations subsequently creates different ideologies (Naidoo, 2002) that are a distinct set of shared values, beliefs and norms that are different than the values, beliefs and norms associated with other groups or functions (Huang et al., 2002).

Interaction of Sub-Cultures

Several distinct subcultures may operate in any organization at the same time (Bloor & Dawson, 1994) and the interaction of these subcultures has a powerful influence on work related behavior (Karahanna et al., 2005). Sub-cultural differences are also a source of latent tension and conflict between groups, functions and values (Huang et al., 2002; Wallace et al., 1999). In the fire service, for example, the different functions and values associated with firefighter safety and operational performance creates tension between the need to prevent firefighter injuries and fatalities and the need to extinguish fires. This would be equivalent to the potential conflict between safety and production in private sector organizations were safety is sacrificed to meet production demands (McLain & Jarrell, 2007).

As subcultures interact and compete to shape behaviors, one or more of the subcultures may become dominant within an organization. Through interaction with other members of the organization, new members are expected to adopt the dominant subculture value system and behavioral norms consistent with that value system. Over time, as the dominant subculture continues to gain influence in the organization, the values, beliefs, norms and practices associated with the dominant subculture will be perceived as so completely legitimate and as such an essential part of the organization's identity that they will become underlying assumptions and beyond question (Bloor & Dawson, 1994).

Subculture dominance may be at the root of the safety performance problem for the US fire service. The subculture of operational performance may be so dominant that the values, beliefs, norms and practices associated with safety as a subculture do not have a significant influence on individual behaviors, resulting in high rates of firefighter injuries and fatalities. Competition among subcultures for dominance in an organization is fundamentally a power struggle for control over the social context through which an organization will function (Denison, 1996).

In the US fire service, the subculture of operational service has likely dominated over the subculture of firefighter safety. Although changes have been made in certain aspects of safety over the last twenty years, they have been incremental changes that have not changed the domination of the subculture of operational service over the subculture of firefighter safety. As discussed previously, this has resulted in relatively high rates of firefighter injuries and fatalities.

The ability to minimize domination of one subculture over others may depend on the level of understanding that members have about different subcultures that operate in their organization and on their capacity to recognize and manage subculture conflicts (Huang et al., 2002). It is important, therefore, for the US fire service to gain a greater understanding of safety as a subculture in organizations to deal more effectively with the problem of firefighter injuries and fatalities.

Safety Culture

Definition and Approaches

In general terms, scholars have defined safety culture as a construct that refers to those factors in high risk organizations that are important to safety (Parker et al., 2006; Sorensen, 2002), or to how people think and behave in relation to safety (Cooper, 2000b). It has also been defined as the shared perceptions of individuals regarding the workplace attributes concerned with safety (Clarke, 2000; Griffin & Neal, 2000). Safety culture is also viewed as a summary of the interpretations, perceptions and beliefs of employees about safety that are used as a frame of reference to guide day to day behavior (Clark, 2000; Silva, Lima, &

Baptista, 2004; Williamson et al., 1997). Other researchers have summarized the essential elements of culture as shared values and beliefs, organizational control systems, and behavioral norms (Reason, 1998).

Some of the proposed definitions of safety culture focus on shared meaning reflected through values and beliefs associated with safety. For example, Clarke (1999) defines safety culture as the values and beliefs of the organization associated with matters of safety. In a later study, Clarke (2000) argues that safety culture is reflected in attitudes, beliefs, perceptions, and values that employees share in relation to safety and result in shared meaning with respect to safety. Other scholars define safety culture as the values, norms, or attitudes associated with safety (Ostrom, Wilhelmsen, & Kaplan, 1993; Mearns et al., 2003; Neal et al., 2000). Another group of scholars defines safety culture as a construct that consists of both values and practices. These scholars argue that safety culture is comprised of shared values, attitudes, beliefs and practices concerning safety that result in patterns of behavior (Glendon & Stanton, 2000), or that safety culture consists of shared values and beliefs that interact with an organizations structure and control system to produce behavioral norms (Cooper, 2000). Some of these same scholars also argue that the definition of safety culture should recognize that safety culture is a sub-set of organizational culture.

Safety culture is an example of an organizational sub-culture that specifically refers to matters of safety (Clarke, 1999; Guldenmund, 2000; Cooper, 2000). As an organizational sub-culture, the definition and variables of safety culture should be consistent with those proposed for organizational culture (Sorensen, 2002). Scholars that focus on safety culture argue that it is essential for the elements or variables of organizational culture and safety culture to be congruent for one of two reasons: either because safety culture exists in and is influenced by organizational culture; or because congruency between variables of sub-cultures, such as safety and service, is essential for the purpose of making assessments and comparisons about how different sub-cultures influence behavior and performance (Grote & Kunzler, 2000; Neal et al., 2000; Naevestad, 2009).

Whether organizational culture is viewed as a global construct or as some form of composite construct formed from various sub-cultures, the construct of safety culture has largely been formed from ideas about organizational culture. Because safety culture is derived from organizational culture, the two constructs should share many of the same features, frameworks, and variables (Clarke, 2000). For example, if organizational culture is defined as the shared perceptions of individuals about organizational management systems, values and beliefs of individuals, and behavioral practices or norms, then safety culture should be defined by using the same variables (Silva et al., 2004).

Researchers take different approaches to the study of safety culture depending on whether they view it as a shared pattern of behaviors or a shared pattern of meaning. This is the same distinction that is used in organizational culture research between the functional and interpretive approaches respectively. The functional approach assumes that safety culture consists of critical variables that influence individual behavior and organizational outcomes. These variables are understood as shared patterns of behavior that form normative behavioral expectations that can be operationalized and measured using quantitative methods (Naevestad, 2009). The functional approach assumes that safety culture consists of the policies, structures, controls, and practices regarding safety and that it is an organizational variable that can be managed and manipulated to serve organizational interests (Glendon & Stanton, 2000; Wiegmann et al., 2004).

From the functional perspective, culture is viewed as an expression of organizational strategy that can be socially engineered by identifying and managing the essential variables (Reason, 1998; Clarke, 2000). In a functional model, management provides extrinsic forms of motivation in an attempt to shape safety culture. However, researchers have recognized that while behavior changes may result from extrinsic motivators, employees may resist attempts by management to change their behaviors (Collinson, 2003). In addition, some researchers argue that intrinsic motivations are more powerful than extrinsic motivations and so even if behavioral changes occur, the underlying values and beliefs of individuals may remain unchanged (Hudson, Parker, & Lawrie, 2004).

From the interpretive approach, safety culture consists of the beliefs, attitudes and values of the members. These are formed by the interaction of members of the organization over time. Interaction forms shared patterns of meaning that are much deeper and more important than shared patterns of behaviors because they provide members with a framework for interpreting their work environment (Glendon & Stanton, 2000). The development of shared meaning also provides intrinsic motivation, legitimizes behavior, and forms the basis for organizational identity (Naevestad, 2009). From the interpretive view, safety culture is a complex outcome that is not easily changed or manipulated. However, while management cannot impose safety culture, it can be changed slowly as members make new interpretations and develop new meanings (Clarke, 2000).

Researchers disagree over whether the functional or interpretive approach is more important with regard to safety performance. Functionalists assert that shared patterns of behavior are more important and argue that behavior has the strongest influence on performance, and that the meaning members attach to behaviors makes little difference

(Reason, 1998). Researchers taking the interpretive approach assert that shared meaning is more important than shared patterns of behavior and argue that perception, interpretation and meaning precede action, and that meaning forms identity in organizations, which functions to support and sustain consistent behavioral patterns and subsequent performance (Glendon & Stanton, 2000).

Other researchers argue that both are equally important. For example, Cooper (2000) argues that safety culture includes elements of both approaches in that managerial strategies emerge from social contexts, and that these are created through a dynamic reciprocal relationship. Other researchers agree that both approaches are essential for achieving a safety culture, but recognize that the functional approach identifies variables of safety culture that are easier to manipulate, that can be shaped by organizational controls, and that can lead to changes in beliefs (Reason, 1998). Behaviors are easier to measure and change than values and beliefs because values and beliefs are cognitive or affective states (Naevestad, 2009). It is much easier to manage organizational policies, structures and control systems, as well as practices and procedures. If safety culture is defined in general terms as the way people think and act in relation to safety, it is much easier to change the way people act than to change the way they think.

Safety Culture and Safety Climate

Disagreements about the definition and approach to safety culture are not the only areas where researches have been unable to reach consensus about important issues involving the construct. Researchers continue to disagree about whether safety culture and safety climate are separate and distinct factors, or whether they are variables of the same construct (Clarke, 2000). As previously discussed in the section on organizational culture, this may be a result of the difference between the functional and interpretive approaches. The disagreement over whether culture and climate are two distinct concepts or simply different approaches to the study of the same concept appears to influence the research on organizational sub-cultures in the same way, creating disagreements about definitions, variables, and research methods.

A few scholars have been bold enough to propose definitions of both safety culture and safety climate in the same study. In a study on safety culture in high-risk occupations, for example, Naevestad (2009) proposed definitions of the constructs based on which approach was used to study them. He argues that the construct of safety culture is based on an interpretive approach and should be defined as shared patterns of meaning, while safety climate is based on a functional approach and should be defined as patterns of behavior. As part of his study on safety climate and behaviors, Neal & Griffin (2002) argues that safety climate refers to perceptions of the work environment and practices related to safety while safety culture refers to safety related values and attitudes. Another distinction between the concepts is associated with the relative time scale. Whereas climate is viewed as a short-term concept that changes more easily over time, culture is viewed as more enduring and more difficult to change (Wiegmann et al., 2004).

Some definitions of safety culture and safety climate are identical (Wiegmann et al., 2004) or use the term interchangeably (Silva et al., 2004). Researchers have described safety climate as a surface feature of safety culture, a feature that can be observed and measured at one point in time, but only functions as an indicator or as a manifestation of the true underlying safety culture (Flin, Mearns, O'Connor, & Bryden, 2000; Mearns et al., 2003). Commonality between the two concepts has motivated some researchers to attempt to develop composite models that integrate the concepts of culture and climate into a single framework (Glendon & Stanton, 2000). For example, Mearns (2003) argues that safety climate and safety management systems are both lower level abstractions and should be considered to be manifestations of overall safety culture. In this model, safety culture is reflected in safety climate and safety management systems.

Several important comparisons can be made about safety culture and safety climate that help to understand how these two separate and distinct concepts have evolved into one integrated concept that is typically described as safety culture. Early research distinguished between climate as a descriptive or cognitive variable and culture as an affective or evaluative variable. Individuals in organizations perceived certain safety related practices that were part of the organizational work environment and had reactions to those same practices (Guldenmund, 2000). Climate refers to the characteristic behaviors in the organization. Culture refers to the reaction, in term of values and beliefs, which members have about those behaviors. So, climate is the perception of a coherent pattern of behaviors and culture is the underlying meaning given to those patterns of behavior.

Another way to compare climate and culture is to think of climate as the object of culture. Perceptions of the practices that occur within the work environment form the basis for safety climate, so safety climate is an organizational attribute. The values and beliefs that individuals form about these practices form the basis for safety culture, so safety culture is an individual attribute. The perceptions of safety related practices are the objects of individual values and beliefs, both of which form the social context of organizations. What researchers seem to have realized in more recent studies is that these two constructs are difficult to separate and that a more productive line of research is to integrate these two constructs into one overall approach toward understanding the social context of organizations

(Guldenmund, 2000). An integrated approach recognizes that both organizational and individual attributes influence behavior and performance, regardless of which term is used to describe the phenomenon. It is apparent, however, that the term "safety culture" is used most often to refer to this type of integrated approach.

Despite efforts to integrate the concepts of safety culture and safety climate and some of the commonalities recognized in the literature, most researchers agree that the relationship between culture and climate is not clear, that there is considerable confusion about the content of safety culture and climate, and that a useful and practical model has yet to be developed (Guldenmund, 2000). For this reason, this thesis will focus on the development of an integrated conceptual model of safety culture to analyze and assess the social context of organizations.

Elements of Safety Culture

Considerable effort has been directed at defining safety culture and toward developing measures of safety culture (Sorensen, 2002). As a result, a major theme in empirical studies has been on defining the elements of safety culture (Clarke, 2000).

Many of the research studies on safety culture are framed within the functionalist approach (Naevestad, 2009). As a result, many researchers describe the elements of safety culture as broad attributes, variables, or measures. Attributes of safety culture are formed into models that are used to understand how practices and values regarding safety are expressed, and how these expressions of safety culture influence individuals and organizations (Glendon & Stanton, 2000). The overall purpose of these frameworks is to develop measures of safety culture that can be used as a basis for change and improvement in safety performance (Cooper & Phillips, 2004). This approach to the research on safety culture has been based on three common assumptions (Glendon & Stanton, 2000). The first is that there are aspects of culture in organizations that affect safety. The second is that members of organizations have shared attitudes, values, beliefs and practices concerning safety. The third is that individual and group attitudes and patterns of behavior determine safety performance.

Some researchers have developed general measures for safety culture that result in one overall index indicating the level of safety culture, but this approach has been criticized as a limited concept of a complex phenomenon, and that safety culture is best considered a multidimensional phenomenon (Parker et al., 2006). Sorensen (2002) argues that the indicators of safety culture should include management practices, attitudes of the individual toward safety, and safety practices. However, Wiegmann (2004) asserts that organizational commitment, management involvement, employee empowerment, reward systems and reporting systems are the best indicators of safety culture. In another study, Flin et al. (2000) uses a different set of indicators that includes workforce perceptions of management behaviors, safety management systems, attitudes toward risk, work pressure and the balance between safety and production, competence of the workforce, and perceptions of safety rules. Williamson (1997) uses another set of eight attributes for safety climate: safety awareness; safety responsibility; safety priority; management commitment; safety control; safety motivation; safety activity; and safety evaluation.

Given the broad range of attributes or indicators used in safety culture research, it is apparent that there is no consensus on the key underlying factors of safety culture (Cooper & Phillips, 2004). The factors or variables used in safety culture research have largely depended on the specific definition of safety culture used by the researcher (Yule & Flin, 2007). The lack of consensus may be more a matter of terminology than of any practical difference in the variables used to define and measure safety culture. Many of the researchers that have conducted some form of empirical analysis of safety culture use very similar variables with slightly different labels and descriptions. When these variables are compared as a whole, there does appear to be at least a limited level of agreement on three general variables that have been used by several researchers as a framework for the assessment of safety culture.

Although several of these variables have been described in slightly different terms, they appear to have the same overall meaning. For example, the variables of safety culture described by Lund & Aaro (2004) include attitudes and beliefs, behavioral norms, and organizational context. Reiman & Oedewald (2007) describes the three interrelated elements of safety culture as internal climate, core tasks, and organizational systems. Reason (1998) describes these variables as the values and beliefs of individuals, behavioral norms with regard to safety practices, and the structure and control system of the organization, and asserts that these three variables interact to form safety culture.

Using a model borrowed from social cognitive theory, Cooper (2000) asserts that safety culture consists of a reciprocal relationship between personal factors, behavioral patterns, and organizational systems that interact to influence actual behaviors. These are the same variables used in a study by Arezes & Miguel (2003) that examined the role of safety culture on safety performance. Mearns (2003) describes these factors as management systems, individual attitudes, and workforce practices. A number of researchers refer to the variables of safety culture as organizational management practices, shared values and beliefs, and individual work practices (Hofstede, 1998; Ouchi & Wilkins, 1985; van den Berg & Wilderom, 2004).

These three overall variables of safety culture correspond to the three levels of organizational culture developed by Schein (2004) in his framework of organizational culture. This is an important consideration because organizational culture may help to explain the factors that influence safety culture (Sorensen, 2002). As previously described, the concept of organizational culture has three levels: underlying assumptions, values and beliefs, and behavioral practices. These are very similar to the concepts that have been used consistently as variables of safety culture, which include organizational systems as the manifestation of underlying assumptions, values and beliefs of individuals, and behavioral norms (Cooper, 2000; Clarke, 2000; Neal et al., 2000, Diaz-Cabrera & Hernandez-Fernaud, 2007).

While much of the research on organizational and safety culture has been focused on values and practices, organizational systems have been identified as an important and distinct element of safety culture, one that has a particularly important role in safety performance (Fernandez-Muniz et al., 2007). Organizational systems are commonly referred to as safety management systems and are described as systematic frameworks that include a number of elements, such as policy, goals, strategy, structure, planning, implementation, and performance management (Cooper, 2000b). These elements interact in an organized way to ensure that individual engage in appropriate safety behaviors (Santos-Reyes & Beard, 2002).

Safety management systems are an important dimension of safety culture for two reasons. First, the characteristics of an organization’s safety management system influence individual values and beliefs regarding safety (Fernandez-Muniz et al., 2007). Secondly, more developed safety management systems have been found to correlate with better safety performance in terms of decreased injury rates and decreased worker compensation costs, as well as with improved levels of operational performance (Mearns et al., 2003; Robson, Clarke, & Cullen, 2007). Effective safety management systems have been described as a set of strategies, functions, roles and practices related to safety that are internally integrated into organizational operations and ensure compliance with external safety related regulations (Fernandez-Muniz et al., 2007; Robson et al., 2007).

Some scholars argue that separating management practices from other behavioral norms provides a more comprehensive perspective on safety culture (Diaz-Cabrera & Hernandez-Fernaud, 2007). Others consider management approaches to safety as the most important dimension of safety culture because perceptions of management systems have been found to have the most significant impact on safety performance (Cooper & Phillips, 2004; Hofmann & Stetzer, 1996; O'Toole, 2002).

In one of the few studies of safety management in emergency services, Cooper (2000) argues that if safety culture is not deliberately and purposely managed, then low levels of both extrinsic and intrinsic motivation will result. Research involving other public sector organizations has found that other factors influence the level of intrinsic or internal motivation and extrinsic or external motivation. These include the degree to which safety is considered a core management responsibility, whether safety is viewed as a critical factor leading to operational success, and whether the cost of injuries is considered to be significant (Wright, 1998). In addition, high risk organizations like the fire service may have low levels of safety motivation because of the traditional acceptance of high levels of risk as part of the occupational hazard that individuals accept, even welcome, when they become part of the organization (Wright, 1998).

Safety Culture and Organizational Performance

A recurring issue recognized in the literature on safety culture is the conflict between individual safety and organizational performance. This conflict becomes evident in the definition of safety proposed by Reason (2000) that is used in much of the research in this field. Reason (2000) defines safety as the ability of individual and organizations to deal with risks and hazards so as to avoid damage or loss and yet still achieve their goals. Based on this definition, safety performance is the product of the interaction of at least two inter-dependent subcultures: safety and production. Within the context of the fire service, which does not produce a product but provides a service, the two interdependent subcultures could be described as safety and service. Safety and service have been recognized as two important organizational subcultures that present competing operational demands (Griffin & Neal, 2000; Zohar & Luria, 2004) because they depend on the same work processes and organizational factors but are perceived as having incompatible goals (Sorensen, 2002). In the fire service, for example, it is assumed that low levels of safety are required to provide a high level of service, and that higher levels of safety would result in lower levels of service, represented by higher direct fire loss and higher civilian fire death rates.

Some researchers describe sub-cultures, such as safety and service, as organizational core tasks (Reiman & Oedewald, 2007) or focal organizational facets (Zohar & Luria, 2005). In the fire service, safety and service could be considered separate but interrelated core tasks or subcultures. Core tasks are defined by a shared purpose that results in organizational activity. Activities are actions in a social context that have a shared objective. Shared objectives are the collective motivation for the activity (Reiman & Oedewald, 2007). Core tasks set demands for activity in organizations. Activities or actual behaviors result from the interaction of cultural elements, such as safety and service. Therefore, actual behaviors are a response to the perceived demands of core tasks.

Analysis of organizational systems, behaviors and attitudes is indicative of which subculture is dominant in an organization (Zohar & Luria, 2005). If service is more dominant than safety, then individuals will circumvent safety rules and procedures to ensure high levels of service (Cooper, 2000a). Workers circumvent safety rules because they prioritize one set of goals over the other and make decisions about actual behavior that are consistent with those priorities (McLain & Jarrell, 2007). At the same time, the conflict between safety and service can obfuscate behavioral expectations, create role ambiguity, and generate conflicting messages, resulting in diminished performance in both safety and service (McLain & Jarrell, 2007).

An important manifestation of an organization's culture is the way in which conflicts between subcultures are resolved (Reason, 2000). Fire service organizations are in the business of taking risks to protect the public from the effects of fire and other incidents that endanger their lives. This service is inherently unsafe, and presents a conflict between safety and service subcultures. Both are essential but are rarely if ever considered equal. Service is more salient, more immediate, and more emotionally compelling than safety. The ability to resolve the conflict between safety and service depends on an adequate perception of the safety and service subcultures (Reiman & Oedewald, 2007). In order to resolve this conflict, it is important to be able to accurately assess safety culture in fire service organizations. Inaccurate conceptions of safety or the dominance of service over safety can result in dysfunctional practices (Reiman & Oedewald, 2007). Unreasonable levels of risk and ineffective practices can be made legitimate and seemingly acceptable when members of the organization strive for rationality consistent with the dominant cultural orientation. If conceptions of the demands of safety are inaccurate or incomplete, then behaviors can be considered legitimate even though they are ineffective and unsafe (Reiman & Oedewald, 2007).

Organizations that have been able to resolve the conflict between safety and performance have been described as high reliability organizations (HRO's). These organizations operate in complex, demanding, and dynamic environments, but avoid serious operational failures while maintaining a high level of operational performance (LaPorte & Consolini, 1991; LaPorte, 1996). Serious operational failures are those classes of incidents or accident judged to result in absolutely unacceptable consequences. For fire service organizations, this would include serious injuries or fatalities. Characteristics of HRO's include an equal commitment to operational performance and safety performance and are viewed as inextricably related. Safety failures are assumed to have a negative effect on the ability of the organization to perform and are not tolerated by members of the organization. Members of the organization are competent in safety practices and in managing safety systems. In addition, operational performance and safety performance are actively measured and result in formalized efforts to continuously improve safety performance and operational performance (LaPorte, 1996).

Another perspective on HRO's views this approach to improving safety as inadequate because it underestimates and oversimplifies the problem (Marais, Dulac, & Leveson, 2004). For example, while it may be desirable to give equal priority to safety and service, it is rarely possible to do so. Safety is not the primary goal of fire service organizations, for example, and operational goals are often best achieved in ways that are not consistent with low risk. Even when management statements are promulgated that declare safety as the top priority, firefighters are often pressured informally to bend safety rules in order to achieve operational objectives. As in other high-risk occupations, the problem is more complex that just prioritizing safety goals. Organizations must work openly toward resolving the conflicts between safety and service goals, recognizing that this is a difficult task to achieve, particularly in the absence of an effective safety management system (Marias, 2004).

Some researchers argue that the most effective means for improving safety is to improve safety systems in organizations rather than to improve reliability (Klein, 1995). A systems safety approach is different from a high reliability approach to improving safety in that the focus of the systems approach is on safety culture rather than the extensive use of redundancy used in high reliability organizations. Critical elements of the systems approach include social structures, social interactions and individual factors. These elements are very similar to the elements that have been previously described as part of the social context of organizations that define its culture. From a systems perspective, safety is assumed to be a property of the relationship of the parts of the system and can be understood only if all properties of the system are considered (Marais et al., 2004). For example, safety performance would be determined by the interaction of the variables of the organizations safety culture - which would include the personal factors, behavioral patterns, and organizational systems - that have been previously described as part of the safety culture model or system developed by Cooper (2000).

Safety Culture and Safety Performance

Much of the research on safety culture is directed at understanding the relationship between safety culture and safety performance. While there is still disagreement about underlying causal models (Lund & Aaro, 2004) there does seem to be a general consensus that a favorable safety culture is essential for improving safety performance (Mearns et al., 2003; Parker et al., 2006) and that the effectiveness of safety culture is reflected in safety performance (Sorensen, 2002). Some scholars argue that perceptions of safety culture form the basis of safety behaviors and therefore the safety performance of an organization (Parker et al., 2006). Others argue that that while safety culture may have some correlation with safety performance, no instrument has yet been developed that can predict actual safety behavior or safety performance (Cooper & Phillips, 2004).

Two approaches to improving safety performance have been identified in the literature. These have been described as the behavior change and culture change approaches (DeJoy, 2005). Behavior-based safety is an extension of an applied behavioral analysis that is focused on producing systematic changes in clearly defined behaviors considered critical for safety performance. The culture change approach is based on management and organizational behavior theory, and is focused on understanding and changing individual values and beliefs about safety.

It is interesting to note that the behavioral and cultural approaches used in safety culture research correspond to the practices and values used as principal variables in organizational culture research. Researchers exploring the relationship between organizational culture and organizational performance appear to use the same variables as researchers exploring the behavior change and culture change approaches to safety performance improvement. The only difference is that the variables are called practices and values in the organizational culture studies and are called the behavior change and culture change approaches in safety culture studies.

The behavior change approach is focused on changing behaviors as the means for improving safety performance (Cooper & Phillips, 2004). A behavior change approach involves the identification of critical safety related behaviors that have direct potential for reducing injuries or other losses. These behaviors become the targets for improvement by establishing performance goals and measures actual behaviors. Behaviors are monitored and feedback is provided on performance. It is proposed that changes in these critical behaviors result in changes in the safety performance of the organization.

In addition, behavior is viewed as under the control of environmental contingencies (DeJoy, 2005). Environmental contingencies are the organizational factors that influence behavior. These factors include the management and normative-based control systems previously discussed in the section on organizational culture. Behaviors that influence safety performance include those behaviors performed by front line employees and those that are part of the safety management system within the organization.

A culture change approach defines culture as the values and beliefs that members hold about safety, and assumes that these factors influence individual behaviors. The focus of this approach is on changing values and beliefs. Just as management and normative control systems influence practices, the values based control system influences values and beliefs. The main focus of this approach is on understating how individual values and beliefs about safety influence the level of compliance with safe work practices.

Each of these approaches has its own set of strengths and weaknesses, and some researchers have argued that the integration of both approaches is required to make significant improvements in safety performance (DeJoy, 2005). Integration of these two approaches would require the development of a model that includes behavioral variables of the climate model and the values and beliefs of the cultural model. A model that includes all three of these variables and their relationship to safety performance would represent a comprehensive model of how organizations work with regard to safety (Sorensen, 2002). Measures for each of the variables would then need to be developed and tested in an actual organizational setting.

Safety culture research has generally not directed much attention toward the development of a theoretical framework that integrates the behavior change and culture change approaches (Parker et al., 2006). Researchers use one approach or the other and tend to use the behavior change approach more frequently than the culture change approach. For example, in the study by Mearns (2003), the relationship between safety management behaviors and safety performance was explored in the context of high-risk occupations. Safety management variables included health and safety policy, organizing for health and safety, management commitment, workforce involvement, safety promotion and surveillance, and safety auditing. Finding from this study indicate that higher levels of safety management behaviors are associated with higher levels of safety performance.

A study by Yule & Flin (2007) also explored the relationship between workforce perceptions of safety management and the behaviors that influence safety performance. Safety management practices were used in the study because this variable is commonly used in the analysis of safety climate factors. Two managerial variables were used in this study:

management commitment and supervisor involvement. Yule’s findings support the proposition that perceptions of safety management practices account for a large percentage of the variation in risk-taking behaviors.

Hoffman and Stetzer (1996) examined the effect of several organizational factors on safety performance in autonomous work teams. They defined what they argue to be important organizational variables as safety climate, and examined the influence of these variables on unsafe behaviors and safety performance. The organizational variables included in that study were perceptions of role overload, perceptions of group processes, management commitment to safety, and worker involvement in safety-related activities. Results of this study found that all of these variables had a small degree of influence on safety performance.

Results from a study by Cooper (2004), however, found that there was no significant association between changes in safety climate and safety behaviors. This is one of the few studies that used a pre-test, intervention, post-test design. Safety climate was operationalized through several variables including: management attitudes towards safety; management actions towards safety; perceived level of risk at workplace; effects of required work pace on safety; importance of safety training; effects of safe conduct on social status and promotion; and status of safety officer and safety committee. Result of the study lead Cooper to conclude that behavior-based improvement programs may lead to behavior change without any significant change in safety climate.

In each of the previous examples, researchers have used a number of different variables to operationalize the significant organizational factors that influence safety performance. Some studies use variables that are consistent with the behavior change approach while others use variables that are more consistent with the culture change approach. Other studies use variables that are consistent with both approaches. Managerial variables, for example, are commonly used in safety culture change studies, but have also been used in behavior change studies (DeJoy, 2005). Advocates of both approaches recognize, however, the critical importance of safety culture as a determinant of safety performance (Clarke, 2000). Proponents of the behavior-based approach argue that a positive safety culture is essential for the success of behavior change programs (Krause, 1997). Despite this mix of approaches and variables, there does appear to be some consistency in the overall framework that researchers have taken toward the analysis of the relationship between safety culture and safety performance.

In the earlier discussion about the relationship between organizational culture and performance, a framework of the relationship between organizational culture, behaviors and performance was described. This theoretical framework is based on the ABC (Antecedents, Behaviors, Consequences) model proposed by Mwita (2000). In this framework, culture is the antecedent of the individual behaviors that determine organizational performance or consequences.

The ABC framework is consistent with much of the research on the relationship between safety culture and safety performance (Griffin & Neal, 2000; Guldenmund, 2000). In a study by Parker (2006), for example, in her research on the development of a framework of safety culture in hazardous industries, she asserts that individual perceptions of the variables of safety culture form the basis for behaviors and subsequently for safety performance. In a study of the impact of managerial factors on safety performance, Yule & Flin (2007) asserts that perceptions of safety management and safety behaviors can have a direct and indirect effect on safety performance. Findings from both of these studies support the assertion that safety culture has a significant impact on safety performance, although Parker argues that the effects of the content of safety management systems on safety performance have largely been ignored, while Yule counters that managerial variables have been demonstrated to be the primary determinant of safety culture and the principal leading indicators of safety performance.

Very different models of safety culture have been used for the purpose of assessing safety culture, for exploring the relationship between safety culture and safety performance, and for understanding, measuring and changing safety culture in organizations. For example, Guldenmund (2000) identified sixteen different causal models of safety culture and climate. Although these models can be categorized as either normative or descriptive, there are substantial differences among the models in terms of the structure, variables, and goals associated with each.

The first causal model of safety culture was developed by Glennon (1982) as a normative model of the cause, content and consequences of safety culture. In this model, organizational characteristics are interpreted by individuals in the organization, which are then formed into perceptions of organizational characteristics. Perceptions of organizational characteristics determine individual behavior, which result in both individual and organizational outcomes.

A model proposed by Clarke (2000) is much more complicated in terms of the number of variables and the hypothesized relationships between the variables. The model is presented below in Figure 9. Five theoretical propositions were used as the basis of this model, but were not tested empirically in the study.

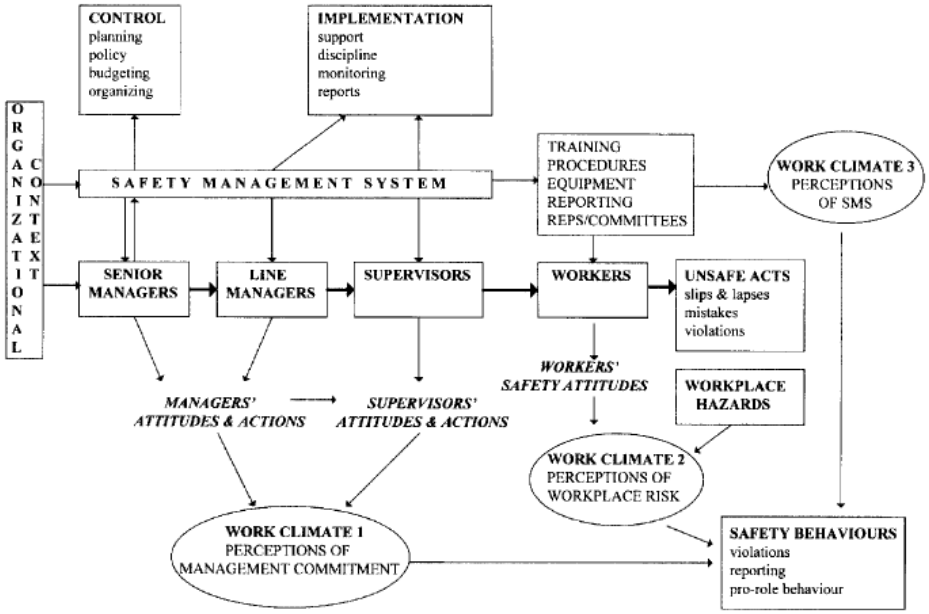

Figure 9. Clarke's Model of Safety Culture

Clarke's propositions include the following: 1) that safety culture affects safety behaviors; 2) that management commitment and supervisor support for safety affect safety outcomes; 3) safety attitudes of individuals influences safety behaviors; 4) perceptions of safety management systems influence safety behaviors; and 5) that work climate provides guidelines for individual behaviors.

A model was developed by DeJoy (2005) in an attempt to integrate the behavior change and culture change approaches into a comprehensive model for managing safety. In this model, presented in Figure 10, the principal inputs into the safety management sequence are three manifestations of culture: policies and practices; operational priorities and rewards; and work behaviors and conditions.

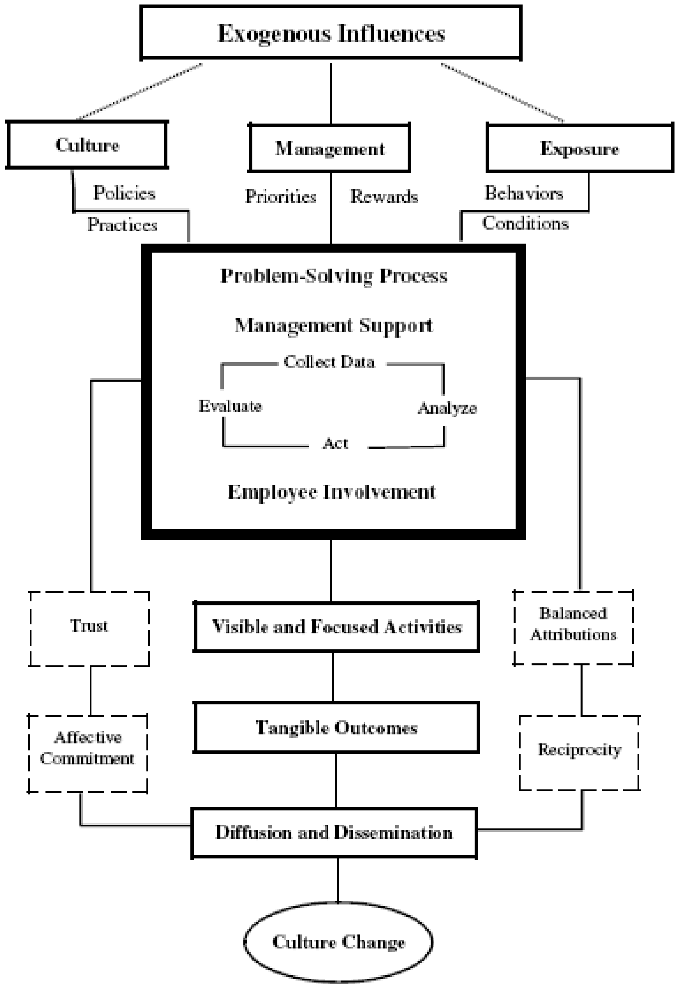

Figure 10. DeJoy's Model of Safety Culture

In this comparative analysis of the two approaches, DeJoy argues that perceptions of management systems and critical safety behaviors are critical factors in culture change and safety performance improvement. In addition, she argues that individually the approaches are not comprehensive enough to result in a change in safety culture or improvement in safety performance. While a strong case for integration of the two approaches is made in this comparative study, the model is not tested empirically.

A model proposed by Cooper (2000) is based primarily on the organizational culture model developed by Schein (2004) and the concepts of Social Cognitive Theory (SCT).

Social cognitive theory (SCT) provides an explanation of psychosocial functioning in organizations, including the motivations and determinants for action. From this perspective, behavior is a function of the bidirectional relationship between three variables: environmental factors, personal factors, and behavioral norms (Wood & Bandura, 1989). According to the social cognitive theory of self-regulation, behavioral choices are regulated by these factors (Bandura, 1991). People form beliefs about what they can do and what they should do through their interpretation of these three factors and the anticipated consequences of those behaviors. As a result, the interaction of these three factors functions as a source of motivation and regulation for human behavior.

Within this theoretical approach, the relationship among the variables is reciprocal. Although the variables in the model interact, they do not have the same level of influence on each other. The theory also postulates that the reciprocal nature of the relationship does not occur simultaneously but sequentially because of the time required for one causal factor to have an effect on other factors and the time required to activate a reciprocal response. In addition, social cognitive theory asserts that human behavior is governed by perception of social environments rather than the objective properties of that environment (Bandura, 1991). This is an important distinction because much of the research on safety culture and organizational culture is based on methods that measure the perceptions that individual members have regarding the variables of culture rather than the objective occurrence of those variables.

The model developed by Cooper (2000) uses the same variables for safety culture as those that form the variables of social cognitive theory; they are also a reflection of the variables of the organizational culture model developed by Schein (2004). In this model, the situational dimension of SCT is equivalent to underlying assumptions in Schein's model. These are defined by Cooper (2000) as those elements of an organization that involve policies, structure, control systems, and management practices. The personal dimension of SCT is equivalent to the values and beliefs in Schein's model and is operationalized by Cooper as values and beliefs toward safety. The behavioral dimension of the SCT model is obviously equivalent to the behavioral dimension in both of the other models. The situational, personal and behavioral variables of the social cognitive theory are labeled as Safety Management Systems, Organizational Safety Climate, and Safety Related Behaviors and form the Reciprocal Determinism Model (RDM) of safety culture. The model proposed by Cooper (2000) is depicted in Figure 11.

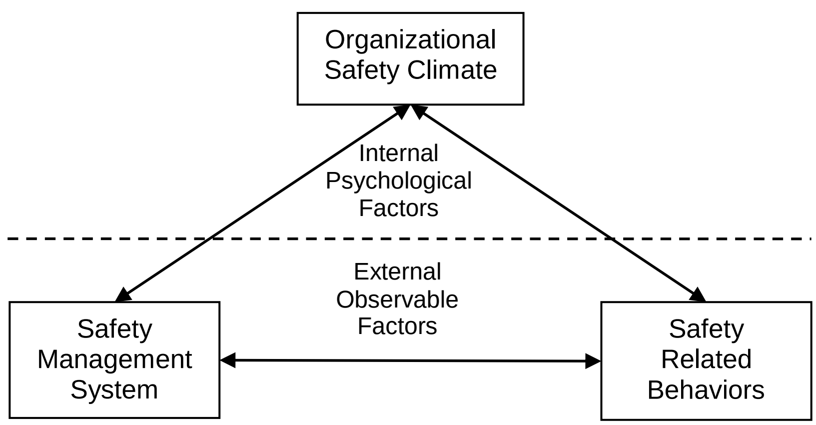

Figure 11. Coopers' Model of Safety Culture

Safety Management Systems and Safety Related Behaviors are external variables that represent the environment described in Lewin's (1951) model of individual behavior. They are considered external variables because they are external to the individual. These two variables are equivalent to the practices, both management practices and individual practices, which have been previously described as part of the definition of organizational culture. Organizational Safety Climate is an internal variable that represents the person described in

Lewin's model. This variable is considered internal because it refers to the internal psychological attributes of individuals, such as cognitive or affective states. This variable is equivalent to the values that have been previously described in the definition of organizational culture.

Safety Management Systems and Safety Related Behaviors are more objective and observable, and so they can be more easily defined and measured than the internal psychological attributes associated with Safety Climate. Management systems and safety behaviors can also be manipulated more easily and directly than the psychological attributes associated with safety climate (DeJoy, 2005). Given a sequential model of the impact of causal factors on other factors, and the higher level of control over management practices and behavioral norms, these external variables could be assumed to initially act on the internal variable causing changes in individual values and beliefs toward safety.

According to Cooper (2000), safety culture includes all three variables described as part of the RDM, because changes in perceptions about how safety is managed and perceptions of the behavioral norms in the organization result in changes in individual values and attitudes toward safety. Changes in perceptions of all three variables of safety culture result in different individual perceptions about the options that are available for individuals in terms of actual behavioral choices (Cooper, 2000b). Consequently, individuals make better choices, resulting in improved safety performance. This model has been empirically tested and has been used in other studies to describe, explain, and predict the safety performance of high risk organizations, such as aircraft carrier flight deck operations, nuclear power plants, and chemical manufacturing (Cooper, 2000b).

Perceptions in the Study of Safety Culture

Perceptions involve individual assessments of attributes within the workplace associated with safety and are considered to have a greater influence on behavior than objective properties of the workplace (van den Berg & Wilderom, 2004). Therefore, as perceptions of safety culture change, behavioral choices change and improve, resulting in improved safety performance. As a result, much of the research on safety culture has used perception surveys to measure the variables of the construct.

Perception surveys are questionnaires that ask members of an organization about their perceptions of the variables used to measure safety culture. For example, Bailey and Peterson (1989) conducted a nine-year study of safety performance in the railroad industry and found that changes in rules, regulations, procedures and the use of engineering-based controls had little effect on safety performance because people held on to certain practices and beliefs, even though they had little to no basis in fact. Perception surveys were used to assess worker behaviors, management systems, and the values and beliefs that affect safety, which were found to be more predictive of safety performance. On the basis of these findings, they concluded that perception-based questionnaires can be effectively used to identify strengths and weaknesses of elements of safety culture, and that the human-behavioral approach was much more effective in making significant improvements in safety performance.

A study by Ostrom (1993) using perception surveys in the context of chemical and nuclear energy employees resulted in similar findings that support using surveys of perceptions as an effective means for assessing variables of safety culture. Since these early studies that use perception based survey instruments, many other researchers have used the same approach to measuring and assessing safety culture (Clarke, 2000; Yule & Flin, 2007; Hofmann & Stetzer, 1996; Parker et al., 2006; O'Toole, 2002, Cooper & Phillips, 2004).

Perceptions of the variables of safety culture are important because they are the initial link in a chain of factors that result in safety performance (Hofmann & Stetzer, 1996). Individuals perceive features of their work environment that are then interpreted through individual values and beliefs. Perceptions and interpretations are used to form meaning, which is defined as the motivational and emotional significance of the features that have been perceived (Brown & Leigh, 1996).

Meaning influences the way that individuals behave, which has a significant impact on safety performance (Yule & Flin, 2007; Parker et al., 2006; Clarke, 1999). Initial perceptions are formed into meanings that influence the frequency of unsafe behaviors, which affects the frequency of accidents, injuries and fatalities (Hofmann & Stetzer, 1996). More favorable or positive perceptions of the variables of safety culture would, therefore, be expected to result in fewer unsafe behaviors and improved safety performance.

The relationship between perceptions and performance is a particularly important consideration for organizations that function through autonomous work teams, such as the fire service. Autonomous work teams are work groups that are responsible for monitoring both operational performance and the safety behavior of the group (Hofmann & Stetzer, 1996). Organizations that operate through autonomous work teams have delegated a high level of control over operational performance and safety performance to the lowest organizational levels due to the complex nature of the work. Autonomous work teams are beneficial for safety performance when perceptions, interpretations, and meaning results in the intrinsic motivation of individual members to produce an appropriate balance between operational performance and safety performance (Grote & Kunzler, 2000). Within high risk occupations, intrinsically motivated behavior has been found to result in higher levels of safety performance without surveillance, which obviously minimizes the level of organizational resources directed toward extrinsic control mechanisms (Parker et al., 2006).

Summary

Safety culture is a sub-culture that exists in high-risk occupations, which includes the fire service. A number of different definitions of safety culture have been proposed in the literature. Variation in the definition of the construct appears to depend on whether the researcher is approaching the concept from a functional or interpretive perspective, which determines whether the study is examining safety climate or safety culture respectively. Some scholars, however, have attempted to integrate the two approaches. They argue that that both safety culture and safety climate are important factors that explain how the social context in an organization influences individual behavior and organizational performance with regard to safety.

A number of different theoretical frameworks have been developed to explain the hypothetical relationship between safety culture and safety performance. In addition, a number of different conceptual models of safety culture have been proposed. Despite these efforts, there is still a great deal of disagreement in the literature about the nature and characteristics of these relationships. As a result, there continues to be a need for the development of a comprehensive theoretical framework that explains the relationship between safety culture and safety performance and for a conceptual model of safety culture that integrates variables associated with the safety culture and safety climate perspectives.

The next chapter on methodology will begin with the explication of a theoretical framework of the relationship between safety culture, individual behavior, and safety performance. In addition, a conceptual model of safety culture will be proposed that integrates the safety culture and safety climate perspectives. A well-defined theoretical framework and conceptual model are essential for the development of an appropriate methodological approach that will answer the research questions that have been posed for this study and to develop more specific hypotheses about the relationship among the variables that are included in the conceptual model.

CHAPTER III: METHODOLOGY

This chapter on the methodological approach used for the analysis of data begins with the development of a theoretical framework for organizational culture formed from the literature review. A theoretical framework for organizational culture must be established to answer the three research questions that have been developed for this pilot study.

To answer the first question about whether a model of safety culture can be adapted from the construct of organizational culture, a theoretical framework for organizational culture is developed that includes a conceptual model of organizational culture. Next, the literature on safety culture is used to determine if a model of safety culture can be adapted to fit within the model of organizational culture. The conditions that should be met to determine whether the model of safety culture is a good fit with the concept of organizational culture are also described. Based on these conditions, a model of safety culture is selected and modified for use in this pilot study.

The answer to the second research question defines and operationalizes the variables of safety culture described in the conceptual model. The literature on safety culture is used to define the variables and to describe the measures that will be used to operationalize the variables. Once the variables associated with the conceptual model of safety culture have been operationalized through data collection instruments, the third research question can be answered through several hypotheses about the nature of the relationship among the variables.

In the last part of the chapter, the methodological approaches to empirically test these hypotheses are described, the results of which provide the answer to the third research question about the characteristics of the relationship among the variables. This includes the details of the instruments used for data collection, the design of the pilot study, as well as the fire service population and sample used for the pilot study. In addition, the procedures used for data collection and the details of the statistical analysis of the data are described. Lastly, the limitations of the pilot study are discussed and the steps taken to insure human subjects protections are described.

Theoretical Framework of Organizational Culture

The main purpose of the thesis is to determine whether the construct of organizational culture can be applied within the context of municipal fire service organizations in the United States as a means for the assessment and analysis of safety culture. Although not a direct consideration, it is assumed that the findings from this pilot study will inform future research that will examine the nature of the relationship between safety culture and safety performance to determine whether changes in safety culture improves safety performance. As a result, a theoretical framework for this pilot study is formed so that the construct of safety culture can be assessed and analyzed within the context of the fire service and also in anticipation of future research that will use the findings from this pilot study to examine the relationship between safety culture and safety performance.

The functional approach toward safety culture forms the foundation for the development of a theoretical framework for this dissertation. The functional approach is more appropriate than the interpretive approach for two reasons. First, the functional approach is consistent with most of the previous research on safety culture. Second, the functional approach provides a framework for answering the three research questions proposed for this pilot study. The first research question asks whether current models of safety culture be adapted for the purpose of assessment and analysis of safety culture in the fire service. The second research question asks what the key variables of safety culture are and how they can be operationalized and measured. Both of these questions are consistent with the functional perspective that it is more important to understand the systematic relationship among the variables rather than to understand the process of how meaning developed. The third research question, which asks about the nature and characteristics of the relationship among the variables, is consistent with the quantitative methods used in functional studies rather than the qualitative methods used in interpretive studies.

The functional approach is also consistent with much of the research on the relationship between culture, behavior, and organizational outcomes. From the functional perspective, organizational attributes are viewed as separate from individuals but have a significant influence on behaviors. Organizational attributes influence behaviors because people respond to their perceptions about events and activities in predictable ways. As a consequence, if the important organizational attributes can be identified and operationalized, then they can be utilized to change behavior and improve organizational performance. The functional approach recognizes that there are two categories of important attributes; practices and values. For the purpose of this pilot study, practices and values are operationalized through variables that are relevant to safety in the context of the fire service.

The functional approach predicts that perceptions of practices and values associated with safety culture influence actual behaviors, which subsequently influence organizational outcomes. The relationship among these factors forms the basis of the theoretical framework used in this dissertation. This framework has been described in other organizational studies as the ABC (Antecedents, Behaviors, Consequences) framework. The descriptive names of the factors are changed to Culture, Behavior, and Outcomes to be more closely aligned with the names used in the previous discussion. The renamed framework is presented in the following diagram.

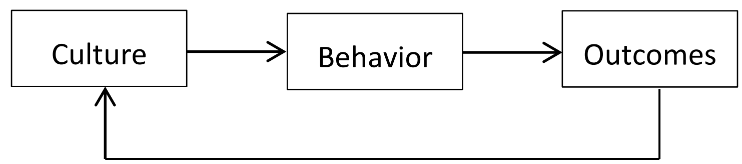

Figure 12. Modified ABC Framework

From a functional perspective, outcomes are limited to those that are relevant to the organization. Some researchers argue that behaviors have outcomes for individuals as well as for the organization (Balthazard et al., 2006). For the purpose of this dissertation, the theoretical framework includes organizational and individual outcomes. Both types of outcomes can be positive or negative. For example, the outcome of certain behaviors may be positive for the organization but negative for the individuals. Other behaviors may result in some outcomes that are positive for the organization or individual and some outcomes that are negative for the organization or individual.

This is an important modification because it results in a more coherent framework that recognizes that the relationship between organizational outcomes and organizational attributes are separate and distinct from the relationship between individual outcomes and individual attributes.   It is reasonable to assume that organizational practices are more strongly influenced by organizational outcomes and individual values are more strongly influenced by individual outcomes. In addition, the framework is modified to reflect practices and values as the critical components of culture. The modified framework is shown in the following diagram.

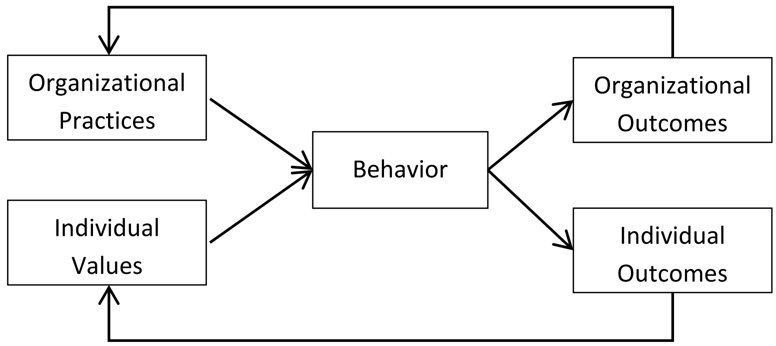

Figure 13. Modified Organizational Culture Framework

As part of the previous discussion on culture, behavior, and performance, a modified version the model developed by Lewin (1951) was presented that stated that behavior is a function of the person and environment. The environment is equivalent to organizational practices. The person is equivalent to individual values. In this model, organizational practices were divided into two elements; management systems and behavioral norms. Values were described as individual values and beliefs. These three variables - management systems, behavioral norms, and individual values and beliefs - form the conceptual model of organizational culture.

The nature of the relationship between practices and values is a key issue in organizational culture studies. Some scholars argue that individual values mediate the relationship between organizational practices and actual behaviors because individual perceptions of their work environment are interpreted through individual values and beliefs (Brown & Leigh, 1996). Scholars disagree about whether perceptions of organizational practices or individual values have a stronger influence on actual behaviors (Denison, 1998; Hofstede, 1998). The important issue is whether or not organizational practices influence individual values. It is important to understand the characteristics of this relationship in order to develop effective interventions designed to change behavior and produce better outcomes (Marcoulides & Heck, 1993).

The conceptual model of organizational culture developed for this dissertation is based on the following three assertions about the relationship between organizational practices and individual values. First, the variables described as organizational practices, which include management systems and behavioral norms, are easier to change and are under the control of organizational managers (Wiegmann et al., 2004; Wallace et al., 1999; Hofstede, 1998). Second, individual values are deeply embedded and are difficult to change through a direct approach because they are beyond managerial control (Wallace et al., 1999; Karahanna et al., 2005). Third, organizational practices influence individual values (Marcoulides & Heck, 1993; Wallace et al., 1999; Hatch, 1993). As a consequence, the most effective approach to changing behaviors and outcomes is to focus on changing the management systems and behavioral norms in the organization (Karahanna et al., 2005).

Applying these assertions to the previous framework results in a conceptual model of organizational culture that specifies the following: first, Management Systems and Behavioral Norms influence individual Values and Beliefs; and second, all three elements of culture influence Behaviors. This framework is shown in Figure 14. Within this framework, the conceptual model of organizational culture has three variables. The organizational elements of the model are Management Systems and Behavioral Norms. The individual element of the model is a single variable described as Values and Beliefs. Values and Beliefs are influenced by Management Systems and Behavioral Norms and also function as a mediating variable between organizational elements of culture and actual behavior.

Behaviors create outcomes for individuals and for the organization. Outcomes can be described as positive or negative. In this framework, individual outcomes influence values and beliefs while organizational outcomes influence management systems and behavioral norms. In addition, management systems and behavioral norms may interact with each other.

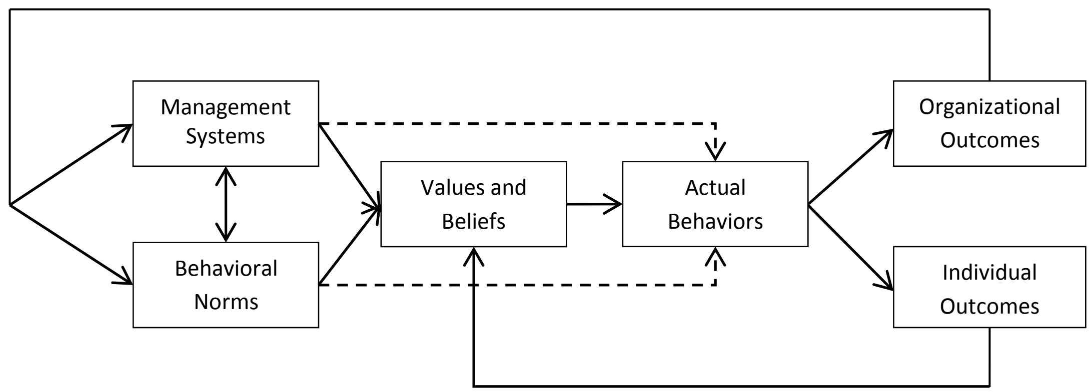

Figure 14. Theoretical Framework and Conceptual Model of Organizational Culture

Perceptual measures of these variables are used in this pilot study because they form the basis for cognitive maps that describe the social context of the work environment (James & James, 1989). Perceptions function as antecedents of behavior because individuals use the cognitive maps that are formed from their perceptions as a frame of reference to guide behavioral choices. Although perceptions may not reflect objective conditions within the work environment, individuals use perceptions as the basis for their behavioral choices.

The theoretical framework established here includes a conceptual model of organizational culture that can be used to analyze the problem of safety culture within the context of the fire service. The proposed theoretical framework establishes the relationship between organizational culture and performance in terms of organizational and individual outcomes. In addition, the framework contains a conceptual model of organizational culture that consists of three interacting variables: management systems, behavioral norms, as well as values and beliefs. Application of the conceptual model for organizational culture to safety culture requires the development of a model that is consistent with the concepts of safety culture but still fits into the overall theoretical framework for organizational culture.

Conceptual Model of Safety Culture

The development of a conceptual model of safety culture that fits with the theoretical framework and conceptual model established for organizational culture is a necessary requirement to answer the first research question proposed for this pilot study: can current models of organizational culture be adapted for the purpose of assessment and analysis of safety culture within the fire service? The answer to this question depends on whether a model of safety culture fits within the variable structure and theoretical parameters of the conceptual model established for organizational culture.

Much of the research on safety culture attempts to develop a theoretical framework of the relationship between the variables of safety culture, to define and operationalize these variables, and to test the relationship among safety culture, safety behavior, and safety performance (Guldenmund, 2000). To be consistent with the theoretical framework and conceptual model established for organizational culture, the construct of safety culture should meet the following six criteria: first, safety culture is defined in a way that is consistent with the definition of organizational culture; second, the conceptual model consists of a limited number of variables that are consistent with organizational culture; third, the conceptual model integrates the concepts of safety culture and safety climate; fourth, the model integrates the behavior change and culture change approaches toward improving safety performance; fifth, the model of safety culture is consistent with the functional approach; and sixth, that the conceptual model fits within the fundamental theoretical assertions used to develop the framework of organizational culture. The following discussion will address each of these criteria.

It is important for the definition of safety culture to be consistent with the concept of organizational culture. Scholars have argued convincingly that these concepts should be consistent for two reasons, each of which is based on a different assumption about the nature of organizational culture. If the assumption is made that organizations consist of one global culture and a number of other sub-cultures, then it is also assumed that safety culture interacts with and is influenced by organizational culture. If the assumption is made that organizations consist of numerous subcultures, then consistency among the definitions and variables of the various sub-cultures is critical for the purpose of making assessments and comparisons among them.

Organizational culture has been defined as the behavioral norms, values and beliefs, and underlying assumptions that interact to determine individual patterns of behavior (Rashid et al., 2004; Naidoo, 2002: Schein, 2004). To maintain a high level of consistency between these two constructs, safety culture is defined for this pilot study as the shared perceptions of individuals regarding behavioral norms, values and beliefs, and underlying assumptions associated with safety (Clarke, 2000; Griffin & Neal, 2000; Reason, 1998). This definition is not only consistent with the definition of organizational culture but also establishes a limited number of variables for safety culture that is consistent with organizational culture.

Few researchers have attempted to develop a model that integrates the safety culture and safety climate perspectives. Some researchers take the functionalist approach and use the variables associated with organizational climate (Zohar & Luria, 2005; Schneider & Salvaggio, 2002; Mearns & Flin, 1999; Cooper & Phillips, 2004). Others take the interpretive approach and use the variables associated with organizational culture (Denision, 1995; Karahanna et al., 2005; Marcoulides & Heck, 1993; Hofstede, 1998). A conceptual model that integrates safety culture and safety climate should include appropriate variables from each concept (Parker et al., 2006). The definition of safety culture integrates the two approaches by including the behavioral norms and management system variables used in safety climate studies and the values and beliefs variable used in safety culture studies.

The definition of safety culture established for this research also provides a basis for integrating the behavior change and culture change approaches to improving safety performance. Safety management systems and critical safety behaviors are used as variables in the behavioral approach toward improving safety performance. Values and beliefs are used as a dimension in the culture change approach toward improving safety performance. All three of these variables are included as part of the overall model of safety culture used in this pilot study, thus integrating the two approaches to improving safety performance.

The theoretical framework for this pilot study is based on a functionalist approach to safety culture. A functionalist approach assumes that organizations have a systematic character in terms of the relationship between the elements of safety culture (Morgan & Smircich, 1980). To assess and analyze the relationship between these elements, it is necessary to establish a conceptual model of safety culture and to define the variables associated with the model. The model then serves as a frame of reference for the use of instruments to measure safety culture. At this point, the model and measures of safety culture have been established. The instruments necessary for the quantitative assessment and analysis of safety culture are developed later in this chapter. However, the development of a model, measures and instruments for the purpose of assessing and analyzing safety culture is consistent with the functionalist approach (van Muijen et al., 1999).

The definition, model and measures of safety culture established for this research fit well with the two foundational theories used to develop the theoretical framework of organizational culture. These two theories are Lewin's conceptual equation for the relationship between individuals and their social environment and the ABC framework that describes the relationship among culture, behavior, and outcomes.

Lewin's (1951) conceptual equation for the relationship between individuals and their social environment asserts that individual behavior is a function of the interaction of individual and organizational factors. The model established for this research includes two organizational variables (behavioral norms and management systems) and one individual variable (values and beliefs) relevant to safety, so the model is consistent with this important assertion that has been used to develop the theoretical framework for organizational culture.

This model also fits within the ABC (Antecedents, Behaviors, Consequences) framework of organizational performance proposed by Mwita (2000). The ABC framework explains safety performance as the consequence of individual behaviors. Decisions about actual behaviors are based on the perceptions that individuals hold about the variables of safety culture and how they interact. The ABC framework does not specify a model of safety culture, but much of the research involving safety culture has established that safety culture influences behaviors and that behaviors influence safety performance in the same way described in the ABC framework.

In addition to meeting the criteria just described, the conceptual model of safety culture should also meet the criteria established as part of the research questions for this dissertation. Two of these criteria that have not been previously discussed include the following: that the model has been used in previous studies of high-risk occupations, and has been shown to produce valid and reliable results.

The only model that meets all of these criteria is the Reciprocal Determinism Model developed by Cooper (2000). This model is most appropriate the assessment and analysis of safety culture within the context of the fire service for a number of reasons. First, the model is consistent with the definition of safety culture and organizational culture in terms of the variables used to define the construct. Second, the model uses only three variables of safety culture, which is consistent with the functionalist assumption that safety culture can be accurately characterized by a limited number of variables (Jones & James, 1979). Third, the model is parsimonious compared to other models of safety culture. Fourth, this model has been used in studies of other high-risk occupations and has been demonstrated to provide valid and reliable results as a tool for the assessment and analysis of safety culture (Cooper, 2000b). Lastly, the model fits well within the theoretical framework of the relationship established for organizational culture.

The RDM includes three elements as the principal variables of safety culture: Safety Management Systems; Safety Related Behaviors; and individual Values and Beliefs about safety. Each of these is consistent with the most commonly used variables of organizational culture. In this model, Safety Management Systems are the manifestation of underlying assumptions about safety that are shared by organizational members. Safety Related Behaviors are the behavioral norms that are shared by members and that guide individuals in making decisions about actual behaviors. Both of these variables are considered to be organizational elements of safety culture because they are external to the affective aspects of individual members. Organizational Safety Climate it the term used to describe the values and beliefs of individuals about safety. This is considered to be an internal variable because values and beliefs are internalized psychological attributes of individuals.

As originally proposed by Cooper, and as the name implies, the variables in the RDM interact in a reciprocal manner. However, the RDM is based on Social Cognitive Theory, which asserts that the relationship between the variables in the model is sequential because it takes time for changes in one or more of the variables to activate a response in the others. For the purpose of this research, it is assumed that the nature of the relationship between the variables is sequential over time rather than immediately reciprocal. In addition, it is assumed that efforts to change and improve safety culture within fire service organizations will be initially directed at making changes in the external variables in the model, which include safety management systems and safety related behaviors. An organizational effort to change safety culture is expected to be focused on these variables because they are easier to manipulate and change than the values and beliefs that constitute the internal variable of the model.

Based on these assumptions, a modified version of the RDM is used in this pilot study. The same basic model is retained, but the assumption about the direction of the relationship among the variables is modified. Because Safety Management Systems and Safety Related Behaviors are both practices, the assumption about the reciprocal nature of the relationship between is retained, that practices influence values at one point in time and values influence practices at other points in time. The assumption about the direction of the relationship between practices and values, however, is modified. Safety Management Systems and Safety Related Behaviors are posited to have a stronger influence on

Organizational Safety Climate. This modification reflects the assertions made in the literature that perceptions of organizational attributes, such as Safety Management Systems and Safety Related Behaviors, have a strong influence on individual attributes, such as Organizational Safety Climate. As a result of this modified assumption, the model predicts that perceptions of the organizational attributes of the model will explain variation of the individual attributes. More specifically, this means that variation of individual perceptions of Safety Management Systems and Safety Related Behaviors will explain a significant amount of variation in Organizational Safety Climate.

Because safety culture is a sub-culture in high-risk occupations, the theoretical framework and conceptual model of safety culture should be consistent with the one proposed for organizational culture. Using the modified RMD model of safety culture, this is a simple matter of substituting the appropriate referent variables into the conceptual model for organizational culture. As has been previously described, these variables are Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate. The safety culture framework is shown in the following diagram.

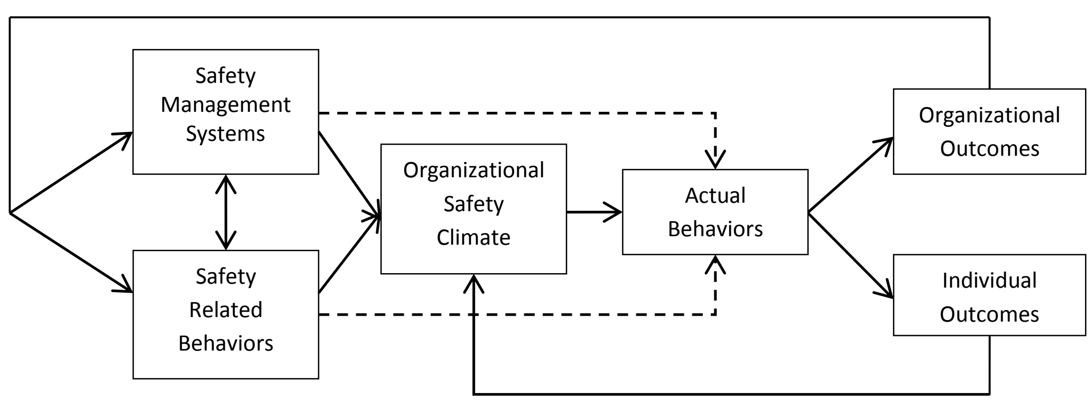

Figure 15. Theoretical Framework and Conceptual Model of Safety Culture

The purpose behind the first research question for this thesis is to determine whether current models of organizational culture can be adapted for the purpose of assessment and analysis of safety culture within the fire service. Based on the concepts of organizational culture, a conceptual model of safety culture has been developed that fits within a larger theoretical framework of the relationship between safety culture, behavior, and outcomes. So the answer to the first research question is positive, a modified version of the Reciprocal Determinism Model can be used to assess and analyze safety culture in the fire service.

The purpose behind the second research question of this pilot study is to determine the key variables in the model of safety culture and how can these variables be operationalized and measured within the context of the fire service. The conceptual model of safety culture that has been developed includes a description of the three key variables in the model. So the answer to the first part of this question is: there are three key variables of safety culture and these are Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate.

The second part of the question - addressing how to operationalize these variables – is addressed in the following section on Measures of Safety Culture. Once the variables have been operationalized, the third research question about the nature of the relationship among the variables will be addressed. This will be accomplished through the development of several hypotheses and specific instruments relevant to the fire service that can be used to explore the relationship among the variables within the context of the fire service.

Measures of Safety Culture

Although considerable variation exists in research studies with regard to how the specific variables of safety culture are measured, there are some commonalities in how these variables are developed. Variables are generally developed from a literature review of relevant studies based on the industry under consideration, which are then formed into categories for each variables. In some studies, an existing set of questions from one industrial sector are modified for application to a different sector (Clarke, 2000). In studies that include a dimension or variable for safety practices, researchers typically include specific organizational behaviors that are relevant for the industry or occupation used in the study (Silva et al., 2004).

A series of questions or items are developed that are considered to be a representation of the variable. Some researchers use variables that have a single level whereby the entire set of questions defines the dimension. Others have developed multi-level variables. These consist of questions that are formed into several elements or sub-element of the dimension. The aggregation of the elements and sub-elements represent the dimension. Whether researchers use a single level or multi-level approach, the most common form of measuring the variables of safety culture and safety climate is through the use of self-administered questionnaires (Guldenmund, 2000).

An example of single level variables is the study by Clarke (1999) that examined the differences in perceptions of safety culture among organizational members from different hierarchical levels. In his study, a questionnaire with 25 items was used to define safety culture. This is an example of a single level dimension because the questions were related directly to the construct of safety culture. In studies that use single level variables, the aggregate of the questions represents safety culture.

A more common approach is to use variables that consist of two or three levels of elements and sub-elements that together represent the dimension being measured. For example, in a study by Silva (2004) that explores the nature of the relationship between organizational climate and safety climate, a safety practices scale was developed that include 22 statements about relevant safety behaviors that described six elements of the safety practices dimension, which was one of several variables used in the study. The safety climate scale developed by Zohar (1980) is also an example of a study that describes a dimension using two levels. The instrument was developed specifically for application in the industrial production sector and consists of seven elements of the dimension of safety climate. The self-administered questionnaire includes forty questions or items, each of which relates to perceptions of one of the seven elements of the dimension.

A study by Yule & Flin (2007) used the Health and Safety Executive (1997) safety climate survey tool as the instrument for measuring safety climate in an examination of the relationship between safety climate and safety behaviors. This instrument includes seventy-one questions that correspond to eight different elements of the dimension of safety climate. The study by Mearns (2003) used the elements of the Health and Safety Executives (1997) safety management system as the basis for the development of a safety management questionnaire. The questionnaire consisted of forty questions or items that were grouped into six elements of perceptions of safety management, all of which were considered elements of the safety management dimension. Each of these studies is an example of a two level approach to defining variables of safety culture and climate, as shown in Figure 16.

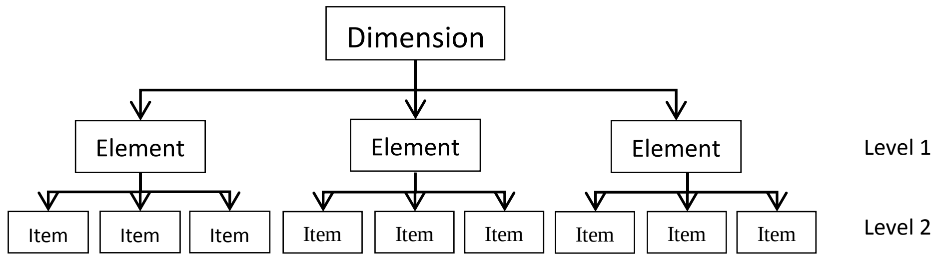

Figure 16. Two-Level Dimension

More recently, Cooper (2008) derived a questionnaire for safety management systems with three levels as shown in Figure 17. The questionnaire was developed from several relevant standards that are used in the UK, including the HSE 65 manual on safety management systems, as well as the OSHAS 18001 and BS 8800 standards for safety management systems. The questionnaire includes questions that relate to sub-elements that are grouped into elements that form a comprehensive measure of safety management systems.

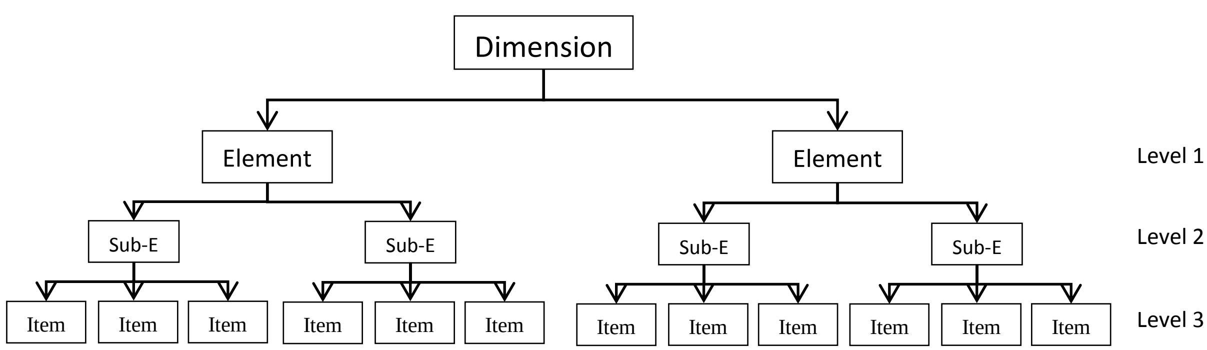

Figure 17. Three-Level Dimension

Although the main focus of safety culture studies is on the relationship among the variables, most studies also explore the relationship among the variables of safety culture and demographic variables such as job functions and years of service. A study by Clarke (1999), for example, examined the differences in the perceptions of safety culture variables by hierarchical level, which included members, supervisors, and senior managers. Mearns (2003) explored the differences in perceptions of safety management systems by both supervisory level and years of service by comparing the mean score of each dimension of safety management systems between each of these two demographic variables. Other studies have used these same two variables to explore within group homogeneity and between group variations in perceptions of safety culture (Parker et al., 2006).

Three variables are used in this thesis to describe safety culture in the context of the fire service: Safety Management Systems (SMS), Safety Related Behaviors (SRB), and Organizational Safety Climate (OSC). The SMS and OSC measures have been developed after a review of the literature identified two questionnaires that have been used in other studies to operationalize these variables. These questionnaires were adapted by changing some of the language in the questions to fit within the context of the fire service. The measure used to operationalize the SRB variable was based on the specific organizational behaviors that are relevant to safety in the fire service. The critical safety related behaviors used in the development of the measure of the SRB variable are based on the activities that result in firefighter injuries and fatalities that were identified in the introductory chapter. Although the measures for each of the variables were developed using different approaches, all three variables are multi-level, consisting of items that are formed into sub-elements, sub-elements that are formed into elements, and elements that are formed into variables.

The details of the instruments used to assess each of these measures is provided in the section on Instruments. An overall description of each measure is provided here as a prelude to the development of several hypotheses about the nature of the relationship among the variables. It is important to provide brief descriptions of the measures at this point because these will help to clarify the hypotheses about the nature of the relationship among the variables.

Several safety standards developed in the United Kingdom were recent used in a study by Cooper (2008) as the basis for development of a questionnaire used to measure Safety Management Systems. These included the HSE 65 manual on safety management systems, which is used as the basis for the development of a questionnaire to measure perceptions of Safety Management Systems for this pilot study. A list of pro forma questions regarding safety management has been developed from the HSE 65 manual, which provides a comprehensive set of questions about safety management systems that can be easily modified for application in the context of the fire service.

The Safety Climate Assessment Toolkit questionnaire is used as the measure of Organizational Safety Climate (HSE, 1997). The toolkit was developed as a joint industry project among several industry sectors, the HSE and Loughborough University in the United Kingdom. It was designed to measure values and beliefs with regard to safety and to produce a safety climate profile for high-risk occupations. The questionnaire can be applied to other industries and occupations with appropriate modifications to the content and format of the questions (HSE, 1999). A practical reason for the use of this questionnaire is that it can be accessed and used free of charge.

Critical Safety Related Behaviors have been developed from analysis of the activities that firefighters are engaged in when injuries and fatalities occur. As described in the first chapter that detailed the problem of firefighter injuries and fatalities, over seventy percent of firefighter casualties are associated with fireground operations, responding to or returning from alarms, and training activities. These activities are, therefore, included as critical safety behaviors. In addition, almost half of the casualties that occur while firefighters are engaged in these activities are associated with some form of cardiac-related problem. The fire service has developed standards for firefighter fitness programs and medical evaluation programs in an effort to reduce the incidence of cardiac-related casualties. Therefore, fitness and medical evaluation programs are also included as critical safety related behaviors.

Survey instruments used to assess the organizational practices and individual values of safety culture will be developed using different approaches. Perception of organizational attributes of the work environment can be measured on the basis of individual descriptions of the presence or absence of the attributes (James & James, 1989). Organizational attributes of safety culture include Safety Management Systems and Safety Related Behaviors. Therefore, these two variables will be measured using a scale that asks respondents to rate their perceptions of the presence or absence of these variables.

The individual attributes of values and beliefs are more evaluative than descriptive. Values and beliefs about safety are included in the Organizational Safety Climate dimension of the model used in this pilot study, so this dimension is measured on the basis of individual evaluations rather than descriptions of their presence or absence. Evaluation of individual values and beliefs is calibrated using a scale that asks respondents to rate each item in terms of how strongly they agree or disagree.

Level and Strength

Research on organizational culture has traditionally focused on the mean of aggregated ratings on various measures of culture in organizations (Dickson, 2006). Recently, however, more research has begun to examine the importance of the level of agreement among members' perceptions of organizational culture. These researchers argue that both the level of the mean rating and the strength of agreement about these rating are important factors that influence individual behaviors and organizational outcomes (Sorensen, 2002; Schneider & Salvaggio, 2002; Zohar & Luria, 2005). Essentially, level is the degree to which individuals perceive the presence of the variable while strength is the degree to which individuals agree on that presence. Level is measured by the scores on a Likert scale that indicates the average score for a variable. Strength is measured by measures of the distribution of scores, such as the standard deviation of scores for a variable. Using these types of measures, level can be described as the individual-level measure of the perceived presence of a variable and strength can be described as the organizational-level measure of the distribution of individual scores.

Aggregation of data from the individual-level to the organizational level differentiates two important measures of organizational culture. The first is the average or mean of the aggregated data. This is the statistic that has typically been used to measure culture in organizations. The second is the variation in the mean of the aggregated data (Dickson, 2006). This statistic has been used much less often in studies of organizational culture but may actually be a better reflection of the presence or absence of culture in organizations because it is a measure of the amount of perceptual agreement among members of the organization on the variables that are used to measure culture.

The mean of the aggregated data on perceptual measures of organizational culture is referred to as culture level. Culture level is a measure of the magnitude of the mean for the items used to operationalize the variable. The level of a dimension refers to the relative score of a dimension and is categorized as high or low (Ouchi & Wilkins, 1985). An organization with higher scores on the variables of safety culture is considered to have a higher level of safety culture than organizations with lower scores. If the mean score for the variables of safety culture are above the ninetieth percentile of the range, for example, then the level of culture would be referred to as high. If the mean scores were in the lower tenth percentile of the range, then the level of culture would be referred to as low. The level of culture is a rating of the degree to which practices are present or absent from the work environment and a rating of which values are most important.

The term “level” has taken on several different meanings in the culture literature. Level sometimes refers to specific variables of culture, such as Schein’s (2004) three levels of culture. It can also refer to the layers of culture, such as the national, institutional, and organizational levels of culture (Karahanna, 2004). In other studies, “level” is used to refer to the relative scores for measures of different cultures or different variables of a single culture (Balthazard et al., 2006; Hatch, 1993). The term “level” of culture will be used here to refer to the magnitude of scores on measures of organizational culture.

The amount of consensus on these measures is referred to as “culture strength”. The strength of the culture in an organization is measured by the degree to which perceptions of the culture variables are consistent, congruent, or homogenous (Hofstede et al., 1993) and is categorized as strong or weak. A small amount of variation in the perceptions of organizational members about the variables that describe safety culture indicates that the culture is strong. Organizations with a strong safety culture have a high degree of shared perceptions about the content of that culture (Reiman & Oedewald, 2007). A large amount of variation in the perceptions of members indicates that the culture is weak (Zohar & Luria, 2005). The strength of culture is a measure of agreement about the presence of absence of practices in the work environment and a measure of agreement about the values that are most important.   This is an important issue involving the measurement of cultural variables because while Sorensen (2002) argues that less variation in culture results in less variation in performance, Schneider & Salvaggio (2002) argues that there is no correlation between the amount of variation in culture and the level of performance in organizations.

Culture strength then is a measure of the variability in the mean for the construct. Variability is measured by the Intraclass Correlation Coefficient (ICC) and standard deviation in the same way that these indicators are used for the aggregation of data: the higher the level of ICC or the lower the standard deviation, the higher the level of agreement indicated between individuals, which indicates a stronger culture (Dickson, 2006; Hofmann & Stetzer, 1996; Schneider & Salvaggio, 2002; van Mierlo, 2009).

Culture level and culture strength can both have a significant influence on individual behaviors and organizational performance. If the perception of culture strength is high (indicated by a high mean score), and is also strong (indicated by low variability in scores), then members would be expected to demonstrate more consistent positive behaviors. If the perception of culture level is low (indicated by a low mean score), and also strong, then members would be expected to demonstrate consistently negative behaviors. If culture is weak, then regardless of the culture level, members' behaviors would be expected to be inconsistent (Schneider & Salvaggio, 2002). Stronger cultures result in more consistent behaviors because there is less ambiguity and more uniformity in organizational norms and practices regarding specific functional areas, such as safety and service, which leads to more uniform perceptions of norms and practices within those functional areas (Dickson, 2006). Culture strength has also been shown to mediate the relationship between culture level and organizational outcomes. The relationship between mean culture level and outcomes have been shown to be stronger when culture strength is high, meaning that when culture strength is high, there is a stronger association between low levels of culture and negative outcomes, and between high levels of culture and positive outcomes (Schneider & Salvaggio, 2002).

Hypotheses

The hypotheses developed for this dissertation are formed in answer to the third research question regarding the nature of the relationship among the variables of safety culture. The theoretical framework established as the foundation for this research includes a conceptual model of safety culture that includes three variables: Safety Management Systems (SMS), Safety Related Behaviors (SRB), and Organizational Safety Climate (OSC). The literature on organizational and safety culture provides theory and knowledge about the relationship among these variables to make three predictions that can be used to form specific hypotheses. The first is that organizational practices will have a significant and influence on individual values. The second is that individuals that hold different job functions will have different perceptions about safety culture. The third is that perceptions of safety culture will vary with the length of time that individuals have worked in an organization.

Research on the nature of the relationship between practices and values asserts that practices and values have a reciprocal relationship. The relationship between these variables is also sequential in that practices are predicted to influence values (Cooper & Phillips, 2004). In addition, organizations will likely direct initial efforts at improving safety performance at changing Safety Management Systems and Safety Related Behaviors because these variables are much more explicit, external, and observable than individual values and beliefs, and are more susceptible to direct efforts to create change and improvement. As a consequence, it is important to examine the relationships between Safety Management

Systems and Safety Related Behaviors, which in this pilot study are classified as practices, and Organizational Safety Climate, which in this pilot study are classified as values. Based on the theoretical framework, it is anticipated that individuals who perceive that their organization has higher levels of safety management and high behavioral norms regarding safety will also hold higher level values and beliefs regarding safety. This assertion forms the basis for the first hypothesis of this pilot study.

> H_1: Higher scores on measures of Safety Management Systems and Safety Related Behaviors will be associated with higher scores on measures of Organizational Safety Climate. Stated as a formula: OSC = f(SMS + SRB)

Many research studies have also examined differences in perceptions of safety culture that exist within organizations across different job functions and years of experience (Hofstede, 1998; Grote & Kunzler, 2000; Silvester et al., 1999; Krause, 1997; Hofmann & Stetzer, 1996; Cooper & Phillips, 2004; Williamson et al., 1997; Neal et al., 2000). This is an important relationship to examine because it is assumed that individuals who have different hierarchical roles and responsibilities have different perceptions about safety culture, and that the same holds true for individuals with different levels of experience. In addition, examining these differences provides a means for testing the discriminant validity of the measures and instruments used to assess safety culture (Grote & Kunzler, 2000; Cooper & Phillips, 2004). Therefore, it is anticipated that individual perceptions of safety culture will differ in terms of both the level and strength of perceptions across categories of job function and years of service. This assertion leads to the following two hypotheses.

H_2: The level of scores for Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate will vary depending on job function and years of service. Stated as a formula: $SC_L = f(\text{Job, Years})$, where SC_L is the Level of the Safety Culture variables as measured by the mean score for each variable.

H_3: The strength of scores for Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate will vary depending on job function and years of service. Stated as a formula: $SC_S = f(\text{Job, Years})$, where SC_S is the Strength of the Safety Culture variables as measured by the standard deviation in scores for each variable.

Levels of Analysis

The construct of organizational culture can be analyzed at several different levels, including the group, organizational, occupational, and national levels. The level of culture under analysis in most organizational and safety culture studies is the organizational level (Cooper, 2000; Wiegmann et al., 2004; Guldenmund, 2000). Some researchers question whether data gathered from individuals can be aggregated into an organizational level variable, while others argue that if the level of homogeneity regarding a cultural dimension is strong enough, then data collected from individuals can be considered an organizational level variable (Guldenmund, 2000; Glisson & James, 2002; van den Berg & Wilderom, 2004). The justification for the aggregation of individual data to the organizational level is an important consideration because safety culture is defined by the idea of shared perceptions among individual members, so if perceptions of safety culture are not shared, then no safety culture exists. Scholars have dealt with this issue in other studies and have justified the aggregation of individual data to the organizational level using several criteria (Jones & James, 1979; Klein & Kozlowski, 2000; van Mierlo, Vermunt, & Rutte, 2008; James, 1982). These criteria establish the rational for aggregation, the criteria for aggregation, and the analytical approaches toward the aggregation of data from the individual to the organizational level.

An important principle of organizational culture is that members of a given organization share individual perceptions of values and practices. The appropriate level of measurement or unit of analysis for the construct of organizational culture, therefore, is the individual. Perceptions of individuals can then be aggregated to the organizational level to describe organizational culture (van den Berg & Wilderom, 2004; van Muijen et al., 1999). As a consequence, organizational culture is a characteristic of the organization, not individuals, but the construct is measured by assessing the perceptions of individuals. Individual-level data is then aggregated to form an organizational level variable referred to as organizational culture (Hofstede, 1998).

The rationale for aggregation of individual-level data to higher levels is based on the assumption that culture can be characterized by a limited set of variables, and that the scores on measures of those variables describe the social context of the organization. Individuals exposed to the same social context will describe that context in similar ways, which is demonstrated by the level of agreement among different members of the organization. If agreement is relatively high, then it is presumed that members experienced a common set of situational conditions, and that these shared perceptions of individuals describe the organizational level of culture (Jones & James, 1979).

Perceptual agreement is considered to be the principal criterion for deciding whether to aggregate individual perceptions of culture to the organizational level (Klein & Kozlowski, 2000; van Mierlo et al., 2008; James, 1982). Specific criteria for aggregation have been suggested in several studies that have used aggregated data to describe organizational culture, two of which are consistently used to demonstrate perceptual agreement. The first criterion is a low level of within-organizational variation in mean scores, which is measured by assessing the Intraclass Correlation Coefficient (ICC) or the standard deviation of scores on measures of organizational culture (Hofmann & Stetzer, 1996; Dickson, 2006).

The ICC is interpreted as a measure of within-group agreement or the level of internal consistency within a group (Lance, Butts, & Michels, 2006). A significant ICC score is considered to be substantive support for the aggregation of individual perceptions to the organizational level, and the higher the level of correlation, the more reliable the resulting organizational level constructs (van Merlo, 2009). A value of .70 is considered an acceptable level of consistency for the ICC and other measures of within group agreement (Bliese, 1998; Klein & Kozlowski, 2000; Lance et al., 2006). However, no minimum level of variance has been established for measures of standard deviation that is consistently considered low enough to support aggregation (Dickson, 2006, James, 1982). As a result, where the ICC is used to justify aggregation, standard deviation is most commonly used to make comparisons of the amount of variation between groups and organizations after the data have been aggregated.

In addition to perceptual agreement among members of an organization, another criterion commonly used to justify aggregation of data is between-group variance in scores on the measures of organizational culture. Between-group variation is demonstrated by significant differences in mean scores across groups or hierarchical levels within an organization. An example of differences across organizational levels is a study by Cooke (1988) which examined the difference in scores on measures of organizational culture by hierarchical level and found significant differences in scores based on whether members were workers, supervisors or top managers. Other researchers are more interested in exploring the differences in organizational culture across organizations (van Muijen,1999; van den Berg & Wilderom, 2004). In either case, the analysis must demonstrate a greater degree of variance between groups than within groups in order to justify aggregation of individual-level data to the higher levels (Glisson & James, 2002; Klein & Kozlowski, 2000). As one or both of these criteria are met, researchers are able to demonstrate stronger within group agreement and greater between-group variation, which justifies the aggregation of individual-level data to the organizational level (Hofmann & Stetzer, 1996).

Researchers aggregate data from the individual to the organizational level using several different analytical approaches (Hofstede et al., 1993). One approach is to analyze all the individual-level data together from several different organizations, regardless of their organizational membership, so that the data are cross-organizational in nature. A second approach is to limit the analysis to individuals within each of the organizations. A third approach is to aggregate measures of the culture variables for each organization as well as exogenous variables that exist at the cultural level, typically by calculating means and standard deviations of individual members of the organization for each measure. A fourth approach is to pool the data for all individuals across all organizations after eliminating the culture level effect by standardizing the individual-level scores. Each of these approaches is used to examine the relationship between measures of organizational culture, and different approaches are used for different purposes.

Another approach to the aggregation of individual-level constructs to organizational level constructs is based on composition models that provide the rationale for aggregation from lower to higher levels (Dickson, 2006). Composition models provide an explicit explanation of how a construct measured at one level can be represented at different levels of analysis, such as work groups within organizations and organizations as a whole (Glisson & James, 2002; Schneider & Salvaggio, 2002). The two composition models most commonly used in organizational research are the direct consensus model and the referent shift model (van Mierlo, 2009).

In the direct consensus model, organizational culture is defined as the average of the most typical way that people in the organization describe it, and within-organization agreement in this model serves as the prerequisite for aggregation of individual-level variables to the organizational level. The focus of this model is on the perceptions of individual members about measures of organizational culture. High levels of individual variability, or low levels of within-organization agreement, indicate that the group does not share the same perceptions associated with the measures of organizational culture, and that the construct does not exist at the organizational level (Schneider & Salvaggio, 2002). If sufficient within-organization agreement is found, then members of the organization share similar perception of the variables of organizational culture, which has been described as one of the defining characteristics of organizational culture (Schneider & Salvaggio, 2002). Sufficient levels of agreement between individual-level ratings can then legitimately be aggregated to the organizational level (Dickson, 2002). The level of agreement in the direct consensus model is measured using several indicators of within group agreement, such as the Intraclass Correlation Coefficient and the standard deviation of the data (Scheider, 2002, van Mielo, 2009)

The referent shift model is very similar to the direct consensus model but is focused on a different individual-level referent. Instead of asking members to assess their own perceptions of organizational culture, members are asked to assess the perceptions of the members of their work group. If a sufficient level of agreement exists at the level of the workgroup, then the construct can be further aggregated to the organizational level (van Mierlo, 2009). The level of agreement within groups is measured using the r_{wg} index which compares the similarity of responses of members in the groups involved in the study sample to what would be expected if the members had responded randomly (van Mierlo, 2009).

The analytic approach that will be used for this dissertation is divided into two stages. In the first stage, the analysis will be based on using individual data from all participating organizations for the purpose of calculating descriptive statistics, to evaluate the reliability and validity of the questionnaires, and to test the hypotheses about the relationship among the variables. In the second stage, the data will be evaluated to determine if the individual data can be aggregated to the organizational level. This will be accomplished by using the Interclass Correlation Coefficient, standard deviation, and between group variance to determine if the aggregation is justified. Aggregation of the data to the organizational level will allow for comparisons across the participating organizations to identify the similarities and differences in safety culture.

Instruments

Included in this section is an overview of the questionnaires used to operationalize the variables of safety culture. A discussion of the different semantic descriptors used in the questionnaires is also included, which includes a discussion of the reasons for using different types of semantic descriptions for this pilot study. Finally, a more detailed description of each survey instrument is provided as well as a description of the two demographic variables that will be used. A copy of the instruments can be found in Appendix A.

The instruments used to measure the three variables of safety culture provide the data needed to conduct statistical analysis relevant to the hypothesis that higher levels of Safety Management Systems and Safety Related Behaviors are associated with higher levels of Organizational Safety Climate. Measures of job function and years of service are required to conduct analysis relevant to the hypotheses that the level and strength of safety culture will vary as a function of these two factors.

Three surveys are used to measure the three variables of the model. Two of the survey questionnaires have been used in previous research. The survey selected for measuring Safety Management Systems (SMS) is based on a questionnaire developed by the Health and Safety Executive in the United Kingdom. This questionnaire is used as part of an auditing process to assess safety management practices in all occupations in the UK, including the fire service. The survey selected for measuring Organizational Safety Climate (OSC) is the questionnaire included in the Safety Climate Assessment Toolkit developed for use in offshore oil drilling organizations and subsequently used to assess safety values and beliefs in other high risk occupations (HSE, 1999).

Assessment of Safety Related Behaviors (SRB) in the fire service required the development of a new questionnaire. Although data on fire service casualties (injuries and fatalities) are collected and reported each year by the National Fire Protection Association and the US Fire Administration, no systematic research has been conducted using a survey questionnaire on the behaviors that firefighters are engaged in when casualties occur. Development of this questionnaire was based on the main categories of activities that result in firefighter casualties as described by the NFPA in their annual injury and fatality reports. These include fire suppression operations, responding and returning to alarms, and training. Physical fitness programs and medical exams are also included because of the high rate of firefighter fatalities that result from cardiac-related problems. Specific items included in the questionnaire were selected from relevant NFPA standards and other published materials considered to represent best practices with regard to each of the elements included in the questionnaire.

All three of the instruments use a 5 point Likert scale. Each point on the scale includes a semantic description. However, a different semantic scale is used for the two instruments that measure behaviors and the one instrument that measures values and beliefs. The instruments that measure safety management systems and safety related behaviors use a scale that is descriptive, while the instrument that measures values and beliefs uses a scale that is evaluative (Guldenmund, 2007). The descriptive scale is intended to measure individual perceptions of the extent to which a practice is present in their work environment (Hofstede, 1998). The evaluative scale is intended to measures the positive or negative response of individuals toward safety related characteristics in their work environment (Hofstede et al., 1990). The semantic scaled used to measure Safety Management Systems and Safety Related Behaviors ranges from No Evidence, indicating the absence of an item, to Full Evidence, indicating the presence of an item.

Also included in these descriptive behavioral scales is a numeric anchor that represents the percentage of behaviors represented by the semantic scale. The purpose of including a numeric as well as a semantic point of reference is to reduce the individual variation in the interpretation of the semantic scale. This practice has been used in studies of safety management systems in health care organizations (HSA, 2006) and is used in this pilot study for the same purpose.

The survey questionnaire developed as part of the Safety Climate Assessment Toolkit uses an evaluative semantic scale. The five points on the Likert scale range from Strongly Disagree to Strongly Agree. Numerical anchors are not included in this survey instrument. While some studies on safety culture were found to have included a numerical anchor for the semantic points on the scale of survey questionnaires on management and safety practices, these were not included on any of the survey questionnaires intended to measure values and beliefs (Hofstede, 1998; Hofstede et al., 1990; Guldenmund, 2007; Grote & Kunzler, 2000; Vrendenburgh, 2002). Therefore, numerical anchors are not included on the survey questionnaire used in this pilot study.

The next section provides details on each of the questionnaires used to assess the variables included in the model of safety culture. Included is a listing of the elements and sub-elements of each variable.

Safety Management Systems

Because the UK fire services have a higher level of safety performance than their American counterparts, the measures used in the UK fire service for managing safety systems will be used as the operationalized measure of Safety Management Systems for this pilot study. As described in the first chapter, the firefighter injury and fatality rates in the UK are four times lower than in the US fire service. This may be a reflection of different national and occupational level cultures in the UK that put more value on safety and a greater emphasis on effective management of safety. Using the same measures for safety management systems is expected to facilitate explicit comparisons between UK and US fire service practices, which may eventually help to explain why the safety performance of the US fire service is so much worse with respect to firefighter injuries and fatalities.

The fire service organizations in the UK use a safety management system that is based on clearly defined occupational health and safety management standards. These standards are known as British Standard (BS) 8800, Occupational Health and Safety Management Systems; OHSAS 18001, Occupational Health and Safety Management Systems – Specifications; and OHSAS 18002, Occupational Health and Safety Management Systems – Guidelines for Implementing OHSAS 18001. The Health and Safety Executive (HSE) used these standards to develop a publication known as HSG 65, Health and Safety Guidance No. 65, which is considered a comprehensive model for effective safety management systems (Cooper, 2008; Cooper, 2000; Santos-Reyes & Beard, 2002).

The basis of these standards can be found in the quality management systems standards produced by the International Organization for Standards, commonly known as ISO. Two of the ISO standards are relevant to this pilot study. They include ISO 9001, Quality Management Systems – Requirements; and IWA 4:2005, Quality Management Systems – Guidelines for the Application of ISO 9001 in Local Government. Both of these standards contain a section on management responsibilities that is very similar to the management systems defined in the BS 8800 standard, the OHSAS 18001 standard, and the HSG 65 guidance document.

The guidance document developed by the HSE is the basis for operationalizing the instrument used to measure individual perceptions of Safety Management Systems. A similar approach has been taken in other studies. For example, the HSE management system was used as the framework for developing specific items to be included in a questionnaire for the analysis of safety management systems in the offshore oil and gas industry (Mearns et al., 2003; Parker et al., 2006; Cooper, 2008) as well as manufacturing plants (Zohar & Luria, 2005). A review of the literature on the effectiveness of safety management interventions by Robson et al. (2007) indicates that the HSE framework has been used in a more than twenty studies in the last fifteen years. The healthcare sector in the UK has also used the HSG 65 guidance document as a guide for the development of a self-assessment tool for use by health care providers in the UK to assess the efficacy of safety management systems (HSA, 2006). In addition, a study of safety management in emergency response services in the UK, including the fire service, proposed a model of safety management systems based on the HSG 65 as one of two options for assessing safety management systems. The other model recommended in the study was the BS 8000 standard, which is very similar in form and content to the HSG 65 guidance document, but differs in that the BS 8800 standard is more focused on implementation.

The HSG 65 guidance document for safety management systems is the only systematic approach to safety management that has been used in studies that involve both fire service and health care organizations. Most fire service organizations in the US, including the three organizations participating in this study, provide fire protection and emergency medical services. Therefore, the HSG 65 safety management system seems to be the most appropriate for the purpose of assessing safety management systems in US fire service organizations.

The basic structure and specific questions used to develop the Safety Management System questionnaire are based on the structure and questions contained in HSE 19, Health and Safety Information Sheet on Audit and Review (HSE, 2007). The HSE 19 questions are developed from the HSG guidance document for safety management systems. Within the HSE 19 document, Safety Management Systems are comprised of four elements. These are listed below. All but the policy element contain four sub-elements, which are also identified. As a result, the SMS variable has three levels.

1) Policy
2) Organizing
   a) Structure
   b) Cooperation
   c) Communication
   d) Competence
3) Planning and Implementation
   a) Performance Standards
   b) Risk Assessment and Control
   c) Hazard Identification
   d) Planning
4) Measuring and Reviewing Performance
   a) Active Monitoring
   b) Reactive Monitoring
   c) Remedial Action
   d) Reviewing Performance

The number of questions under each sub-element ranges from two to ten items. Each of the items was reviewed and modified as necessary to be relevant to the context of the fire service. For example, questions that made reference to the Head of Department were changed to refer to the Fire Chief. A similar approach to modifying questionnaire items has been used in a study of safety culture in aviation (Flannery, 2001).

The rating scale used will include five ratings (No Evidence, Little Evidence, Reasonable Evidence, Significant Evidence, Full Evidence). For the purpose of data entry and analysis, No Evidence is entered into the data system as a 1, Little Evidence as a 2, Reasonable Evidence as a 3, Significant Evidence as a 4, and 5 is used to indicate Full Evidence. These numbers are not included on the survey questionnaires.

To assist participants in accurately scoring the elements of the Safety Management System questionnaire, the numerical percentage is provided below the rating description. Instructions included in the questionnaire explain to the participants that the numerical scale is intended to provide a percentage comparison of the difference between the semantic descriptions. An example of the rating scale is provided in Figure 18. The entire question set is provided in the Appendix.

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
Risk assessments are derived from hazard identification		✓			

Figure 18. Safety Management System Rating Scale

Safety Related Behaviors

Identification of relevant behaviors is one of the first steps in developing a safety related research methodology (Zohar & Luria, 2003). These are usually critical safety related behaviors that are specific to the industry or profession under consideration (Cooper & Phillips, 2004; DeJoy, 2005). As previously described, annual firefighter casualty data provided by the National Fire Protection Association (NFPA) clearly indicates that most firefighter casualties result from three categories of activities: fireground operations, responding to and returning from incidents, and training. These activities account for seventy eight percent of fatalities and sixty six percent of injuries, as indicated in Table 2 below.

Table 2

Percentage of Fatalities and Injuries by Activity

Activity	**Percent of Fatalities**	**Percent of Injuries**
Fireground	41	52
Responding and Returning	27	6
Training	10	8
Total Percent	78	66

Cardiac-related problems also contribute significantly to the rate of firefighter fatalities, accounting for approximately forty-four percent of firefighter fatalities, some of which occur during fireground operations, responding and returning to alarms, and during training exercises. The presences or absence of physical fitness programs and medical evaluations has been identified as a major contributing factor to cardiac-related firefighter deaths (NFFF, 2004). Therefore, these two categories of activities are also included in the survey questionnaire for Safety Related Behaviors.

As a result of the evaluation and analysis of the activities that result in the highest levels of firefighter fatalities and injuries, the Safety Related Behaviors (SRBs) examined in this pilot study include the key or critical behaviors within four elements of fire service practices. Each of the elements includes several sub-elements, resulting in a three level variable. These elements and sub-elements include the following:

1) Fitness and Medical
   a) Fitness Program
   b) Medical Evaluation
2) Structural Firefighting

    a) Command and Control
    b) Communications
    c) Accountability
    d) Operational Risk Management
3) Vehicle Safety
    a) Seat Belt Use
    b) Response Policy and Procedures
    c) Training
    d) Supervision
4) Training
    a) Instructors
    b) Planning
    c) Facilities
    d) Safety Requirements

The critical behavioral elements included in the Safety Related Behavior questionnaire came from several sources. Questionnaire items for fitness and medical elements were selected from a review of NFPA Standard 1583, Standard on Health Related Fitness Programs for Fire Fighters (NFPA, 2000), and NFPA Standard 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments (NFPA, 2007). Questions regarding fireground operations were selected from the NFPA Standard 1561, Standard on Emergency Services Incident Management System (NFPA, 2005). The NFPA Standard 1451, Standard for a Fire Service Vehicle Operations Training Program (NFPA, 2007), was used to develop questions for the Vehicle Safety elements. Training related questions were developed from the Health and Safety Guidelines for Firefighter Training developed by the University of Maryland (MFRI, 2006).

The same scale, semantic descriptors, and percentage anchors use for the Safety Management System questionnaire are used for rating the questions included in the Safety Related Behavior questionnaire. An example of the rating scale is provided in Figure 19. The entire question set is provided in the Appendix.

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
Fitness assessments include a component for muscular endurance				✓	

Figure 19. Safety Related Behavior Rating Scale

Organizational Safety Climate

The questionnaire developed as part of the Safety Climate Measurement Toolkit has been selected as the method for operationalizing the Organizational Safety Climate variable. The questionnaire is considered to be well developed and has been used extensively in the offshore oil and gas industry and other occupations (HSE, 1999). In addition, the questionnaire was developed from a theoretical perspective that is very similar to that which forms the basis for this thesis (HSE, 1997). For example, the questionnaire was designed from a definition of safety culture that includes the shared values and beliefs of individuals that characterize the organization. The approach used to assess safety climate is to measure individual perceptions about those values and beliefs using evaluative questionnaire items and rating scales. When used to assess safety climate in other high risk occupations, the questions are revised so that thier language is consistent with that used in the occupational sector (HSE, 1999).

The Safety Climate Survey Toolkit was developed by Loughborough University in cooperation with the Health and Safety Executive. Subsequent to the cooperative development of this toolkit, the HSE developed another toolkit for regulating safety throughout the UK (Yule & Flin, 2007). The questionnaires in these toolkits appear to be very similar in terms of the elements and sub-elements used in the questionnaires. While the two questionnaires are similar, the HSE toolkit questionnaire has been used more extensively in the UK across all industrial sectors. An important difference between the two questionnaires, however, is that the HSE questionnaire must be purchased while the questionnaire developed by Loughborough University is available free of charge.

Several broad elements of organizational safety climate are measured with the questionnaire used in this pilot study. These include Organizational Context, Social Environment, Individual Appreciation, and Work Environment. The purpose of the questionnaire is to measure the degree to which individual values and beliefs regarding these particular safety characteristics are shared among members of the organization (HSE, 1997). Each of these elements consists of a number of specific sub-elements that create a three level variable. These are listed and briefly described below.

1) Organizational Context
   a) Management Commitment: perceptions of management's overt commitment to health and safety issues.
   b) Communications: the nature and efficiency of health and safety communications within the organization.
   c) Priority of Safety: the relative status of health and safety issues within the organization.
2) Social Environment
   a) Supportive Environment: the nature of the social environment at work, and the support derived from it.
   b) Involvement: the extent to which safety is a focus for everyone and all are involved.
3) Individual Appreciation
   a) Personal Priorities and Need for Safety: the individuals' view of their own health and safety management and need to feel safe.
   b) Personal Appreciation for Risk: how individuals view the risk associated with work.
4) Work Environment.
   a) Physical Work Environment: perceptions of the nature of the physical environment.

The rating scale for the Organizational Safety Climate questionnaire is similar to those used for the Safety Management System and Safety Related Behavior questionnaires in that a five point Likert scale is used. However, the Organizational Safety Climate questionnaire uses an evaluative form of semantic descriptors for each of the ratings.

Descriptors for the Organizational Safety Climate questionnaire are: Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, Strongly Agree. An example of the rating scale is provided in Figure 20. The entire question set is provided in Appendix.

Please check the appropriate box to indicate your level of agreement	**Strongly disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
Health and safety issues are very important					✓

Figure 20. Organizational Safety Climate Rating Scale

Survey Scoring

Very few studies have attempted to develop a standardized metric for scoring assessments of safety culture. Most studies compare scores of one organization to another in term of the relative relationship between mean scores on survey instruments (Silvester et al., 1999; Balthazard et al., 2006; Rad, 2006; Hofstede et al., 1990; Parker & Bradley, 2000; Clarke, 1999; Mearns & Flin, 1999; Neal et al., 2000; Silva et al., 2004). Organizational safety culture is judged in relative terms compared to other organizations as better or worse depending on the relative standing of mean scores. Organizations with higher scores are considered to have a better safety culture than those with lower scores. What this tells practitioners is that the safety culture of their organization may be better than another organization, but elements of safety culture may still be inadequate.

An exception to this pattern is a framework developed by Cooper (2008) for assessing and comparing safety culture profiles using a fixed ranking of scores that can be used to evaluate the level of safety culture in organizations separate from relative comparisons with scores of other organizations. The proposed scale provides an absolute scale rather than a relative scale of safety culture. It is important to establish a framework for rating the scores of participating organizations in absolute terms as well as relative terms because this pilot study is using a small sample of organizations and is based on an functional approach to safety culture. Scores on safety culture are not examined in relationship to safety performance, which has been used in previous studies as a measure of the development of an organization's safety culture. To assess the development of organizational safety culture in those organizations participating in this pilot study, it is necessary to use a fixed rather than a relative measurement scale, which is what the framework developed by Cooper is intended to provide.

Three elements form the model of safety culture within Coopers' measurement framework. These are the same variables that have been selected for use this pilot study: Safety Management Systems, Safety Behaviors, and Safety Climate. Within this framework, Safety Management Systems are described as those elements and sub-elements present in the BS 8800 and OSHAS 18001 standards and the HSG 65 guidance document on management systems. Safety Behaviors are described as those behaviors that individuals engage in that cause incidents. Safety Climate is described as the values and beliefs of employees with regard to organizational safety.

Instruments that measure these variables typically use a 5 point Likert type scale, as is the case in the present pilot study. In order to rate safety culture profiles, Cooper (2008) proposes a common metric for scoring all three variables. Percentage ratings for the Likert scale are used to form ranges of scores. Scores that fall within 0-50 percent of the Likert scale are considered alarming. Scores that range from 51-70 percent are considered average. Those falling within the 71-90 percent range are considered good. Scores that range fall within the 91-100 percent category are considered excellent. The rating scale is summarized in the following table, which includes the low and high Likert scores that frame each of the categories.

Table 3

Safety Culture Rating Scale

	Likert Score		
Percentage	**Low**	**High**	**Rating**
0-50	1.00	2.50	Alarming
51-70	2.51	3.50	Average
71-90	3.51	4.50	Good
91-100	4.51	5.00	Excellent

The semantic scale levels used in the safety culture questionnaires provide data on the relative levels of perceptions across participating organizations. Using this type of data, organizations can compare the relative level of their safety culture scores to those of other organizations. The rating scale proposed by Cooper (2008) provides organizations with a standard for evaluating their own safety culture, independent of other organizations, to determine whether their safety culture is excellent, good, average, or alarming.

Job Function and Years of Service

Most studies of safety culture that include job function as a demographic variable use three categories: workers, supervisors, and managers (Mearns et al., 2003; Grote & Kunzler, 2000; Yule & Flin, 2007). These same categories will be used to differentiate job functions for this dissertation. The workers category includes firefighters, engineers, and paramedics. The supervisor category includes company officers with the rank of Lieutenant and Captain. The manager category includes shift commanders and administrative officers such as Battalion Chiefs, Assistant Chiefs, Deputy Chiefs, and the Fire Chief. The three categories will be labeled as Firefighters, Company Officers, and Chief Officers respectively.

There is more variation in the categories of years of service when used as a demographic variable in safety culture studies. Some use a range of categories from 1-5 years, 6-10 years, and over 10 years of service (Mearns et al., 2003). Other studies have used a range from 1-5, 6-15, 16-25, and over 25 years of service (Cooper & Phillips, 2004). Because many career members of the fire service work for more than 20 years, the later scale will be used for categorizing years of service for this pilot study but will be modified so that the categories are all five years apart, as follows: 0-5, 6-10, 11-15, 16-20, and over 20 years of service.

Study Design

Research designs for safety culture and climate research are typically either exploratory or confirmatory in that the researcher is attempting to explore the characteristics of the relationship between the variables or to confirm a preconceived structure between those variables (Guldenmund, 2000). This thesis adopts an exploratory approach to determine if the data support the hypotheses. The research is exploratory in that the conceptual model used to examine safety culture in other high-risk occupations has not been used in any previous research to examine safety culture in fire service organizations. In addition, although the instrument used to measure Safety Management Systems has been used in similar forms in research involving other high-risk occupations and in fire service organizations on other countries, it has not been used in the context of the fire service within the United States. Similarly, the instrument used to measure Organizational Safety Climate was developed for other high-risk occupations, and has not been applied to fire service organizations. Also, the instrument used to measure Safety Related Behaviors has been developed from the analysis of activities that firefighters are engaged in when injuries and fatalities occur, and has not been used in any previous research. An exploratory approach is necessary because no research has yet been conducted on safety culture using the model and combination of measures and instruments that will be used to assess safety culture in this research project.

A cross-sectional design is used to collect data that will then be used to examine the relationships among the variables. The cross-sectional design is used in exploratory and developmental research on safety culture in other high-risk occupations. This design has been used in several studies to explore the relationship between measures of safety culture at one point in time as a preliminary test of theoretical models that can then be used in further research to test the relationship between safety culture and behavior or between safety culture and performance (Cooper, 2000; Mearns et al., 2003; Grote & Kunzler, 2000; Sorensen, 2002; Yule & Flin, 2007).

Each of the three variables in the model of safety culture will be assessed using survey questionnaires. These instruments are intended to provide a quantitative measure of individual perceptions for each variable in the model. Participants will complete one questionnaire for each variable. The surveys will be self-administered paper based forms. Each participating member will complete these forms individually and anonymously. All three surveys will be attached together to assure that the same individual completes the three surveys.

Population and Sample

According to the National Fire Protection Association (NFPA), the U.S. fire service is made up of approximately one million firefighters and more than 30,000 fire departments (NFPA, 2009). Approximately 321,000 (28%) of firefighters are fully paid career personnel and

827,000 (72%) are volunteer personnel. It is estimated that 74% of career firefighters work in communities that have populations of 25,000 or larger. In addition, it is estimated that 94% of volunteers work in communities smaller than 25,000 in population, and more than half protect communities that have a population smaller than 2500 people.

The US Fire Administration has established a national fire department census database for the purpose of providing basic information about fire departments that can be used in research studies (USFA, 2009). A list of potential participants was developed from the fire department census. Fire departments considered for participation in the pilot study were limited to those that were fully career departments with at least 250 members and no more than 600 members. Limiting potential participants to a specific type of department and range of size is intended to minimize differences in participants based on the level of hazard that firefighters are exposed to in their work environment in order to control for the level of risk as a potential mediating factor in the relationship between the variables (Cooper, 2000b).

Limiting the type and size of departments participating in the pilot study reduces the potential for task factors and organizational factors to mediate the relationship between the variables (Cooper, 2000b). Task factors include the size of the workgroup, the complexity of work tasks, and task strategies. Organizational factors include communications, management practices, organizational structure and resources. Using larger departments in terms of the number of firefighters also reduces the number of fire departments that are necessary for participation to achieve a large sample size, and minimizes the logistical demands necessary to complete the project.

Using the list developed from the national census database, participating organizations were recruited by sending letters out to the fire chiefs of thirty fire departments asking for their participation in the project. The letter explained the purpose of the project, the need for a high level of cooperation and participation by members of the department if they should decide to participate, and explained what would be involved in participation in the project. The letter also explained the problem of firefighter casualties and the need for better research to reduce firefighter injuries and fatalities. Out of the thirty departments that were recruited to participate in the project, only six indicated that they would participate fully. The only condition that they requested was that the identity of their department would be kept confidential.

Three fire departments were eventually selected for participation in the research project. Selection of the three participating organizations was based on several factors in addition to the criteria for type and size of department already discussed. First, they have similar organizational and hierarchical structures and operate using similar procedures. The participating fire departments serve communities that have a similar level of risk and hazard in terms of the age and type of buildings that they protect. Similarities in these areas are intended to limit the influence of the hazard, task and organizational factors that might mediate the relationship between the variables. In addition, each department is located in a different region of the country, with one in the West, one in the Midwest, and one in the South. Using organizations from different regions is intended to increase the ability to generalize the findings. Despite these efforts to insure that the sample of fire departments included in this pilot study is reflective of the overall population of fire departments in the US, the sample must be described in general terms as a convenience sample.

Data Collection

After initial contact was made with each of the participating fire departments, a site visit was scheduled to meet with representatives of labor and management in each organization. The purpose of the meeting was to more fully describe the logistical arrangements that what would be necessary to distribute the questionnaires, to address any concerns regarding confidentiality and human subject protections, and to confirm the procedures for returning completed questionnaires.

The procedure used to distribute, complete, and return the questionnaires were the same for all three participating fire departments. Each department was provided with enough paper copies of the questionnaires to distribute to every member. The three questionnaires were attached to insure that the same member completed all three forms. Instructions for completion of the questionnaires were included at the beginning of each questionnaire. In addition, each member received a self-addressed and postage paid envelope for returning the questionnaires to insure confidentiality.

A representative of each department was designated to distribute the questionnaires to every fire station for each work shift. The questionnaires were distributed and competed while the members were on duty at the fire station. After completing the questionnaires, each individual inserted the forms into the envelope and sealed the envelope. Completed questionnaire envelopes were returned to fire department headquarters for mailing to the principal investigator.

Data Analysis

Participants completing the questionnaires place a check mark in one of five boxes indicating the level of their perceptions to the questionnaire items associated with the three variables of safety culture. The questionnaires for safety management and safety behaviors use five descriptive semantic levels. The semantic levels are entered as numeric data as follows: No Evidence = 1; Little Evidence = 2; Reasonable Evidence = 3; Significant Evidence = 4; Full Evidence = 5. The questionnaire for safety climate uses five evaluative semantic levels. These are entered as numeric data as follows: Strongly Disagree = 1; Disagree = 2; Neither Agree or Disagree = 3; Agree = 4; Strongly Agree = 5. For all three questionnaires, higher levels of the variable are indicated by higher numerical data points.

Data were entered into an Excel spreadsheet by two student assistants over the course of three months. The students were instructed on how to enter the semantic levels as numeric levels, and were provided with a coding sheet for the demographic data. Demographic data included the name of the department, job function, and years of service. Participating departments were coded as 1, 2, or 3. Job functions were coded as follows: Firefighter = 1, Company Officer = 2, Shift Commander = 3, Chief Officer = 4, Other = 5. The Firefighter job function is equivalent to the worker level described previously. The Company Officer is equivalent to the supervisor level while the job functions of Shift Commander and Chief Officer are equivalent to the manager level. The years of service were entered as whole numbers. If participants indicated a fractional level of service, such as 1.5 years of service, these were entered as the lowest whole number indicated regardless of the fractional years indicated. For example, a participant indicating that they had 14 years 7 months of service was entered as 14 years of service.

After data entry was completed, the data were cleaned and standardized. The data were first reviewed for inclusion in the pilot study. Several criteria were established for determining whether the data for each case would be included in the pilot study. If a case did not include data for all three surveys, then it was excluded. For example, some cases included data from two of the three surveys, but not all three. These cases were deleted from the database. In addition, if the total percentage of responses was less than ninety percent of the total items in the questionnaires, then these cases were also excluded. A total of fifty-seven of the initial 1100 cases were excluded based on these criteria, leaving a total of N for the pilot study of 1043 cases.

Next, the data were analyzed for an appropriate range of scores. Each item was reviewed to insure that the range of scores was between 1 and 5. Any questions that had an entry outside of the expected range were left blank. The percentage of completed items was checked again after this step to make sure that none of the cases had fallen below the ninety percent complete criteria.

The structure of the safety culture model includes three levels of data: questionnaire items that are grouped into sub-elements; sub-elements that are grouped into elements, and elements that are grouped into variables. For example, with regard to Safety Management Systems, questionnaire items are grouped into the sub-elements, such as Management Commitment, Safety Rules and Procedures, Communications, and the Priority of Safety. These sub-elements are grouped into the element of Organizational Context. The Organizational Context element and three other elements form the Safety Management System variable. Analysis of data was conducted on variables and elements within each variable. A number of studies involving safety culture use this type of multilevel model involving two levels for the purpose of data analysis (Silva et al., 2004; Sarros et al., 2005; Vrendenburgh, 2002; Cooper & Phillips, 2004; Cooke & Rousseau, 1988; James & James, 1989; Guldenmund, 2007).

Five sets of statistical analysis are to be derived from the data. The first set consists of descriptive statistics. This set includes the response rate and demographic data for each participating organization. Descriptive statistics for the items include the mean, standard deviation, minimum and maximum scores. Descriptive data for elements and variables includes the mean, standard deviation, and range for each element and variable (Grote & Kunzler, 2000; Mearns et al., 2003; Sarros et al., 2005). A correlation matrix of the elements within each of the three safety culture variables and a matrix of the correlations between the three variables is part of the descriptive data set (Zohar & Luria, 2005).

The second set of statistical analysis involves evaluation of the reliability and validity of the questionnaires to determine whether certain items can be eliminated from the surveys to make them shorter and to increase their reliability (Cooper & Phillips, 2004). The survey instruments for safety management systems and safety related behaviors are particularly large in terms of the total number of questions, requiring a relatively long time for participants to complete the surveys. It is important, therefore, to reduce the number of questions in these two surveys so that they are shorter and easier to complete, which should help to increase return rates in future studies. In addition, making the surveys shorter by eliminating highly correlated questions is expected to improve the overall reliability and validity of the instruments.

A correlation matrix will be produced for all items in each element, which will be evaluated to identify possible problems with multi-collinearity. Items with high levels of multi-collinearity (over .70) with more than two other items will be eliminated. Principal Components Analysis will be conducted on elements for the purpose of data reduction. Factor loadings resulting from the principal components analysis will be used to determine which if any of the items should be eliminated from the questionnaires (Cooper & Phillips, 2004; Yule & Flin, 2007). Items that have a factor loading of less than 0.4 will be eliminated (Diaz-Cabrerra, 2007). The reliability of the modified questionnaires will then be reevaluated after assessing the correlation matrix and the results of Principal Components Analysis using Cronbach's alpha coefficient.

Validity of the instruments will also be evaluated as part of the second data set. Few studies have attempted to assess the predictive validity of the instruments used to measure safety culture. Discriminant validity, however, is frequently assessed by examining the difference in scale scores of safety culture across demographic variables, such as job function and years of service (Cooper & Phillips, 2004; Grote & Kunzler, 2000). The discriminant validity of the three instruments used to assess safety culture will be examined using one way ANOVA to determine whether the instruments are able to discriminate among the level of scores across categories of job function and years of service.

The third set of analyses is designed to evaluate the hypothesis that higher individual perceptions of Safety Management Systems and Safety Related Behaviors predict higher individual perceptions of Organizational Safety Climate. Analysis of the nature and characteristics of the relationship between these variables will be examined through Multiple Regression and Confirmatory Factor Analysis. Multiple regression is used in a number of studies on organizational safety culture to determine how much of the variation in the dependent variable is explained by the independent variables, and the relative contribution made by each of the independent variables in the model (Sorensen, 2002; Vrendenburgh, 2002). Confirmatory factor analysis is used to determine how well the proposed model and factors fit the data (Yule & Flin, 2007; van Mierlo et al., 2008). Goodness of fit statistics will include the RMSEA (root mean square error of approximation) and the GFI (goodness of fit index) that have been used in previous studies of safety culture that include confirmatory factor analysis (Silva et al., 2004; Sarros et al., 2005).

The fourth data analysis set examines the hypotheses that the perceptions of the level and strength of safety culture will vary across higher level job functions and longer terms of service. Level is measured as the mean score on a variable and strength is measured as the standard deviation of the mean. It is hypothesized that individuals in different job functions will have different perceptions of safety culture, indicated by higher or lower levels in the mean scores, and that these perceptions will be stronger as well, indicated by lower standard deviations of the mean score.

As previously described, one way analysis of variance on the sub-elements and elements of each variable across specified categories of job function and years of service will be used to determine the discriminant validity of the survey instruments. Results from this analysis will also be used to determine whether the data support the hypotheses that individuals in different job functions and with different years of service have different perceptions of safety culture (Mearns et al., 2003; Zohar & Luria, 2005). The Tukey post-hoc test will be used to identify which groups are significantly different from each other and whether the mean scores of each group change across job functions and years of service as proposed in the hypotheses. Determination of whether strength varies as predicted will be based on the results of one-way analysis of variance and the Tukey post-hoc tests on the standard deviation of the elements and variables across job function and years of service.

The fifth and last set of data and analysis involved the aggregation of individual-level scores on safety culture to the organizational level and comparisons of aggregated data across organizations. The level of analysis for this pilot study is the perceptions of the individual participants. However, it may be possible to aggregate individual responses to the organizational level. Assessment of within-group consistency and between group differences are preconditions for aggregation of individual-level measures into higher-level constructs (Glisson & James, 2002). If the data indicate sufficiently high within-group homogeneity and between-group variance, then scores can be aggregated to the organizational level (Zohar & Luria, 2005; Guldenmund, 2007; van Mierlo et al., 2008). Within-group homogeneity will be assessed by calculating the Intraclass Correlation Coefficient (ICC). Between-group variance will be assessed using the findings from one way analysis of variance.

If the results indicate sufficient within-group consistency and between-group variation for the aggregation of individual-level data into organizational level data, then additional analysis will be conducted to explore the similarities and differences in safety culture among the three participating organizations. Comparisons across organizations will include the level and strength of scores and correlations among the elements and variables for each organization (James & James, 1989; Sarros et al., 2005; Diaz-Cabrera & Hernandez-Fernaud, 2007; Williamson et al., 1997; Mearns et al., 2003; Grote & Kunzler, 2000).

Limitations

Ideally, if a research study is drawing inferences from aggregated data about situational conditions, then some method should be established to directly assess the degree of correspondence between perceptions and conditions (Williamson et al., 1997). One of the limitations of this pilot study is that no such comparisons are made between perceptions and objective conditions.

Sample selection bias is clearly another major limitation of this pilot study. The sample of fire departments that self-selected as participants in the pilot study may be systematically different in some important way from non-participating organizations. Although participants were selected to be similar in terms of the size and type of organization, very little information is available on fire departments in the US that can be used to detail the similarities and differences between participants and non-participants at the organizational level. If significant differences exist between the participants and non-participants, then the results may be biased, which threatens the internal and external validity of the findings (Cuddleback, Wilson, Orme, & Combs-Orme, 2004). In addition, because completion of the questionnaires is voluntary, individual members who completed the questionnaires may be systematically different from those who did not. Because of the limitations on demographic data collected on individual participants due to concerns about confidentiality, it is not possible to explore the possible differences between participants and non-participants at the individual level.

Another important limitation of this pilot study is the reliance on self-reports of perceptions. The use of self-reported data tends to underestimate undesirable behaviors (Yule & Flin, 2007). As a result, the data on management practices and safety practices may reflect a negative bias. Scores may be higher than true individual perceptions because of the bias inherent in the use of questionnaires that rely on self-reports of these behavioral variables. In addition, some researchers have expressed concern about whether perceptual data are influenced by individual characteristics that would lead to erroneous interpretation and inferences from that data (Jones & James, 1979).

Social desirability bias has also been found to influence individual rating on self-reported questionnaires involving values and practices, which can moderate the relationship between variables (Chung & Monroe, 2003; Fisher & Katz, 2000). Social desirability bias occurs when individuals provide socially desirable answers to questionnaire items in an effort to reflect culturally accepted standards rather than their true perception of values and practices. Distortion of responses can occur as a result of two factors: self-deception and impression management (Fisher & Katz, 2000). Self-deception occurs when an individual provides an honest but overly favorable response. Impression management occurs when individuals consciously misrepresent their true perceptions in order to present values and practices in socially acceptable ways or to avoid evaluation by others (Neferhoff, 1987; Fisher & Katz, 2000). Individuals are more highly motivated to distort their responses to items that are more strongly prescribed within the culture. As a result of social desirability bias, individuals tend to underestimate participation in undesirable practices or deny undesirable values. Distortion of responses in this way can have a serious impact on the validity of these measures.

Attributional bias involving the assessment of management system factors may be a further limitation of this pilot study. Management systems are one of the three variables in the model of safety culture used in this pilot study. In addition, three hierarchical levels of job functions are used as demographic variables, which include workers, supervisors, and upper management. The inclusion of management systems as a main variable and use of job functions as a demographic variable may influence the perceptions of individuals working in management level job functions. The level of scores on management systems for upper management level positions may be influenced by attributional bias (Grote & Kunzler, 2000).

Attributional bias occurs when management is perceived to be more responsible for safety management than lower level job functions. Because higher level perceptions are more supportive of a positive self-image for those responsible for safety management, individuals in higher level management positions may have a positive bias in their perceptions of management system factors. As a result, higher level scores on safety management related elements and sub-elements by higher level job functions may be the result of attributional bias rather than true perceptions of these factors.

A number of mediating variables may influence individual perceptions of the variables in the safety culture model. These include individual-level variables such as individual ability, commitment, goal conflict, and training (Cooper, 2000b). Additional mediating variables that are not fully controlled in this pilot study include job factors and organizational factors (Cooper & Phillips, 2004). A limited attempt has been made to control for these factors by selecting participants who are relatively closely matched in terms of operating practices, organizational structure, size and type of fire service organization, and the characteristics of the community they serve. However, this was not a formal or detailed attempt to match the participating organizations on these variables. Therefore, it is possible that exogenous variables such as these may influence individual perceptions of the variables associated with safety culture. Another factor that may influence the relationship between the safety culture variables is the level of perceived conflict between the sub-cultures of safety and operational performance (Cooper & Phillips, 2004). This pilot study does not examine the perceived level of conflict between these two sub-cultures within participating organizations.

The cross-sectional design of this pilot study is another limitation. The cross-sectional approach provides data on the nature of the relationship between the variables in the model at one point in time. This limits the conclusions that can be formed from the findings to those related to descriptive or explanatory relationships rather than predictive relationships.

Human Subjects Protection

Because individual participants were requested to complete a questionnaire, it was necessary to obtain permission to conduct this pilot study through the Institutional Review Board (IRB) process. Funding for this pilot study was provided by a grant from the National Fallen Firefighters Foundation (NFFF) and the Public Entity Risk Institute (PERI) and was administered through Oklahoma State University. Approval for ceding IRB review to Oklahoma State University was obtained from the University of Colorado Denver under IRB Authorization Agreement. Application was made to the IRB at Oklahoma State University which was initially approved on July 6, 2007 and continued on June 23, 2008 through June 22, 2009. Documentation regarding the IRB process and copies of the relevant approvals are included in Appendix C.

Summary

This chapter has described the methodological approach used to answer the three research questions proposed for this pilot study. The discussion in this chapter answers the first two research questions and details the empirical analysis that will be used to answer the third research question in the following chapter on Results.

The discussion about the first research question is an investigation as to whether current models of organizational culture can be adapted for the purpose of assessment and analysis of safety culture within the context of the US fire service. In order to determine this, a theoretical framework of organizational culture has been developed that describes the relationship among organizational culture, behavior, and outcomes. The theoretical framework includes a conceptual model of organizational culture that consists of three variables: management systems, behavioral norms, and individual values and beliefs. The theoretical framework stipulates that management systems and behavioral norms influence values and beliefs. In addition, the framework predicts that while values and beliefs have the most direct and strongest influence on behavior, all three of these variables influence the actual behavioral choices that individuals make in the work environment. Finally, the framework predicts that behaviors result in individual as well as organizational outcomes. Individual outcomes will have a direct influence individual values and beliefs while organizational outcomes will influence perceptions about management systems and behavioral norms.

For the purpose of this pilot study it is important to establish a theoretical framework of organizational culture for two reasons. The first reason is because the main purpose of studying organizational culture is to determine how the variables of culture influence behaviors and outcomes in organizations. A theoretical framework describes the assumptions made about the characteristics of the relationship between culture, behavior, and outcomes and also establishes the variables of culture. Once the variables have been established, empirical analysis can then be conducted on the characteristics of the relationship among the variables and on the influence that the variables have on behavior and outcomes. The second reason is because safety culture is viewed as a sub-culture in high-risk organizations. In order to determine whether a model of organizational culture can be adapted to analyze safety culture, the model of organizational culture must be established and then a model of safety culture must be compared to determine whether the model of safety culture is consistent with the model of organizational culture.

A modified version of the Reciprocal Determinism Model (RDM) of safety culture was found to be consistent with the theoretical framework and conceptual model of organizational culture. This determination answers the first research question in the affirmative: the RDM can be adapted for the purpose of assessment and analysis of safety culture within the fire service.

The discussion about the second research determines the key variables in the model and how these variables can be operationalized and measured within the context of the fire service. Using the conceptual model of organizational culture and adapting the variables in this model to fit within the context of safety culture, the three variables of safety culture are described as Safety Management Systems (SMS), Safety Related Behaviors (SRB), and Organizational Safety Climate (OSC). These are equivalent to the management systems, behavioral norms, and individual values and beliefs described as the variables of organizational culture. The variables are operationalized using instruments that ask organizational members specific questions about the presence or absence of the elements of safety management systems, the presence or absence of critical safety related behaviors, and whether they agree with statements about safety related values and beliefs. Establishing the variables of safety culture and operationalizing the variables answers the second research question of the pilot study.

The third research question asks about the nature of the relationship among the variables by proposing three hypotheses. These hypotheses make specific assertions about the nature of the relationship among the variables. While the answers to the first two research questions were based largely on the analysis of the theory behind organizational culture and safety culture, the answer to the third research question is based on the empirical analysis of data. The last part of the methods chapter has described the methodological approach used in the overall design of the pilot study, the population and sample of fire departments used in the pilot study, the collection of data, and the plan for the analysis of data that will test the hypotheses about the relationship among the variables. The next chapter on Results describes the findings from the empirical analysis of the data. This includes descriptive statistics, analysis of the reliability and validity of the questionnaires, and analysis to determine if the results support the three hypotheses about the relationship among the variables.

CHAPTER IV: RESULTS

In this chapter on Results, the main focus is on testing the three hypotheses formed from research question 3 that describe the nature of the relationship among the variables of safety culture. The chapter begins with the presentation of descriptive statistics on response rates for each participating fire department and the job function and years of service of the individual participants who completed the questionnaires. The next section explores the reliability of the three questionnaires used to measure the variables to determine whether the proposed items and the structure of each variable is an accurate reflection of the data.

The structure of the relationship among the variables was described in the conceptual model of safety culture that was previously presented. Development of the conceptual model is the first step toward answering the second research question about the key variables of the model. Establishing the model, however, does not fully determine if the variables can be used to operationalize and measure the variables of the model within the context of the fire service. In order to do this, it is important to examine the reliability of the structure of each variable in the model. If the reliability of any of the three original variables is not adequate, then they will need to be restructured into new variables that meet the criteria for reliability before further analysis can be conducted on the nature of the relationship among them.

Initial analysis of the data includes a review of the correlation matrix for each variable to eliminate any items that were highly correlated with two or more other items in an effort to improve reliability. Next, the Cronbach's alpha coefficient was determined for each element of the individual variables and for the variables. Initially, the reliability of several elements of safety climate was below the acceptable cutoff point of 0.70 for Cronbach's alpha. As a result, the data were analyzed using Principle Components Analysis (PCA) to further reduce the number of items and increase reliability. The PCA analysis did not reduce the number of items, so another attempt was made to increase reliability through Principle Axis Factoring (PAF) determine of a different structure within the variables would result in higher levels of reliability. Results of PAF produced a different structure for the elements of the variables, reduced the number of items in the variables, and improved the reliability of the variables to acceptable levels.

Analysis of the relationship among the variables proceeds using the restructured variables. Several statistical methods are used to explore the nature of the relationship among the variables and to test the three hypotheses of the pilot study. Multiple regression and Confirmatory Factor Analysis are used to test the first hypothesis that predicts how Safety Management Systems and Safety Related Behaviors will influence Organizational Safety Climate. Analysis of variance and post-hoc tests are used to determine whether the second and third hypotheses are supported that predict differences in the level and strength of scores based on job functions and years of service.

All of the data from the three participating fire departments are combined for the initial development of the variables and to test the three hypotheses proposed for this dissertation. This means that the initial analysis of the data was conducted at the individual level for the purpose of testing the conceptual model of safety culture. If the results of this study are to be useful from a practical perspective, then the data must be aggregated to the organizational level. The Interclass Correlation Coefficient (ICC) is used to determine if the data can be aggregated to the organizational level for further analysis. A score of 0.7 or higher supports the aggregation of individual level data to the organizational level. Results of this analysis indicate that the data can be considered an organizational-level variable. As a result, further analysis of the data was conducted for each participating fire department regarding the relationship among the variables.

The chapter concludes with a brief description of how the data can be presented in a useable format for fire service managers. It is suggested that radar charts provide a way to visually present the scores for the level and strength of the elements of each variable of safety culture that is easy to understand and interpret.

Descriptive Statistics

Response Rate

Response rates from the three participating fire departments range from 44% of department members to 91% of department members for an average response rate of 71% for all three departments combined. The number of department members and participants from each organization are listed in Table 4.

Table 4

Percent of Participants by Department

Variable	Members	Participants	Response Rate
Department A	311	239	0.77
Department B	540	238	0.44
Department C	623	566	0.91
Total	1473	1043	0.71

The response rate for Department C was 14% higher than Department A and 47% higher than Department B. There are probably two reasons for the higher response rate from Department C. First, a significant roll-over vehicle accident had occurred several months before the surveys were distributed. A fire engine was responding to a call at a high rate of speed and rolled over at an intersection, resulting in significant injuries to four firefighters and the total destruction of the fire engine. Second, Department C used a different approach to the distribution and completion of the questionnaires. While the other departments distributed the questionnaires to the stations, Department C requested that their members complete the questionnaires during a regularly scheduled training session. As a result, more crews from Department C completed and submitted the questionnaires.

Participants by Job Function and Years of Service

The original five categories of job functions were consolidated into three categories because the category for chief officer was considerably smaller than the other categories, which could present problems with analysis of variance among groups of very different sizes. The shift commander and chief officer categories were combined into a category labeled "Chief Officer" since shift commanders hold the title of Battalion Chief and are considered to be part of the administrative staff of the fire department. Some participants used language to indicate that their job function that did not clearly indicate which of the three categories should be used. For example, some of the participants used "Paramedic" as their job function when the department had paramedics within the ranks of Firefighter and Company Officer. Any job function that could not clearly be placed into one of the three categories of rank was placed into the "Other" category. The numbers and percentages of participants by job function are provided in Table 5.

Table 5

Frequency and Percent of Participants by Job Function

Variable	Frequency	Percent
Firefighter	527	50.53
Company Officer	249	23.87
Chief Officer	175	16.78
Sub-Total	951	91.18
Other/Missing	92	8.82
Total	1043	100.00

Years of service were grouped into five categories. The groupings were chosen because they are consistent with those used in other studies and because they provide relatively similar group sizes. The number and percent of participants by years of service are listed in Table 6.

Table 6

Frequency and Percent of Participants by Years of Service

Variable	Frequency	Percent
0 to 5	202	19.37
6 to 10	224	21.48
11 to 15	205	19.65
16 to 20	132	12.66
over 20	265	25.41
Sub-Total	1028	98.56
System Missing	15	1.44
Total	1043	100.00

Mean, Standard Deviation and Range for Items and Elements

Descriptive statistics for the 223 items in the three surveys are listed in the appendix. Included in this table are the variable number and name, the N for each item, the mean, standard deviation, minimum and maximum score, and the skewness for each item. Skewness was included to evaluate the assumption for analysis of variance that the data are normally distributed. Distributions that are skewed more than +1.0 or less than -1.0 are considered markedly skewed, indicating a departure from the normal curve. Only three of the items are skewed less than -1.0, and thirteen of the items are positively skewed more than +1.0. Analysis of variance (ANOVA) is robust to data that are skewed more than +1/-1, so this should not have a significant influence on the results. Review of the descriptive data on the items shows that all the items have the expected minimum and maximum scores expected. As shown in the descriptive data, 1043 individuals participated in the pilot study. Only three percent or a total of seven of the 223 items that make up the three variables have an N of less than 1000, indicating that the completion rate for the questionnaires is relatively high.

Each of the three variables used to operationalize the construct of organizational safety culture is formed from four separate elements. The elements of Organizational Safety Climate are Organizational Context, Social Environment, Individual Appreciation of Risk, and Work Environment. The elements of Safety Management Systems are Policy, Organizing, Planning and Implementing, as well as Measuring and Reviewing Performance. For Safety Related Behaviors, the elements include Fitness and Medical, Vehicle Safety, Structural Firefighting, and Training. The mean, standard deviation, and range for these elements are listed in Table 7.

Table 7

Means, Standard Deviations, and Range for Elements of Variables (N = 1043)

Variable	M	SD	Range
Organizational Safety Climate			
Organizational Context	3.45	0.54	3.22
Social Environment	3.55	0.49	3.25
Individual Appreciation of Risk	3.62	0.41	3.40
Work Environment	3.12	0.60	3.67
Safety Management Systems			
Policy	3.31	0.73	4.00
Organizing	3.18	0.74	4.00
Planning and Implementing	3.13	0.77	4.00
Measuring and Reviewing	3.18	0.72	4.00
Safety Related Behaviors			
Fitness and Medical	3.73	0.62	4.00
Vehicle Safety	3.31	0.72	4.00
Structural Firefighting	3.86	0.61	4.00
Training	3.59	0.77	4.00

Mean, Standard Deviation and Correlations among Elements of Variables

The correlation between the elements for Organizational Safety Climate, Safety Management Systems, and Safety Related Behaviors are provided in Table 8, 9, and 10 respectively. Also included in these tables are the means and standard deviations for each element. Correlations among the elements of safety climate are lower than those for safety management and safety behaviors, indicating a lower level of association among these elements. However, the correlation coefficient for most of the elements of safety climate is between 0.4 and 0.5, indicating a medium level of association among the elements (Cohen, 1988). The level of association among the elements of safety management and safety behaviors varies between 0.6 and 0.8, indicating a very high level of association among the variables (Cohen, 1988). Such high correlation coefficients may also indicate a problem with multi-collinearity and poor discriminant validity, particularly with regard to the elements of safety management, since all of these elements are correlated above the 0.85 level (van Mierlo et al., 2008).

Table 8

Means, Standard Deviations, and Intercorrelations for Elements of Organizational Safety Climate (N = 1043)

OSC Elements	M	SD	1	2	3	4
1. Organizational Context	3.45	0.54	-			
2. Social Environment	3.55	0.49	.594(**)	-		
3. Individual Appreciation of Risk	3.62	0.41	.506(**)	.399(**)	-	
4. Work Environment	3.12	0.60	.593(**)	.278(**)	.435(**)	-

**p* < .05; ***p* < .01.

Table 9

Means, Standard Deviations, and Intercorrelations for Elements of Safety Management Systems (N = 1043)

SMS Elements	M	SD	1	2	3	4
1. Policy	3.31	0.73	-			
2. Organizing	3.18	0.74	.921(**)	-		
3. Planning and Implementing	3.13	0.77	.861(**)	.871(**)	-	
4. Measuring and Reviewing	3.18	0.72	.884(**)	.873(**)	.875(**)	-

**p* < .05; ***p* < .01.

Table 10

Means, Standard Deviations, and Intercorrelations for Elements of Safety Related Behaviors (N = 1043)

SRB Elements	M	SD	1	2	3	4
1. Fitness and Medical	3.73	0.62	-			
2. Vehicle Safety	3.31	0.72	.549(**)	-		
3. Structural Firefighting	3.86	0.61	.782(**)	.648(**)	-	
4. Training	3.59	0.77	.648(**)	.612(**)	.734(**)	-

**p < .05; **p < .01.*

Mean, Standard Deviation and Intercorrelations among Variables

An examination of the descriptive statistics for the variables indicates some interesting comparisons between the level and strength of the variables. The relative mean score for safety behaviors, safety climate, and safety management are close to equally separated and can be rated as high, middle, and low respectively. The descriptive data for the variables is provided in Table 11. The variable with the lowest average level is Safety Management Systems (M = 3.20), which also has the highest standard deviation (SD = 0.70), indicating the lowest average strength. These scores indicate that individual perceptions of the presence of safety management are low but that there is also a large amount of disagreement among individuals about the presence or absence of safety management practices. Safety Related Behaviors has the highest average level (M = 3.62), however, it also has a standard deviation of 0.59, which is lower than that of safety management (0.70) but higher than that of safety climate (0.40).

These scores indicate that individual perceptions of the presence of safety related practices is high but that there is a moderate level of disagreement about the presence or absence of safety related practices. Organizational Safety Climate has the middle range level (M = 3.44), but has the lowest standard deviation (SD = .40), indicating that perceptions of this variable are strong. These scores indicate that individual perceptions of the presence of safety related values is moderate but that the level of agreement among individuals about the presence or absence of safety related values is high. In relative terms, there is a higher level of agreement about perceptions of safety related values as described by the safety climate variable than the other two variables, which measure individual practices (Safety Related Behaviors) and organizational practices (Safety Management Systems).

Table 11

Means, Standard Deviations, and Intercorrelations for Organizational Safety Climate and Predictor Variables (N = 1043)

Variable	M	SD	1	2
Organizational Safety Climate	3.44	0.40	.519(**)	.532(**)
Predictor variable				
1. Safety Management Systems (SMS)	3.20	0.70	-	.690(**)
2. Safety Related Behaviors (SRB)	3.62	0.59	-	-

$*p < .05$; $**p < .01$.

Correlations among the variables of organizational safety culture are significant at the 0.01 level, as indicated in Table 11. The level of correlation between safety climate and safety management is slightly lower than the correlation between safety climate and safety behaviors, but both are above 0.50, indicating a high level of association (Cohen, 1988). The correlation between safety management and safety behaviors is higher, at 0.690, indicating a high level of overlap between the two independent variables. A higher level of correlation between safety management and safety behaviors may be a reflection of the relationship among the elements of these variables. For example, the purpose of safety management systems is to control safety related behaviors, so there would likely be a higher level of correlation among these two variables than among either of them and safety climate. Also, both the Safety Management Systems and Safety Related Behavior variables are measures of practices while the Organizational Safety Climate variable is a measure of values. A higher level of correlation might be expected among two measures of practices than among one measure of practices and second measure of variables.

Reliability of Questionnaires

Cronbach's Alpha Coefficient

Before the reliability of the questionnaires was assessed, a correlation matrix was produced for all the items in each element to determine if any of the items had a high level of multi-collinearity with other items. Any item that was correlated at the 0.70 level with more than two items was eliminated from that element. The correlation matrix tables for each of the elements are included in the appendix. A total of thirteen items were eliminated from the safety management questionnaire after assessing inter-item correlations.

After eliminating items that contributed to multi-collinearity, the reliability of the elements and variables was examined by assessing the Cronbach's alpha coefficient for the elements in each variable and then for the variables. Cronbach's alpha for the elements are presented in safety management and safety behaviors were all above 0.80, indicating an acceptable level of reliability. Several of the alpha coefficients for the elements for safety climate, however, were in the 0.5 to 0.6 range. These results are lower than 0.70, which is the commonly accepted cutoff point for the Cronbach's alpha coefficient (Cohen, 1988). The alpha coefficients for the elements of safety climate are presented in Table 12.

Despite the relatively low level of reliability in the elements of safety climate, the reliability coefficient for the safety climate variable was above the 0.70 level, as shown in Table 13. The other two variables of safety culture also have reliability coefficients above the 0.70 level, indicating that at the variable level, all three of the measures of organizational safety climate are reliable measures of the construct.

Table 12

Cronbach's Alpha and Number of Items for Elements in Organizational Safety Climate

Variable	Cronbach's Alpha	N of Items
Organizational Context	0.895	19
Social Environment	0.672	9
Individual Appreciation of Risk	0.550	9
Work Environment	0.616	6

Table 13

Cronbach's Alpha and Number of Items for Variables

Variable	Cronbach's Alpha	N of Items
Organizational Safety Climate	0.773	4
Safety Management Systems	0.967	4
Safety Related Behaviors	0.881	4

Reliability scores for three of the four elements of the Organizational Safety Climate variable were below the accepted cut-off point, indicating that the structure of this variable may not be an accurate reflection of the data. To improve the reliability of the elements of Organizational Safety Climate, all three variables were subjected to further analysis to determine if a different structure within the elements of the variables would result in higher levels of reliability for the elements of Organizational Safety Climate while sustaining acceptable levels of reliability for the elements of the other variables.

Factor Analysis and Subsequent Alpha Coefficient

To improve the reliability of the safety climate variable, all of the elements in each of the variables were subjected to Principal Components Analysis (PCA) with varimax rotation in an attempt to eliminate items from the elements that had a factor loading of less than 0.40 on their respective element. The results of PCA did not eliminate any of the items from the safety climate variable, so no improvement was made in the reliability for this variable. The only change was to eliminate one item from the safety management variable.

A second attempt to improve the reliability of the safety climate elements was made by subjecting the each element to Principal Axis Factoring (PAF) with varimax rotation. Factor loadings of less than 0.40 were eliminated from the elements. The results of Principal Axis Factoring are usually different than those of PCA because the two factor analysis procedures are based on different approaches to the data. Whereas PCA is designed for data reduction, PAF is designed to explore underlying factors in the data. The two approaches use different statistical processes that return different results (Norusis, 2006).

After Principal Axis Factoring, the alpha coefficients for two of the three elements of safety climate that had been below 0.70 were found to be above that mark, showing significant improvement in the reliability of these elements and an overall improvement in the reliability coefficient for the safety climate variable. The Cronbach's alpha coefficients for the elements of safety climate after PAF are listed in Table 14, which shows that three of the four elements of OSC were above the accepted cut-off point for reliability.

Table 14

Cronbach's Alpha and Number of Items for Elements in Organizational Safety Climate after PAF

Variable	Cronbach's Alpha	N of Items
Organizational Context	0.890	18
Social Environment	0.709	7
Individual Appreciation of Risk	0.743	6
Work Environment	0.616	6

Conducting Principal Axis Factoring on the elements of the variables not only improved the reliability for safety climate, it also resulted in a reduction in the number of the items in each of the three variables. Compared to the original version of the variables, the reduced the number of items in the Organizational Safety Climate instrument from 43 to 37 items. The Safety Management System instrument was reduced from 95 to 81 items. The Safety Related Behaviors instrument was reduced from 85 to 80 items. Overall, the instruments have been reduced from 223 items to 198 items, a reduction of approximately thirteen percent. The alpha coefficient and number of items for the elements in the safety management and safety behavior variables after Principal Axis Factoring are presented in Tables 15 and 16 respectively.

Table 15

Cronbach's Alpha and Number of Items for Elements in Safety Management Systems after PAF

Variable	Cronbach's Alpha	N of Items
Policy	0.951	16
Organizing	0.954	20
Planning and Implementing	0.954	16
Measuring and Reviewing	0.956	29

Table 16

Cronbach's Alpha and Number of Items for Elements in Safety Related Behaviors after PAF

Variable	Cronbach's Alpha	N of Items
Fitness and Medical	0.922	23
Vehicle Safety	0.895	15
Structural Firefighting	0.965	33
Training	0.872	9

Also as a result of PAF, the reliability of the Organizational Safety Climate instrument was increased from 0.773 to 0.788, as shown in Table 17, which also includes the alpha coefficient for Safety Management Systems and Safety Related Behaviors. The reliability coefficient for Safety Management Systems remained basically unchanged, while the reliability of the Safety Related Behavior instrument increased slightly from 0.881 to 0.904.

Table 17

Cronbach's Alpha and Number of Elements for Variables after PAF

Variable	Cronbach's Alpha	N of Elements
Organizational Safety Climate	0.788	4
Safety Management Systems	0.968	4
Safety Related Behaviors	0.904	4

The results of Principle Components Analysis on the original elements of the variables indicated that the original structure of the elements within the Organizational Safety Climate variable was not adequate. As a result, the elements of all three variables were analyzed using Principle Axis Factoring, resulting in higher levels of reliability for three of the four elements of Organizational Safety Climate and higher overall levels of reliability for all three variables. Analysis of the data using PAF also caused the factor structure within each of the elements of the variables to change significantly. For some of the elements, sub-elements within the original elements were dropped and new ones were added to the element, while in other cases the sub-elements were dropped altogether. For other elements, the items in the sub-elements changed but the sub-element retained a similar name because the composition of the items within the sub-element is similar. The changes in factor structure of the elements are shown in the following table.

Table 18

Revised Factor Structure of Elements

Original	Revised
Safety Management Systems	
Policy	Policy
Organizing	Organizing
Structure	Safety Performance Management
Cooperation	Safety Committee
Communication	
Competence	
Planning and Implementation	Planning and Implementation
Performance Standards	
Risk Assessment and Control	
Hazard Identification	
Planning	
Measuring and Reviewing Performance	Measuring and Reviewing Performance
Active Monitoring	Safety Performance and Management System
Reactive Monitoring	Performance Feedback
Remedial Action	Safety Reporting
Reviewing Performance	
Safety Related Behaviors	
Fitness and Medical	Fitness and Medical
Fitness Program	Fitness and Medical Assessment
Medical Evaluation	Fitness Program
	Fitness Participation
	Medical Program
Structural Firefighting	Structural Firefighting
Command and Control	Risk Management Systems
Communications	Incident Management Systems
Accountability	Span of Control
Operational Risk Management	Communications Systems
Vehicle Safety	Vehicle Safety
Seat Belt Use	Safety Driving Practices
Response Policy and Procedures	Vehicle Operating Policy
Training	Driver Training
Supervision	
Training	Training
Instructors	
Planning	
Facilities	
Safety Requirements	
Organizational Safety Climate	
Organizational Context	Organizational Context
Management Commitment	Management Priority
Communications	Safety Rules and Procedures
Priority of Safety	Management Action
	Communications
Social Environment	Social Environment
Supportive Environment	Support
Involvement	Involvement
	Review
Individual Appreciation	Individual Appreciation
Personal Priorities and Need for Safety	Personal Priority of Risk
Personal Appreciation for Risk	Personal Responsibility
	Accident Risk
Work Environment	Work Environment

Although the results of PAF and the changes in the factor structure of the elements resulted in an improvement in overall reliability of the elements and variables, the original elements in each variable were retained in the analysis. To determine if the reliability of the variables might be improved still further, the variables were analyzed for a third time. The variables were analyzed using PAF but all the items were included in each of the variables. As a result of the analysis, the factor structure of the elements in each of the variables changed significantly but the overall level of reliability was lower, particularly for Organizational Safety Climate, which was lower than the acceptable cut-off level. The reliability levels for the variables after this second series of PAF analysis are shown in Table 19.

Table 19

Cronbach's Alpha and Number of Elements for Variables after PAF

Variable	Cronbach's Alpha	N of Elements
Organizational Safety Climate	0.685	5
Safety Management Systems	0.929	7
Safety Related Behaviors	0.880	9

In addition to the lower overall levels of reliability for the variables compared to the first analysis using PAF, the reliability level for three of the new elements were found to be below the cut-off level. These included two elements in Organizational Safety Climate and one in Safety Related Behaviors.

Reliability of the questionnaires was analyzed in three different ways. First, the data were analyzed using Principle Components Analysis. Results of this analysis were less than satisfactory because the level of reliability for three of the elements of Organizational Safety Culture was found to be below the acceptable level. Second, the data were analyzed using Principle Axis Factoring in which the original elements in each variable were retained.

Results of this analysis were improved because only one of the elements of Organizational Safety Climate was less than the acceptable level and the overall level of reliability for the variables improved. While the elements remained the same for each variable, the sub-elements within the elements changes substantially. Third, the variables were again analyzed using PAF but all items in each variable were used in the analysis, which allowed the factor structure of the elements and sub-elements to change within each variable. Results of this analysis showed substantial changes in the factor structure of the elements and sub-elements, but the overall reliability of the variables dropped from the previous analysis. In addition, the level of reliability for three of the elements was below the acceptable level.

Based on the results of the factor analysis of the variables, the second set of data will be used for further analysis. The second set of data has the highest overall level of reliability and the fewest elements with lower than acceptable levels of reliability. Analysis of the revised sub-elements for each element of the variables is discussed in the following section.

Results of Principal Axis Factoring on Elements in Variables

Conducting Principal Axis Factoring resulted in new sub-elements for each of the elements within the three variables of organizational safety culture. Although analysis of data is conducted at the level of elements and variables, and not at the level of sub-elements, it is important to describe the new sub-element structure so that the detailed model can be explored in subsequent research. Clarifying the new sub-element structure also has implications from a practical perspective for organizations interested in developing interventions aimed at making changes in safety culture. The sub-elements may be very helpful in categorizing the results of an assessment of safety culture into manageable factors for the development of a safety improvement plan.

Principal axis factoring was conducted on the elements of each variable by including all of the items within the element in the analysis. A rotated component matrix is subsequently produced from the analysis that lists the items in each factor and the factor loading for each item. The factors identified in the table represent the sub-elements within the element. The items included in each sub-element were then examined and a name provided for each of the sub-elements identified by the analysis. Some of the elements did not break down into sub-elements but most of them did, and in several cases resulted in sub-elements that are substantively different from the original model. A brief description of the sub-elements identified in each element is provided for Organizational Safety Climate, Safety Management Systems, and Safety Related Behaviors, in that order.

The assumptions for factor analysis were checked for each of the elements. In every case, the determinant was higher than .00001, indicating that the items are at least moderately correlated. The Kaiser-Meyer- Oberlin (KMO) measure was higher than 0.70, indicating that the variables are linearly related. Bartlett's test of sphericity was significant in each case, indicating that the variables are correlated highly enough to provide a reasonable basis for factor analysis.

The elements of Organizational Safety Climate were the first to be examined. Organizational Context separated into four factors, as identified in Table 20. The factors were examined and labeled as follows: Management Priority, Safety Rules and Procedures, Management Action, and Communications. Question items in the Management Priority sub-element ask respondents about their perceptions of management's commitment to safety, whether management considers safety as important as performance, the degree to which members perceive that management assigns a high priority to safety, and whether management considers the safety of employees to be important. Question items about Safety Rules and procedures explore perceptions about the practicality of safety rules and how well safety rules are followed. Items in the Management Action sub-element refer to perceptions of whether management takes action when informed about unsafe practices and how quickly management acts to correct safety problems. Questions about communications examine the level of safety related communication between members and their direct supervisor. After rotation the first factor accounted for 36.63% of the variance, the second factor accounted for 9.56%, the third factor for 6.00%, and the fourth factor accounted for 5.27%. The four factors account for 57.46% of the total variance.

Table 20

Factor Loadings for the Rotated Factors from Organizational Safety Climate, Organizational Context

	Factor Loading				
Item	1	2	3	4	Communality
13	0.668				0.538
28	0.624				0.431
18	0.595		0.449		0.562
24	0.552				0.382
46	0.543			0.441	0.462
9	0.532				0.356
27	0.489				0.402
50	0.477				0.346
48	0.447				0.365
43		0.699			0.357
25		0.696			0.379
29		0.647			0.354
17	0.481		0.591		0.558
34			0.588		0.374
41	0.480		0.564		0.572
39				0.652	0.349
36				0.551	0.323
Eigenvalues	6.96	1.82	1.14	1.00	
% of Variance	36.63	9.56	6.00	5.27	

Note: Loadings < .40 are omitted.

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 7 iterations.

The rotated factor matrix for Social Environment identified three factors that have been labeled Support, Involvement, and Review, as identified in Table 21. Support items explore perceptions about the level of support among co-workers for reporting unsafe conditions, raising safety concerns, and helping each other work safely. Involvement items refer to the degree to which members are involved with important safety issues. The one question that refers to Review asks respondents to rate their perceptions about the ongoing review of safety in the workplace. After rotation the first factor accounted for 30.71% of the variance, the second factor accounted for 12.61%, and the third factor for 11.59%. The four factors account for 54.91% of the total variance.

Table 21

Factor Loadings for the Rotated Factors from Organizational Safety Climate, Social Environment

	Factor Loading			
Item	1	2	3	Communality
23	0.703			0.312
30	0.601			0.266
11	0.405			0.162
21		0.656		0.249
16		0.564		0.239
37		0.408		0.210
47			0.453	0.206
Eigenvalues	2.76	1.14	1.04	
% of Variance	30.71	12.61	11.59	

Note: Loadings < .40 are omitted.
Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 3 iterations.

The rotated factor matrix for Individual Appreciation of Risk identified three factors that have been labeled Personal Priority of Risk, Personal Responsibility, and Accident Risk. These are shown in Table 22. Personal Priority of Risk items measure the degree to which safety has personal importance and meaning during emergency incident operations. Personal

Responsibility items explore perceptions about how well individuals understand safety rules and whether they take personal responsibility for following safety rules. The one item labeled as Accident Risk asks individuals about their perceptions about the likelihood of being involved in an accident. After rotation the first factor accounted for 30.39% of the variance, the second factor accounted for 15.36%, and the third factor for 11.70%. The four factors account for 57.45% of the total variance.

Table 22

Factor Loadings for the Rotated Factors from Organizational Safety Climate, Individual Appreciation of Risk

	Factor Loading			
Item	1	2	3	Communality
44	0.579			0.319
20	0.556			0.358
31	0.513			0.168
10	0.451			0.279
19		0.739		0.362
42		0.522		0.263
32			0.687	0.114
Eigenvalues	2.74	1.38	1.05	
% of Variance	30.39	15.36	11.70	

Note: Loadings < .40 are omitted.
Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.

Work Environment is comprised of only one factor. Items in this element refer to perceptions about the level of conflict between safety measures and operational requirements, and the availability of personnel, time, and equipment required to work safely. Only 35.50% of the variance is accounted for by this factor. This is substantially lower than the amount of variance accounted for in the other elements. This may be a result of the low level of reliability for this element compared to the others that make up safety climate. Another possibility is that the low level of variance accounted for by this element may be the result of the conflict between operational culture and safety culture in high-risk occupations.

The elements of Safety Management Systems were the next group to be examined. The Policy element did not separate into sub-elements. Policy related items explore perceptions about how safety policy established or identifies a number of safety related issues. These include overall responsibility for safety, recognition of safety as an integral part of organizational performance, and establishing safety as a core management function. This factor accounts for 57.74% of the variance.

The element named Organizing rotated into two factors labeled as Safety Performance Management and Safety Committee. Safety performance related items ask respondents about their perceptions of safety performance standards, the organization's safety management system, as well as participation in reviewing performance. Items in the Safety Committee sub-element ask about the establishment of a safety group or committee and involvement in the committee by representatives of employee groups. As shown in Table 23, the first factor accounts for 54.45% of the variance. The second factor accounts for 6.65% of the variance. The two factors account for a total of 61.11% of the variance.

Table 23

Factor Loadings for the Rotated Factors from Safety Management Systems, Organizing

	Factor Loading		
Item	1	2	Communality
172	0.751		0.642
152	0.750		0.629
173	0.738		0.598
175	0.735		0.644
171	0.734		0.638
159	0.732		0.601
169	0.730		0.641
193	0.730		0.600
153	0.714		0.583

Table 23 (cont.)

155	0.698		0.566
160	0.671		0.566
141	0.658		0.451
154	0.647		0.476
156	0.646		0.511
146	0.646		0.460
168	0.572		0.477
167	0.511	0.505	0.517
220	0.480		0.378
162		0.887	0.841
161		0.796	0.684
Eigenvalues	10.89	1.33	
% of Variance	54.45	6.65	

Note: Loadings < .40 are omitted.
Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 3 iterations.

Planning and Implementing is another element that did not factor into sub-elements. Items in this element ask respondents about their perceptions of risk control systems used to identify hazards and control risk, implementation of safety precautions, and implementation of the safety and health plan. A total of 59.49% of the variance is accounted for in this element.

Measuring and Reviewing Performance is the last element of safety management to be examined, and separated into three factors as listed in Table 24. These are labeled as Safety Performance and Management System, Performance Feedback, and Safety Reporting. Safety performance system items inquire about perceptions of how safety performance is monitored and compared to performance objectives, procedures for reporting near misses, and the use of information to identify causes of safety problems. Performance feedback items inquire about perceptions of how accident investigations are conducted, the involvement of senior management in accident investigations, and arrangements for taking remedial action. Items included in Safety Reporting ask respondents about arrangements for reporting hazards, accidents, injuries, and ill health. The first factor accounts for 48.72% of the variance. The second factor accounts for 9.31% of the variance. The third factor accounts for 4.44% of the variance. In total, 62.46% of the variance is accounted for by the three sub-elements.

Table 24

Factor Loadings for the Rotated Factors from Safety Management Systems, Measuring and Reviewing Performance

	Factor Loading			
Item	1	2	3	Communality
197	0.801			0.687
198	0.794			0.684
201	0.772			0.672
202	0.720			0.588
195	0.717			0.615
149	0.689			0.558
222	0.687	0.412		0.672
223	0.682			0.650
151	0.678			0.532
157	0.668			0.498
204	0.666			0.565
219	0.601	0.515		0.682
137	0.588			0.407
200	0.587			0.428
211	0.542	0.448		0.580
221	0.524	0.487		0.588
209	0.476			0.389
231	0.475	0.427		0.513
212	0.435	0.417		0.421
215		0.752		0.752
216		0.720		0.698
214		0.634	0.454	0.647
213		0.543	0.404	0.510
218	0.444	0.536		0.539
207			0.894	0.821
206			0.755	0.661
208			0.717	0.582
210			0.689	0.636
205			0.541	0.422
Eigenvalues	14.13	2.70	1.29	
% of Variance	48.72	9.31	4.44	

Note: Loadings < .40 are omitted.

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 6 iterations.

Three of the four elements of Safety Related Behaviors separated into sub-elements. After rotation, four factors were identified for the Fitness and Medical element. Factor loadings for this element are listed in Table 25. These were labeled Fitness and Medical Assessment, Fitness Program, Fitness Participation, and Medical Program. Fitness and medical assessment questions ask about fitness medical assessments for potential candidates and current members of the department, and the components of these assessments. Fitness program question focus on the availability or opportunity that member have to engage in fitness training. Fitness participation items ask respondents about their perceptions regarding the level of participation in fitness training and the degree to which that participation is required. Questions about the medical program ask about the confidentiality of medical information, reporting of medical conditions that interfere with the ability to perform essential job tasks, and the criteria for developing essential job tasks. The first factor accounts for 37.31% of the variance. The second factor accounts for 9.61% of variance. The third factor accounts for 5.67% of variance, and the fourth factor for 4.95% of the variance.

Table 25

Factor Loadings for the Rotated Factors from Safety Related Behaviors, Fitness and Medical

	Factor Loading				
Item	1	2	3	4	Communality
82	0.852				0.730
76	0.729				0.578
85	0.717				0.606
133	0.708				0.662
78	0.695				0.545
87	0.684				0.591
99	0.450		0.435		0.516
72	0.448				0.356
134	0.445				0.441
127		0.786			0.698
123		0.733			0.628
124		0.695			0.561
128		0.649			0.556

Table 25 (cont.)

121		0.572			0.501
70			0.672		0.476
65			0.620		0.403
69			0.581		0.398
93			0.544		0.444
64			0.543		0.367
89			0.506		0.431
66			0.499		0.391
97				0.599	0.315
60				0.561	0.292
Eigenvalues	9.33	2.40	1.42	1.24	
% of Variance	37.31	9.61	5.67	4.96	

Note: Loadings < .40 are omitted.
Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.

Factor analysis of the Vehicle Safety element resulted in three factors labeled as Safety Driving Practices, Vehicle Operating Policy, and Driver Training. Items in the Safe Driving Practices factor inquire about actual driving practices, such as speed, use of seat belts, stopping at negative right away or blind intersections. This factor also asks questions about the reporting of violations of safe driving practices and whether supervisors take corrective action when such violations occur. Items in the Vehicle Operating Policy factor include questions about the response policy for non-urgent incidents, policy and procedures for safe driving during an emergency response, and the use of warning equipment. Driver Training items inquire about the adequacy and appropriateness of the training that apparatus drivers receive and whether that training is commensurate with the duties they are expected to perform. The first factor accounts for 41.58% of the variance. The second factor accounts for 11.55% of the variance. The third factor accounts for 8.21% of the variance. Factor loadings for Vehicle Safety are listed in Table 26.

Table 26

Factor Loadings for the Rotated Factors from Safety Related Behaviors, Vehicle Safety

	Factor Loading			
Item	1	2	3	Communality
74	0.764			0.647
75	0.737			0.637
102	0.622			0.478
108	0.587			0.568
107	0.571		0.402	0.576
109	0.562			0.575
54	0.459			0.235
104		0.819		0.629
103		0.790		0.611
129		0.699		0.500
114		0.540		0.301
73		0.447		0.304
55		0.439		0.205
106			0.819	0.708
105			0.808	0.711
Eigenvalues	6.24	1.73	1.23	
% of Variance	41.58	11.55	8.21	

Note: Loadings < .40 are omitted.
Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 5 iterations.

The items in the Structural Firefighting element loaded onto four factors. These have been labeled as Risk Management Systems, Incident Management Systems, Span of Control, and Communications Systems. Items in the risk management factor ask about accountability for resources during the course of emergency incidents, the use of safe systems of work at operational incidents, and the level of discipline to work with accepted safety procedures. Items in this factor also ask about the operational risk management practices used to identity risk, assess hazards, and develop controls. Incident management items cover issues involved in the development and use of an appropriate command structure based on the size, type, and complexity of emergency incidents. The span of control factor is closely related to incident management, and from a practical perspective is often thought of as an essential part of any incident management system. Items in this factor ask about the degree to which an appropriate span of control is developed and maintained throughout the course of emergency incidents. Items that loaded onto the communications factor involve the provision for an adequate number of communications channels and whether the communications systems established at emergency incidents is able to meet demands. These four factors account for 58.77% of the variance in Structural Firefighting. The first factor accounts for 46.76% of the variance. The second factor accounts for 5.47% of the variance. The third factor accounts for 3.74% of the variance. The fourth factor accounts for 2.81% of the variance. Factor loadings for Structural Firefighting are listed in Table 27.

Table 27

Factor Loadings for the Rotated Factors from Safety Related Behaviors, Structural Firefighting

	Factor Loading				
Item	1	2	3	4	Communality
116	0.735				0.605
117	0.725				0.616
118	0.681				0.649
110	0.647				0.569
115	0.617	0.401			0.641
111	0.609				0.654
113	0.571				0.556
92	0.569				0.630
101	0.548		0.454		0.528
91	0.543				0.588
126	0.503				0.525
98	0.479				0.475
71	0.461				0.495
88	0.458	0.401			0.619
68	0.456				0.604
95	0.437	0.404			0.569
90	0.414				0.444
119		0.739			0.603
132		0.668			0.569
122		0.659			0.537

Table 27 (cont.)

96		0.625			0.526
135		0.613	0.411		0.573
86		0.591			0.663
58		0.541		0.449	0.614
59		0.537		0.420	0.608
112	0.451	0.498			0.589
125		0.410			0.365
100			0.604		0.526
84		0.401	0.582		0.525
57			0.499		0.368
61				0.682	0.677
62				0.654	0.670
77	0.400	0.438		0.463	0.650
Eigenvalues	16.84	1.97	1.35	1.01	
% of Variance	46.76	5.47	3.74	2.81	

Note: Loadings < .40 are omitted.
Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 7 iterations.

The last element included in the Safety Related Behavior variable is Training. This element did not separate into any sub-elements as a result of the factor analysis. Items in the element ask about the facilities used for training, the development of a safety plan for training evolutions, the use of personal protective equipment in practice training, and the qualifications of instructors. A total of 50.24% of the variance is accounted for by this factor.

A number of the sub-elements in several elements of the variables include items that load on more than one factor. For example, in the factor matrix shown above for structural firefighting, items 115, 101, 88, and several others load onto more than one factor. Removing those items that load onto multiple factors may reduce the number of items in the questionnaires and may also improve the reliability of the sub-elements and elements. In order to determine of removal of the items that load on multiple factors would improve the reliability of the questionnaires, those items were removed from the data and the Cronbach's alpha was again calculated for the sub-elements and elements, this time excluding the multiple load items. Results of the analysis showed that for all but one of the sub-elements, reliability scores dropped slightly. The only area to show improvement in reliability was the Performance Feedback sub-element of the Measuring and Reviewing Performance element of the Safety Management Systems variable. The changes in reliability for those sub-elements and related elements that had multiple load items are shown in Table 28.

Table 28

Change in Reliability for Sub-elements with Multiple Load Items

Variable/Element/Sub-Element	**Including Multiple Load Items**		**Excluding Multiple Load Items**	
Safety Management Systems	**Cronbach's alpha**	**N of Items**	**Cronbach's alpha**	**N of Items**
Organizing	.954	20	.952	19
Safety Performance Management	.954	18	.953	17
Measuring and Reviewing Performance	.956	29	.941	20
Safety Performance and Management System	.955	19	.937	13
Performance Feedback	.881	5	.913	2
Safety Reporting				
Safety Related Behaviors	**Cronbach's alpha**	**N of Items**	**Cronbach's alpha**	**N of Items**
Fitness and Medical	.922	23	.917	22
Fitness and Medical Assessment	.905	9	.899	8
Structural Firefighting	.965	33	.951	24
Incident Management Systems	.916	10	.868	6
Span of Control	.736	3	.588	2
Risk Management Systems	.946	17	.929	13
Vehicle Safety	.895	15	.833	14
Safety Driving Practices	.859	7	.833	6
Organizational Safety Climate	**Cronbach's alpha**	**N of Items**	**Cronbach's alpha**	**N of Items**
Organizational Context	.890	17	.830	13
Management Action	.780	3	N/A	1
Management Priority	.857	9	.857	7

Rather than improving the reliability of the questionnaires as was expected, removal of the multiple load items resulted in a decrease in the reliability of the questionnaires. In addition, many of the questions that were removed asked about issues that are critical for firefighter safety. Most of the questions that loaded on multiple factors were from the Measuring and Reviewing Performance element of the Safety Management Systems variable or from the Structural Firefighting element of the Safety Related Behaviors variable. These two elements accounted for 18 of the 25 questions that were removed for the analysis because they loaded on multiple factors.

If these items were to be removed from the questionnaires, then several critical areas of firefighter safety would not be evaluated. For example, several of the questions that would be eliminated from the Safety Management Systems questionnaire ask about whether immediate and underlying causes of poor performance are identified, whether performance measurement information is used to identify areas where corrective action is necessary, and whether arrangements are in place to ensure a consistent response to substandard performance. Some of the questions that would be removed from the Structural Firefighting element of the Safety Related Behaviors questionnaire ask about whether the command structure is appropriate for the scale of emergency operations, whether communications systems provide an adequate number of operational and command channels, and whether the department provides adequate and useful information about operational hazard identification, risk assessment, and risk control. These questions assess critical areas of safety performance management and structural firefighting operations. If they were to be removed from the questionnaires, these areas would not be assessed. Because the effort to reduce the number of items in the questionnaires for an academic benefit of fewer questions is not worth at the potentially negative impact from a practical perspective of overlooking critical areas of firefighter safety that need to be assessed.

Summary of Reliability and Factor Analysis

The key variables of safety culture are identified in the earlier discussion about the conceptual model of safety culture. Identifying the key variables in the model is the first step toward answering research question 2 of this pilot study. Research question 2 asks the following: what are the key variables in the model of safety culture and how can these variables be operationalized and measured within the context of the fire service? While the variables described in the conceptual model answer the first part of the research question, the analysis of the reliability and factor structure of the questionnaires used to measure the variables answers the second part of the research question about how the variables can be operationalized and measured.

The reliability of the initial data indicated that the reliability of the questionnaires used to measure the variables was not adequate. Several of the elements of Organizational Safety Climate had reliability levels that were considered unacceptable. As a result, the data were restructured and reanalyzed three different times to determine if the reliability of the questionnaires could be improved. The final results of this analysis is used to establish a factor structure for the variables and elements that meets the requirements for reliability, which is used in this pilot study as the initial criteria for determining if the questionnaires can be used to operationalize and measure the variables within the context of the fire service.

Results of the reliability and factor analysis indicate that the second set of data provides the best way to operationalize and measure the variables. The first set of data was inadequate because the reliability of several of the elements of Organizational Safety Climate were below the acceptable level. Even after conducting Principle Components Analysis on this data set, the reliability of the elements did not improve. The second set of data resulted from conducting Principle Axis Factoring on the initial data set. Results of PAF on the elements of the variables increased the reliability of the elements that had previously been inadequate and improved the reliability of the variables. The third analysis of the data examined the factor structure of the variables, which allowed the restructuring of the elements and sub-elements in the variables. Results of this analysis was slightly lower levels of reliability overall and unacceptable levels of reliability for several elements and for one of the variables. A fourth set of data was produced by analyzing the reliability of the elements again, but this time the items that loaded on multiple factors were removed before conducting the reliability analysis. Results of this analysis showed lower levels of reliability for all but one of the sub-elements. In addition, some of the items that were removed for the academic analysis of reliability would result in the elimination of questions that ask about critical areas of firefighter safety.

As a result of these four different approaches to the analysis of reliability and factor structure of the variables, the second data set will be retained for further analysis. Again, this is the data set that resulted from the analysis of the questionnaires using Principle Axis Factoring that retained the elements in each variable, but resulted in new sub-elements. This data set is used for several reasons. First, the level of reliability for each of the elements of the variables is above the cut-off level for Cronbach's alpha. Second, the level of reliability for the variables is highest with this data set. Third, this data set eliminated 25 items from the questionnaires while still retaining high levels of reliability. Lastly, this data set retains critical questions about firefighter safety that are important from a practical perspective.

Validity of Questionnaires

Validity of the instruments used to assess organizational safety culture in this pilot study can be evaluated in several ways. Content validity is a subjective evaluation of whether the measurement instruments cover all of the attributes of safety culture (Nachmias & Nachmias, 2000). Content validity of the questionnaires is based on two arguments. The first concerns the face validity of the model. The second involves the face validity of the measures. The Reciprocal Determinism Model of safety culture is a logical and appropriate representation of safety culture that has been used in several studies (Cooper 2000; Cooper & Phillips, 2004; Cooper,2008).   In addition, the questionnaires used to operationalize the variables in the model are also appropriate measures that accurately describe the variables they are intended to measure. Slightly different versions of two of the measures used in this pilot study (Safety Management Systems and Organizational Safety Climate) have been used in other studies to measure the same variables. The third measure (Safety Related Behaviors) was developed from a standards of best practice in the fire service.

Convergent Validity

Construct validity can be assessed by looking at the extent to which the variables in the model either converge or discriminate among the variables as expected (Nachmias & Nachmias, 2000). Convergent validity of the instruments is demonstrated by the difference in correlations between the two variables that represent practices in the model, Safety Management Systems and Safety Related Behaviors, and the variable that represents values in the model, Organizational Safety Climate. The instruments demonstrate at least some convergent validity because the correlation between the two variables that represent practices in the model is higher than the correlation of either of the these variables and the variable that represents values in the model. Correlations among the variables after Principal Axis Factoring are presented in Table 29.

Table 29

Means, Standard Deviations, and Intercorrelations for Organizational Safety Climate and Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2
Organizational Safety Climate	3.40	0.41	0.513**	0.517**
Predictor variable				
1. Safety Management Systems (SMS)	3.29	0.68	-	0.706**
2. Safety Related Behaviors (SRB)	3.61	0.58	-	-

$*p < .05$; $**p < .01$.

The level of correlation between safety management and safety behaviors is 0.706, whereas the correlation between these variables and safety climate are 0.513 and 0.517 respectively. A higher level of correlation between safety management and safety behaviors would be expected from the theoretical model because these are the external variables of the model and because safety management practices are generally directed at managing safety related behaviors. A lower level of correlation would be expected between the external or practice based variables of the model and the internal or values based variable because they are different types of variables and because the external variables are used as predictors for the internal variable. The difference between the level of association within the external variables and between the external variables and the internal variables of the model provide some support for construct validity. A better method for evaluating construct validly, however, is to explore the discriminant validity of the instruments.

Discriminant Validity

The discriminant validity of instruments used in safety culture studies is generally evaluated by examining the ability of the instruments to discriminate among two categorical variables: job function, and years of service (Cooper & Phillips, 2004; Grote & Kunzler, 2000). In order to evaluate the discriminant validity of the variables in this pilot study, one-way analysis of variance is used to determine whether there are significant differences among categories of job function and years of service across the variables and elements of the model. One-way analysis of variance is used to test the equality of population means (Weinberg & Abramowitz, 2002). Results of the analysis support the discriminant validity of the instruments if a significant difference exists between the mean scores of variables and elements across categories of job function and years of service. If the means are different, the F ratio will be used to identify the magnitude of the differences.

One of the important assumptions of one-way analysis of variance is that the variance of the groups is equal. This will be checked using the Levene statistic. If the Levene statistic is not significant, then there is no significant difference in the variance of the groups, and the assumption of homogeneity of variance has not been violated. Even if the Levene statistic is found to be significant, ANOVA is robust to violations of this assumption when group sizes are equal (Weinberg & Abramowitz, 2002). As shown in the descriptive statistics, however, that is not the case with the data in this pilot study. Relatively large differences in group size are found among the categories of job function and years of service. As a result, the Welch and Brown-Forsythe tests will also be used to confirm whether differences between groups are significant (Norusis, 2006). Because the Welch and Brown-Forsythe tests take differenced in group size into consideration in the calculation of significance, the results of these tests will be used made a final determination of whether the assumption of homogeneity of variance has been met.

Analysis of variance was first run for job function as a function of the three variables of safety culture. The results, shown in Table 30, indicate that a significant difference exists among categories of job functions for Safety Management Systems, *F*

(2/947) = 6.66, $p < .01$, but that no significant difference exist among categories of job functions for Organizational Safety Climate, F (2/947) = .97, $p > .01$, or among categories of job function for Safety Related Behaviors, F (2/947) = 1.45, $p > .01$.

Table 30

One-Way Analysis of Variance for Job Function as a Function of OSC, SMS, and SRB

Variable and source	*df*	*MS*	*F*
Job Function			
Organizational Safety Climate	2.00	0.16	0.97
Safety Management Systems	2.00	2.99	6.66**
Safety Related Behaviors	2.00	0.48	1.45

*$p < .05$; **$p < .01$.

The Levene statistic is significant for Safety Management Systems, $p = .03$. However, results of the Welch and the Brown-Forsythe statistic are also significant for Safety Management Systems, indicating that when the differences in group size are taken into account, the differences in group means among the categories of job function are indeed significant.

Further analysis of variance on the elements of safety management was run, and the results show that the variable “job function” discriminates among scores for three of the four elements of safety management. The three elements shown to be significant include Policy, F (2/947) = 6.41, $p < .01$, Organizing, F (2/947) = 5.55, $p < .01$, and Planning and Implementing, F (2/947) = 13.46, $p < .01$. The Measuring and Reviewing Performance element was not significant, F (2/947) = .88, $p > .01$.

The Levene statistic was significant for Policy and Organizing, but not for Planning and Implementing. The Welch and Brown-Forsythe tests were also significant, however, indicating that the assumption of homogeneity of variance was not violated when the differences in group size were taken into account.

After completing the analysis of variance of the job function variable as a function of the variables of safety culture, the same analysis was conducted for years of service as a function of the variables. These results are displayed in Table 31 and show that there is a significant difference across the categories of years of service for Organizational Safety Climate, F (4/1023) = 4.31, $p < .01$, Safety Management Systems, F (4/1023) = 8.53, $p < .01$, and for Safety Related Behaviors, F (4/1023) = 5.57, $p < .01$. For all three variables the Levene statistic was not significant while the Welch and Brown-Forsythe statistic was significant, indicating that the assumption of homogeneity of variance was not violated.

Table 31

One-Way Analysis of Variance for Years of Service as a Function of OSC, SMS, and SRB

Variable and source	*df*	*MS*	*F*
Years of Service			
Organizational Safety Climate	4	0.72	4.31**
Safety Management Systems	4	3.80	8.53**
Safety Related Behaviors	4	1.85	5.57**

$*p < .05$; $**p < .01$.

Additional analyses of variance were conducted on each element of the variables. For all the elements that were found to demonstrate significant differences among categories of years of service, the Levene statistic was not significant at the .05 level, while the Welch and Brown-Forsythe test was significant, indicating that the assumption of homogeneity of variance was not violated for the elements of the variables as well.

The results of analysis of variance on the elements of Organizational Safety Climate demonstrate that significant differences in the elements exist across the categories of year of service. Three of the four elements show significant differences, including Organizational Context, F (4/1023) = 7.37, $p < .01$, Social Environment, F (4/1023) = 4.74, $p < .01$, and Work Environment, F (4/1023) = 5.21, $p < .01$.

Analysis of variance on the elements of Safety Management Systems shows that all four of these elements demonstrate differences in perceptions of the elements across the years of service categories. The Policy element was significant, F (4/1023) = 8.67, $p < .01$, as was Organizing, F (4/1023) = 3.93, $p < .01$, Planning and Implementing, F (4/1023) = 11.26, $p < .01$, and Measuring and Reviewing Performance, F (4/1023) = 7.00, $p < .01$. The F ratio for Planning and Implementing is the largest of all the elements, indicating that the variance between groups is much larger than the variance within groups for this element.

Lastly, analysis of variance was run on the elements of Safety Related Behaviors. Again, all of the elements demonstrated significant differences among categories of year of service. The Fitness and Medical element was significant, F (4/1023) = 4.82, $p < .01$, as was Vehicle Safety, F (4/1023) = 3.57, $p < .01$, Structural Firefighting, F (4/1023) = 2.61, $p < .05$, and Training, F (4/1023) = 6.48, $p < .01$. The F ratio for Structural Firefighting is the lowest for all the elements found to demonstrate a significant difference among the categories of year of service.

In summary, analysis of variance for job function as a function of the variables of safety culture demonstrates a limited level of discriminant validity. Only one of the variables demonstrated a significant level of discrimination across job functions. However, analysis of variance for year of service as a function of the variables demonstrated a high level of discriminant validity, since all three of the variables showed significant differences across the categories of years of service, as did all but one of the twelve elements of the variables.

Relationship among the Variables: Hypothesis 1

It is hypothesized that higher perceptions of Safety Management Systems and Safety Related Behaviors will be positively and significantly associated with higher perceptions of

Organizational Safety Climate. Multiple regression is used to examine the relationship among the independent and dependent variables identified in this hypothesis. Before conducting the analysis, it is important to determine whether the data meet the assumptions of multiple regression. These assumptions include the following: that the relationship between each independent variable and the dependent variable is linear; that the error associated with the dependent variable is normally distributed and uncorrelated with the independent variables; and that multicollinearity is not a problem between the independent variables.

Multiple Regression: Checking the Assumptions

A scatterplot matrix was created for the purpose of checking the assumption that the relationship between each of the two independent and the dependent variables is linear. The scatterplot for the relationship between Safety Management Systems and Organizational Safety Climate represents a linear relationship, as does the scatter plot for the relationship between Safety Related Behaviors and Organizational Safety Climate.

Another scatterplot was created to test the assumption that the predictive and residual values associated with the regression equation are uncorrelated. The scatterplot showed no pattern, indicating that the data meet the assumption that the errors are normally distributed and are uncorrelated. The previously described scatterplot diagrams are listed in Appendix B.

As described previously, the correlation between Safety Management Systems and Safety Related Behaviors, after conducting data reduction and principal axis factoring, is .706. Correlations at this level are considered to be relatively high, so multi-collinearity may be a problem with these data. However, the two independent variables are very different in terms of the elements that make up the measures and the questions contained in the instruments, so it is unlikely that the high level of correlation is the result of the problem of two variables containing the same information.

Another explanation for the high level of correlation between the two variables is that they may be measuring the same underlying construct of safety practices. For example, Safety Management Systems are made manifest by the practices of managers who are engaged in directing and controlling the safety behaviors of employees. Employees engage in the Safety Related Behaviors that are the critical practices relevant to safety within the organization. Also, because management practices are directed at controlling employee practices, there may be a strong level of correlation between measures of these two variables. In either case, the higher level construct may be practices. This explanation would be consistent with the theory that the two principle variables of organizational culture are practices and values and that the system of practices and values are defined through variables that are relevant to understanding the context of the organization (Denison, 1996; Hofstede, 1998; Ouchi & Wilkins, 1985; van den Berg & Wilderom, 2004; Wallace et al., 1999; Bloor & Dawson, 1994; Balthazard et al., 2006). Within the context of safety culture both Safety Management Systems and Safety Related Behaviors are variables that define practices and are relevant to understanding the context of safety in fire service organizations.

Multiple Regression: Results

The data appear to meet the assumptions of multiple regression, with some concern for the possibility of multicollinearity between the independent variables. Therefore, multiple regression was conducted to determine whether the combination of Safety Management Systems and Safety Related Behaviors predicts Organizational Safety Climate. The means, standard deviations, and intercorrelations are shown in Table 32. The combination of the safety management and safety behavior variables significantly predicts safety climate scores, F (2/1040) = 234.62, $p < .001$, with both variables making a significant contribution to the prediction. The beta weights for the variables are presented in Table 33, and suggest that safety behaviors contribute slightly more to the prediction of individual levels of safety climate. The adjusted R^2 value is .31, indicating that 31% of the variance in safety climate is explained by the model. This is considered a large effect (Cohen, 1988).

Table 32

Means, Standard Deviations, and Intercorrelations for Organizational Safety Climate and Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2
Organizational Safety Climate	3.40	0.41	0.513**	0.517**
Predictor variable				
1. Safety Management Systems (SMS)	3.29	0.68	-	0.706**
2. Safety Related Behaviors (SRB)	3.61	0.58	-	-

**p < .05; **p < .01.*

Table 33

Simultaneous Multiple Regression Analysis Summary for Safety Management Systems and Safety Related Behaviors Predicting Organizational Safety Climate (N = 1043)

Variable	*B*	*SEB*	β
Safety Management Systems	0.18	0.02	0.29**
Safety Related Behaviors	0.22	0.03	0.31**

Note. $R^2 = .31$; $F(2,1040) = 234.62$, $p< .001$
**p < .05; **p < .01.*

Several additional regression analyses were conducted to provide a deeper understanding of the relationship among the variables. First, regression was conducted on Organizational Safety Climate using the eight elements of Safety Management Systems and Safety Related Behaviors as predictor variables. The means, standard deviations, and intercorrelations are presented in Table 34. Using the elements as variables significantly predicted safety climate, F (8/1034) = 61.764, $p < .001$, but only three of the elements significantly contributed to the prediction. The elements contributing to the prediction are Policy, $\beta = .35$, $p < .01$, Vehicle Safety, $\beta = .09$, $p < .05$, and Training, $\beta = .12$, $p < .01$. The beta weights suggest that Policy has an important influence on individual perceptions of safety climate. The adjusted R^2 value is .32, indicating that 32% of the variance in safety climate is explained in the model using the elements of Safety Management Systems and Safety Related Behaviors.

Next, a series of multiple regressions were conducted on the four elements of Organizational Safety Climate using the eight elements of Safety Management Systems and Safety Related Behaviors. The means, standard deviations and intercorrelations for these four multiple regression analyses can be found in the appendix. The first regression analysis was on the Organizational Context element of safety climate. The combination of all eight elements of safety management and safety behaviors significantly predicted levels of organizational context, F (8/1034) = 58.977, $p < .001$, with three of the elements significantly contributing to the prediction. The elements that contribute to the prediction are Policy, $\beta = .48$, $p < .01$, Vehicle Safety, $\beta = .10$, $p < .05$, and Training, $\beta = .17$, $p < .01$. The beta weights suggest that Policy has an important influence on individual perceptions of organizational context. The adjusted R^2 value is .31, indicating that 31% of the variance in organizational context is explained in the model using the elements of Safety Management Systems and Safety Related Behaviors.

Table 34

Means, Standard Deviations, and Intercorrelations for Organizational Safety Climate and Elements of Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
Organizational Safety Climate	3.40	0.41	0.525**	0.419**	0.470**	0.470**	0.433**	0.454**	0.443**	0.465**
Predictor variable										
1. SMS Policy	3.31	0.73	-	0.781**	0.886**	0.820**	0.572**	0.635**	0.559**	0.606**
2. SMS Organizing	3.22	0.82		-	0.747**	0.676**	0.488**	0.490**	0.444**	0.472**
3. SMS Planning and Implementing	3.17	0.74			-	0.804**	0.516**	0.623**	0.521**	0.599**
4. SMS Measuring and Reviewing	3.47	0.68				-	0.600**	0.630**	0.639**	0.631**
5. SRB Fitness and Medical	3.49	0.61					-	0.611**	0.711**	0.665**
6. SRB Vehicle Safety	3.40	0.69						-	0.666**	0.660**
7. SRB Structural Firefighting	3.90	0.64							-	0.730**
8. SRB Training	3.63	0.75								-

$*p < .05$; $**p < .01$.

The second regression analysis was on the Social Environment element of safety climate. The combination of all eight elements of safety management and safety behaviors significantly predicted levels of social environment, F (8/1034) = 32.825, $p < .001$, with two of the elements significantly contributing to the prediction. The elements that contribute to the prediction are Policy, $\beta = .30$, $p < .01$, and Structural Firefighting, $\beta = .10$, $p < .05$. The beta weights suggest that Policy has an important influence on individual perceptions of social environment. The adjusted R^2 value is .20, indicating that 20% of the variance in social environment is explained in the model. This is considered a medium effect (Cohen, 1988).

The third regression analysis was on the Individual Appreciation of Risk element of safety climate. The combination of elements significantly predicted levels of individual appreciation of risk, F (8/1034) = 15.237, $p < .001$, with two of the elements significantly contributing to the prediction. The elements that contribute to the prediction are Policy, $\beta = .18$, $p < .05$, and Planning and Implementing, $\beta = .16$, $p < .05$. The beta weights suggest that the Policy and Planning and Implementing elements have a relatively smaller but equal influence on individual appreciation of risk. The adjusted R^2 value is .11, indicating that 11% of the variance in individual appreciation of risk is explained in the model.

The fourth regression analysis was on the Work Environment element of safety climate. The combination of elements significantly predicted levels of work environment, F (8/1034) = 26.554, $p < .001$, but only one of the elements significantly contributes to the prediction. The element that contributes to the prediction is Vehicle Safety, $\beta = .11$, $p < .05$. The adjusted R^2 value is .17, indicating that 17% of the variance in individual appreciation of risk is explained in the model.

Confirmatory Factor Analysis

Another approach to exploring the relationship between the variables in the model is to conduct Confirmatory Factor Analysis. The model used in this pilot study is defined by the relationship between the three variables of organizational safety culture and the elements that comprise each variable. Confirmatory factor analysis is commonly used to determine the degree to which a predefined factor model fits a set of data (Arbuckle, 2005). Variables in the analysis include observed variables and latent variables. Observed factors are classified as dependent variables while latent factors are classified as independent variables. The conceptual model of safety culture used in this pilot study consists of three latent variables: Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate. Each of these latent variables is measured using four observed factors. For example, the observed factor for the latent variable of Safety Related Behaviors includes measures of Structural Firefighting, Training, Fitness and Medical programs, and Vehicle Safety.

The degree to which a model fits the data is determined by calculating one of more of the goodness of fit indices. Two of the more commonly used goodness of fit indicators include the RMSEA (Root Mean Square Error of Approximation) and the GFI (Goodness of Fit Index). Models are considered to be a reasonable fit if the RMSEA for the data set is less than 0.08 and if the GFI is over 0.90. Models with a RMSEA of greater than 0.1 are considered unacceptable (Arbuckle, 2005). Both of these fit measures will be used to assess the level of fit between the model of organizational safety culture and the data from the three participating organizations.

Results of confirmatory factor analysis include Standardize Regression Weights and Squared Multiple Correlation. Both these coefficients provide an indication of the influence of the latent variable on the observed factors. The Standardized Regression Weights are an indication of the correlation between the observed variables and the latent factor. The Squared Multiple Correlation represents the proportion of variance in the observed factor explained by the latent variable.

Confirmatory factor analysis was run using maximum likelihood estimation. Results of the analysis suggest a reasonably good fit for the data to the model. The model fit indicators are shown in Table 35. The RMSEA is 0.085, and the GFI is 0.931. Taken together, these fit indicators suggest that the data fit the model reasonably well, but would not be considered a close fit since the RMSEA score is above the 0.08 level considered acceptable but below the 0.1 level considered the point at which the model should be rejected (Arbuckle, 2005).

Table 35

Model Fit Indices for Organizational Safety Culture

Model	*Chi-square*	*df*	*RMSEA*	*GFI*
Organizational Safety Culture	433.623**	51	0.085	0.931

*N = 1043; **p , .01*

The standardized regression weights for the model are presented in Table 36. Standardized regression weights provide an indication of how much each of the observed factors contributes to the definition of the latent variables. These are listed for each variable from the element with the highest weight to the lowest. These weights suggest that while Organizational Safety Climate contributes most to the definition of Organizational Context, the variable explains much less of the other three elements, which includes Social Environment, Work Environment, and Individual Appreciation of Risk. Weights for Safety Related Behaviors and Safety Management Systems suggest that these variables have nearly the same level of influence on the four elements included in each of the variables.

Table 36

Summary of Standardized Regression Weights for the Model of Organizational Safety Culture (N = 1043)

	Standardized Regression Weights		
Item	OSC	SRB	SMS
Organizational Safety Climate			
Organizational Context	0.869		
Social Environment	0.634		
Work Environment	0.611		
Individual Appreciation of Risk	0.573		
Safety Related Behaviors			
Structural Firefighting		0.850	
Training		0.845	
Fitness and Medical		0.799	
Vehicle Safety		0.794	
Safety Management Systems			
Policy			0.957
Planning and Implementing			0.924
Measuring and Reviewing			0.866
Organizing			0.805

The squared multiple correlations for the variables and elements are presented in Table 37. The elements of each variable are listed in order from the element with the highest correlation to the lowest. Results of the analysis indicate that the Organizational Safety Climate variable contributes the most to the definition of Organizational Context element (76%), but much less to the Social Environment, Work Environment, the Individual Acceptance of Risk elements. There is also a substantial difference in the range of variance accounted for by Safety Management Systems. This variable accounts for 92% of the variance in Policy, but only 65% of the variance in Organizing.

Results of the Confirmatory Factor Analysis show that the Organizational Safety Climate variable explains relatively low levels of variance for three of the four measured elements. These results may help explain why the model is not a better fit. The items in the questionnaire for Organizational Safety Climate may need to be modified in order to improve the overall fit of the model or it may be necessary to use a completely different questionnaire to measure this variable in order to obtain a better fit.

Table 37

Summary of Squared Multiple Correlations for the Model of Organizational Safety Culture (N = 1043)

	Squared Multiple Correlations		
Item	OSC	SRB	SMS
Organizational Safety Climate			
Organizational Context	0.756		
Social Environment	0.402		
Work Environment	0.373		
Individual Appreciation of Risk	0.328		
Safety Related Behaviors			
Structural Firefighting		0.722	
Training		0.715	
Fitness and Medical		0.639	
Vehicle Safety		0.631	
Safety Management Systems			
Policy			0.916
Planning and Implementing			0.855
Measuring and Reviewing			0.749
Organizing			0.648

Level and Strength: Hypotheses 2 and 3

The mean score on elements and variables is used as the measure for “level”. The standard deviation of the means is used as the measure for “strength”. It is hypothesized that the level and strength of individual perceptions of safety culture will vary as a function of job function and years of service. As a reminder, job functions are categorized from lowest to highest in a hierarchical manner from Firefighter, to Company Officer, to Chief Officer. Years of service are categorized from 0 to 5, 6 to 10, 11 to 15, 16 to 20, and over 20 years of service.

Analysis of variance and the Tukey post-hoc test are used to determine whether the hypotheses are supported. Analysis of variance is used to determine if a difference exists in the level and strength of the safety culture variables as a function of job function and years of service. The Tukey post-hoc test specifies which groups have different means by placing groups into homogenous subsets. Groups of job functions and years of service are placed into the same subsets if their means are similar. The data will support hypothesis 2 if the level of scores varies depending on job function and years of service. The data will support hypothesis 3 if the standard deviation of scores varies depending on job function and years of service. Lower standard deviations indicate less variation in the means, which is used as the measure of strength. Lower standard deviations indicate higher strength while higher standard deviations indicate lower strength.

As part of the previous analysis that examined the discriminant validity of the instruments, analysis of variance and post-hoc tests were run on job function and years of service as a function of the variables and elements of safety culture. The Tukey post-hoc test run in conjunction with the ANOVA produced a table for each variable and element that separated the means of each category of job function and years of service into homogenous subsets by level. An additional series of analysis of variance were run on job function and years of service as a function of the standard deviation of the variables and elements to determine if strength varies with job function and years of service as predicted in the hypotheses.

As discussed previously, group sizes vary substantially among the categories of job function and years of service, so the Welch and Brown-Forsythe tests were conducted for the analysis of variance on standard deviation as well. For each variable and element in which significant differences exist in level and strength, the Welch and Brown-Forsythe test were significant, indicating that when the differences in the size of the categories were taken into account, the assumption of homogeneity of variance was met.

Level

The initial analysis of variance on job categories found statistically significant differences in the level of safety management systems across job categories at the .05 level of significance. The post-hoc test results shown in Table 38 indicate that the mean scores for Company Officers and Chief Officers place them in the same subset, but the scores for Fighter place them into a separate subset. The mean scores for the Officer group are lower than the mean scores for the Firefighter group, suggesting that the level of scores for Safety Management Systems increases with lower level job functions.

Table 38

Means for Groups of Homogenous Subsets for Job Function as a Function of Safety Management Systems

Variable	*N*	*Subset 1*	*Subset 2*
Company Officer	249	3.19	
Chief Officer	175	3.20	
Firefighter	526		3.35

Post-hoc test for the elements of safety management that showed statistically significant differences in level across job functions were found to demonstrate the same pattern, where the level of scores for officers were lower than that of firefighters. This pattern holds for the Policy, Organizing, and Planning and Implementing elements of safety management. Tables showing the means for the groups of homogenous subsets for these elements can be found in Appendix B.

Analysis of variance on years of service found statistically significant differences in levels of all three variables across the categories of year of service. Two basic patterns emerged from the data. In the first pattern, which is found in the Organizational Safety

Climate variable and the Organizational Context element, the members with the shortest and the longest years of service make up a homogenous subset of means, indicating that members in these categories share the same level of perceptions about these factors, as shown in Table 39 and 40 respectively.

Table 39

Means for Groups of Homogenous Subsets for Years of Service as a Function of Organizational Safety Climate

Variable	*N*	*Subset 1*	*Subset 2*
16 to 20	132	3.32	
11 to 15	205	3.33	
6 to 10	224	3.42	3.42
over 20	265		3.44
0 to 5	202		3.45

Table 40

Means for Groups of Homogenous Subsets for Years of Service as a Function of Organizational Context

Variable	*N*	*Subset 1*	*Subset 2*	*Subset 3*
16 to 20	132	3.24		
11 to 15	205	3.30	3.30	
6 to 10	224		3.41	3.41
over 20	265			3.48
0 to 5	202			3.49

In the second pattern, members in the 11-15 and the 16-20 years of service categories make up a homogenous subset of lower scores, while members with 0-5 years of service make up a separate homogenous subset with higher scores. An example of this pattern is shown in Tables 41and 42 for the Safety Related Behaviors variable and the Organizing element of safety management, respectively. Variations of this basic pattern were found for the data on the Policy and the Planning and Implementing elements of the safety management variable, and for the Structural Firefighting element of the safety behavior variable. Tables showing the results of the post-hoc tests for these and the other variables and elements not displayed can be found in the appendix.

Table 41

Means for Groups of Homogenous Subsets for Years of Service as a Function of Safety Related Behaviors

Variable	*N*	*Subset 1*	*Subset 2*
16 to 20	132	3.49	
11 to 15	205	3.52	
6 to 10	224	3.60	3.60
over 20	265	3.63	3.63
0 to 5	202		3.74

Table 42

Means for Groups of Homogenous Subsets for Years of Service as a Function of Organizing

Variable	*N*	*Subset 1*	*Subset 2*
16 to 20	132	3.08	
11 to 15	205	3.14	
over 20	265	3.17	3.17
6 to 10	224	3.28	3.28
0 to 5	202		3.37

Strength

Analysis of variance on years of service found no statistically significant differences in strength across the categories of this variable. Analysis of variance on job categories found statistically significant differences in strength in the Safety Management System and Safety Related Behavior variables but no significant differences in the Organizational Safety Climate variable.

Three patterns emerged from the analysis of variance. The first pattern, found in four of the eight variables and elements with significant differences, grouped Firefighters and Company Officers into one homogenous subset with stronger perceptions than the Chief

Officers who made up the other subset and were found to have weaker perceptions. This pattern was found for the Safety Management Systems variable, for the Organizing and the Planning and Implementing elements of safety management, and for the Vehicle Safety element of safety behaviors. An example of this pattern is shown in Tables 43 and 44 for Safety Management Systems and Organizing, respectively.

Table 43

Means for Groups of Homogenous Subsets for Job Function as a Function of Safety Management Systems

Variable	*N*	*Subset 1*	*Subset 2*
Firefighter	526	0.65	
Company Officer	249	0.66	
Chief Officer	175		0.75

Table 44

Means for Groups of Homogenous Subsets for Job Function as a Function of Organizing

Variable	*N*	*Subset 1*	*Subset 2*
Firefighter	526	0.67	
Company Officer	249	0.67	
Chief Officer	175		0.75

A second pattern was found in the Safety Related Behavior variable as well as the Fitness and Medical element. In this pattern, the Firefighter and Chief Officer categories made up separate homogenous subsets, with Firefighters having stronger perceptions on these factors than Chief Officers. An example of this pattern is shown in Table 45. As indicated in the table, the Company Officer category is part of both subsets.

Table 45

Means for Groups of Homogenous Subsets for Job Function as a Function of Safety Related Behaviors

Variable	*N*	*Subset 1*	*Subset 2*
Firefighter	526	0.79	
Company Officer	249	0.84	0.84
Chief Officer	175		0.86

In the third pattern, Company Officers and Chief Officers make up one homogenous subset, while Firefighters comprise a separate subset. This pattern occurs in the Measuring and Reviewing Performance element of safety management and in the Structural Firefighting element of safety behaviors. Company Officers and Chief Officers have stronger perceptions for the Measuring and Reviewing Performance element, but weaker perceptions for the Structural Firefighting element. Results of the post-hoc tests for these elements are shown in Tables 46 and 47, respectively.

Table 46

Means for Groups of Homogenous Subsets for Job Function as a Function of Measuring and Reviewing

Variable	*N*	*Subset 1*	*Subset 2*
Chief Officer	526	0.72	
Company Officer	249	0.77	
Firefighter	175		0.88

Table 47

Means for Groups of Homogenous Subsets for Job Function as a Function of Structural Firefighting

Variable	*N*	*Subset 1*	*Subset 2*
Firefighter	526	0.61	
Company Officer	249		0.67
Chief Officer	175		0.69

Results of analysis of variance for years of service as a function of the variables found no significant difference in the strength of the variables across the categories of years of service. For all three variables, the Levene statistic was found to be above the p = .05 level of significance, but the Welch and the Brown-Forsythe tests were also above this level, suggesting that the assumption of homogeneity of variance was not met after the differences in the size of the categories was taken into consideration.

Relationship Between Level and Strength

Researchers examining organizational culture have predicted that if strength is high, then a stronger association will exist between variables (Schneider & Salvaggio, 2002). Although the relationship between the level and strength of perceptions of the variables is not directly related to the hypotheses about the relationship among the variables, it is relatively simple to examine and may provide some additional insight into the nature and characteristics of these relationships.

The relationship between level and strength of perceptions was analyzed by producing a correlation matrix between the means scores for each variable and the average standard deviation for each variable. Results of the analysis indicate that as the level of perceptions increases, the standard deviation decreases. This means that as the level of perceptions increase, perceptions become stronger. In addition, the correlation between level and strength is larger for Organizational Safety Climate (r = -.33, p = .000) than for either Safety Management Systems (r = -.15, p = .000) or Safety Related Behaviors (r = -.13, p = .000). The Pearson's Correlation Coefficient (r) for each of the variables shows that as perceptions of the presence of the variables increases the amount of variation in perceptions decreases. This means that as the perceived level of the variables increases, the strength of the perceptions also increases. The correlation between level and strength is much higher for

Organizational Safety Climate than for the other two variables, indicating that the relationship between level and strength is higher for values than for practices.

Aggregation: Individual to Organizational Level

The two main criteria for aggregation of individual-level data to the organizational level are within group homogeneity and between group variance. Calculation of the Intraclass Correlation Coefficient is used to evaluate within group homogeneity and analysis of variance is used to evaluate variance between groups (Zohar & Luria, 2005). Individual-level variables must demonstrate a reasonable level of homogeneity within each organization in order to be considered an organizational level variable. The variables must also demonstrate the ability to differentiate across organizations in order to be considered an organization-level variable (Klein & Kozlowski, 2000).

The Intraclass Correlation Coefficient (ICC) was calculated for the three variables of safety culture for each participating organization as shown in Table 48. A score for each variable was calculated by using the elements of each variable in the analysis. Variation between organizations was assessed by using department as a factor variable and the elements of each variable as the dependent variable in the analysis of variance model. Support for aggregation from the individual-level to the organization-level is demonstrated when the ICC coefficient is higher than .7 and significant for each organization, and when the analysis of variance for the elements of the variables results in a significant F statistic. Results of the ICC analysis provide support for the aggregation of all three variables to the organizational level. The coefficients for Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate are above the .70 threshold required for aggregation and are significant for all three organizations.

Table 48

Intraclass Correlation Coefficient for Variables by Participating Department

	Department A		Department B		Department C	
Variable	*ICC*	*p*	*ICC*	*p*	*ICC*	*p*
Organizational Safety Climate	0.773	0.000	0.779	0.000	0.749	0.000
Safety Management Systems	0.931	0.000	0.957	0.000	0.926	0.000
Safety Related Behaviors	0.890	0.000	0.946	0.000	0.850	0.000

The results of analysis of variance on the variables are mixed. Significant differences exist between organizations with regard to Safety Management Systems and Safety Related Behaviors, demonstrating support for the aggregation of these variables to the organizational level. Variation between organizations on Organizational Safety Climate is not significant, indicating that the instruments may not demonstrate enough variation across organizations to justify aggregation of this variable to the organizational level. These results are shown in Table 49.

Table 49

One-Way Analysis of Variance for Department's as a Function of Organizational Safety Culture

Variable	*df*	*MS*	*F*
Organizational Safety Climate	2	.23	1.35
Safety Management Systems	2	4.09	9.01**
Safety Related Behaviors	2	5.97	18.08**

**p < .05; **p < .01.*

Additional analysis of variance was conducted on the differences between organizations across the elements of each variable. Results for this analysis are shown in Table 50. All but one of the elements has a significant F statistic. The Work Environment element of safety climate does not have significant F statistic, indicating there is no significant difference between departments for this factor. The other three elements of safety climate and all of the factors of safety management and safety behavior have a significant F statistic, indicating a significant difference across department’s on these factors.

Table 50

One-Way Analysis of Variance for Department's as a Function of the Elements of Organizational Safety Culture

Variable	*df*	*MS*	*F*
Organizational Safety Climate			
Organizational Context	2	1.37	4.52*
Social Environment	2	3.95	13.08**
Individual Appreciation of Risk	2	1.54	6.45**
Work Environment	2	0.32	0.89
Safety Management Systems			
Policy	2	5.48	10.61**
Organizing	2	13.64	21.27**
Planning and Implementing	2	7.43	13.78**
Measuring and Reviewing	2	1.72	3.72*
Safety Related Behaviors			
Fitness and Medical	2	9.97	27.91**
Vehicle Safety	2	4.37	9.35**
Structural Firefighting	2	10.61	27.64**
Training	2	10.54	19.47**

$*p < .05$; $**p < .01$.

Overall, the ICC coefficients and the results of the ANOVA suggest strong support for aggregation of the Safety Management Systems and Safety Related Behaviors variables to the organizational level. Although analysis of variance at the variable level did not result in a significant difference across organizations for the safety climate variable, subsequent analysis of variance at the element level provides strong support for the aggregation of all three variables to the organizational level.

Organizational Level Analysis

Analysis of the data at the organizational level provides a more detailed perspective on the nature and characteristics of the relationship among the variables and elements of organizational safety culture. In order to more fully understand the relationship among the variables, this section provides comparative data across organizations for the level and strength of scores. This section also provides comparative regression data that examines the influence of safety management and safety behavior on safety climate at the variable and element levels.

Descriptive Statistics

Means and standard deviations by department for the variables of safety culture are shown in Table 51. As indicated by a lower standard deviation in scores, perceptions of safety climate are stronger than perceptions of safety management and safety behaviors across all three departments. In addition, the standard deviation for safety management in Department B is particularly high, indicating that perceptions of this variable are weak compared to the other departments. The means and standard deviations for the elements of each variable by department are shown in Table 52.

Table 51

Means and Standard Deviations for Variables by Department

	Department A		Department B		Department C	
Variable	M	SD	M	SD	M	SD
Organizational Safety Climate	3.43	0.392	3.42	0.436	3.38	0.411
Safety Management Systems	3.36	0.603	3.42	0.789	3.21	0.649
Safety Related Behaviors	3.43	0.540	3.57	0.707	3.69	0.525

As part of the descriptive statistics for the analysis of safety culture by department, a series of correlation tables were produced. Correlation tables for the variable and elements of safety culture are provided in Appendix B. These tables indicate a significant correlation between the external variables of the model (Safety Management System and Safety Related Behaviors) and the internal variable of the model (Organizational Safety Climate) at the variable and element levels for each department. Correlations among the variables and elements range from .3 to .5 for all three departments, indicating moderate to strong relationships among the external and internal factors in the model (Cohen, 1988).

Table 52

Means and Standard Deviations for Elements by Department

	Department A		Department B		Department C	
Variable	M	SD	M	SD	M	SD
Organizational Safety Climate						
Organizational Context	3.36	0.520	3.49	0.567	3.37	0.557
Social Environment	3.70	0.514	3.57	0.571	3.48	0.555
Individual Appreciation of Risk	4.08	0.460	4.19	0.511	4.21	0.492
Work Environment	3.09	0.551	3.11	0.608	3.15	0.617
Safety Management Systems						
Policy	3.39	0.629	3.45	0.826	3.22	0.706
Organizing	3.48	0.737	3.27	0.879	3.09	0.792
Planning and Implementing	3.18	0.661	3.38	0.831	3.08	0.720
Measuring and Reviewing	3.39	0.617	3.56	0.814	3.47	0.643
Safety Related Behaviors						
Fitness and Medical	3.40	0.551	3.30	0.726	3.61	0.555
Vehicle Safety	3.26	0.634	3.53	0.759	3.39	0.671
Structural Firefighting	3.68	0.593	3.84	0.761	4.03	0.562
Training	3.39	0.703	3.61	0.799	3.74	0.722

Multiple Regression Analysis

Regression analysis was conducted to further explore the nature and characteristics of the relationship among the variables. Initially, multiple regression was conducted for the safety management and safety behavior variables predicting safety climate for each department. Results of this analysis are shown in Table 53. Next, a series of additional regression analyses were conducted for the elements of safety management and safety behavior predicting safety climate, for the safety management and safety behavior variables predicting each of the elements of safety climate, and for the elements of safety management and safety behavior predicting the elements of safety climate. For each analysis, the beta weights are used to indicate the relative amount of variation accounted for by each variable or element used as a predictor. The total amount of variation accounted for by the predictor variables is indicated by the adjusted R^2 coefficient. Results of these three sets of regression analysis are presented in Tables 54 through 56.

Results of the first regression analysis, shown in Table 53, indicate that for Department A, both the safety management and safety behavior variables significantly predict safety climate, $F(2/236) = 64.63$, $p < .001$, and that safety management has a substantially stronger influence on safety climate than safety behaviors, as indicated by the respective beta weights. The adjusted R^2 value is .35, indicating that the variables account for 35% of the variance in safety climate, which is considered a large effect (Cohen, 1988). Results for Department B are quite different. While the combination of variables significantly predict safety climate, $F(2/235) = 73.76$, $p < .001$, only safety behaviors significantly contributes to the prediction. However, the adjusted R^2 value is .39, indicating that although only one of the variables contributes significantly to the prediction, 39% of the variation in safety climate in this department is explained by the model. Results for Department C show that both variables contribute significantly to the prediction of safety climate, $F(2/563) = 112.77$, $p < .001$, and that the variables explain 29% of the variance in perceptions of safety climate. The beta weights suggest that in Department C, perceptions of safety behaviors contribute slightly more to the prediction.

Table 53

Simultaneous Multiple Regression Analysis Summary for Safety Management Systems and Safety Related Behaviors Predicting Organizational Safety Climate

Variable	*B*	*SEB*	β
Department A (N = 239)			
Safety Management Systems	0.27	0.05	0.41**
Safety Related Behaviors	0.16	0.06	0.22**

$R^2 = .35$; $F(2/236) = 64.63$, $p< .001$			
$*p < .05; **p < .01$.			
Department B (N = 238)			
Safety Management Systems	0.01	0.06	0.03
Safety Related Behaviors	0.40	0.06	0.64**
$R^2 = .39$; $F(2/235) = 73.76$, $p< .001$			
$*p < .05; **p < .01$.			
Department C (N = 566)			
Safety Management Systems	0.17	0.03	0.27**
Safety Related Behaviors	0.25	0.04	0.31**
$R^2 = .29$; $F(2/563) = 112.77$, $p< .001$			
$*p < .05; **p < .01$.			

The second regression analysis by department examines the relationship between safety climate and the elements of safety management and safety behaviors. The results of this analysis are shown in Table 54. For Department A, while the combination of all eight elements significantly predicts levels of safety climate, $F(8/230) = 17.306$, $p< .001$, only the Policy element significantly contributes to the prediction. The combined elements explain 38% of the variance, as indicated by the adjusted R^2 value. This is a moderate to strong effect (Cohen, 1988). The combination of elements also significantly predicts safety climate levels in Department B, $F(8/229) = 19.242$, $p< .001$, but none of the elements significantly contributes to the prediction individually. Altogether though, the combination of elements explains 40% of the variance in safety climate. In Department C, three of the elements significantly contribute to predicting levels of safety climate. These include Policy, $\beta = .34$, Structural Firefighting, $\beta = .14$, and Training, $\beta = .10$, respectively. The combination of elements significantly predicts safety climate, $F(8/557) = 30.946$, $p< .001$, with an adjusted R^2 value of .31, indicating that 31% of the variance in safety climate is explained by the elements of safety management and safety behaviors.

Table 54

Simultaneous Multiple Regression Analysis Summary for Elements of Safety Management Systems and Safety Related Behaviors Predicting Organizational Safety Climate

Variable	*B*	*SEB*	β
Department A (N = 239)			
Safety Management Systems			
Policy	.170	.086	.273*
Organizing	.083	.044	.156
Planning and Implementing	.084	.069	.141
Measuring and Reviewing	.102	.074	.161
Safety Related Behaviors			
Fitness and Medical	.095	.060	.134
Vehicle Safety	.022	.047	.036
Structural Firefighting	.046	.061	.070
Training	.084	.050	.151
$R^2 = .38$; $F(8/230) = 17.306$, $p < .001$			
*$p < .05$; **$p < .01$.			
Department B (N = 238)			
Safety Management Systems			
Policy	.120	.088	.228
Organizing	.079	.052	.160
Planning and Implementing	.094	.075	.180
Measuring and Reviewing	.070	.065	.131
Safety Related Behaviors			
Fitness and Medical	.094	.061	.156
Vehicle Safety	.122	.063	.212
Structural Firefighting	.023	.066	.040
Training	.117	.073	.214
$R^2 = .40$; $F(8/229) = 19.242$, $p < .001$			
*$p < .05$; **$p < .01$.			
Department C (N = 566)			
Safety Management Systems			
Policy	.199	.047	.342**
Organizing	.007	.029	.013

Planning and Implementing	.035	.045	.061
Measuring and Reviewing	.066	.040	.103
Safety Related Behaviors			
Fitness and Medical	.031	.038	.042
Vehicle Safety	.048	.031	.078
Structural Firefighting	.105	.040	.144**
Training	.061	.029	.107*

$R^2 = .31$; $F(8/557) = 30.946$, $p < .001$
*$p < .05$; **$p < .01$.

The third regression analysis explores the relationship among the elements of safety climate and both the safety management and safety behavior variables. The results of this analysis are shown in Table 55. The beta weights for shown for each cell in the table, providing an indication of the contribution that the variables make toward predicting the respective elements of safety climate. The last row for each department is the adjusted R^2 for the combination of variables, indicating how much of the variation in the element is explained by the variables. Elements listed in the table include Organizational Context (OC), Social Environment (SE), Individual Appreciation of Risk (IAR), and Work Environment (WE).

Each department has a different pattern of relationships between perceptions of safety management and the elements of safety climate, and between perceptions of safety behaviors and the elements of safety climate. A review of the beta weights for Department A indicates that safety management contributes most significantly toward predicting perceptions of safety climate elements, particularly Organizational Context and Social Environment. In Department B, it is safety behaviors that contribute most significantly toward predicting perceptions for all of the safety climate elements. For Department C, the beta weights indicate that perceptions of both safety management and safety behaviors influence perceptions of the elements of safety climate.

Analysis of the beta weights indicates that the pattern of influence of safety management and safety behaviors on the elements of safety climate appears to be different for each department. Analysis of the pattern for the adjusted R^2 values, however, shows a very similar pattern across departments. In each case, the variables explain the amount of variance in the elements of safety climate in the same order. The variables explain the highest amount of variance in the Organizational Context element, with R^2 values that average .30. The Social Environment element is the next highest with an average R^2 value of .23. At the low end is the Individual Appreciation of Risk element with an average R^2 value of .15, indicating that the variables explain half as much of the variance in this element as the Organizational Context element. The average adjusted R^2 value for the Work Environment element is also relatively low, indicating that across the three departments, only 17% of the variance in this element is explained by the safety management and safety behavior variables. This is still considered a medium effect but is relatively smaller than the effect size of the variables on the Organizational Context and Social Environment elements, which are considered large (Cohen, 1988).

Table 55

Simultaneous Multiple Regression Analysis Summary for Safety Management Systems and Safety Related Behaviors Predicting Elements of Organizational Safety Climate

Variable	OC	SE	IAR	WE
Department A (N = 239)	β	β	β	β
Safety Management Systems	.499**	.485**	.257**	.153
Safety Related Behaviors	.070	.018	.189*	.309**
R^2	.30	.24	.17	.18
**p < .05; **p < .01.*				
Department B (N = 238)	β	β	β	β
Safety Management Systems	.029	.062	.088	.000
Safety Related Behaviors	.543**	.580**	.358**	.419**
R^2	.32	.27	.18	.17
**p < .05; **p < .01.*				

Department C (N = 566)	β	β	β	β
Safety Management Systems	.269**	.263**	.092	.199**
Safety Related Behaviors	.303**	.187**	.244**	.245**
R^2	.27	.17	.10	.16

**p < .05; **p < .01.*

The fourth and last of the regression analysis of the data by department examines the relationship among the elements of safety climate and those of safety management and safety behaviors. These results are presented in Table 56. An interesting pattern emerges from an examination of the beta weights across departments. The adjusted R^2 values for most of the elements of safety climate are relatively large, ranging from .13 to .35, with seven of the twelve values above .20, which is considered a large effect (Cohen, 1988). These relatively large effect sizes are achieved with only one to three of the elements of safety management or safety behavior having a significant influence in predicting perceptions of the safety climate elements.

Table 56

Simultaneous Multiple Regression Analysis Summary for Elements of Safety Management Systems and Safety Related Behaviors Predicting Elements of Organizational Safety Climate

Variable	OC	SE	IAR	WE
Department A (N = 239)	β	β	β	β
Safety Management Systems				
Policy	.402**	.297*	.184	.007
Organizing	.087	.151	.128	.113
Planning and Implementing	.054	.169	.127	.017
Measuring and Reviewing	.121	.231	.063	.030
Safety Related Behaviors				
Fitness and Medical	.030	.169	.335**	.113
Vehicle Safety	.059	.207*	.108	.140
Structural Firefighting	.133	.018	.054	.013
Training	.099	.037	.073	.130
R^2	.326	.303	.232	.193
**p < .05; **p < .01.*				
Department B (N = 238)	β	β	β	β
Safety Management Systems				
Policy	.538**	.130	.320	.078
Organizing	.110	.181	.260*	.014
Planning and Implementing	.265	.113	.011	.088
Measuring and Reviewing	.098	.161	.131	.173
Safety Related Behaviors				
Fitness and Medical	.144	.196	.022	.072

Vehicle Safety	.105	.045	.092	.310*
Structural Firefighting	.136	.094	.175	.126
Training	.141	.208	.013	.194
R^2	.351	.295	.225	.195

$*p < .05$; $**p < .01$.

Department C (N = 566)	β	β	β	β
Safety Management Systems				
Policy	.454**	.230**	.283**	.179*
Organizing	.045	.037	.054	.047
Planning and Implementing	.006	.105	.083	.142
Measuring and Reviewing	.132	.091	.026	.061
Safety Related Behaviors				
Fitness and Medical	.062	.014	.032	.048
Vehicle Safety	.102*	.021	.031	.067
Structural Firefighting	.014	.157**	.235**	.120*
Training	.187**	.034	.025	.050
R^2	.317	.184	.126	.176

$*p < .05$; $**p < .01$.

Summary

In this section data have been presented to justify the aggregation of individual-level data to the organizational level. Analysis of within-organization homogeneity and between organization variance was found to provide adequate justification for aggregation. Several comparisons among the three participating departments were then conducted. First, the level and strength of perceptions was compared. Second, statistically significant correlations were found among the variables in each department. Third, a series of four multiple regression analyses was conducted to explore the nature and characteristics of the relationship among the variables in more detail.

The results of the regression analyses suggest that to a large degree, each department has a unique culture in terms of the characteristics of the relationship between the independent variables, which includes Safety Management Systems and Safety Related Behaviors, and the dependent variable, safety climate. As the radar charts demonstrate, however, the three organizations have very similar cultures in terms of the level and strength of all three variables.

Results of the multiple regression analysis indicate that the relationship among the variables is very different for each participating fire department in several ways. First, the amount of variation in Organizational Safety Climate explained by Safety Management Systems and Safety Related Behaviors was different for each department. The adjusted R^2 for Department C was low, with the predictor variables explaining only 29% of the variation in OSC, while the predictor variables explained 35% of the variation for Department A and 39% of the variation in Department B. Second, the amount of variation in OSC explained by each of the predictor variables separately was very different in each department. For Department A, the SMS variable explained the most variation in OSC, while the SMS variable explained the most variation in Department C. For Department B, the SMS variable explained almost none of the variation while the SRB variable explained 64% of the variation in OSC.

Another way in which the relationship among the variables differs among the participating organizations is the relationship among the elements of the predictor variables and the OSC variable. In each department, different elements of the predictor variables had statistically significant relationships with the OSC variable. For Department A, the Policy element of the SMS variable is the only element with a significant relationship with OSC, accounting for 27% of the variation in OSC. For Department B, none of the elements explains a significant amount of variation in OSC. For Department C, the Policy element accounts for 34% of the variation in OSC, while Structural Firefighting accounts for 14% and Training accounts for 11% of the variation in OSC. The data also show that the participating organizations are different in terms of the amount of variation explained in the elements OSC by the predictor variables and in the amount of variation in the elements of OSC explained by the elements of the predictor variables.

Despite the differences in the relationship among the variables, there are some striking similarities it the level and strength of the variables. All three organizations show high level scores in several elements of the OSC and SRB variables. These include the Individual Appreciation of Risk and Social Environment elements of the OSC variable and the Structural Firefighting and Training elements of the SRB variable. The organizations share low level scores for the Work Environment element of the OSC variable and the Planning and Implementing element of the SMS variable.

There are also shared patterns in the strength of the elements in the variables. Three of the four elements of OSC have a low standard deviation, which indicates that perceptions of these elements are strong among the members of all three organizations. These include the Individual Appreciation of Risk, Social Environment, and Organizational Context elements of OSC. Several elements of the SMS and SRB variables have high standard deviations, indicating a large amount of variation in perceptions by members of the participating organizations. Weak scores are found for the Policy, Organizing, and the Planning and Implementing elements of SMS as well as the Training and Vehicle Safety elements of the SRB variable.

CHAPTER V: DISCUSSION AND CONCLUSIONS

Introduction

In this chapter the results of the analysis and assessment of the variables of safety culture will be discussed. This will include a detailed discussion of each of the hypotheses developed as part of research question three, each of which make assertions about the nature of the relationship among the variables. The discussion will examine the relationship among the variables from the individual and organizational levels. In addition, the argument will be made that a comprehensive approach to the analysis and assessment of organizational culture should include the same type of analysis that has been used in this pilot study, which includes the following: the analysis of the relationship among the variables; analysis of the level of the variables; and analysis the strength of the variables.

The discussion and conclusions from the findings of the analysis of the data will be discussed from both a research perspective and a practitioner perspective. From a research perspective, the findings will be discussed and conclusions made about the nature and characteristics of the relationship among the variables. From a practitioner perspective, the findings will be discussed and conclusions made about what the findings mean for the development of interventions that will effectively improve safety performance in fire service organizations.

The chapter includes a discussion of the strengths and limitations of the pilot study. Recommendations for future research on organizational culture are also discussed. The chapter and the dissertation will end with a section on conclusions.

Discussion

The purpose of this thesis is to determine whether the construct of safety culture can be applied within the context of municipal fire service organizations in the United States as a means for the assessment and analysis of safety culture. To formulate this determination, three research questions were used to guide the development of a conceptual model of safety culture for the pilot study. The first question is: which model of safety culture is best for the purpose of assessment and analysis of safety culture in US fire service organizations? It is important to develop a model of safety culture because a model of the construct provides the conceptual foundation that describes the variables in the model that can then be used to form hypotheses about the relationship among the variable that can be tested using empirical data. The second question is: what are the key variables in the model and how can these variables be operationalized and measured. This question is important because while a model of safety culture provides a framework for empirical analysis, the development of questionnaires provides a means for collecting the data that will be used in the analysis and assessment of the variables. The third question is: what is the nature of the relationship among these variables? While the findings of this research only begins to answer this question, it is an important question to begin to address because to make effective changes and improvements in safety performance, researchers and practitioners must better understand the characteristics of the relationship among the variables of safety culture.

In this pilot study, three hypotheses about the nature of the relationship among the variables of safety culture are tested by analyzing the data from three fire service organizations. The first hypothesis makes the assertion that the variables used to measure organizational practices will influence individual values. This hypothesis is based on previous studies of organizational culture in which researchers have made the assertion that perceptions of practices influence values and beliefs (Carr et al., 2003; Hofstede, 1998) and the research by Cooper (2000) that makes the same assertion about the relationship among the variables of safety culture. The second hypothesis makes the assertion that the level of scores for the variables of safety culture will vary across job functions and years of service. This hypothesis is based on previous research that examines the difference in scores on the variables of organizational and safety culture by demographic variables, such as the job they perform and the number of years they have worked in the profession (Willamson, 1997; Clark, 1993; Mearns et al., 2003; Parker et al., 2006). It is hypothesized that individuals who work in different job roles and who have worked in the profession for longer periods of time will have different work related experiences, resulting in different perceptions about the variables of safety culture. The third hypothesis asserts that the strength of the scores for the variables of safety culture will also vary across job functions and years of service. This assertion is based on research that has focused on the strength of scores as a better measure of organizational culture than the level of scores because it reflects the degree to which perceptions are shared by individuals within an organization, which is an essential part of the definition of organizational culture (Sorensen, 2002; Schneider & Salvaggio, 2002; Zohar & Luria, 2005).

Since the first two research questions have been answered previously, the discussion of the answer to these will be relatively brief. The detailed discussion of the answer to the first research question can be found in the Chapter III, Methodology, in the sections titled Conceptual Model of Safety Culture (pg. 112-19). The answer to the second research question can be also be found in Chapter III, Methodology, in the sections on Measures of

Safety Culture (pg. 120-130) and Instruments (pg. 136-150). The focus of this chapter is on the findings and analysis related to the three hypotheses that were formed from the third research question about the nature of the relationship among the variables of safety culture.

The first research question of this pilot study was answered in two steps. The first step described the current models of safety culture. The second part was to develop criteria that could be used to decide which of the current models would be the best one to use in the analysis of safety culture within the context of the US fire service. Material from the literature review describes the current models used to analyze and assess organizational culture and safety culture and was used to develop the criteria for deciding which model could best be adapted to the fire service.

After evaluating several models of safety culture against the established criteria, a modified version of the Reciprocal Determinism Model (RDM) was selected as the best conceptual model of safety culture for the purpose of assessment and analysis of safety culture within the US fire service. The key variables in the model are Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate. The original RDM proposed that the variables of organizational culture include Environmental Factors, Behavioral Norms, and Individual Factors. The original RMD was modified to reflect the research on safety culture as an organizational sub-culture and to describe the variables in a way that worked within the context of the fire service. As a result, the names of the variables were changed. In addition, the nature of the relationship among the variables was modified to reflect the proposition that Safety Management Systems and Safety Related Behaviors influence Organizational Safety Climate.

The conceptual model of safety culture used in this pilot study and represented by the modified RDM is based on a functionalist approach to safety culture. Organizations are viewed as having systematic characteristics regarding safety culture that can be best understood by developing a model, measures and instruments for the quantitative assessment of the construct (van Muijen, 2002). In addition, the model represents an integrated approach to the development of a model and measures of safety culture because it includes critical variables used in both culture and climate studies (van den Berg & Wilderom, 2004). One of the significant gaps in the research on safety culture has been the lack of a comprehensive model of safety culture that is also practical and useful (Sorensen, 2002; Guldenmund, 2000). The development of an integrated model is essential for making significant improvements in safety performance (DeJoy, 2005; Morgan & Smircich, 1980). The development of an integrated model also provides a more practical and useful approach to understanding the social context of organizations, (Guldenmund, 2000). Culture studies focus more on underlying assumptions, while climate studies focus more on values and practices. This pilot study includes all three variables in the model used to assess the social context of organizations regarding safety.

This model also integrates the important elements of the culture change and behavior change approaches to improving safety performance. The culture change approach focuses on changing values and beliefs, while the behavior change approach focuses on changing management practices and behavioral norms as the means for improving safety performance (DeJoy, 2005). Individual values and beliefs are represented by the Organizational Safety Climate variable. Organizational management practices are represented by the Safety Management Systems variable, while behavioral norms are represented by the Safety Related

Behaviors variables. The model used in this research includes all three variables, providing a foundation for future research into the relationship between the variables and safety performance.

The primary variables in the conceptual model of safety culture used in this pilot study are Practices and Values. These two variables are considered the principle variables of organizational culture (Bloor & Dawson, 1994; Marcoulides & Heck, 1993; Schraeder et al., 2005). Practices are considered to be organizational variables in that they are under the control of organizational actors such as supervisors, managers and administrators. Values are considered to be individual variables that are under the control of individual members of the organization. Values are influenced by practices and both variables influence behaviors (Hofstede, 1998. Another way to describe the proposed relationship among the variables is that individual values and beliefs moderate the relationship between organizational practices and actual behavior.

Within the context of this dissertation on safety culture, practices include organizational management practices and individual safety practices. Organizational practices are viewed as consisting of two variables: management practices and work practices (Marcoulides & Heck, 1993; Bloor & Dawson, 1994; Denison, 1996; Hofstede, 1998; van den Berg & Wilderom, 2004). Because this dissertation is focused on safety culture, these variables are called safety management practices and safety related behaviors. It is important to make a distinction between the types of organizational practices because researchers argue that practices can be changed more easily than values and beliefs (Reason, 1998). In addition, it is important to understand the interaction among the variables of safety culture because it is the interaction of the variables that helps to explain and predict individual behaviors (Karahanna et al., 2005; Bloor, 2004; van den Berg & Wilderom, 2004, Naidoo, 2002). While all three variables influence behavior, organizational practices will influence individual perceptions about the importance of safety and the level of agreement with desirable and appropriate safety values and beliefs (Carr, 2003; Hofstede, 1998). As a result, it can be argued that values and beliefs moderate the relationship between practices and the choices that individuals make to engage in either safe behaviors or high-risk behaviors (Karahanna et al., 2005). One of the most significant contributions of this dissertation is the development of a model and measures that can be used to analyze and assess the interaction of the variables of safety culture.

Instruments used to measure these variables are designed to collect data on the perceptions that individuals have about the variables rather than their objective occurrence. Perceptual measures are used because it is the perceptions of individuals that are used to make decisions about behavioral choices (Bloor & Dawson, 1994; Moran & Fredericks, 1992; van den Berg & Wilderom, 2004). In addition, researchers have argued that the defining characteristic of organizational culture is shared perceptions of the important variables of the construct and that the perceptions of organizational culture interact to influence individual behavior (Bloor & Dawson, 1994; Naidoo, 2002; Karahanna et al., 2005).

The ability to understand how the variables of organizational culture interact provides a framework for the development of effective interventions designed to change behavior and improve performance (Karahanna et al., 2005; Schraeder et al., 2005). Managers must be able to understand, measure, monitor, and assess the variables of organizational culture in order to understand how changes in these variables influence individual values and beliefs

(Parker et al., 2006). Within the context of safety culture, it is assumed that organizational variables are under the control of managers who can manage and change the variables of safety culture to improve both organizational and individual consequences. The deliberate and purposeful management of safety culture is expected to result in higher levels of extrinsic and intrinsic motivation to engage in safer behaviors because they will result in more positive organizational and individual outcomes.

The conceptual model of safety culture fits within a larger framework that describes how the variables of safety culture influence behavioral choices and how behavioral choices result in consequences that influence the variables of safety culture. In this theoretical framework, organizational consequences influence organizational practices while individual consequences influence individual values and beliefs. More specifically, the theoretical framework proposes that organizational outcomes influence Safety Management Systems and Safety Related Behaviors while individual consequences influence Organizational Safety Climate. The development of a theoretical framework for how safety culture influences behavior is important because it answers the question about why the conceptual model and variables of safety culture are important. They are important because of the influence that the variables have on individual behavioral choices. For example, the framework proposes that variables of safety culture have an influence on whether individuals engage in high risk behaviors or low risk behaviors. If firefighters engage in more high risk behaviors, then more injuries and fatalities are likely to result. If firefighters engage in more low risk behaviors, then fewer injuries and fatalities are likely to result.

The second research question of the dissertation was answered by operationalizing the variables in the conceptual model so that they could be measured with empirical data.

The safety management variable has been operationalized using a questionnaire based on internationally recognized standards of best practices for managing safety that has been used to assess safety management in other high risk occupations. The safety behavior variable has been operationalized through a questionnaire developed from the critical safety behaviors involved in over 70% of firefighter injuries and fatalities. Safety climate has been operationalized using a safety climate assessment questionnaire that has also been used in other high risk occupations.

To answer the third research question about the nature of the relationship among the variables of safety culture, three hypotheses were made about that relationship in the form of hypotheses. The first hypothesis asserts that higher scores on measures of Safety Management Systems and Safety Related Behaviors will be associated with higher scores for Organizational Safety Climate. The assertion made in this hypothesis is that practices influence values. Practices influence values in that perceptions of individuals about how safety is managed and about the behavioral norms related to safety will predict safety related values and beliefs. It is anticipated that the relationship between these variables is positive and significant. Individuals who score higher on safety related management practices and work practices will also score higher on safety related values and beliefs. Support for this hypothesis would be found, for example, if the data indicate that individual who score higher for planning and implementing risk controls, which are elements of the Safety Management System variable, are also found to have higher scores for elements of Organizational Safety Climate, such as individual appreciation of risk.

The second hypothesis is that the level of scores for Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate will vary across the classifications of job function and years of service. Individuals with different work related experiences will have different perceptions of the work environment. As a result, scores are expected to vary across the three basic job functions and the groupings for years of service because different jobs create different responsibilities and experiences and as individuals work longer they experience different events. The third hypothesis is similar to the first but asserts that the strength of scores will vary across the classification of job function and years of service. The difference between hypothesis II and III is that hypothesis II asserts that scores will vary from low to high across job functions and years of service while hypothesis III asserts that scores will vary from weak to strong across job functions and years of service.

Analysis of the data initially examined the relationship among the variables at the individual level. After making the determination that the data could be aggregated to the organizational level, the analysis looked at the similarities and differences in the relationship among the variables across the three participating organizations. The discussion of the findings follows this format, with an initial discussion of the findings at the individual level and then at the organizational level. Before beginning the discussion about the relationship among the variables, however, it is important to discuss whether or not the instruments are reliable and valid measures of the variables.

Because these instruments have not been used to assess safety culture in fire service organizations, it is particularly important to evaluate the reliability and validity of the questionnaires as they were used in this context. The final version of the three questionnaires was formed through a process of data reduction and factor analysis. Results of analysis of reliability using the Cronbach's alpha coefficient show that each of the questionnaires has a high level of reliability. The Cronbach's alpha coefficient for Safety Management Systems is

0.97, the coefficient for Safety Related Behaviors is 0.90, and the coefficient for Organizational Safety Climate is 0.79. Reliability of the elements in each variable was also found to be sufficient, with all elements having a Cronbach's alpha coefficient above 0.70, with the exception of the Work Environment element of safety climate. These findings suggest a high level of reliability within the questionnaires when used in the context of the fire service.

The construct validity of the questionnaires was evaluated be examining their discriminant and convergent validity. The discriminant validity of the questionnaires was assessed through analysis of variance to determine if the questionnaires were able to discriminate among categories of jobs and years of service as a function of the variables. The discriminant validity of the questionnaires across job functions was limited to the safety management systems variable. Neither the safety climate nor the safety behavior variables showed any significant discriminant validity across job functions. The discriminant validity of the questionnaires across years of service categories, however, demonstrated significant discriminant validity for all three variables. It is very possible that the job function and years of service variables interact to influence the variables, since individuals promoted to higher level job functions will typically have longer years of service. It seems clear, however, that the years of service variable has the stronger influence in terms of differentiating among scores on the variables, since significant differences were found among the scores for all three variables across the categories of years of service.

The convergent validity of the questionnaires was evaluated by examining the correlations among the variables to determine if they converged as expected. The correlation between the safety management and safety behavior variables are higher than the correlation between each of these variables and the safety climate variable. The safety management and safety behavior variables have a higher level of convergence between themselves than they have between themselves and the safety climate variable. This is the relationship that would be expected given the model of safety culture used in the pilot study. The safety management and safety behavior measures are the practices based variables in the model, while the safety climate measure is the values based variable in the model. It is reasonable to expect that the practices based variables would demonstrate a higher level of correlation than between each of these and the values based variable. These findings suggest that the three key variables in the model were measured using the three questionnaires and that these instruments are a reliable and valid means for operationalizing the variables.

Although the instruments used to measure the variables have an adequate level of reliability, the structure of the variables was changed through the process of factor analysis in order to gain an improved level of reliability. The structure of the variables was not adequate as originally developed from theory, as indicated by the Cronbach's alpha scores that were below acceptable levels for several elements of the variables. This may be an indication that the instruments need further modification in order to gain still higher levels of reliability or that other instruments may prove to be better measures of the variables.

The work environment element of the Organizational Safety Climate variable is the only element that did not have an adequate level of reliability. This is an interesting finding because one of the criteria for selection of the participating organizations was that they shared a similar work environment to reduce the potential for task factors and organizational factors to mediate the relationship among the variables (Cooper, 2000b). The low Cronbach's alpha score for the work environment element may be a reflection of the similarities in the work environment of all three participating fire departments rather than a reflection of a poor level of reliability of the questionnaire. If the participating organizations share very similar work environments, then any instrument would likely have a relatively low level of reliability and discriminant validity for measures of the work environment because it would not be able to differentiate scores on this element.

The reliability and validity of the instruments may also vary across other types of organizations. For example, the three fire departments that participated in this pilot study are all fully paid career departments that operate in an urban environment, are similar in size, use similar procedures, and serve communities with a similar level of risk. The questionnaires used to measure the variables may have a different level of reliability and validity for fire service organizations that are all volunteer departments or are combination departments with both paid and volunteer members. Reliability and validity may also vary with the size of the community and the level of risk in the community served by the fire department. It will be difficult to fully assess the reliability and validity of these instruments until more fire departments that operate in different work environments participate in safety culture studies.

Hypothesis One: SMS and SRB Predict OSC

An examination of the correlations between the variables in the model provides an initial perspective on the nature of the relationship among the variables. The Pearson Correlation Coefficient for the relationship between safety management and safety behaviors is .706, indicating a very strong relationship between these two predictor variables. The correlation between safety management and safety climate is .513 and the correlation for the relationship between safety behaviors and safety climate is .517, indicating a strong relationship between each of the predictor variables and safety climate.

A stronger correlation between the two predictor variables is not unexpected since both are part of the higher level construct of practices, one the two principle measures of culture. A strong relationship between these two variables would be anticipated because safety management practices are directed at managing critical safety related behaviors. A high correlation, however, does not mean that the nature of the relationship is causal. The data do not indicate whether safety management practices influence safety behaviors, or if safety behaviors influence safety management practices.

The means and standard deviation provide comparative information about the level and strength of each variable. Higher level scores on the Safety Management Systems (SMS) and Safety Related Behaviors (SRB) variables means that individuals perceive a greater presence of these variables in the work environment. Higher level scores on the Organizational Safety Climate (OSC) variable means that the individual agrees more strongly with safety related values and beliefs. A low standard deviation indicates less variation in the perceptions of individuals about the presence of the SMS and SRB variables and greater agreement with safety related values and beliefs.

The mean scores for each variable indicated that safety behaviors are higher than those for safety management systems. When these scores are evaluated using the standardized scoring metric proposed by Cooper (2008), the overall scores for safety management systems are average and the overall scores for safety behaviors are good. Safety climate also falls within the range of average scores. This result is interesting because the representatives of the organizations that chose to participate in the pilot study all indicated that their safety culture was relatively high compared to other fire service organizations. The sense that their organizations had a relatively high level of safety culture was one of the factors in deciding to participate in the pilot study for these organizations. When contacted personally by the principal investigator to encourage the participation of other organizations that had been contacted but had not responded, concern that their organization had a relatively low level of safety culture was cited as one of the reasons for not participating. Not only is this a clear indication of selection bias, it also suggests that the organizations participating in the pilot study may represent the higher range of scores for the variables of safety culture, suggesting that at best, fire service organizations may be considered average in terms of overall safety culture.

The standard deviations for safety management and safety behaviors are larger than for safety climate, indicating a larger amount of variance in the scores for these two variables. The larger variance suggests that perceptions of safety management and safety behaviors are weaker and that perceptions of safety climate are stronger. These finding indicate that within the fire service, individual values are stronger than organizational practices. Individual perceptions of values and beliefs may be stronger because they are internal to the individual and individuals may have a higher level of confidence about their own internal values and beliefs than about external management systems and behavioral norms. The indication that values are stronger than beliefs supports the idea that values are more difficult to change than practices, suggesting that practices are a better starting point for the development of interventions designed to improve safety performance.

Results from multiple regression analysis provide strong support for the hypothesis that individual perceptions of safety management and safety behavior predict individual perceptions of safety climate. Perceptions of safety management and safety behaviors explain 31% of the variance in safety climate. The beta weights for the two predictor variables shows that they both make a significant contribution to the model. Individual perception of safety behaviors has a slightly higher beta weight, indicating that this variable is slightly more important in predicting safety climate. These findings are consistent with the assertions made by other researchers about how organizational practices influence individual values (Carr et al., 2003; Hofstede, 1998)

Multiple regression was also used to examine the relationship among the eight elements of safety management and safety behaviors as predictor variables and safety climate as the single dependent variable. Results from this analysis suggest that individual perception of the Policy element of safety management is the most important predictor of overall safety climate. Perceptions of the Vehicle Safety and Training elements of safety behaviors are also significant, but have a much weaker level of influence on safety climate. The Policy element of safety management appears to have a dominant influence on safety climate. When all eight of the elements of safety management and safety behaviors are used to explain the variation in the four individual elements of safety climate, Policy is the most important element in predicting three of the four elements of safety climate, which includes the elements of Individual Appreciation of Risk, Organizational Context, and Social Environment. The following discussion explores the relationship among these elements of the dependent variable and the elements of the predictor variables in more detail.

Elements that make a significant contribution toward explaining the variation in Organizational Context include Policy, Vehicle Safety, and Training. Policy has the highest correlation with Organizational Context and the highest beta weights compared to the other two elements. The Policy element measures the perceptions that individuals have with regard to several factors related to safety policy. These include: the extent to which the organization's safety policy recognizes safety as an integral part of improving organizational performance; establishes a high level of management commitment to safety; clarifies safety roles and responsibilities; provides for the participation of employees in developing safety policy; and establishes a commitment to measure and manage safety performance. The Organizational Context element measures perceptions that individuals have about the management priority of safety, the effectiveness of safety rules and procedures, and the adequacy of communications about safety concerns and issues between members and their direct supervisor. The results of the regression analysis suggest that when individuals have higher levels of perceptions on the policy related factors, they will also perceive that safety is a priority for management, that safety rules and procedures are effective, and that they have good communications with their direct supervisor about safety problems.

The Social Environment element of safety climate measures perceptions about the level of support and encouragement that individuals receive for dealing with safety concerns openly, the level of involvement of individuals in safety issues, and the degree to which individuals participate in the ongoing review of safety. The Policy element of safety management has a strong influence on perceptions of this element of safety climate as well. This would indicate that perceptions about safety policy influence the degree to which individual feel supported and involved in dealing with safety concerns, and whether they believe they can deal openly with safety problems. Perceptions of the Structural Firefighting element of safety behaviors make a significant contribution to predicting perceptions of Social Environment, but the beta weight for this element suggests a much weaker influence than Policy.

Two elements of safety management have a significant influence on the Individual Appreciation of Risk element of safety climate: Policy and Planning and Implementing. With regard to this factor, however, Policy and the Planning and Implementing elements have with almost equal beta weights suggesting an almost equal contribution to predicting individual perceptions about risk. The Planning and Implementing element measures perception of the degree to which risk control systems, performance standards, and safe work practices have actually been planned and implementing in the work environment. Individual Appreciation of Risk is a measure of the extent to which members understand their personal responsibilities for safety as well as the extent to which safety is a personal priority. Although these two elements explain a relatively low level of variance in Individual Appreciation of Risk, these findings suggest that individual with higher perceptions regarding the combination of perceptions about safety policy and risk control systems may also view safety as a higher priority and take more personal responsibility for safety.

The only element that significantly predicts Work Environment perceptions is the Vehicle Safety element of safety behaviors. The Work Environment element measures perceptions of the extent to which individuals believe that they have sufficient resources to work effectively. Resources include the people, time, and equipment that they need to get their job done. It also measures the degree to which individual recognize the inherent conflict between operational requirements and safety measures and whether their work environment hinders their ability to work safely. The Vehicle Safety element measures perceptions of safety driving practices, vehicle operating policy, and the adequacy of driver training. Although the work environment involved in firefighting and other emergency operations is inherently unsafe, it may be that the overall sense of safety associated with vehicle operations is more important in predicting the general sense that individuals have about the safety of their work environment. For example, responding to emergency incidents might make the inherent conflict between safety (driving slow enough to avoid accidents) and performance (driving fast enough to get to the emergency quickly) more explicit than other activities involved in emergency operations.

The hypothesis that perceptions of safety management and safety behaviors predict perceptions of safety climate is supported by the amount of variation in OSC that is explained by the SMS and OSC variables, and by the results of the analysis of the relationship among the elements of the variables. The safety management and safety behavior variables explain 31% of the variance in safety climate scores. In addition, when the relationship among the elements of the variables in examined, the elements of safety management and safety behaviors combine in different ways to have a large effect on Organizational Context and Social Environment, as well as a medium effect on Individual Appreciation of Risk and Work Environment. These findings suggest strong support for Hypothesis One.

While the data support Hypothesis One, the results of Confirmatory Factor Analysis indicate that the overall fit of the model is marginal for the RMSEA statistic but acceptable for the GFI statistic. The standardized regression weights and squared multiple correlations indicate that the latent variable of Organizational Safety Climate explains a low amount of variation in three of the four element of the OSC variable when compared to the elements of the other latent variables. The three elements of OSC with low indices include Social Environment, Work Environment, and Individual Appreciation of Risk. A comparison of the standardized regression weights shows that the elements of SMS and SRB range from 0.794

to 0.957 while the range for the three lowest elements of OSC is from 0.573 to 0.634. A comparison of the squared multiple correlations shows the same pattern, with the three elements of OSC having much lower indices than the elements of the other variables.

The lower ratings for these three elements of OSC indicate that the instrument used to measure safety values and beliefs may not be a good fit within the model. It is likely that the low ratings for these three elements are the cause of the overall low rating for the RMSEA index and that the GFI index would be higher as well if not for the low ratings in these elements. These findings suggest that the model may result in a better fit if another instrument is used to measure the Organizational Safety Climate variable.

The overwhelming influence of the Policy element of Safety Management Systems on three of the four elements of Organizational Safety Climate was unexpected and there are some important implications from this relationship. The items in the Policy element ask a number of questions about whether the organizations policy expresses a commitment to safety on the part of the management. These questions cover a broad range of topics that include whether safety is viewed as a core management function, the effectiveness of communications about safety issues, whether safety policies are reviewed for improvement, if the policy identifies responsibilities for safety, and whether the policy recognizes the importance of preventing injuries. As the scores in these area increase, the scores for Individual Appreciation of Risk, Organizational Context, and Social Environment also increase.

The implication is that as the evidence of a comprehensive safety policy increases, individual values and beliefs become aligned more closely with the values and beliefs that are considered desirable and that lead to improved safety performance. This relationship is reflected in the large influence that Policy has in the three element of OSC, which can be described through the influence the Policy has on the items in these elements. For example, individuals who perceive their organization to have a strong safety policy are more likely to value safety as the highest priority when responding and working at the scene of an emergency, to believe that they have a clear understanding of their individual responsibility for safety, and to believe that management considers safety of great importance. They are also more involved in informing management about safety concerns and to believe that they can influence safety performance in their organization.

As fire service managers look at this model and consider how to develop effective interventions, it is clear that the development of safety related policies represents an important consideration. A comprehensive and well defined set of policy statements appears to have a strong influence on the development of the values and beliefs that are assumed to influence behavioral choices and to improve safety performance by reducing injuries and fatalities. Although this thesis does not explore the reasons for such a strong influence of policy, it is possible that robust policy is viewed as a reflection of effective leadership and a high level of commitment to safety by the management team.

Hypothesis Two: Level by Job Function and Years of Service

The second hypothesis of this thesis makes the prediction that mean scores will vary across job functions and years of service. Analysis of variance found significant difference in job categories as a function for only one variable: Safety Management Systems. Post-hoc tests on this variable indicate that Firefighters have slightly higher scores than Company Officers and Chief Officers, and that the mean scores for Company Officers and Chief Officers are close enough that they are placed in the same subset. This could be considered an unusual finding because Firefighters and Company Officers work much more closely together than Company Officers and Chief Officers, so it might be expected that they would share many of the same perceptions. Results of the post-hoc test suggest, however, that Company Officers and Chief Officers have similar perceptions about the Policy, Organizing, and the Planning and Implementing elements of safety management.

Hypothesis two also predicts that means scores will vary across the categories of years of service. Analysis of variance found significant difference in scores across the categories of years of service that formed several patterns in the variation of scores across elements of all three variables. In the pattern of scores for the Organizational Safety Climate variable and the Organizational Context element, the means for the 0-5 and the over 20 years of service categories were so close that they were placed into the same subset with the highest scores. The middle ranges of years of service were found to have lower scores.

A second pattern emerged from the data for the Safety Related Behavior variable and the Organizing element of the Safety Management Systems variable. In this pattern, the means for the 11-15 and the 16-20 years of service categories were close enough for them to be placed in the same subset with relatively lower scores than the 0-5 years of service category. The 6-10 and the over 20 years of service categories are shared in both subsets. Slight variations of this same pattern were found in the results of post-hoc tests for the Policy and the Planning and Implementing elements of safety management, and for the Structural Firefighting element of safety behaviors.

These results suggest that with regard to perceptions of safety values and beliefs in general, the newest and presumably youngest members share the same perceptions as the members who have been on the job for 20 years or more and are presumably the oldest members. Further research and analysis will be necessary to sort out why individual in these two categories share similar perceptions of safety values and beliefs. It is much easier to speculate about why members in these categories might share similar perceptions of the Organizational Context. The items in this element ask about safety related communications, management actions and procedures, and safety rules. It is possible that the level of perception of the presence of these items is perceived to be higher for the younger and older categories because the factors they represent may be viewed as more important for members in these categories.

Analysis of differences in the level of scores by job functions and years of service revealed some surprising relationships. For example, the only significant differences in perceptions by job functions were for the Safety Management Systems variable and the Policy, Organizing, and the Planning and Implementing elements of this variable. A similar pattern was revealed in the SMS variable when examined for differenced by years of service in that the same elements of the variable showed significant differences. Although the SMS variable was the only one to show differences in level by job functions, the same elements of SMS showed significant differences for both job functions and years of service. In addition, when the variables were examined for differences by years of service, the SMS and SRB variables showed a similar pattern of difference by years of service. The pattern of difference by year of service was quite different for the OSC variable. This is an indication of that the variables used to measure practices and values have different patterns in the level of scores across categories of years of service.

The important implication of these differences in the level of scores across job functions and years of service is that it may be possible to target interventions based on these differences. For example, scores for the Organizational Context element of the OSC variable are lower for individuals in the middle range of year of service but are higher for individuals with 0-5 year and over 20 years of service. Knowing the difference in the level of scores by years of service means that an intervention can be targeted to improve this element for those individuals in the middle range of years of service. A targeted approach based on the categories of job functions and years of service may help to improve the effectiveness of interventions and to increase the efficient use of the limited resources available for the development and implementation of safety culture interventions.

The results of analysis of variance found a similar pattern of scores across years of service for the SMS and SRB variables, both of which are measures of practices. The pattern in these variables was different than the pattern found for OSC, which is a measure of values. Practices and values have been described previously as the principle variables of organizational culture. This comparative difference in the patterns of scores by years of service for practices and values provides support for the idea that the SMS and SRB variables are measures of a higher order construct since they share the same pattern. Knowing that there may be differences in the pattern of scores across year of service may also be important when examining the impact of a planned intervention. For example, changes in elements of the SMS and SRB variables may appear to have limited impact if viewed across an entire organization. When examined by differences in categories of years of service, however, the intervention may be found to have had significant impact on some categories and limited impact on others. In the same way that a targeted intervention may be useful for the development of safety culture interventions, the knowledge that interventions may have a different impact on different categories of years of service may be useful for understanding the impact of the safety culture intervention on values and beliefs.

These results provide only partial support for the hypothesis that mean scores will vary across job functions and years of service. Only the Safety Management variable demonstrated statistically significant difference across job functions, but all three variables showed significant difference across the categories of years of service. Perceptions of safety management practices are similar for individuals who work in the Company Officer and Chief Officer job categories, while Firefighters have slightly higher level of perceptions about safety management practices. The data indicate that the patterns of variation in the scores across years of service are similar for the variables that represent practices and that these patterns are slightly different for the variable that represents values and beliefs. The pattern in the practices variables indicate that individual within the middle ranges for years of service (11-16 and 16 to 20) had similar scores that are lower than the scores for the individuals with the fewest years of service (0-5). The pattern for the values variable indicate that the scores for individuals with the fewest (0-5) years of service and the most (over 20) years of service had similar scores that are higher than individuals in the middle ranges (11-15 and 16-20) for years of service.

Hypothesis Three: Strength by Job Function and Years of Service

Hypothesis three predicts that the strength of perceptions varies across job functions and years of service. Stronger perceptions are indicated by lower standard deviations, while weaker perceptions are indicated by higher standard deviations. For the SMS and SRB variables, the standard deviation represents the degree of consensus about the presence or absence of safety related management practices and work practices respectively. For the

OSC variable, the standard deviation represents the degree to which individuals hold the same values and beliefs about safety. While most studies focus on the level of the variables used to measure organizational culture, it may be more useful to focus on the strength of organizational culture because the construct is defined by the concept of shared perceptions. For the purpose of this dissertation, the degree to which perceptions are shared is measured using the standard deviation of the variables.

Results of the analysis of variance across years of service found no difference in the strength of perceptions for any of the variables and no difference in the strength of perceptions of the OSC variable across job functions. Significant differences were found for the SMS and SRB variables across job functions both for the variables and for several elements of the variables. These differences formed several patterns.

The pattern for Safety Management Systems was found to be different from the pattern for Safety Related Behaviors. This finding suggests that different variables or elements may have different strength patterns. For example, the overall pattern for safety management found Firefighters and Company Officers have similar perceptions and that these perceptions are stronger than those of Chief Officers. As members of autonomous work teams, Firefighters and Company Officers work together and share responsibility for managing safety during emergency operations, so they might be expected to share similar perceptions about this variable. The overall pattern for safety behaviors found Firefighters and Chief Officers to have different perceptions, with firefighters again having the stronger perceptions. In this case, the Company Officers share perceptions with each of the other subsets. This may reflect the role of the Company Officer as a first-line supervisor and a part of the management team. Firefighters work closely together and are directly engaged in safety practices, so they would be expected to share similar perceptions about this variable. Chief Officers are removed from directly participating in many of the safety practices that firefighters engage in because they are more involved with incident management activities such as command and control, so it is not unexpected that their perceptions about these practices would vary.

A third pattern was found in one element of safety management and one element of safety behaviors that is different from the other two patterns found at the variable level. The pattern of job functions that formed subsets is similar for both elements. The Company Officer and Chief Officer categories comprise one subset, with Firefighters comprising the other. For the safety management element (Measuring and Reviewing Performance), the Company Officers and Chief Officers subset has the stronger perceptions. For the safety behavior element (Structural Firefighting), Firefighters have the stronger perceptions. Company Officers and Chief Officers arguably share similar perceptions about measuring and reviewing performance because they are responsible for this function as supervisors and managers, whereas firefighters would not be responsible for completing any type of performance review. The difference in strength for the structural firefighting element may be the result of the type of questions contained in this element, which focus on incident communications, command and control, and personnel accountability. These are primarily the responsibility of Company Officers and Chief Officers operating at the scene of structure fire incidents, so it would be expected that they would share similar perceptions about these practices.

The results of the analysis of variance and post-hoc tests on the strength of the variables across job functions and years of service support the hypothesis that strength varies across job functions but does not support the hypothesis that strength varies across years of service. This finding indicates that whether individuals agree or disagree about the presence of safety related management practices and safety-related work practices does not depend on the number of years they have been in the organization. It also indicates that whether individual agree or disagree with desirable safety values and beliefs does not depend on their years of service. So, regardless of whether the perception of the variables is strong or weak, there is no significant difference in strength across the years of service categories.

What does make a difference in the amount of consensus on these variables is the job function that individual hold in the organization but that only applies to the SMS and SRB variables. So, there are differences in the strength of perceptions across the three categories of job functions. In this case, individuals in one job category may share the same perceptions about safety management practices while individuals in another job category may have very different perceptions about safety management practices.

While there are differences in the strength of perceptions across job functions for the two variables that represent practices, there is no significant difference in the strength of perceptions for the OSC variable across job functions. This finding indicates that the strength of safety values and beliefs is similar regardless of which job function individuals hold. As discussed previously, there is no significant difference in the strength of safety values and beliefs across years of service either. Neither of these factors is able to differentiate the strength of values and beliefs. The strength of the variables used to measure organizational culture is arguably one of the most important factors that must be considered in the development of effective interventions.

It is apparent from these findings that the years of service and job function factors do not differentiate the strength of safety values and beliefs. There are two possible explanations for these findings. The first is that some other factor can be used to differentiate the strength of safety values and beliefs (Hoffmann & Stetzer, 1996). For example, members of the same work group, who work the same shift at the same fire station, may share the same values and beliefs about safety while members at a different station on a different shift may have different values and beliefs about safety. The second possibility is that there is simply very little difference in the strength of safety values and beliefs across members of the participating organizations, which may be a reflection of an occupational level of culture with regard to values and beliefs (Wallace et al., 1999; Ouchi & Wilkins, 1985). The degree of consensus about some safety values and beliefs may be very high, indicating a strong culture for these variables or elements, while the degree of consensus for other values and beliefs may be very low, indicating a weak culture for these variables or elements, but whether they are strong or weak does not vary across job functions or years of service for the three participating organizations. What is important for the development of effective interventions, however, is to understand which variables and elements of culture are strong and which are weak so that the intervention can be targeted at making the culture stronger, which is assumed to result in better organizational performance.

Relationship Between Level and Strength

The relationship between level and strength appears to be consistent with the idea that as the level of perceptions increases, so does the strength of perceptions, depending on the variable. The strongest association among level and strength is found in the safety climate variable. The correlation coefficient for safety climate is substantially higher than the correlation between level and strength for safety management and safety behaviors. Of interest is that the association between level and strength is strongest for values and weaker for practices. Individuals may have a stronger need for internal consistency and congruency with regard to values as an individual factor than for practices as an organizational factor. As a result, as perceptions of factors increase, individual perceptions also become stronger to maintain congruency with currently held values and beliefs. This may be an important factor in the normalization of high risk behaviors, but is beyond the scope of this research. However, these findings point out the value of exploring the nature and characteristics of the relationship among variables based on the strength of perceptions and not just the level of perceptions.

The relationship between level and strength can be visualized by putting each element of the variables into a table that shows where each element falls. The elements can be divided into those that are high or low by using the score of 3.50 to differentiate the levels. The safety culture rating scale proposed by Cooper (2008) puts this score at the high end of the Average score category, so this number was used to divide high scores from low scores based on the assumption that high scores are above average and low scores are average and below. For the purpose of demonstrating how the elements can be categorized, the elements are subjectively divided into weak and strong scores by dividing the range of scores in half, which resulted in the standard deviation of 0.65 as the dividing score. The following table shows how each of the elements would be placed into the categories for level and strength.

As the table shows, all of the elements of the Safety Management Systems variable fall into the Low and Weak category. While all of the Organizational Safety Climate elements fall into the Strong category, the Individual Appreciation of Risk and Social

Environment elements fall into the High category and the Organizational Context and Work Environment elements fall into the Low category. The ability to categorize the elements of the variables using both Level and Strength as variables provides a much greater understanding of the culture that exists in an organization. As an example, if just the Level variable is used to assess culture, then Safety Related Behaviors would be rated as high while Safety Management Systems and Organizational Safety Climate would be rated as low.

Table 57

Level and Strength by Element

	Weak	Strong
High	SRB Training	SRB Structural Firefighting OSC Individual Appreciation of Risk OSC Social Environment
Low	SMS Policy SMS Organizing SMS Planning and Implementing SMS Measuring and Reviewing SRB Vehicle Safety	SRB Fitness/Medical OSC Organizational Context OSC Work Environment

Categorizing the elements of the variables by level and strength also highlights interesting aspects of the relationship between the independent and dependent variables. For example, because of the strong influence that the Policy element has on explaining much of the variation in the elements of Organizational Safety Climate, it might be expected that this element would fall into the High and Strong category. As shown in the table, however, the Policy element falls into the Low and Weak category, along with all the other element of Safety Management Systems. If the Policy element has such a strong influence on elements of OSC when rated Low and with a relatively low amount of agreement about Policy practices, it would be interesting to see how much that influence might increase after an intervention intended to bring that element into the High and Strong category.

Many research studies examine only the level of the variables of organizational culture (Hofstede, 1998; Deshpande & Farley, 2004; Marcoulides & Heck, 1993; Balthazard et al., 2006; Rad, 2006; Rashid ete al., 2004; Hofstede et al., 1990; Parker & Bradley, 2000; Ostrom et al., 1993; Clarke, 1999). Instruments are developed to measure the variables of organizational culture and the data are collected and analyzed, but the assessment of organizational culture is limited to the level or average score for each variable. Culture is referred to as being strong if scores are high, but the amount of variation in the scores is not examined. The amount of variation in scores determines whether perceptions are shared by members of the organization or to what degree they are shared, and is a more accurate measure of the presence of organizational culture. Because they measure different aspects of the organizational culture variables, the inclusion of both Level and Strength as factors for the assessment and analysis of organizational culture provides a deeper understanding of the nature and characteristics of culture.

If managers have a better understanding of the culture in their organization, they will be able to develop more effective interventions to change behaviors and improve organizational performance. For example, the Vehicle Safety element is both low and weak, which means that members perceive that there is little evidence that members participate in vehicle safety practices. Vehicle safety practices include the following: an adequate driver training program; all persons riding on the apparatus use seat belts; emergency vehicles come to a full stop at intersections; drivers do not exceed a safe speed; and that supervisors take corrective action when a violation of safe driving practices occur. The Vehicle Safety practices are particularly important because of the high incidence of injuries and fatalities that occur while responding to emergencies, so this element might be one that a fire department would want to target first for an improvement intervention. The ability to assess safety culture using the level and strength of the elements of the variables of culture allows managers to develop interventions that are focused on specific practices, such as those listed above. Rather than trying to change organizational culture as a whole, this approach breaks down the effort to change and improve organizational culture into manageable elements. The assumption here is that targeting change and improvement efforts at manageable elements of culture is a more practical and effective approach.

Organizational Level Results

The discussion in this section focuses on the results of analysis at the organizational level. Aggregation of the data from the individual level to the organizational level is supported by the ICC coefficient for each organization and by the results of the analysis of variance of the elements of the variables for each department. An adequate ICC coefficient means there is enough within group homogeneity to justify aggregation of the data. Significant differences in the elements of the variables across the three participating organizations means there is also enough between group variance to justify aggregation. After determining that the data could be aggregated, the analysis of the data was conducted using the same statistical methodology used previously to test the three hypotheses associated with research question three. These are discussed in more detail and comparisons made about the differences and similarities found across the three organizations that participated in the pilot study.

Relationship among the variables by department.

Results of the regression analysis for the three organizations in the pilot study indicate that the independent variables explain different amount of variation in the dependent variable for each organization. For Department A, the model explains 35% of the variation in OSC, with SMS explaining twice as much variation in OSC than the SRB variable does. For Department B, the model explains 39% of the variation in OSC, with SRB explaining a large percentage of the variation in OSC, but SMS does not make a significant contribution toward explaining the variation in OSC at all. For Department C, the model explains 29% of the variation in OSC, with SMS and SRB explaining an approximately equal amount of variation in OSC. From these results, the conclusion can be made that safety management practices and work practices have a different level of influence on safety values in each organization. This is the first indication that safety culture is different for each organization, at least in terms of the nature of the relationship among the variables.

Several factors may explain the differences in the relationship among the variables. While the participating organizations were selected for this pilot study in part because of their similarities, they may emphasize different aspects of safety culture. For example, Department A may emphasize safety management practices more than safety work practices while Department C may emphasize both of these practices more equally and Department B emphasizes safety work practices only. Another possibility is that the level and strength of the safety practices influences the amount of variation that these factors explain in safety values and beliefs. The mean scores and standard deviations for the variables across each department indicate that the safety management variable is weakest for Department B and gradually gets stronger for Department A and Department C. This gradual increase in strength is consistent with the gradual increase in the amount of variation in the OSC variable explained by the SMS variable. At least for the SMS variable, it appears that as strength increases, the impact of this variable on the OSC variable also increases.

The impact of strength is not the same, however, for the safety work practices variable. The standard deviation for the SRB variable for Department B is the highest of all three departments, indicating that the strength of this variable for Department B is the weakest of all three departments, and yet this variable explains the most variation in the OSC variable across all three departments. The differences in how the level and strength influence the relationship among the variables may be another factor that differentiates safety culture across organizations. Safety culture may be different in each organization not only in terms of the relationship among the variables but also in terms of how the level and strength of variables influences that relationship.

As might be expected, the relationship among the elements of the SMS and SRB variables and the elements of the OSC variable are different for each organization although there are some similarities in the relationship among the elements as well. As discussed previously, the Policy element of safety management practices has the most influence on element of the OSC variable. When examining the relationship among the elements of the variables, it is clear that the Policy element has the most influence on both the amount of variation in the elements and the number of the OSC elements influenced. The Policy element has the strongest influence on the Organizational Context element of the OSC variable for all three departments and also has a significant impact on the Social Environment element for Departments A and C. In addition, the Policy element has a significant influence on all four elements of the OSC variable for Department C. The data showing the relationship among the elements of the variables can be found in Table 56.

The level of detail provided by examining the relationship among the elements of the variables is important information for managers because it helps them to better understand the safety culture in their organization. The relationship among the elements of the variables is different for each organization, which means that the interventions designed to create change and improvement in safety culture will be different for each organization. For example, a manager in Department B would expect that making changes in safety policy should result in changes in perceptions related to the organizational context of safety, whereas a manager in Department C should expect to see changes in all four elements of safety values and beliefs. The knowledge about which elements of the SMS and SRB variables are likely to have the most influence on which elements of the OSC variable can help managers to anticipate how changes in safety practices will influence safety values and beliefs.

While the relationship among the element appears to be different for each organization, the amount of influence that the elements of the SMS and SRB variables has on the elements of the OSC variable is surprisingly similar for all three organizations. The overall influence of the SMS and SRB elements on each element of the OSC variable is indicated by the adjusted R^2 values shown in Table 56.

In general, the elements of the SMS and SRB variables explain a similar amount of variation in each of the elements of the OSC variables in the same order. They explain the most variation in the Organizational Context, followed by the Social Environment, Individual Appreciation of Risk, and Work Environment elements. The amount of variation explained in each of the OSC elements is also very similar. For the Organizational Context element, the R^2 values range from .317 to .351, indicating that the amount of variation explained in this element is very similar across all three organizations. The pattern in the amount of variation explained changes somewhat for the other three OSC elements. For two of the three departments, the amount of variation in the Social Environment, Individual Appreciation of Risk, and Work Environment element is almost identical at approximately 30%, 22%, and 19% respectively. The amount of variation in the OSC elements explained in Department C is lower and the pattern is slightly different in terms of the order of the amount of variation explained, but the overall pattern of the order and amount of variation explained in the elements of the OSC variable is surprising given all the other differences in the relationship among the variables across the three departments.

Another interesting finding in the relationship among the elements of the variables is that despite the lack of a significant relationship between the SRB variable and the OSC variable for Department B, two of the elements of the SRB variable have a significant influence on two of the elements of the OSC variable. The regression analysis shown in Table 56 indicates that the Policy element has a significant influence on the Organizational Context element and the Organizing element has a significant influence on the Individual Appreciation of risk element. In addition, despite the large amount of variation in OSC explained by the SRB variable for Department B, the only significant relationship among the elements is between the Vehicle Safety element of the SRB variable and the Work Environment element of the OSC variable. There are a limited number of statistically significant relationships among the elements in each of the three departments, which indicates that even though many of the elements of the SMS and SRB variables do not have statistically significant influence on the elements of the OSC variable, they do contribute to the overall relationship.

Data Presentation Format

An important consideration for this pilot study is the need to present the data in a form that is understandable and usable for fire service managers. A number of studies involving organizational culture and safety culture have used radar charts to present scores for variables (Balthazard et al., 2006; van Muijen et al., 1999; Denison, 1991; Parker & Bradley, 2000). Radar charts can provide a graphic comparison of scores for the variables and elements of safety culture for individual fire departments and can also be used to compare scores across a number of departments. Fire department managers can easily identify low or high scores on a radar chart, which provides a starting point for further analysis of the data and the development of a plan for improving specific elements of safety management or safety behaviors.

Radar charts have been produced for the level and strength of the elements of safety culture for each department in the pilot study to provide a graphic display of the data that is easy to understand and interpret. In the following three figures (Figures 21-23), the level of each element is displayed in the radar chart format. The scale for the radar charts ranges from one to five, which corresponds to the Likert scales used in the questionnaires. Around the radar chart are the individual elements of each variable. From the twelve o'clock position on the chart and moving clockwise, these include the elements of safety climate, safety management, and safety behaviors. This format provides a visual presentation for fire service managers of the safety culture profile for their department.

A graphic comparison among the three participating departments for the level of each element is provided in Figure 24. It is not difficult to visualize the pattern of scores for the level of the elements using radar charts as the presentation format. Using the rating scale developed by Cooper (2008), scores for Individual Appreciation of Risk and Structural Firefighting are Good, while most of the other scores are Average. Perceptions of Work Environment have the lowest scores, but are still within the Average range.

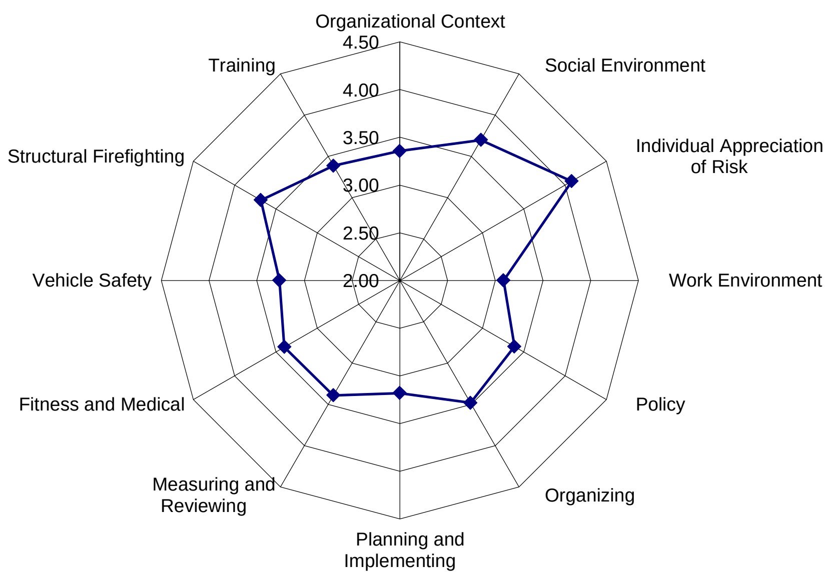

Figure 21. Safety Culture Level Department A

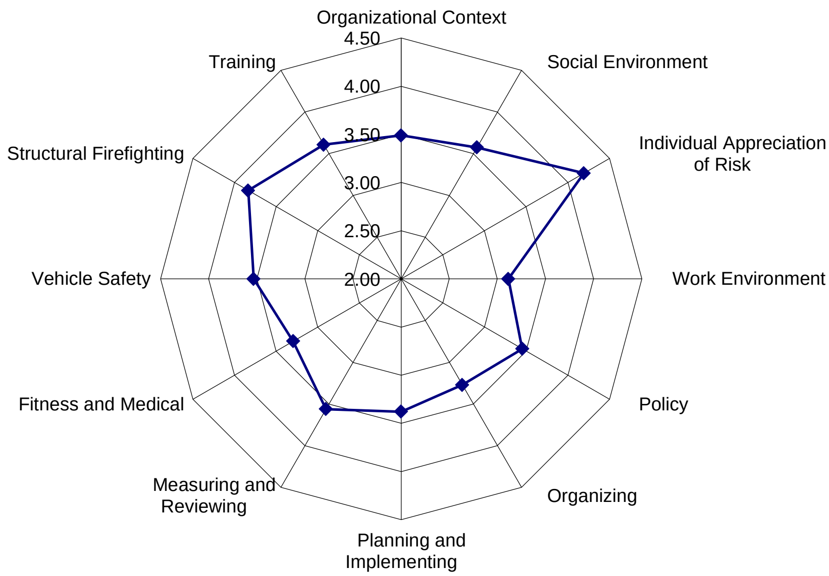

Figure 22. Safety Culture Level Department B

Figure 23. Safety Culture Level Department C

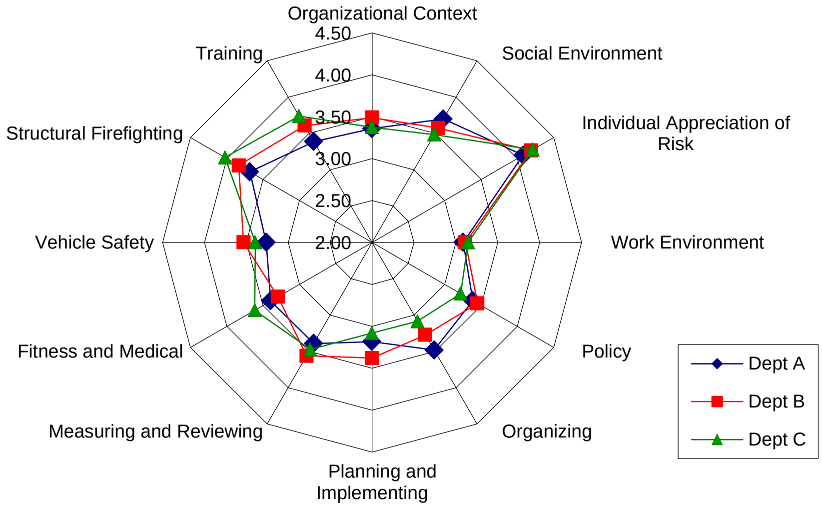

Figure 24. Safety Culture Level Comparison

The radar chart format can also be used to present data on the strength of the elements of safety culture. Using the same basic format for listing of the elements of safety culture around the radar chart, the following three figures (Figures 25-27) provide a graphic presentation of the strength of the elements for each department. The scale for strength is based on the standard deviation for the elements. This means that higher standard deviation scores indicate more variation in the scores, which is an indication of a weak element. Also, the scale range used for indicating the strength of scores for strength is 0.0 to 1.0 because standard deviations would not exceed 1.0 for any of the elements.

A comparison of the strength of safety culture is provided in Figure 28. Surprisingly, the three participating departments share a similar pattern not only in the level of the elements, but in the strength of the elements as well. It is interesting to note in comparing the patterns across participating departments for level and strength that the data indicates perceptions of Individual Appreciation of Risk are generally high and strong, whereas perceptions of the Work Environment are generally low and weak. The same pattern is apparent in the Structural Firefighting element, which appears to be high and strong compared to other elements, such as Organizational Context, which is low and weak. Perceptions of the Vehicle Safety element are also low and weak. The comparative radar chart also shows that Department C has the highest amount of variation in scores, indicated by the higher standard deviations for several elements. This is notable because Department C also had the highest response rate, which might lead to the expectation they would have the lowest level of variation in scores because of the greater number of respondents.

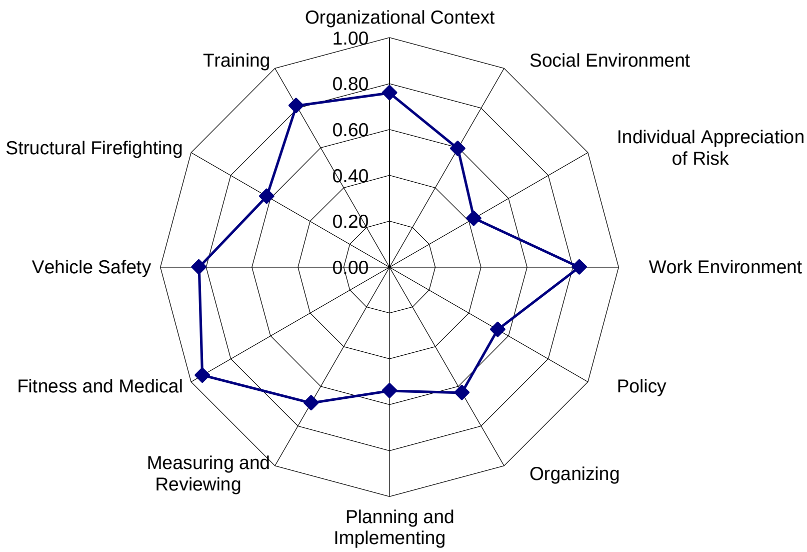

Figure 25. Safety Culture Strength Department A

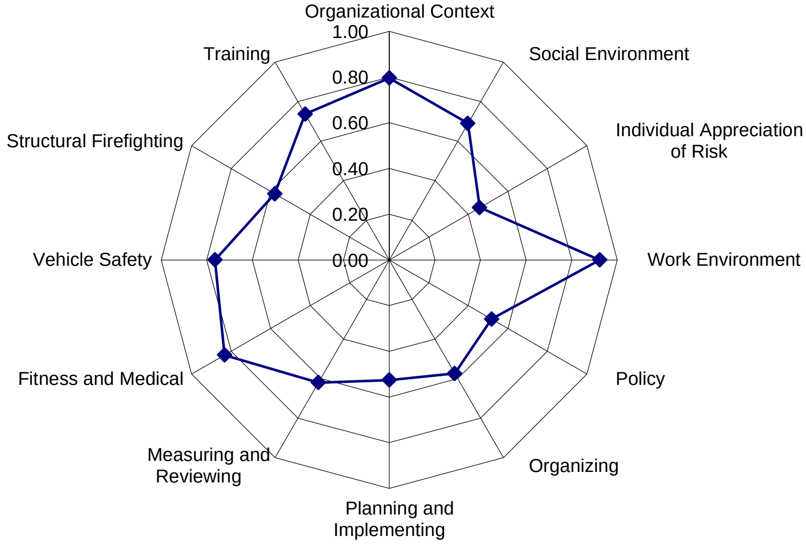

Figure 26. Safety Culture Strength Department B

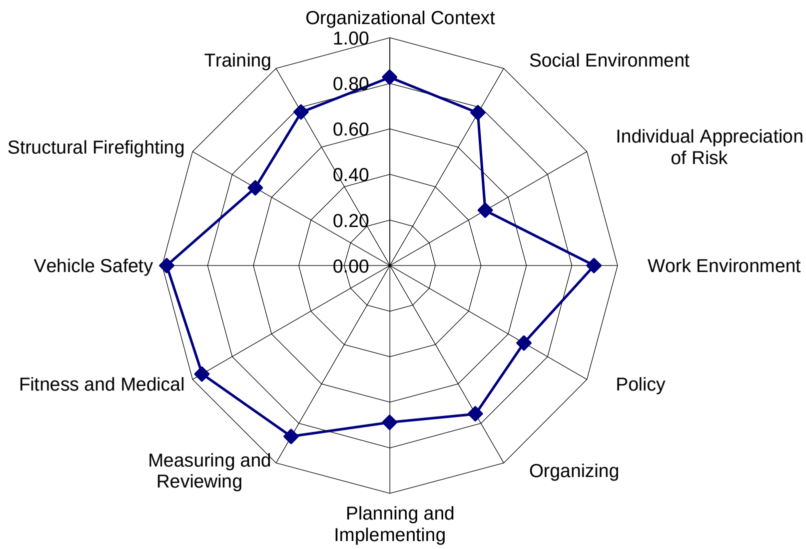

Figure 27. Safety Culture Strength Department C

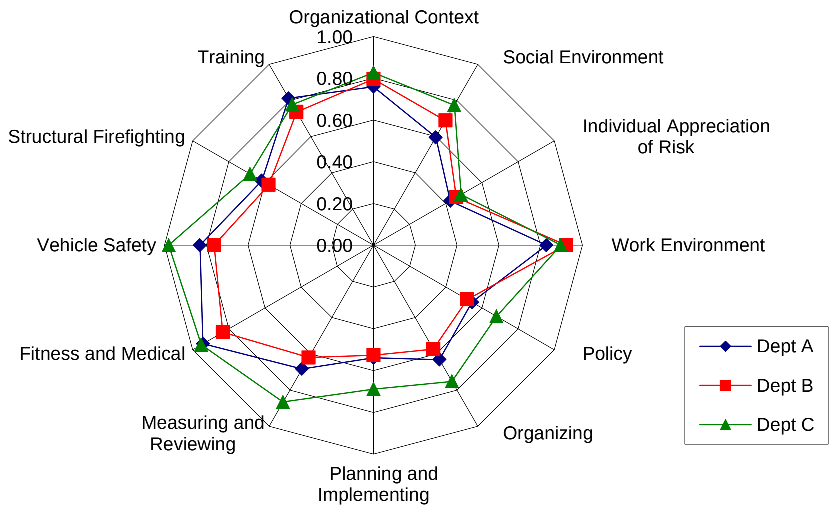

Figure 28. Safety Culture Strength Comparison

Level and strength of variables by department.

Two of the graphs shown previously depict the level and strength of the elements of the variable for each of the participating fire departments. The graph labeled Figure 24 shows the level of the elements and the graph labeled Figure 28 shows the strength of the elements for each department.

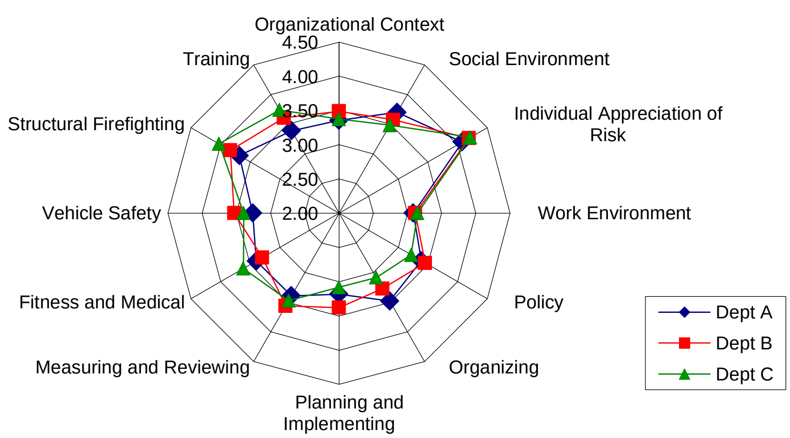

Figure 24. Comparison of Safety Culture Level by Department

As a reminder, level refers to the mean score for the elements for each department. An examination of Figure 24 indicates that the level for most of the elements appear to be very similar for the three departments. The exceptions are the Organizing and the Planning and Implementing elements of the SMS variable and all four of the elements of the SRB variable. These include the Fitness/medical, Vehicle Safety, Structural Firefighting, and Training elements. While there is some difference in the scores for these elements, the magnitude of the differences is small. Scores can range from 1.0 to 5.0 for level and yet none of the scores on the elements are more than 0.39 points apart, which is a difference of about 10 percent of the entire range of scores. In addition, it is apparent from the graph that the scores for the three different departments appear to have the same relative level for each element, which is indicated by the similar shape of the graph for each department. For example, the score for Work Environment is low for all three department while the score for Individual Appreciation of Risk is high all three departments.

If the level of the scores for the variables were the only factor used to analyze and assess safety culture, it would be logical to conclude that the culture for all three of these departments is the same, since the level of the scores are all very similar and the pattern of the scores is also very similar. For many if not most studies, the level of scores on the variables used to define organizational culture is the main factor used to draw conclusions about the similarities and differences across organizations. Using only one factor to measure organizational culture, however, does not provide a comprehensive analysis of the complex relationship among the variables. The previous discussion on the relationship among the elements of the variables based in the results of multiple regression analysis showed that the relationship among the variables can be quite different for organizations, even when the level of the scores are quite similar. The inclusion of several factors in the analysis and assessment of organizational culture provides academics with much more useful information from which to draw conclusions about the nature of the relationship among the variables and to guide the development of future research. It also provides practitioners with a better understanding of the culture in their organization that can be used to develop more effective interventions.

A comprehensive approach should include a means for analyzing the relationship among the variables, the level of the variables, and the strength of the variables as well. A comparison of the strength of the elements of the variables is provided in Figure 28. Again, as a reminder, the standard deviation of the elements is used as the measure of strength. Higher standard deviations indicate weak cultural elements while lower standard deviations indicate strong cultural elements.

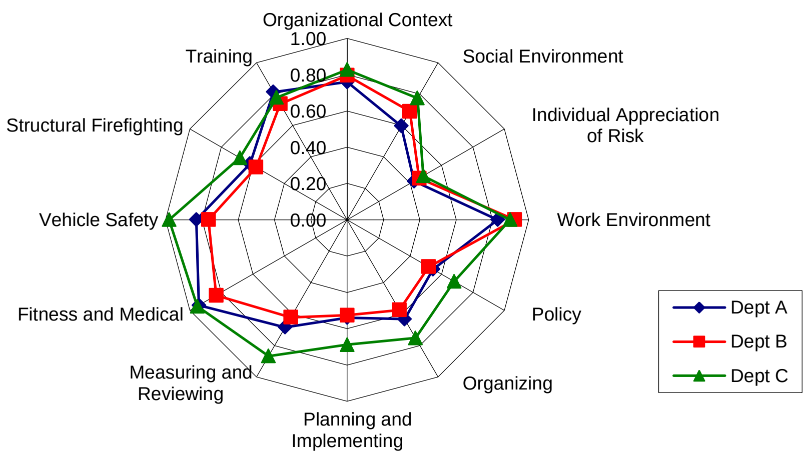

Figure 28. Comparison of Safety Culture Strength by Department

The standard deviation statistic is a measure of how much the distribution of scores deviates from the mean. The range of scoring for standard deviations is 0.0 to 1.0, with low scores indicting very little deviation from the mean and high scores indicating larger amounts of deviation from the mean. A weak culture is one in which there is larger amounts of variation from the mean, while a strong culture is one in which there are smaller amounts of variation from the mean. As discussed earlier, this may be a better measure of the presence or absence of organizational culture, since the principle concept of culture is the idea that perceptions are shared among members of an organization, which would be indicated by low standard deviations on the variables.

The graph for the strength of the elements shows that the pattern of stronger and weaker elements is similar for each of the three departments. For example, the Individual Appreciation of Risk element is strong for all three departments as indicated by the lower standard deviation, compared to the Work Environment element, which is weak for all three departments as indicated by the higher standard deviation. While the pattern of the strength of the elements is similar across departments, there are larger differences in the standard deviation scores for several elements. For example, the difference in the standard deviation for the Measuring and Reviewing element is 0.20 standard deviation, or about 20% of the range of scores. This is twice the amount of difference in scores for strength than the difference in scores for level. In addition, more of the elements have greater differences in scores. As indicated in Figure 28, all of the SMS elements (Policy, Organizing, Planning and Implementing, and Measuring and Reviewing) have relatively large differences in scores compared to the elements of the OSC variable (Organizational Context, Social Environment, Individual Appreciation of Risk, and Work Environment). Within the SRB variable, two of the elements have larger differences in strength (Vehicle Safety and Fitness and Medical) while two others have smaller differences in strength (Training and Structural Firefighting).

Differences in the strength of the elements indicate that there is more variability among the departments in the strength of scores then there is for the level of scores. The largest difference in scores for level is approximately 10% of the range while the difference in scores for level is approximately 20% of the range. In addition, six of the elements have large differences in scores for strength while only three of the elements have large differences in scores for level. A comparison of the findings for level and strength suggests that the safety culture for the participating departments is similar in terms of the level of scores but that there is more variation in the strength of scores.

The scores for the Measuring and Reviewing performance element provide an example of how scores for level and strength differ across organizations. The scores for level on this element are very similar at approximately 3.50, which as an average score. The scores for strength vary more widely, indicating that there is more agreement about the level of scores on this element for some departments and less agreement about the level of scores for others. The standard deviation for this element in Department B is 0.62 but is 0.87 for Department C, indicating a strong culture for one department and a weak culture for the other department, even though the level of scores for these departments are very close.

The relationship between level and strength may be an important factor in the development of effective intervention strategies. Within the three participating fire departments, there are some similarities and differences in the pattern of which elements are weak or strong and which are high or low. The distribution of the elements into categories of weak or strong and high or low is shown in Tables 58 through 60 for Departments A, B, and C respectively.

The pattern for how the elements fall into the categories is similar in that some of the elements fall into the same category for all three departments. The Organizational Context and Work Environment elements of the OSC variable, for example, fall into the Low/Strong category for all three departments. There are also some differences in that the same element falls into different categories for each of the three departments. For example, the Fitness/Medical element falls into the Low/Strong category for Department A, the Low/Weak category for Department B, and the High/Strong category for Department C.

Table 58

Relationship Between Level and Strength for Department A

	Weak	Strong
High		SRB Structural Firefighting OSC Social Environment OSC Individual Appreciation of Risk
Low	SMS Organizing SMS Planning/Implementing SRB Training	SMS Policy SMS Measuring and Reviewing SRB Fitness/Medical SRB Vehicle Safety OSC Organizational Context OSC Work Environment

Table 59

Relationship Between Level and Strength for Department B

	Weak	Strong
High	SMS Measuring and Reviewing SRB Vehicle Safety SRB Structural Firefighting SRB Training	OSC Social Environment OSC Individual Appreciation of Risk
Low	SMS Policy SMS Organizing SMS Planning/Implementing SRB Fitness/Medical	OSC Organizational Context OSC Work Environment

Table 60

Relationship Between Level and Strength for Department C

	Weak	Strong
High	SRB Training	SRB Fitness/Medical SRB Structural Firefighting OSC Individual Appreciation of Risk
Low	SMS Policy SMS Organizing SMS Planning/Implementing SRB Vehicle Safety	SMS Measuring and Reviewing OSC Organizational Context OSC Social Environment OSC Work Environment

Development of an effective intervention strategy should be focused on the elements of the Safety Management Systems and Safety Related Behavior variables. As discussed earlier, these variables are under the direct control of managers and are easier to change than the values and beliefs measured by the Organizational Safety Climate variable. The SMS and SRB elements should then be prioritized to determine which elements are the most important to change first. Elements can be prioritized based on which will have the most impact on improving safety performance or by the three categories of Level and Strength with the exception of the High/Strong category, since no change is needed for any elements in this category.

A high priority element that is likely to significantly improve safety performance is the Vehicle Safety element of the SRB variable. All three departments may decide to develop an intervention strategy for this element because of the anticipated impact on safety performance but the strategy for effectively changing this element of safety culture may look very different for each department. A different strategy would be developed in each department because the element has different scores for Level and Strength in each. For example, the Vehicle Safety element falls into the Low/Strong category for Department A, the High/Weak category for Department B, and the Low/Weak category for Department C. The strategy for Department A will focus on improving the level for this element from Low to High. The strategy for Department B will focus on improving the strength from Weak to Strong. The strategy for Department C will focus on improving the level from Low to High and the strength from Weak to Strong. Each of the strategies will likely be very different in each department even though each is attempting to change and improve the same element.

Another approach to prioritizing the elements is to decide which category of Level and Strength should be targeted first. For example, Department A may decide that the SMS and SRB elements in the Low/Strong category are the highest priority because agreement is strong that the level is low, which may provide a higher level of motivation for change. There are four of the SMS/SRB elements in this category, so it would also be necessary to prioritize the elements within the category. Because of the strong influence of the Policy element on elements of the OSC variable, this element may be the highest priority within the category of the Vehicle Safety element may be selected as the highest priority because of a high number of vehicle accidents in the department.

Other departments may decide that other categories are a higher priority or are easier to change. For example, Department B may decide that the High/Weak category should be the highest priority for the development of an intervention. For this category, the intervention might first attempt to determine if the perceptions of the Structural Firefighting element are weak because of misperceptions about these practices or if they are simply not part of structural firefighting operations.

The effort here is to determine if the structural firefighting element of safety culture is weak because the practices are present and members are not aware of their presence or if it is because the practices are absent from firefighting operations. For example, a number of the questions in the Structural Firefighting element ask about the appropriate use of the incident command system to manage fireground operations. It may be that Company Officers and Chief Officers do in fact establish and operate an effective incident command system, but if firefighters are not aware of the objective occurrence of these practices then that would likely lead to differences in perceptions about these practices. Different perceptions about practices will result in a high standard deviation for scores on this element, which is the definition of a Weak cultural element. If it is determined that these practices do occur, then the strategy should be focused on improving communication about the use of the incident command system. A re-assessment of this element may then show that the scores have moved from Weak to Strong, which would indicate a successful intervention. If it is determined that the practices do not occur, then the strategy would focus on improving the use of the incident command system during emergency operations.

Finally, some departments may decide that the Low/Weak category is the highest priority because elements in this category need the most improvement. The strategy for interventions would be to improve both the Level and Strength of these elements of safety culture at the same time. For example, Department C may decide to improve the SMS elements of Policy, Organizing, and Planning and Implementing. A strategy for improving the level and strength of these elements may include a comprehensive review of the entire safety management program by a project team that includes members of the department from different ranks stations throughout the department. This strategy would be intended to improve the level of these elements through the review and improvement of the safety management program and would strengthen the perceptions about the safety management program by involving members of the department in the process.

The Level and Strength of safety culture are both important variables to consider in the development of interventions intended to change and improve safety performance. Most research studies use the level of variables as the factor that defines and describes an organizations culture. The argument has been made here that organizational culture and sub-cultures, such as safety culture, is a more complex phenomenon that requires a more comprehensive approach. A more comprehensive approach includes several factors in the analysis and assessment of organizational culture. These include the level of variables, the strength of variables, and the relationship between level and strength. Using this approach to the analysis and assessment of organizational culture variables provides better understanding the relationship among the variables, which can be used to prioritize the variables for change and to develop more effective intervention strategies.

Summary

The purpose of this chapter has been to discuss the results from the analysis of the data collected on safety culture. The discussion has focused on the three hypotheses developed to answer the third research question of this pilot study about the nature of the relationship among the variables of safety culture. The discussion initially explored the individual level results and then moved to a discussion of the organizational level results.

At the individual level of analysis, the model developed in this pilot study appears to be robust in that over thirty percent of the variation in perceptions of safety climate is explained by the combination of safety management and safety behavior perceptions.

Overall, perceptions of safety management and safety behaviors have almost the same level of influence on safety climate, as indicated by the beta weights for each. Results of the multiple regression analysis of the variables support the hypothesis that the SMS and SRB variables explain a statistically significant and large amount of variation in the OSC variable. This holds true for the analysis of the relationship among the elements of the variables as well.

The analysis of the relationship among the elements of the variables showed that the Policy element of safety management plays an important role in shaping perceptions of safety climate. The Policy element has a significant role in the relationship with three of the four elements of safety culture. Understanding the importance of different elements in the relationship among the variables is an example of the value of a comprehensive model in the development of planned change in safety culture. It seems clear that Policy, for example, is an important factor in the development of individual values and beliefs about safety and may have a significant influence on subsequent behaviors.

Analysis of the standard deviation for the variables shows that there is more variation in scores for the Safety Management Systems and Safety Related Behaviors variables and less variation for the Organizational Safety Climate variable. This indicates that there is more disagreement about practices and more agreement about values in the fire service organizations that participated in the pilot study. The differences in the level of agreement about practices and values is an interesting finding because it supports the proposition that the two main variables of culture are practices and values and the argument that values are more difficult to change than practices. One of the reasons that values may be more difficult to change is because there may be a high level of agreement about safety related values across the fire service at the occupational level.

The conceptual model of safety culture was assessed using Confirmatory Factor Analysis, the results of which indicate that the model and variables used to measure the variables is a marginal fit at best. One of the reasons for the relatively low fit on the RMSEA index may be the similarities in the work environment across the three participating organizations. Another possible cause is that the instrument used to measure the Organizational Safety Climate variable is not a good measure of the variable, since the Standardized Regression Weights and the Squared Multiple Correlations were very low for three of the four elements for this variable.

The discussion on the second hypothesis explored how the level of scores varied across job functions and years of service. Results of the analysis of variance support the hypothesis that the level of scores varies across job functions for the SMS variable and that the level of scores varies across year of service for all the variables of safety culture. The patterns in the variation of the scores were discussed and possible explanations for these differences were presented for consideration.

The discussion on the third hypothesis explored how the strength of scores varied across job functions and years of service. No difference in scores was found in strength for any of the variables across year of service or for the strength of scores for the OSC variable across job functions. Significant differences were found in the strength of scores for the SMS and SRB variables across job functions. The strength of scores across job functions also presented some interesting patterns of variation. These were discussed and possible explanations were presented.

The discussion about the relationship between level and strength described how these two factors could be used to better understand safety culture. The argument was made that while each of these factors on their own provides valuable information about safety culture, it is also important to examine the relationship between level and strength for each element. Knowledge of whether the elements have a high or low level and whether the elements are strong or weak can be used to develop more effective intervention strategies for change and improvement in safety culture.

At the organizational level, the model explains from 29% to 39 % of the variation in the OSC variable in the three participating organizations. Examination of the relationship among the variables showed that the SMS and SRB variables contributed differently to the variation in the OSC variable for each department. This is an indication that the safety cultures of the three organizations are different in terms of the nature of the relationship among the variables. The nature of the relationship among the elements of the variables is also different for the three organizations, providing even stronger support for the proposition that the safety culture of organizations may be very different in terms of the relationship among the elements of the variables.

The discussion about the similarities and differences in the level and strength of the variables across organizations explored how these factors can be used to develop effective interventions for improving safety culture. Results of the analysis of these factors showed that the level and strength of the element of the variables is different in important ways across the participating organizations. The argument was made that knowledge about how level and strength varies within an organization can be used to prioritize interventions and to develop appropriate intervention strategies that will result in effective change.

Throughout the discussion in this chapter the argument is made that the analysis and assessment of organizational culture should not be limited to the level of scores on variables used to measure the construct. A comprehensive approach to the analysis of organizational culture or any organizational sub-culture should include the following factors: the structure or characteristics of the relationship among the variables; the level of the variables; and the strength of the variables.

The pattern of the relationship among the variables and elements will explain which of the independent variables have the most influence on the dependent variables and how the relationship among these variables is unique for each organization. Similarly, data on the level and strength of culture within each organization is likely to be unique, so it is important for managers to understand all three of these factors to determine which elements of organizational culture are most important and to develop effective strategies for changing and improving these elements. Although the level of scores is used most frequently to assess organizational culture, it is argued that the strength of scores is a better indicator of the existence of organizational culture, which is defined by the existence of shared perceptions. If perceptions are not shared, then the culture is weak or non-existent. A better approach is to determine the degree to which members share perceptions in the organization by evaluating the strength of the variables, then to determine whether members perceive the presence of the variables by evaluating the level of scores for the variables, and to also include the assessment and analysis of the relationship among the variables and elements to better understand how the variables interact and influence one another.

Strengths and Limitations

This research has several strengths from both a theoretical and practical perspective. From a theoretical perspective, the model is parsimonious and the measures are both reliable and valid. In addition, the results provide three different quantitative perspectives on safety culture. From a practical perspective, the model and measures can be used to develop interventions designed to change safety culture and improve safety performance. This pilot study is limited, however, in that only three fire departments were used in the pilot study and all of these are of the same type serving similar communities. In addition, the pilot study examines the relationship among the variables of safety culture but cannot make any assertions about the causal nature of these relationships. The strengths and limitations of the pilot study are discussed in more detail in the following paragraphs.

The most important factor in the strength of this research is the integrated approach that has been used to the development of a model, measures and instruments for assessing and analyzing safety culture. This research integrates the functional and interpretive approaches and the variables used in both culture and climate studies into a parsimonious model of safety culture. The instruments used to measure the variables of the model are another indication of the strength of this research. The instruments used to assess and analyze safety culture have been demonstrated to be reliable and valid measures of the variables. Also, because the model is relatively simple, it should be relatively easy for fire department members to understand, particularly the graphic display of data on the strength and level of the variables.

The results of this research are another strong point in that safety culture can be assesses and analyzed from three different perspectives. First, the level of the variables, elements, sub-elements and items can be examined to determine which of these are high or low and if any pattern exists in these findings. Second, the strength of perceptions of the variables, elements, sub-elements and items can also be examined to determine which are strong or weak and if any patterns exist in these findings as well. Third, the nature and characteristics of the relationship among the variables can be explored. Results of the multiple regression analysis provide valuable information on which predictor variables have the most influence on the elements of safety culture and how much of the variation in the elements is accounted for by the predictor variables.

Another strong point of this research is the practical application of the model, measures and instruments. Results of the assessment and analysis can be displayed easily so that fire service managers can decide which of the elements, sub-elements or items are most important. Based on these priorities, they can then develop interventions designed to increase the level and/or strength of the most important factors. Although additional research will be required to determine the nature of the relationship between safety culture and safety performance using this model, there is sufficient evidence in other research regarding this relationship to recommend that the model be used in efforts to improve safety performance in the fire service (Cooper, 2001; Lok & Crawford, 1999; Schraeder et al., 2005).

Several limitations are evident in this pilot study. Although at the individual level the number of cases is high, with over 1000 participants, the number of cases at the organizational level is low, with only three fire departments participating in the pilot study. This raises concerns about the generalizability of the findings, particularly to other types of fire service organizations. The three departments participating in the pilot study are all career or fully paid members. Results from this pilot study may not be generalizable to all volunteer departments or even to combination departments that consist of both paid and volunteer members.

Another limitation of this pilot study is that although the results provide a large amount of information about the relationship among the variables, no assertions can be made about the causal nature of these relationships. To determine if a causal relationship exists between safety management and safety behaviors as independent variables and safety climate as a dependent variable, the model would have to be tested experimentally. This could be accomplished by randomly assigning work teams in a fire department into experimental and control groups. The safety culture of the groups would be assessed in a pre-test. A safety culture improvement plan would then be developed from the findings of the pre-test assessment. The experimental group would then be subject to the intervention, which would involve efforts to increase the strength and/or level of several elements of the independent variables. The safety culture of the experimental and control groups would then be re-assessed in the post-test to first determine whether any change occurred in the elements included in the intervention, and then to determine whether any change occurred in the elements of safety climate. An experimental approach to exploring the relationship among the variables would provide valuable information about the causal nature of the relationship, but would be difficult to complete. In addition, it might take several months if not years to complete the pre-test, intervention, and post-test process.

In addition, the interpretation and conclusions are limited by the focus on quantitative results and the lack of qualitative data. The addition of qualitative methods as part of the research methodology would provide a deeper understanding of the social meaning and social relationships that represent the work environment and the construct of safety culture.

Qualitative information might also help clarify and explain the quantitative findings, suggest new interpretations, and open new lines if inquiry (Needleman & Needleman, 1996). The inclusion of qualitative methods, such as structured interviews, would also provide a better understanding of the socially constructed and subjective interpretations of the work environment in four specific ways. First, the narrative analysis of qualitative information provides important information about the history of participating organizations that can be used to develop more effective interventions. For example, qualitative data provides insights into how organizational members define the problem, how they view cause and effect relationships, and the social dynamics in the organization. Second, qualitative data can be used to correct for the oversimplification that inherently results from the reduction of complex social phenomenon into quantitative data. Third, qualitative methods can be used to help interpret results, understand meaning, and to develop conclusions that explain the reasons for the quantitative results. Lastly, qualitative methods maximize the opportunity to challenge basic assumptions that framed the initial research, to reframe the issues that need to be studied, and to conceptualize the research problem in new ways. It would be possible to obtain qualitative information by conducting structure interviews with a sample of members from those organizations participating in the pilot study.

Recommendations for Future Research

Using the framework, model, and measures developed in this pilot study as a foundation, several lines of research can be formed. Five different lines for future research are discussed in this section. First, it will be important to explore the relationship between safety culture and safety performance. The theoretical framework established for this dissertation predicts that the variables of safety culture will influence behaviors and that behaviors will result in organizational and individual consequences. The organizational and individual consequences can be viewed as the performance outcomes of behavioral choices. Whether this theoretical relationship among culture, behavior, and performance actually exists has not been tested but would certainly make for some interesting research in the future. Second, to change and improve safety performance, organizational managers will need to develop interventions designed to increase the strength and level of safety culture, so additional research is necessary in this area. Managers in different organizations are likely develop different approaches to making change and improvement in the elements of safety culture, some of which might work and of which might not; such is the nature of experiments. It will be interesting to explore the processes used to develop interventions as well as the actual content and practices used to create change. Third, other factors are likely to influence perceptions of safety culture that have not been included in this pilot study. Research in this area is important because understanding the impact of exogenous factors on perceptions of safety culture may help to increase the amount of variation in performance explained by the model. Fourth, the differences in safety culture across different types of fire service organizations represents another important area for future research. Different types of fire service organizations may require the development of different types of interventions if efforts to change and improve safety culture and safety performance are to be effective. The fifth line of future research is the conflict between safety and operational performance that is already building in the fire service.

Determining whether the model, variables and instruments developed through this research can be used effective to change safety culture and improve safety performance will be an important aspect of future research. However, the findings in this pilot study have established a foundation for exploring the relationship among safety culture, behavior, and safety performance based on the ABC framework of behavior change (Mwita, 2000; Ayers, 1995; Daniels, 1989). As was explained in the literature review, the three elements of this model are Antecedents, Behaviors, and Consequences. The variables of safety culture are the antecedents of actual behavioral choices by individuals. Behavioral choices result in consequences for the organization in terms of what is important regarding organizational level performance. Behavioral choices also have consequences in different terms for what is important for the individuals who work in the organization (Hofstede, 1998).

If future research is to use this framework to determine whether changes in safety culture result in improvements in safety performance, then it is important to take a comprehensive approach. The most comprehensive approach for changing and improving safety performance using the ABC framework would be to first examine the relationship between safety culture and behaviors and then to examine the relationship between behaviors and both individual and organizational consequences (Karahanna et al., 2005; Bloor & Dawson, 1994; van Muijen et al., 1999; Schraeder et al., 2005). An example of such a framework is provided in Figure 29.

The present pilot study has explored the relationship among the antecedent variables of safety as an organizational sub-culture. In terms of safety, these variables have been labeled as Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate. In terms of other organizational sub-cultures, these variables would be labeled as Management Systems, Behavioral Norms, and individual Values and Beliefs.

Future research will first need to examine the relationship between the antecedent variables and individual behavioral choices. As shown in Figure 29, individual values and beliefs may have the strongest and most direct influence on individual behaviors, with the organizations management system and behavioral norms having a more indirect influence. The next step for future research would be to explore the relationship between individual behavioral choices and consequences. Individual behavioral choices have consequences for individuals and for the organization. It might be predicted that individual consequences should have a direct influence on individual values and beliefs, and that organizational consequences should have a direct influence on the organizational management system and behavioral norms.

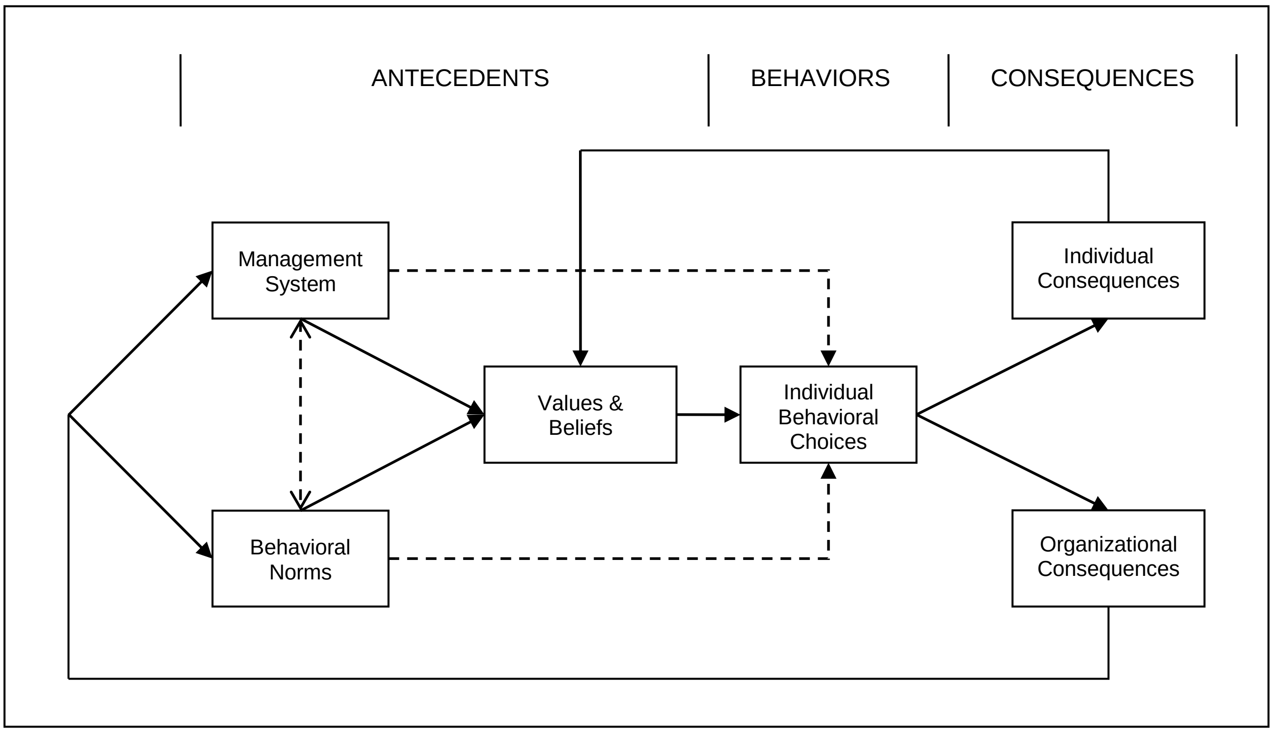

Figure 29. ABC Framework of Organizational Culture and Performance

Organizational and individual consequences can be categorized as positive or negative (Hofstede, 1998). For example, behavioral choices that result in fewer injuries would be considered a positive individual and organizational consequence, resulting in improvements in safety performance. When organizational and individual consequences are positive as a result of behavioral choices, then it would be expected that organizational management systems and behavioral norms would increase in level and would become stronger in support of those behaviors. It would also be expected that individual values and beliefs would increase in level and would also become stronger in support of those behaviors.

The relationship between the antecedent variables and behavioral choices could be explored using the instruments developed in this pilot study and measures of actual behaviors, such as behavioral checklists. The relationship between behavioral choices and consequences could be measured using the behavioral checklists and measures of important organizational and individual consequences. The impact of individual and organizational consequences on the antecedent variables could be evaluated by comparing changes in consequences with changes in the variables.

Analysis of the nature and characteristics of the relationships among the antecedents, behaviors, and consequences based on this framework will make a significant contribution toward understanding how organizational culture influences performance. The development of a common framework, model and variables for exploring this relationship continues to elude researchers and practitioners (Detert, 2000; Jones et al., 2005). The model and variables of safety culture used for the purposes of this research was developed within the ABC framework, and represents a new approach toward exploring and understanding the relationship between organizational sub-cultures and organizational performance. Hopefully, this presents an exciting opportunity for other researchers to use this model as a tool for the development of new knowledge about how the social context of organizations influences organizational performance.

Another, arguably less ambitious, area for future research is the development of interventions designed to increase the level and strength of the variables in the model. The safety management variable represents best practices for organizations based on internationally recognized standards. The safety behavior variables represent best practices for fire service organizations with regard to the critical behaviors that result in firefighter injuries and fatalities. Therefore, fire service organizations should attempt to increase the level and strength of safety management and safety behavior elements and sub-elements as part of their effort to improve safety performance.

Based on the findings of this pilot study and the ABC framework of behavior change, it is assumed that improvements in the elements and sub-elements of the safety management and safety behavior variables will result in improvements in safety related values and beliefs. Improvements in these antecedent variables are expected to improve behavioral choices, resulting in improved individual and organizational outcomes. Making improvements in the safety management and safety behavior variables means that interventions are designed to increase the level and strength of perceptions that individual in the organization have about the elements and sub-element of these variables. Therefore, it is important to explore the relationship between different interventions and whether those interventions have the intended effect.

Elements or sub-elements of the safety management and safety behavior variables targeted for improvement will be those with a low level, those that are weak, or those that are both low and weak. Interventions designed to improve safety performance will, therefore, take one of three approaches. These three approaches are depicted in Figure 30 as a two by two matrix. The three options for the development of interventions are labeled as Option A, Option B, and Option C.

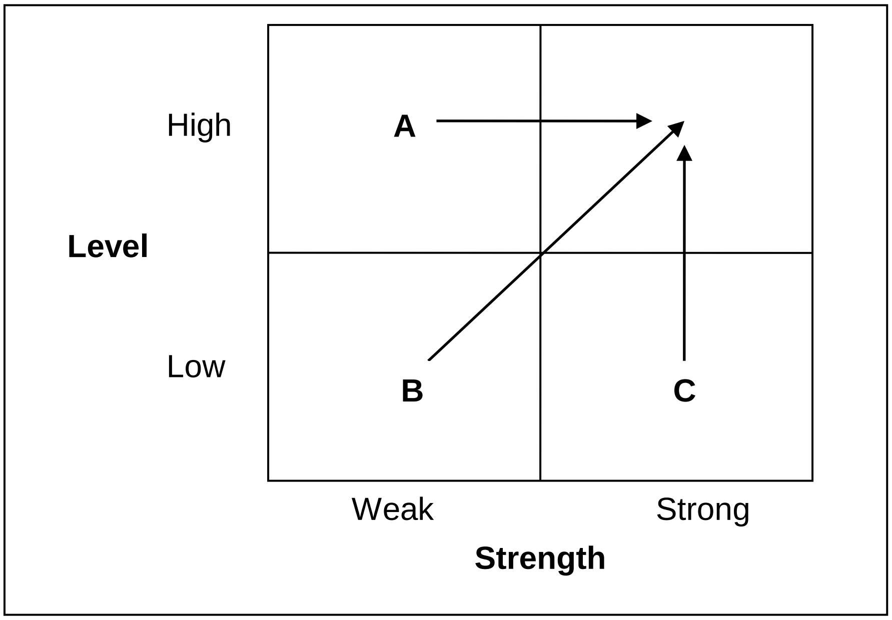

Figure 30. Intervention Approach Options

The purpose of all three intervention options is to move perceptions that are low, weak, or both low and weak into the high and strong cell of the matrix. Each option may require a different approach in order to develop an intervention that will effectively change perceptions. For example, an intervention designed to increase the level of a factor from low to high may not have any effect on the strength of that factor. Increasing the strength of a actor may require a very different approach in order to be effective.

One of the major limitations of this pilot study is that the influence of exogenous factors outside of the model is not included in the analysis. Factors that could influence perceptions include individual factors, task factors and organizational factors (Cooper & Phillips, 2004). Individual factors that could influence perceptions include education, age, gender, ethnicity, and an individual’s socio-economic background. Members of a fire department with different levels of education, different levels of life experience, and with different histories in terms of their ethnic upbringing, social experiences, and economic status may have very different values and beliefs regarding safety.

Task factors vary with differences in the communities that the fire department serves. For example, some communities are mostly residential while others are mostly industrial. Some communities have older buildings with less built in fire protection than newer communities where buildings are constructed to more stringent fire codes and include built in fire protection. These types of factors may influence the perceptions of firefighters in terms of what is considered appropriate behavioral norms. This pilot study attempted to control for differences in task factors by selecting participating organizations that operated in similar work environments, thereby limiting the influence of task factors on perceptions of safety culture. That effort was apparently successful, given the lack of variation in perceptions of work environment between the three participating departments. However, it will be important to explore the differences in perceptions associated with fire departments that operate in different work environments, such as urban, suburban, and rural communities.

Organizational factors may also influence individual perceptions. The internal structure of most fire departments is generally organized along the lines of a hierarchical paramilitary structure that includes firefighters, first line supervisors, shift commanders, and chief officers. Fire departments vary more significantly by type. The typology used to categorize fire service organizations includes the following: fully paid or career departments, combination departments that consist of career and volunteer members, and volunteer departments that consist of all volunteer members. Considerable variation in the perceptions of safety culture may exist among these different types of fire service organizations, which may have a significant influence on the level of performance of fire service organizations by type. In addition, the safety culture in career departments may be very different than the culture in volunteer departments, which means that a different approach to changing and improving safety performance may be required for different types of fire service organizations.

Organizational factors, task factors, and individual factors may have an overall or generalized influence on safety culture, or they may have a stronger influence on one variable or another. Organizational, task, and individual factors align with the three variables of safety culture: safety management, safety behaviors, and safety climate. Organizational factors may have the strongest influence in predicting perceptions of safety management, while task factors may have the strongest influence on perceptions of behavioral norms, and individual factors may have the strongest influence on individual values and beliefs. Additional research will be necessary to understand the influence of these and other exogenous variables on perceptions of safety culture and their impact on actual behaviors.

Another area of interest for future research is the comparison of fire departments with high and strong perceptions of safety culture against departments with low and weak perceptions of safety culture. Of particular interest is the difference in safety performance and operational performance between these types of organizations. The model predicts that organizations with strong and high perceptions of safety culture will have higher levels of safety performance than those with low and weak perceptions. Higher levels of safety performance are also predicted to result in higher levels of operational performance. If findings from future research in this area support these assertions, then fire department managers will have stronger support for the commitment of community resources to improve safety culture. The basic approach to this research would involve the analysis of the relationship between safety culture as the independent variable and several dependent variables. Firefighter injury rates could be used as the measure of safety performance. Civilian injury rates and direct fire loss could be used as measures of operational performance. The proposition for this line of research is that organizations with higher and stronger safety cultures will have lower firefighter injury rates, lower civilian injury rates, and less direct fire loss.

The relationship among the variables used to measure safety culture, safety performance and operational performance is also of interest for future research because of the inherent conflict between safety and extinguishment. In the fire service, there is already a growing conflict between those who believe that the fire service needs to have a culture of safety and those who believe that the fire service should focus on a culture of extinguishment. This is the classic safety/performance conflict that exists in many high-risk occupations. Those who support a culture of extinguishment argue that increased levels of safety will result in decreased operational performance. Those who support a culture of safety argue that increased level of safety will result in the same levels of operational performance but improved levels of safety performance. Other high-risk occupations have found that increasing safety culture actually increases operational performance and safety performance (Brown & Leigh, 1996; Rose, 2008; Mwita, 2003; Griffin & Neal, 2000; Reason, 2000; McLain & Jarrell, 2007). It will be important to conduct research in this area to determine the impact of safety culture on operational performance and whether increases in safety culture in the fire service results in the same kind of improvements in operational performance found in other high-risk occupations.

Conclusion

The results of this pilot study advance the research agenda for safety culture and organizational sub-cultures in three ways. First, based on a comprehensive but parsimonious model of safety culture, three key variables have been identified and operationalized: Safety Management System, Safety Related Behaviors, and Organizational Safety Climate. Second, instruments have been developed to measure these variables, which have been found to be valid and reliable measures of safety culture. Third, the data acquired through these instruments provides information that can be used to better understand safety culture through the analysis of data on the level, strength, and the characteristics of the relationship among the variables. These results provide strong support for the value of an integrated approach to the assessment and analysis of safety culture, and other organizational sub-cultures.

Very little attention has been given to the development of integrated models of safety culture (Parker et al., 2006). This dissertation makes a key contribution to the research on safety culture and organizational sub-cultures because it attempts to integrate several different approaches. First, this dissertation has attempted to integrate the functional and interpretive approaches to safety culture. Second, this dissertation has integrated the culture and climate perspectives on safety. Third, the dissertation integrates the behavior change and culture change approaches to improving safety performance. Variables commonly used in research taking a functional approach are the same variables used in climate studies and in the behavior change approach to performance improvement. Variables commonly used in research taking the interpretive approach are the same variables used in culture studies and the culture change approach to performance improvement. This pilot study includes variables from the functional/climate perspective (safety management and safety behaviors) and the interpretive/climate perspective (safety climate) and forms them into an integrated model. A significant contribution of this research is in development of a model, variables, and instruments that can be used to define and describe an effective organizational safety culture.

An integrated approach is the most useful way to examine safety culture because it results in a meaningful assessment of the three critical variables of safety culture. A greater understanding of the level and strength of the variables of safety culture, and the characteristics of the relationship among these variables, make the safety culture in an organization more explicit. This information gives organizational members a greater understanding of the pattern of interaction among the variables of safety culture and how their organization functions with regard to safety. When organizational members have a better understanding of how their organization functions, they have an increased capacity to make and sustain change in safety culture, improve safety performance, and reduce injury and fatality rates. It is anticipated that the outcome of these changes, initiated through the assessment and analysis of safety culture, is a reduction in the emotional and physical suffering resulting from firefighter injuries and fatalities. Another, less important, outcome that can be anticipated is a significant reduction in the financial impact of firefighter injuries and fatalities on local government and communities.

Firefighter injuries and fatalities continue to be an important problem for the fire service and for the local communities that they serve. The consequences of firefighter casualties are high in terms of the emotional and physical suffering of firefighters and their families and in terms of the economic impact that casualties have on local government. Previous efforts to change and improve the safety performance of the fire service have been unsuccessful, in large part because these efforts have been made without a clear understanding of safety culture (NFPA, 2004).

The results of this research provide a model and measures of safety culture that can be used by fire service managers to develop a safety culture profile for their organization. Based on this profile, fire service managers will have a much clearer understanding of the safety culture in their organization. They will be able to display graphically the strength and level of the measures of safety culture, and will have a better understanding of the nature and characteristics of the relationship among the variables of safety culture. The ability to assess and analyze safety culture is just the first step in improving safety performance, but it is the most important step because it provides a new direction for further research and a different approach for fire service managers toward the problem of firefighter injuries and fatalities.

The theoretical framework and conceptual model of safety culture presented in this dissertation hold the potential to transform the safety culture of the fire service in the United States, resulting in a dramatic reduction of firefighter injuries and fatalities. The model presented here provides the fire service with a reliable and replicable way to analyze and assess safety culture that has not been previously available. The analysis and assessment of safety culture can be used by fire service managers to define and describe safety culture and to develop goals for changing the safety culture in their organization. In addition, the theoretical framework presented in this dissertation establishes a link between changes in safety culture and improvements in organizational outcomes, such as safety performance and operational performance. With a new model and measures of safety culture now available to the fire service, it is hoped that these will actually be used as a new approach to reducing firefighter injuries and fatalities.

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APPENDIX A: Organizational Safety Culture Questionnaires

Safety Management Systems Survey

We would like to find out how you feel about your department's safety management system. In order to do this, we would like you to complete this questionnaire. It is important for you to be completely honest about your feelings. Please do not respond with answers that you think, for example, the fire chief or the union would want you to provide. Please note:

A. All responses will be held in strict confidence. All completed surveys will be placed in locked box to which only the two field researchers have keys. Only the study researchers will have access to the stored data. The data will be kept for up to three years and then destroyed. The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and well being of people who participate in research.
B. Your participation in the study is voluntary. You can choose not to participate or discontinue participation at any point without reprisal or penalty.
C. There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.
D. There are no personal benefits or compensation associated with participation, the purpose of the research is to help make fire departments in American safer places to work.
E. If you have any questions about the study please contact: Chief Bill Pessemier at 303-419-0599 or at wlpessem@mho.net. If you have any questions about your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu

Do not put your name on the questionnaire. But, so that we can match your responses for all three study surveys, please put your STUDY IDENTIFICATION CODE on the survey (the initials of your first given name and last family name and the last four digits of your social security number—for William Pessemier this would be WP4172). **Only the study researchers will have access to these codes.**

It should only take about 30 minutes to complete this questionnaire.

Thank you for your co-operation!

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ED-07-2

Survey A: Safety Management Systems Survey

We would like to find out how you feel about your department's safety management systems. In order to do this, we would like you to complete this questionnaire. ***All responses will be held in strict confidence.*** Do not put your name on the questionnaire. In addition, while the previous page indicates that a Study Identification Code will be used, that code has been eliminated from the survey.

Before you begin the survey, please enter the requested demographic information, which includes department, job function or rank, total number of years of service in the fire service, and indicate if you have ever been involved in a safety related incident/accident (answer yes or no).

(V1) Department	
(V2) Job Function	
(V3) Total years of service	
(V4) Involved in a safety-related incident or accident	Yes _____ No _____

In the following questions, you will be presented with a series of statements concerning safety management systems in your department. You should indicate your response by assessing the degree to which in your opinion evidence suggests that there is no evidence, little evidence, reasonable evidence, significant evidence, or full evidence to support the statement. The numerical scores are intended to provide a percentage comparison of the different degrees of evidence used in the ratings. This will allow us to measure quantitatively the intensity of your attitudes and provide a measure for the difference between the ratings. Please "'check" the box that best represents your feeling about the question. ***Check only one box for each question.*** For example, if you believe that there is little evidence to support the statement, "Risk assessments are derived from hazard identification in your department," you would place a check mark in the "little evidence" box, as in the example:

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
Risk assessments are derived from hazard identification		✓			

It should only take about 30 minutes or so to complete this questionnaire.

Thank you for your co-operation!

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V137) Performance review is used as a means to identify and implement best practices and performance within the public safety sector and other appropriate sectors relevant to the organization					
(V138) Safety and health policy is recognized and implemented as an integral part of improving organizational performance					
(V139) Senior management takes an active role in the safety management of the Fire Department					
(V140) The safety and health policy establishes a commitment to treat safety and health as a core management function					
(V141) Training is aimed at enabling compliance with safety performance standards					
(V142) The safety and health policy expresses a commitment to maintaining effective systems of communication on safety and health matters					
(V143) The safety and health policy expresses a commitment to ensuring the competence of employees					
(V144) Appropriate and specific safety and health objectives have been established					
(V145) The safety and health policy makes a commitment to measure safety and health performance					
(V146) Staff are aware of the appropriate safety standards which apply to their work activities					
(V147) The safety and health policy expresses a commitment to review and develop policy					
(V148) The safety and health policy establishes the responsibilities of managers in policy implementation					
(V149) The department has an effective program of safety and health performance inspections					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V150) The safety and health policy identifies who has overall responsibility for safety within the Fire Department					
(V151) The achievement of safety and health objectives is measured during inspection					
(V152) The safety management system provides an effective safety and health organizational structure to implement safety related policy and achieve managerial control					
(V153) Responsibility, authority, and accountability for safety and health are delegated appropriately through a management structure from the department head to line supervisors					
(V154) The Head of the Department takes an active role in safety management					
(V155) The duties of persons with safety management responsibilities is well defined and documented					
(V156) Persons who are delegated responsibility and authority for safety are appraised on their safety and health performance					
(V157) Safety and health measurement information is used to provide feedback and motivation					
(V158) Risk assessments are used to define skills needed to carry out tasks safely					
(V159) Effective arrangements are in place to identify, eliminate, or control safety and health hazards and risks					
(V160) Arrangements are in place for the involvement and participation of all employees in developing health and safety policies					
(V161) A safety and health consultative group or committee has been established					
(V162) This group involves representative from all employee groups					
(V163) This group contributes to setting safety and health objectives					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V164) All members of this group are involved in establishing and maintaining performance standards					
(V165) The group is involved in devising procedures for the control of risk					
(V166) The group takes part in measuring performance					
(V167) The group takes part in reviewing performance					
(V168) Other, less formal, means exist to encourage employee participation					
(V169) The department has satisfactory arrangements for the dissemination of information or guidance relating to safety and health					
(V170) The safety and health policy expresses commitment to progressive improvement in safety and health performance					
(V171) Arrangements are in place for obtaining up-to-date safety and health information on hazards, risks and preventative measures					
(V172) Written information on hazards, risks and preventative measures is communicated throughout the organization					
(V173) Line and staff personnel are provided with adequate and appropriate safety and health training					
(V174) The safety and health policy commits senior managers to the provision of adequate and appropriate resources					
(V175) Access is provided to competent safety and health advice for both line and staff personnel					
(V176) All the main hazards have been identified and the risks from these controlled					
(V177) An effective, dynamic safety and health planning process is used to implement safety and health policy					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V178) Written performance standards are used for the control of risk					
(V179) Performance standards identify who is responsible for action					
(V180) Performance standards identify when the action must be taken					
(V181) Adequate safety precautions have been designed, developed and implemented for specific work related activities and are proportionate to the needs, hazards and risks of the organization					
(V182) Risk assessments have been carried out for specific departmental activities					
(V183) Risk control measures have been derived from risk assessments					
(V184) Risk assessments are derived from hazard identification					
(V185) Hazard identification is based on critical appraisal of all activities					
(V186) Hazard identification is based on accident, ill health and incident data					
(V187) A written safety and health plan has been established					
(V188) The safety and health policy makes a commitment to planning for safety					
(V189) Safety and health objectives are measurable					
(V190) Safety and health objectives are to be achieved in a specified time or during specific activities					
(V191) Priorities are set based on the outcome of risk assessments					
(V192) Plans have been developed covering the management of change of either a permanent or temporary nature					
(V193) The Department has satisfactory arrangements for the identification of safety training needs for line and staff personnel and for the provisions of that raining					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V194) Plans have been established for implementing corrective actions					
(V195) Safety and health performance is effectively monitored					
(V196) The safety and health policy establishes the contribution that employees can make to policy implementation					
(V197) Safety and health performance are measured against pre-determined plans					
(V198) Safety and health performance are measured against performance standards					
(V199) The safety and health policy communicates a commitment to safety and health by the Fire Chief					
(V200) Monitoring of safety and health performance is a specified line management responsibility					
(V201) Safety performance inspections check whether performance standards are being implemented					
(V202) Safety performance plans specify frequency of inspection					
(V203) The safety and health policy recognizes the importance of minimizing risk and the prevention of injury, ill health, disease, and incidents					
(V204) Records are kept for each inspection with details of both positive and negative findings					
(V205) All injuries, accidents, and incidents are reported					
(V206) Arrangements are in place for reporting hazards					
(V207) A procedure is in place for reporting accidents and injuries					
(V208) A procedure is in place for reporting ill health					
(V209) A procedure is in place for reporting near misses and other losses					
(V210) Arrangements are in place for carrying out accident investigations					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V211) Both immediate and underlying causes of negative findings are identified in inspections and investigations					
(V212) Line managers are involved in investigations					
(V213) There is a mechanism for ensuring that Senior Management becomes involved in the investigation of serious incidents					
(V214) The results of investigations are recorded					
(V215) Arrangements are in place for implementing remedial action following hazard, inspection and accident reports					
(V216) These arrangements specify who is responsible for taking remedial action					
(V217) Arrangements are in place to ensure that the remedial action has been taken					
(V218) The Head of Department receive written reports on monitoring activities					
(V219) Safety and health performance measurement information is used to identify areas where corrective action is necessary					
(V220) Safety and health are a standing agenda item at senior management meetings					
(V221) Arrangements are in place to ensure a consistent response to, and thorough investigation of, substandard performance including accidents					
(V222) Safety and health performance is effectively reviewed to ensure progressive improvement					
(V223) Periodic reviews of safety and health performance are undertaken					
(V224) These periodic reviews examine the entire safety and health plan, including the achievement of objectives					
(V225) Periodic reviews of safety include risk assessments					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V226) Periodic reviews of safety examines inspection reports which are used to identify common trends and weaknesses					
(V227) Periodic reviews of safety examine the results of audits					
(V228) The findings of periodic reviews of safety are implemented					
(V229) The outcome of the periodic review process is used to revise the safety and health policy					
(V230) The safety and health policy is effective					
(V231) The department maintains satisfactory records of accidents, incidents, dangerous occurrences and records of ill health. These are analyzed with a view to identifying causes so possible remedial measures can be identified					

Safety Related Behaviors Survey

We would like to find out how you feel about your department's safety related behaviors. In order to do this, we would like you to complete this questionnaire. It is important for you to be completely honest about your feelings. Please do not respond with answers that you think, for example, the fire chief or the union would want you to provide. Please note:

A. All responses will be held in strict confidence. All completed surveys will be placed in locked box to which only the two field researchers have keys. Only the study researchers will have access to the stored data. The data will be kept for up to three years and then destroyed. The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and well being of people who participate in research.
B. Your participation in the study is voluntary. You can choose not to participate or discontinue participation at any point without reprisal or penalty.
C. There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.
D. There are no personal benefits or compensation associated with participation, the purpose of the research is to help make fire departments in American safer places to work.
E. If you have any questions about the study please contact: Chief Bill Pessemier at 303-419-0599 or at wlpessem@mho.net. If you have any questions about your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu

Do not put your name on the questionnaire. But, so that we can match your responses for all three study surveys, please put your STUDY IDENTIFICATION CODE on the survey (the initials of your first given name and last family name and the last four digits of your social security number—for William Pessemier this would be WP4172). **Only the study researchers will have access to these codes.**

It should only take about 30 minutes to complete this questionnaire.

Thank you for your co-operation!

OSU
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Approved 7/6/07
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Initials [illegible]
EC-07-2

Survey B: Safety Related Behaviors Survey

We would like to find out how you feel about your department's safety related behaviors. In order to do this, we would like you to complete this questionnaire. ***All responses will be held in strict confidence.*** Do not put your name on the questionnaire. In addition, while the previous page indicates that a Study Identification Code will be used, that code has been eliminated from the survey.

Before you begin the survey, please enter the requested demographic information, which includes department, job function or rank, total number of years of service in the fire service, and indicate if you have ever been involved in a safety related incident/accident (answer yes or no).

(V1) Department	
(V2) Job Function	
(V3) Total years of service	
(V4) Involved in a safety-related incident or accident	Yes _____ No _____

In the following questions, you will be presented with a series of statements concerning safety related behaviors in your department. You should indicate your response by assessing the degree to which in your opinion evidence suggests that there is no evidence, little evidence, reasonable evidence, significant evidence, or full evidence to support the statement. The numerical scores are intended to provide a percentage comparison of the different degrees of evidence used in the ratings. This will allow us to measure quantitatively the intensity of your attitudes and provide a measure for the difference between the ratings. Please "'check" the box that best represents your feeling about the question. ***Check only one box for each question.*** For example, if you believe that there is little evidence to support the statement, "Risk assessments are derived from hazard identification in your department," you would place a check mark in the "little evidence" box, as in the example:

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
Risk assessments are derived from hazard identification		✔			

It should only take about 30 minutes or so to complete this questionnaire.

Thank you for your co-operation!

85-Item Safety Related Behaviors Survey

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V52) The personnel accountability system is based on the size, complexity, type and needs of the incident					
(V53) Systematic rest and rehabilitation is provided for responders operating at the scene of an emergency					
(V54) Drivers never exceed a speed that is safe and prudent based on road conditions and vehicle capabilities					
(V55) The department has a policy for non-emergency response to incidents classified as non-urgent					
(V56) Fuel load and potential exposure to high temperatures is monitored during live fire training evolutions					
(V57) The communications system provides the capability to communicate with mutual aid resources					
(V58) The incident management system provides a series of supervisory levels to be implemented to create a command structure					
(V59) The command structure utilized during incidents is appropriate based on the nature of the incident, as well as the scale and complexity of operations					
(V60) Every member of the department cooperates, participates, and complies with the requirements of the fitness program					
(V61) The command structure for each incident is developed so that an effective span of control is maintained					
(V62) An effective span of control is maintained throughout the incident management system so that supervisors are able to monitor the activities of assigned subordinates					
(V63) Fire department training faculties used for the purpose of live fire training are designed, built, and/or used in a way that ensures a safe training environment					
(V64) Medical requirements are based on essential job tasks which are developed from an assessment of the types and levels of service provided by the department					
(V65) The department ensures the privacy and confidentiality of medical information					
(V66) Alternative duty positions are available for those who are on temporary work restrictions					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V67) Adequate and appropriate training and familiarization on the incident management system is provided					
(V68) Tactical level supervisors are able to maintain accountability for the resources operating under them					
(V69) Members report any medical condition that could interfere with their ability to safety perform essential job tasks					
(V70) The medical evaluation is able to identify any conditions that interfere with a members physical or mental ability to safely perform their essential job tasks without undue risk to themselves or others					
(V71) Accountability is maintained when units are relocated during the course of an incident					
(V72) The annual medical evaluation includes blood tests for total cholesterol, HDL and LDL					
(V73) Our response procedures minimize travel times while also maximizing response safety					
(V74) Drivers do not move vehicles until all persons on the vehicle are seated and secured with seat belts					
(V75) All persons riding in or on vehicles are always seated and secured by seat belts when the vehicle is moving, with the exception of momentarily providing medical care to patients in ambulance type vehicles					
(V76) Fitness assessments include a component for aerobic capacity					
(V77) An effective span of control is maintained throughout the incident management system so that supervisors are able to communicate effectively with assigned subordinates					
(V78) Fitness assessments include a component for body composition					
(V79) The safety plan for training evolutions includes the method of communications, evacuation signals, a designated safety officer, protective backup lines, rapid intervention teams, accountability, and incident management					
(V80) All personnel participating in practice training evolutions are required to wear the appropriate personal protective equipment					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V81) A qualified and experienced safety officer is designated for all live fire training evolutions					
(V82) Fitness assessments include a component for muscular strength					
(V83) Fire department instructors provide instruction on proper hydration prior to emergency training					
(V84) The communications system provides for an adequate number of separate dispatch, tactical, and command channels					
(V85) Fitness assessments include a component for muscular endurance					
(V86) The incident management system is able to meet the characteristics of incidents based on the size, type, complexity, and operating environment of the incident					
(V87) Fitness assessments are conducted annually					
(V88) Incident commanders mange safety by constantly monitoring the situation and reviewing the effectiveness of existing control measures					
(V89) Members cooperate, participate and comply with the medical evaluation process					
(V90) A system of resource accountability has been adopted and is defined and documented in writing					
(V91) The department provides the support necessary to ensure that personnel remain safe in hostile operational environments					
(V92) Supervisors maintain constant awareness of the position and function of all resources assigned to operating under them					
(V93) Members provide accurate and complete information during the course of their occupational medical evaluation					
(V94) The annual medical evaluation includes a stress EKG					
(V95) Accountability is maintained when units are evacuated from an area as a result of imminent threat					
(V96) A personnel accountability system has been adopted and is defined and documented in writing					
(V97) The department requires structured participation of all members in the fitness program					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V98) Members remain under the supervision of their assigned supervisor					
(V99) The medical program includes medical evaluation of current members					
(V100) The communications system is able to meet the demands of large scale emergencies					
(V101) The department provides adequate and useful information about operational hazard identification, risk assessment, and risk control					
(V102) Emergency vehicles come to a full stop before entering a negative right of way intersection, blind intersection, or whenever the driver cannot account for traffic in all oncoming lanes					
(V103) The department has established procedures for safety driving, riding within, and operating emergency vehicles during an emergency response					
(V104) Procedures for emergency response emphasize the importance of the safe arrival of vehicles and personnel and the emergency scene as the first priority					
(V105) The departments driver training program is adequate and appropriate for the purpose of preventing vehicular accidents, deaths, and injuries to members and the public					
(V106) The department provides driver training and education commensurate with the duties and functions they are expected to perform					
(V107) Members perform their driving duties and functions in a manner that does not pose a hazard for themselves, other members, or the public					
(V108) Violations of safe driving practices and procedures are reported immediately to personnel with the authority and responsibility to take corrective action					
(V109) Supervisors take corrective action whenever a violation of safe driving practices or procedures occurs					
(V110) Operations level personnel are able to identify the hazards encountered during various operations, assess those risks, and take action to control risks					
(V111) Incident commanders are able to identify hazards, assess risk, and make appropriate judgments about using resources effectively and within an acceptable level of safety during operations					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V112) A system of resource accountability is used at the scene of emergencies involving multiple units					
(V113) Individuals are able to make professional judgments about the appropriate use of resources in order to control the risks inherent in operational environments					
(V114) Warning lights and audible warning devices are used whenever emergency vehicles are operating in the emergency response mode					
(V115) Safe procedures and systems of operational work have been developed and are used at incidents					
(V116) Members are self disciplined and work within accepted procedures and systems of operational work					
(V117) Members are vigilant for their own safety and the safety of others					
(V118) Incident commanders, supervisors, and team leaders engage in the continuous assessment and control of risk in the rapidly changing circumstances or operational incidents					
(V119) The incident management system is implemented and used for unusual or large scale incidents					
(V120) Fire department instructors have the required knowledge and skill in the areas of instructional methods, training applications, and safety					
(V121) The department has established a health related fitness program that enables members to develop and maintain a level of health and fitness to safety perform their assigned functions					
(V122) The incident management system is implemented and used for routine incidents					
(V123) An exercise training program is available to all members					
(V124) Education and counseling regarding health promotion is available for all members					
(V125) Only those elements of the incident management system that are necessary for the effective control of the incident are activated or applied					
(V126) The personnel accountability system is effective					
(V127) The department provides the opportunity and means for implementing the fitness program					

Please check the appropriate box to indicate your level of agreement	**No Evidence**	**Little Evidence**	**Reasonable Evidence**	**Significant Evidence**	**Full Evidence**
	0	**25**	**50**	**75**	**100**
(V128) The department provides the opportunity and means for regular exercise training					
(V129) The department has established clear policies and procedures for emergency response driving					
(V130) A safety plan is developed for all training evolutions, including live fire training					
(V131) Fire department instructors monitor weather and environmental conditions (heat/cold) throughout the course of training evolutions					
(V132) The department has a formally adopted incident management system that is defined and documented in writing					
(V133) Fitness assessments include a component for flexibility					
(V134) The medical program includes medical evaluation of potential candidates					
(V135) The communications system is able to meet the demands of routine emergencies					
(V136) The department has designated a fire department physician to direct the occupational medical program					

Organizational Safety Culture Survey

We would like to find out how you feel about your department's safety culture. In order to do this, we would like you to complete this questionnaire. It is important for you to be completely honest about your feelings. Please do not respond with answers that you think, for example, the fire chief or the union would want you to provide. Please note:

A. All responses will be held in strict confidence. All completed surveys will be placed in locked box to which only the two field researchers have keys. Only the study researchers will have access to the stored data. The data will be kept for up to three years and then destroyed. The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and well being of people who participate in research.

B. Your participation in the study is voluntary. You can choose not to participate or discontinue participation at any point without reprisal or penalty.

C. There are no known risks associated with this project which are greater than those ordinarily encountered in daily life.

D. There are no personal benefits or compensation associated with participation, the purpose of the research is to help make fire departments in American safer places to work.

E. If you have any questions about the study please contact: Chief Bill Pessemier at 303-419-0599 or at wlpessem@mho.net. If you have any questions about your rights as a research volunteer, you may contact Dr. Sue C. Jacobs, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu

Do not put your name on the questionnaire. But, so that we can match your responses for all three study surveys, please put your STUDY IDENTIFICATION CODE on the survey (the initials of your first given name and last family name and the last four digits of your social security number—for William Pessemier this would be WP4172). **Only the study researchers will have access to these codes.**

It should only take about 20 minutes to complete this questionnaire.

Thank you for your co-operation!

OSU
Institutional Review Board
Approved 7/6/07
Expires 7/5/08
Initials enm
EG-07-2

Survey C: Organizational Safety Culture Survey

We would like to find out how you feel about your department's safety culture. In order to do this, we would like you to complete this questionnaire. ***All responses will be held in strict confidence.*** Do not put your name on the questionnaire. In addition, while the previous page indicates that a Study Identification Code will be used, that code has been eliminated from the survey.

Before you begin the survey, please enter the requested demographic information, which includes department, job function or rank, total number of years of service in the fire service, and indicate if you have ever been involved in a safety related incident/accident (answer yes or no).

(V1) Department	
(V2) Job Function	
(V3) Total years of service	
(V4) Involved in a safety-related incident or accident	Yes _____ No _____

In the following questions, you will be presented with a series of statements concerning health and safety in your department. You should indicate your response by "checking" the appropriate box. For example, if you agreed with the following statement you would check under the "Agree" category, as shown in the following example:

Please check the appropriate box to indicate your level of agreement	**Strongly disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
Health and safety issues are very important				✓	

It should only take about 15 minutes or so to complete this questionnaire.

Thank you for your co-operation!

43-Item Organizational Safety Culture Survey

Please check the appropriate box to indicate your level of agreement	**Strongly disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
(V9) Management operates an open door policy on safety issues					
(V10) Safety is the number one priority in my mind when responding to and working at the scene of an emergency					
(V11) Co-workers often give tips to each other on how to work safely					
(V12) Safety rules and procedures are carefully followed					
(V13) Management clearly considers the safety of employees of great importance					
(V14) I am sure it is only a matter of time before I am involved in an accident					
(V15) Sometimes I am not given enough time to get the job done safely					
(V16) I am involved in informing management of important safety issues					
(V17) Management acts decisively when a safety concern is raised					
(V18) There is good communication here about safety issues which affect me					
(V19) I understand the safety rules for my job					
(V20) It is important to me that there is a continuing emphasis on safety					
(V21) I am involved with safety issues at work					
(V22) This is a safer place to work than other departments I have worked for					
(V23) I am strongly encouraged to report unsafe conditions					
(V24) In my workplace management turns a blind eye to safety issues					
(V25) Some safety rules and procedures do not need to be followed to get the job done safely					
(V26) I am rarely worried about being injured on the job					
(V27) Management acts only after accidents have occurred					

Please check the appropriate box to indicate your level of agreement	**Strongly disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
(V28) I believe that safety issues are not assigned a high priority					
(V29) Some health and safety rules and procedures are not really practical					
(V30) Employees are not encouraged to raise safety concerns					
(V31) Personally I feel that safety issues are not the most important aspect of my job					
(V32) In my workplace the chances of being involved in an accident are quite high					
(V33) I do not receive praise for working safely					
(V34) Corrective action is always taken when management is told about unsafe practices					
(V35) Operational requirements and activities often conflict with safety measures					
(V36) My line supervisor does not always inform me of current concerns and issues					
(V37) I can influence health and safety performance here					
(V38) Sometimes conditions here hinder my ability to work safely					
(V39) Safety information is always brought to my attention by my line supervisor					
(V40) When people ignore safety procedures here, I feel it is none of my business					
(V41) In my workplace management acts quickly to correct safety problems					
(V42) I am clear about what my responsibilities are for health and safety					
(V43) Sometimes it is necessary to depart from safety requirements in order to achieve operational objectives					
(V44) A safe place to work has a lot of personal meaning to me					
(V45) There are always enough people available to get the job done safely					

Please check the appropriate box to indicate your level of agreement	**Strongly disagree**	**Disagree**	**Neither agree or disagree**	**Agree**	**Strongly agree**
(V46) In my workplace managers and supervisors show interest in my safety					
(V47) I am never involved in the ongoing review of safety					
(V48) Management considers safety to be equally as important as performance					
(V49) A no-blame approach is used to persuade people acting unsafely that their behavior is inappropriate					
(V50) Managers and supervisors express concern if safety procedures are not followed					
(V51) I cannot always get the equipment I need to do the job safely					

APPENDIX B: Statistical Data Tables

Table

Means, Standard Deviations, Minimum, Mazimum, Skewness and Kurtosos for Questionnaire Items (N = 223)

Variable	N	M	SD	Min.	Max.	Skewness	Kurtosis
9	1040	3.81	0.89	1	5	-0.82	0.71
10	1043	4.21	0.81	1	5	-1.10	1.41
11	1043	3.85	0.80	1	5	-0.76	0.74
12	1040	3.56	0.82	1	5	-0.62	0.06
13	1040	4.00	0.88	1	5	-0.98	1.08
14	1041	2.85	1.04	1	5	0.11	-0.63
15	1039	2.60	0.96	1	5	0.51	-0.29
16	1036	3.32	0.97	1	5	-0.40	-0.38
17	1039	3.46	1.00	1	5	-0.48	-0.32
18	1038	3.66	0.88	1	5	-0.71	0.36
19	1040	4.23	0.58	1	5	-0.70	3.22
20	1041	4.39	0.68	1	5	-1.03	1.38
21	1040	3.83	0.85	1	5	-0.62	0.39
22	1027	3.49	0.82	1	5	0.58	-0.30
23	1041	3.86	0.89	1	5	-0.69	0.29
24	1039	2.00	0.87	1	5	1.06	1.43
25	1040	2.55	1.10	1	5	0.37	-0.75
26	1042	2.97	1.04	1	5	-0.01	-1.03
27	1043	2.93	1.14	1	5	0.25	-0.94
28	1042	2.36	0.89	1	5	0.94	0.70
29	1041	3.07	1.03	1	5	-0.10	-0.96
30	1038	2.26	0.85	1	5	1.01	1.15
31	1038	2.29	1.02	1	5	0.83	0.19
32	1039	3.64	1.08	1	5	-0.61	-0.46
33	1039	3.12	1.06	1	5	-0.08	-0.72
34	1042	3.12	0.95	1	5	-0.08	-0.55
35	1040	3.08	0.99	1	5	-0.08	-0.89
36	1040	2.48	0.93	1	5	0.68	0.04
37	1039	3.80	0.79	1	5	-1.00	1.50
38	1039	3.09	1.07	1	5	-0.09	-1.04
39	1039	3.44	0.87	1	5	-0.45	-0.25
40	1042	2.06	0.81	1	5	1.03	1.82
41	1039	3.36	0.95	1	5	-0.34	-0.37
42	1036	3.97	0.68	1	5	-0.90	2.24
43	1040	3.11	1.05	1	5	-0.24	-0.93
44	1040	4.09	0.72	1	5	-0.79	1.54
45	1042	2.86	1.21	1	5	0.14	-1.12
46	1043	3.94	0.71	1	5	-0.94	2.09

47	1043	2.80	0.93	1	5	0.43	-0.50
48	1040	3.60	0.88	1	5	-0.63	0.16
49	1042	2.70	0.95	1	5	0.19	-0.33
50	1043	3.86	0.73	1	5	-1.14	2.57
51	1043	2.83	1.08	1	5	0.29	-0.82
52	1033	3.61	1.02	1	5	-0.51	-0.05
53	1040	3.60	0.98	1	5	-0.26	-0.59
54	1040	2.54	0.98	1	5	0.36	-0.19
55	1037	4.16	0.92	1	5	-0.94	0.43
56	1030	3.31	1.18	1	5	-0.33	-0.65
57	1038	3.68	1.13	1	5	-0.41	-0.80
58	1038	4.27	0.83	1	5	-1.01	0.84
59	1038	4.20	0.87	1	5	-1.00	0.83
60	1039	2.33	0.99	1	5	0.41	-0.27
61	1039	3.96	0.87	1	5	-0.42	-0.39
62	1041	3.86	0.86	1	5	-0.36	-0.26
63	1034	3.49	1.15	1	5	-0.53	-0.40
64	1036	3.34	1.03	1	5	-0.14	-0.45
65	1040	3.63	1.12	1	5	-0.49	-0.49
66	1041	4.10	0.94	1	5	-0.88	0.29
67	1041	3.57	0.98	1	5	-0.32	-0.37
68	1042	3.77	0.83	1	5	-0.37	0.06
69	1038	3.23	0.94	1	5	0.07	-0.37
70	1042	3.28	0.96	1	5	-0.08	-0.35
71	1041	3.66	0.88	1	5	-0.27	-0.19
72	1037	4.39	0.89	1	5	-1.48	1.84
73	1034	3.58	0.95	1	5	-0.35	-0.22
74	1036	3.38	1.07	1	5	-0.19	-0.65
75	1037	3.42	1.12	1	5	-0.36	-0.50
76	1034	3.96	1.09	1	5	-0.84	-0.06
77	1034	3.91	0.82	1	5	-0.43	0.01
78	1035	3.89	1.13	1	5	-0.79	-0.17
79	1037	3.80	1.01	1	5	-0.67	0.08
80	1042	4.25	0.84	1	5	-1.01	0.76
81	1035	3.83	1.13	1	5	-0.78	-0.12
82	1037	4.15	0.95	1	5	-0.98	0.45
83	1041	3.24	1.11	1	5	-0.07	-0.75
84	1042	3.96	1.01	1	5	-0.73	-0.14
85	1036	3.87	1.06	1	5	-0.60	-0.44
86	1042	4.12	0.81	1	5	-0.55	-0.29
87	1039	4.32	0.94	1	5	-1.46	1.79
88	1041	3.93	0.81	1	5	-0.42	-0.03
89	1038	3.65	0.92	1	5	-0.20	-0.37

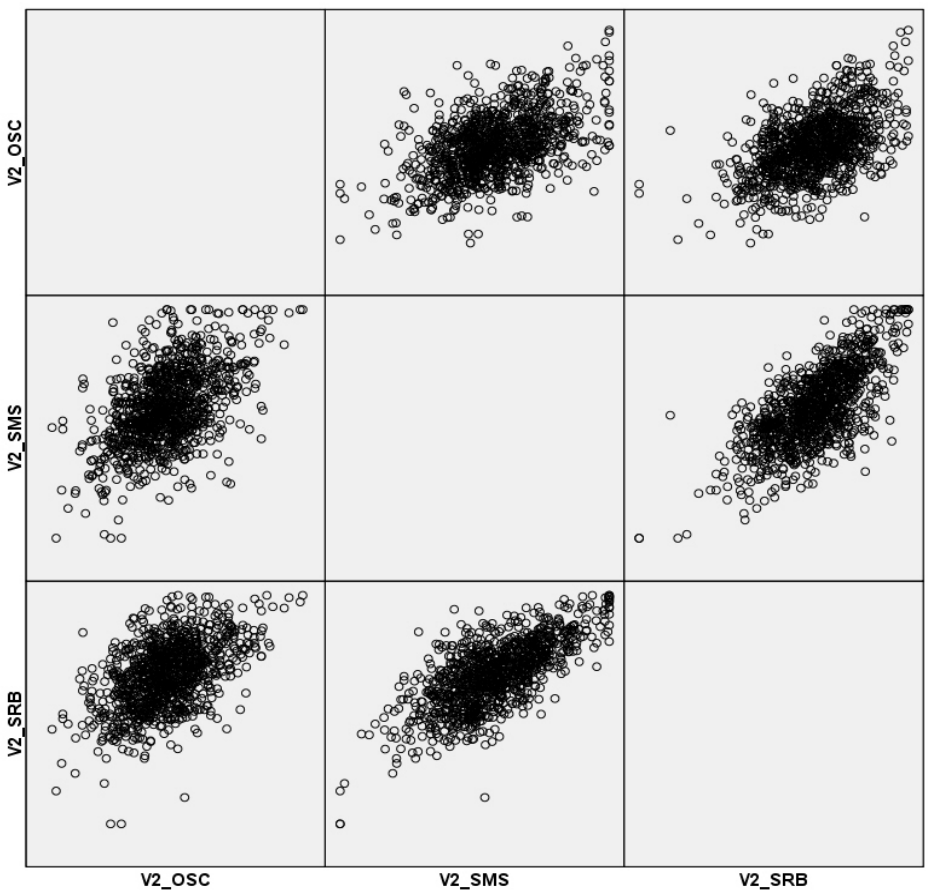
90	1038	3.79	0.99	1	5	-0.50	-0.30
91	1040	3.71	0.89	1	5	-0.32	-0.25
92	1041	3.67	0.85	1	5	-0.27	-0.11
93	1036	3.48	0.94	1	5	-0.24	-0.10
94	1033	3.68	1.33	1	5	-0.67	-0.71
95	1040	3.95	0.93	1	5	-0.58	-0.14
96	1041	4.34	0.87	1	5	-1.22	0.95
97	1040	2.61	1.32	1	5	0.35	-0.98
98	1040	3.75	0.88	1	5	-0.31	-0.25
99	1040	4.06	0.94	1	5	-0.82	0.25
100	1036	3.83	1.01	1	5	-0.62	-0.15
101	1038	3.50	0.91	1	5	-0.08	-0.31
102	1036	3.31	1.03	1	5	-0.16	-0.47
103	1039	4.05	0.96	1	5	-0.79	0.09
104	1039	4.08	0.90	1	5	-0.81	0.26
105	1038	2.94	1.16	1	5	0.11	-0.77
106	1037	2.97	1.13	1	5	0.14	-0.69
107	1038	3.34	0.91	1	5	-0.19	-0.05
108	1039	3.15	1.09	1	5	-0.07	-0.61
109	1039	3.24	1.01	1	5	-0.13	-0.35
110	1038	3.51	0.85	1	5	-0.25	0.12
111	1039	3.74	0.81	1	5	-0.28	-0.12
112	1042	4.00	0.87	1	5	-0.55	-0.16
113	1041	3.68	0.81	1	5	-0.24	-0.03
114	1040	4.38	0.80	1	5	-1.15	0.96
115	1042	3.87	0.82	1	5	-0.30	-0.31
116	1042	3.52	0.85	1	5	-0.20	0.02
117	1041	3.60	0.86	1	5	-0.34	0.17
118	1039	3.77	0.80	1	5	-0.24	-0.03
119	1038	4.31	0.81	1	5	-1.00	0.63
120	1040	3.58	1.00	1	5	-0.50	-0.06
121	1040	3.67	1.08	1	5	-0.52	-0.39
122	1041	4.14	0.91	1	5	-0.85	0.13
123	1037	4.10	1.10	1	5	-1.09	0.33
124	1034	3.71	1.13	1	5	-0.52	-0.59
125	1038	3.69	0.93	1	5	-0.41	-0.08
126	1041	3.94	0.93	1	5	-0.60	-0.14
127	1042	3.85	1.05	1	5	-0.63	-0.30
128	1041	3.96	1.02	1	5	-0.76	-0.07
129	1040	3.96	0.96	1	5	-0.65	-0.16
130	1039	3.68	1.04	1	5	-0.41	-0.44
131	1038	3.48	1.06	1	5	-0.30	-0.47
132	1040	4.30	0.85	1	5	-1.04	0.56

133	1038	4.17	1.00	1	5	-1.10	0.54
134	1035	4.15	0.99	1	5	-1.06	0.60
135	1041	4.18	0.90	1	5	-0.85	0.11
136	1040	3.66	1.39	1	5	-0.70	-0.80
137	1036	2.93	1.03	1	5	0.14	-0.40
138	1038	3.31	0.92	1	5	-0.02	-0.35
139	1037	3.36	0.97	1	5	-0.18	-0.42
140	1035	3.43	0.93	1	5	-0.14	-0.37
141	1038	3.46	0.94	1	5	-0.29	-0.22
142	1039	3.33	0.88	1	5	-0.02	-0.23
143	1034	3.14	0.98	1	5	-0.08	-0.33
144	1037	3.49	0.92	1	5	-0.26	-0.10
145	1037	3.27	0.94	1	5	-0.06	-0.39
146	1036	3.54	0.86	1	5	-0.22	-0.10
147	1039	3.33	0.91	1	5	-0.15	-0.16
148	1038	3.34	0.96	1	5	-0.13	-0.35
149	780	3.16	0.99	1	5	0.08	-0.52
150	1042	3.68	0.94	1	5	-0.35	-0.28
151	1043	2.98	0.94	1	5	0.10	-0.29
152	1038	3.20	0.89	1	5	-0.01	-0.09
153	1040	3.36	0.97	1	5	-0.19	-0.28
154	1040	3.44	1.06	1	5	-0.33	-0.49
155	1039	3.43	0.98	1	5	-0.17	-0.45
156	1041	2.87	1.03	1	5	0.12	-0.42
157	1041	2.81	1.04	1	5	0.17	-0.54
158	1041	2.93	1.02	1	5	-0.01	-0.42
159	1039	3.21	0.94	1	5	-0.14	-0.18
160	1040	3.09	1.03	1	5	-0.04	-0.49
161	1040	3.39	1.15	1	5	-0.31	-0.66
162	1040	3.10	1.17	1	5	-0.08	-0.79
163	816	3.19	1.08	1	5	-0.12	-0.56
164	1038	2.95	1.02	1	5	0.05	-0.37
165	1038	2.97	1.00	1	5	-0.04	-0.33
166	1037	2.80	1.02	1	5	0.11	-0.45
167	1034	2.86	1.04	1	5	0.07	-0.46
168	1036	2.83	1.02	1	5	0.10	-0.42
169	1038	3.17	0.98	1	5	-0.12	-0.30
170	1040	3.29	0.96	1	5	-0.18	-0.24
171	1039	3.12	1.03	1	5	0.00	-0.53
172	1041	3.19	1.01	1	5	0.02	-0.56
173	1041	3.18	1.01	1	5	-0.04	-0.51
174	1038	3.10	0.98	1	5	-0.01	-0.27
175	1037	3.21	0.98	1	5	-0.10	-0.34

176	1038	2.96	0.98	1	5	0.03	-0.35
177	860	3.06	0.96	1	5	0.02	-0.20
178	1042	3.07	1.04	1	5	0.02	-0.54
179	1041	3.23	1.02	1	5	-0.17	-0.39
180	1037	3.15	1.03	1	5	-0.05	-0.50
181	1039	3.38	0.91	1	5	-0.12	-0.16
182	1037	3.12	0.97	1	5	-0.09	-0.26
183	1039	3.07	0.98	1	5	-0.01	-0.32
184	1037	3.16	0.97	1	5	-0.08	-0.22
185	1036	3.10	0.99	1	5	-0.04	-0.27
186	1035	3.14	0.98	1	5	-0.08	-0.29
187	1034	3.60	0.99	1	5	-0.27	-0.40
188	1037	3.44	0.96	1	5	-0.26	-0.16
189	1035	3.29	0.97	1	5	-0.15	-0.31
190	1035	3.07	0.98	1	5	0.01	-0.29
191	1037	3.08	0.98	1	5	-0.02	-0.34
192	1032	3.00	0.97	1	5	0.01	-0.20
193	871	3.05	1.00	1	5	0.04	-0.33
194	1039	3.22	0.99	1	5	-0.02	-0.49
195	1037	3.08	0.96	1	5	0.02	-0.37
196	1040	2.94	0.99	1	5	0.04	-0.34
197	1035	2.88	0.99	1	5	0.07	-0.38
198	1035	2.97	1.01	1	5	0.00	-0.39
199	1039	3.36	1.08	1	5	-0.24	-0.53
200	1036	3.17	0.97	1	5	-0.08	-0.28
201	1036	2.93	1.01	1	5	0.05	-0.37
202	1036	2.91	1.03	1	5	0.09	-0.49
203	1036	3.45	0.95	1	5	-0.17	-0.22
204	1034	3.05	1.09	1	5	0.04	-0.55
205	1036	3.49	1.10	1	5	-0.37	-0.52
206	1039	3.85	0.96	1	5	-0.49	-0.29
207	1038	4.21	0.86	1	5	-0.84	0.23
208	1037	3.94	1.02	1	5	-0.71	-0.12
209	936	2.93	1.28	1	5	0.14	-0.99
210	929	4.01	0.95	1	5	-0.67	-0.05
211	1036	3.11	0.99	1	5	-0.01	-0.30
212	1037	3.16	1.01	1	5	-0.11	-0.33
213	1037	3.62	1.01	1	5	-0.38	-0.37
214	1040	3.75	0.99	1	5	-0.46	-0.16
215	1039	3.42	1.01	1	5	-0.19	-0.36
216	1035	3.30	1.03	1	5	-0.10	-0.41
217	1040	3.22	1.03	1	5	-0.10	-0.41
218	1032	3.22	1.09	1	5	-0.18	-0.54

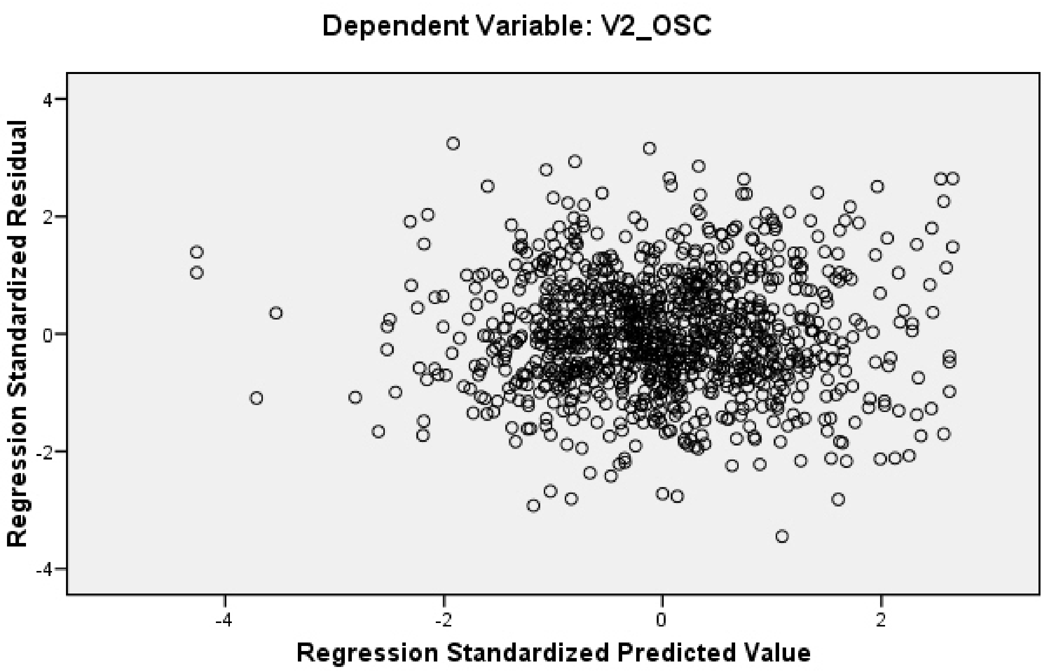
219	1039	3.22	0.97	1	5	-0.12	-0.34
220	1030	3.11	1.07	1	5	-0.11	-0.44
221	1038	3.27	0.98	1	5	-0.10	-0.27
222	1035	3.10	0.98	1	5	-0.10	-0.39
223	1034	3.11	0.99	1	5	0.02	-0.37
224	1035	3.02	1.02	1	5	0.03	-0.37
225	909	2.97	1.02	1	5	0.05	-0.39
226	1038	2.91	0.99	1	5	0.14	-0.27
227	1036	2.75	1.01	1	5	0.18	-0.28
228	1036	2.86	1.01	1	5	0.12	-0.31
229	1039	2.95	1.01	1	5	0.08	-0.36
230	1038	3.19	0.98	1	5	-0.07	-0.25
231	1038	3.42	1.02	1	5	-0.25	-0.32

Scatterplot Matrix for Organizational Safety Culture Variables



Scatterplot for Residual and Predicted Values

Scatterplot



Means, Standard Deviations, and Intercorrelations for OSC Element Organizational Context and Elements of Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
Organizational Context	3.40	0.55	0.525**	0.388**	0.463**	0.438**	0.390**	0.438**	0.390**	0.453**
Predictor variable										
1. SMS Policy	3.31	0.73	-	0.781**	0.886**	0.820**	0.572**	0.635**	0.559**	0.606**
2. SMS Organizing	3.22	0.82		-	0.747**	0.676**	0.488**	0.490**	0.444**	0.472**
3. SMS Planning and Implementing	3.17	0.74			-	0.804**	0.516**	0.623**	0.521**	0.599**
4. SMS Measuring and Reviewing	3.47	0.68				-	0.600**	0.630**	0.639**	0.631**
5. SRB Fitness and Medical	3.49	0.61					-	0.611**	0.711**	0.665**
6. SRB Vehicle Safety	3.40	0.69						-	0.666**	0.660**
7. SRB Structural Firefighting	3.90	0.64							-	0.730**
8. SRB Training	3.63	0.75								-

Means, Standard Deviations, and Intercorrelations for OSC Element Social Environment and Elements of Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
Social Environment	3.55	0.56	0.432**	0.373**	0.387**	0.378**	0.324**	0.309**	0.330**	0.325**
Predictor variable										
1. SMS Policy	3.31	0.73	-	0.781**	0.886**	0.820**	0.572**	0.635**	0.559**	0.606**
2. SMS Organizing	3.22	0.82		-	0.747**	0.676**	0.488**	0.490**	0.444**	0.472**
3. SMS Planning and Implementing	3.17	0.74			-	0.804**	0.516**	0.623**	0.521**	0.599*
4. SMS Measuring and Reviewing	3.47	0.68				-	0.600**	0.6300**	0.639**	0.631**
5. SRB Fitness and Medical	3.49	0.61					-	0.611**	0.711**	0.665**
6. SRB Vehicle Safety	3.40	0.69						-	0.666**	0.660**
7. SRB Structural Firefighting	3.90	0.64							-	0.730**
8. SRB Training	3.63	0.75								-

$^*p < .05$; $^{**}p < .01$.

Means, Standard Deviations, and Intercorrelations for OSC Element Individual Appreciation of Risk and Elements of Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
Individual Appreciation of Risk	3.52	0.47	0.265**	0.217**	0.219**	0.259**	0.260**	0.263**	0.278**	0.270**
Predictor variable										
1. SMS Policy	3.31	0.73	-	0.781**	0.886**	0.820**	0.572**	0.635**	0.559**	0.606**
2. SMS Organizing	3.22	0.82		-	0.747**	0.676**	0.488**	0.490**	0.444**	0.472**
3. SMS Planning and Implementing	3.17	0.74			-	0.804**	0.516**	0.623**	0.521**	0.599**
4. SMS Measuring and Reviewing	3.47	0.68				-	0.600**	0.630**	0.639**	0.631**
5. SRB Fitness and Medical	3.49	0.61					-	0.611**	0.711**	0.665**
6. SRB Vehicle Safety	3.40	0.69						-	0.666**	0.660**
7. SRB Structural Firefighting	3.90	0.64							-	0.730**
8. SRB Training	3.63	0.75								-

*$p < .05$; **$p < .01$.

Means, Standard Deviations, and Intercorrelations for OSC Element Work Environment and Elements of Predictor Variables (N = 1043)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
Work Environment	3.12	0.60	0.354**	0.279**	0.340**	0.336**	0.331**	0.354**	0.337**	0.350**
Predictor variable										
1. SMS Policy	3.31	0.73	-	0.781**	0.886**	0.820**	0.572**	0.635**	0.559**	0.606**
2. SMS Organizing	3.22	0.82		-	0.747**	0.676**	0.488**	0.490**	0.444**	0.472**
3. SMS Planning and Implementing	3.17	0.74			-	0.804**	0.516**	0.623**	0.521**	0.599**
4. SMS Measuring and Reviewing	3.47	0.68				-	0.600**	0.630**	0.639**	0.631**
5. SRB Fitness and Medical	3.49	0.61					-	0.611**	0.711**	0.665**
6. SRB Vehicle Safety	3.40	0.69						-	0.666**	0.660**
7. SRB Structural Firefighting	3.90	0.64							-	0.730**
8. SRB Training	3.63	0.75								-

**p* < .05; ***p* < .01.

Table

Means for Groups of Homogenous Subsets for Job Function as a Function of Policy

Variable	*N*	*1*	*2*
Company Officer	249	3.20	
Chief Officer	175	3.22	
Firefighter	526		3.37

Table

Means for Groups of Homogenous Subsets for Job Function as a Function of Organizing

Variable	*N*	*1*	*2*
Company Officer	249	3.10	
Chief Officer	175	3.13	3.13
Firefighter	526		3.29

Table

Means for Groups of Homogenous Subsets for Job Function as a Function of Planning and Implementing

Variable	*N*	*1*	*2*
Chief Officer	175	3.00	
Company Officer	249	3.04	
Firefighter	526		3.27

Table

One-Way Analysis of Variance for Years of Service as a Function of OSC, SMS, and SRB

Variable and source	*df*	*MS*	*F*
Years of Service			
Organizational Safety Climate	4	0.72	4.31**
Safety Management Systems	4	3.80	8.53**
Safety Related Behaviors	4	1.85	5.57**

*$p < .05$; **$p < .01$.

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Organizational Safety Climate

Variable	*N*	*1*	*2*
16 to 20	132	3.32	
11 to 15	205	3.33	
6 to 10	224	3.42	3.42
over 20	265		3.44
0 to 5	202		3.45

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Safety Management Systems

Variable	*N*	*1*	*2*	*3*
16 to 20	132	3.14		
11 to 15	205	3.18	3.18	
over 20	265	3.26	3.26	
6 to 10	224		3.35	3.35
0 to 5	202			3.50

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Safety Related Behaviors

Variable	*N*	*1*	*2*
16 to 20	132	3.49	
11 to 15	205	3.52	
6 to 10	224	3.60	3.60
over 20	265	3.63	3.63
0 to 5	202		3.74

Table

Test of Equality of Means for Years of Service as a Function of OSC, SMS, and SRB

Variable	*Welch*	*Brown-Forsythe*
Organizational Safety Climate	0.00	0.00
Safety Management Systems	0.00	0.00
Safety Related Behaviors	0.00	0.00

Table

One-Way Analysis of Variance for Years of Service as a Function of the Elements of OSC

Variable and source	*df*	*MS*	*F*
Years of Service			
Organizational Context	4	2.19	7.37**
Social Environment	4	1.44	4.74**
Individual Appreciation of Risk	4	0.42	1.92
Work Environment	4	1.84	5.21**

*$p < .05$; **$p < .01$.

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Organizational Context

Variable	*N*	*1*	*2*	*3*
16 to 20	132	3.24		
11 to 15	205	3.30	3.30	
6 to 10	224		3.41	3.41
over 20	265			3.48
0 to 5	202			3.49

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Social Environment

Variable	*N*	*1*	*2*
16 to 20	132	3.47	
11 to 15	205	3.49	
0 to 5	202	3.53	3.53
6 to 10	224	3.55	3.55
over 20	265		3.68

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Work Environment

Variable	*N*	*1*	*2*
16 to 20	132	3.05	
over 20	265	3.05	
11 to 15	205	3.08	3.08
6 to 10	224		3.22
0 to 5	202		3.24

Table

Test of Equality of Means for Years of Service as a Function of the Elements of OSC

Variable	*Welch*	*Brown-Forsythe*
Organizational Context	0.00	0.00
Social Environment	0.00	0.00
Individual Appreciation of Risk	0.09	0.11
Work Environment	0.00	0.00

Table

One-Way Analysis of Variance for Years of Service as a Function of the Elements of SMS

Variable and source	*df*	*MS*	*F*
Years of Service			
Policy	4	4.41	8.67**
Organizing	4	2.59	3.93**
Planning and Implementing	4	5.94	11.26**
Measuring and Reviewing	4	3.16	7.00**

**p < .05; **p < .01.*

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Policy

Variable	*N*	*1*	*2*
16 to 20	132	3.16	
11 to 15	205	3.17	
over 20	265	3.30	
6 to 10	224	3.36	3.36
0 to 5	202		3.53

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Organizing

Variable	*N*	*1*	*2*
16 to 20	132	3.08	
11 to 15	205	3.14	
over 20	265	3.17	3.17
6 to 10	224	3.28	3.28
0 to 5	202		3.37

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Planning and Implementing

Variable	*N*	*1*	*2*	*3*
16 to 20	132	2.98		
11 to 15	205	3.06	3.06	
over 20	265	3.08	3.08	
6 to 10	224		3.25	3.25
0 to 5	202			3.42

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Measuring and Reviewing

Variable	*N*	*1*	*2*
11 to 15	205	3.34	
16 to 20	132	3.35	
over 20	265	3.48	3.48
6 to 10	224	3.50	3.50
0 to 5	202		3.66

Table

Test of Equality of Means for Years of Service as a Function of OSC, SMS, and SRB

Variable	*Welch*	*Brown-Forsythe*
Policy	0.00	0.00
Organizing	0.00	0.00
Planning and Implementing	0.00	0.00
Measuring and Reviewing	0.00	0.00

Table

One-Way Analysis of Variance for Years of Service as a Function of the Elements of SRB

Variable and source	*df*	*MS*	*F*
Years of Service			
Fitness and Medical	4	1.76	4.82**
Vehicle Safety	4	1.68	3.57**
Structural Firefighting	4	1.04	2.61*
Training	4	3.55	6.48**

**p* < .05; ***p* < .01.

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Fitness and Medical

Variable	*N*	*1*	*2*
16 to 20	132	3.37	
11 to 15	205	3.41	
over 20	265	3.51	3.51
6 to 10	224	3.52	3.52
0 to 5	202		3.62

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Vehicle Safety

Variable	*N*	*1*	*2*
16 to 20	132	3.29	
11 to 15	205	3.30	
6 to 10	224	3.41	3.41
over 20	265	3.42	3.42
0 to 5	202		3.52

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Structural Firefighting

Variable	*N*	*1*	*2*
16 to 20	132	3.80	
11 to 15	205	3.84	3.84
6 to 10	224	3.91	3.91
over 20	265	3.93	3.93
0 to 5	202		4.00

Table

Means for Groups of Homogenous Subsets for Years of Service as a Function of Training

Variable	*N*	*1*	*2*
16 to 20	132	3.49	
11 to 15	205	3.52	
6 to 10	224	3.58	
over 20	265	3.67	3.67
0 to 5	202		3.83

Table

Test of Equality of Means for Years of Service as a Function of OSC, SMS, and SRB

Variable	*Welch*	*Brown-Forsythe*
Fitness and Medical	0.00	0.00
Vehicle Safety	0.01	0.01
Structural Firefighting	0.04	0.04
Training	0.00	0.00

Table

Means for Groups of Homogenous Subsets for Job Function as a Function of Planning and Implementing

Variable	*N*	*1*	*2*
Firefighter	526	0.60	
Company Officer	249	0.61	
Chief Officer	175		0.70

Table

Means for Groups of Homogenous Subsets for Job Function as a Function of Fitness and Medical

Variable	*N*	*1*	*2*
Firefighter	526	0.89	
Company Officer	249	0.96	0.96
Chief Officer	175		0.98

Table

Means for Groups of Homogenous Subsets for Job Function as a Function of Vehicle Safety

Variable	*N*	*1*	*2*
Firefighter	526	0.87	
Company Officer	249	0.90	
Chief Officer	175		0.98

APPENDIX C: IRB Documents

University of Colorado Denver
Downtown Campus

1380 Lawrence Street, Suite 300
Campus Box 120
P.O.Box 173364
Denver, CO 80217-3364

William Pessemier
8142 S. Saint Paul Way
CENTENNIAL CO, 80122

06/06/2008

Certificate of Approval

Investigator:	William Pessemier	
Sponsor(s):	National Fallen Firefighters Foundation | Public Entity Risk Institute	
Subject:	HSRC Protocol 2008-162 Initial Review (APP001) 1st	Title: THE INFLUENCE OF SAFETY CULTURE ON FIREFIGHTER LINE OF DUTY DEATH AND INJURY
Approval Date:	**27 May 2008**	
Expiration Date:	**27 May 2009**	
Expedited Category:	n/a	
Approval Includes:	Protocol - Investigator	

This study is approved by HSRC via the Cooperative Agreement with the designated IRB of Record.

The designated IRB of record will provide oversight and continuing review for the remainder of time that the protocol is active. Please notify HSRC when this protocol is closed.

Mary Geda, MSN Tony Robinson

Revised 03/05 2008-162 Panel: O

SU- EG-07-2

HSRC#2008-162

IRB Authorization Agreement

Name of Institution or Organization Providing IRB Review (Institution A):
Oklahoma State University, Stillwater, Oklahoma

IRB Registration #: IRB00001305 **Federalwide Assurance (FWA) #, if any:** 00000493

Name of Institution Relying on the Designated IRB (Institution B):
University of Colorado Denver – Downtown Campus

OHRP Federalwide Assurance (FWA) #: 00000066

The Officials signing below agree that The University of Colorado Denver –Downtown Campus may rely on the designated IRB for review and continuing oversight of its human subject research described below:

(XX) This agreement is limited to the following specific protocol:

> **Name of Research Project:** The Influence of Organizational Culture on Firefighter Line of Duty Deaths and Injuries
> **Name of Principal Investigators**: Chris Neal, Oklahoma State University, William Pessemier, University of Colorado – Denver
> **Sponsor or Funding Agency:** National Fallen Firefighters Foundation, Public Entity Risk Institute
> **Award Number**: NFFF Grant No. 5-18677. PERI Grant No. 5-12906

The review and continuing oversight performed by the designated IRB will meet the human subjects protection requirements of Institution B's OHRP-approved FWA. The IRB at Institution A will follow written procedures for reporting its findings and actions to appropriate officials at Institution B. Relevant minutes of IRB meetings will be made available to Institution B upon request. Institution B remains responsible for ensuring compliance with the IRB's determinations and with the terms of its OHRP-approved Assurance. This document must be kept on file at both institutions and provided to OHRP upon request.

Signature of Signatory Official (Institution A):

Stephen Mckeever Date: 5/29/08

Print Full Name: Stephen W. S. McKeever, Ph.D.
Institutional Title: Vice President for Research and Technology Transfer

Signature of Signatory Official (Institution B):

Angela Wishon Date: 6-5-08

Print Full Name: Angela Wishon, JD,
Institutional Title: Assistant Vice Chancellor for Regulatory Compliance

Approved

MAY 27 2008

HSRC

HSRC Protocol Attachment P

PROTOCOL #: 2008-162

(Use Protocol Manager on the HSRC Website)

CAMPUS BOX #: **TELEPHONE #: 303-798-9248 Fax #:**

Project Title: The influence of safety culture in firefighter line of duty death and injury

Principal Investigator:

I. Hypotheses and Specific Aims/Purpose: The main purpose of this study is to determine whether improvements in safety performance can be realized and sustained by developing and implementing a safety performance improvement intervention that directly influences the way in which safety is managed, and by specifically targeting critical behaviors of individuals and work teams. The hypothesis for this study is that the development of an effective safety performance improvement intervention and the successful implementation of the intervention will result in improvement in safety management systems, safety related behaviors, and organizational safety climate. The long term outcome of improvements in these variables is expected to result in reduced firefighter injury and death rates.

II. Background and Significance: Over 100 firefighters are killed in the line of duty each year, and over 80,000 are injured. The rate of firefighter deaths and injuries the US is 4 to 5 time higher than in other industrialized nations, such as the UK. Despite changes and improvements in personal protective equipment, fire apparatus, fire codes and standards, and safety related standards for fire operations, the actual rate of firefighter deaths per 100,000 fires is actually increasing in the US. In addition, the economic impact of firefighter deaths and injuries has been estimated be more than 4.8 billion dollars annually.

Other high risk occupations have been successful at reducing injury and death rates by developing comprehensive safety management systems that are directed at critical safety related behaviors. Numerous studies have been conducted using other high risk occupations and professions to evaluate the impact of engineering, administrative, and behavioral approaches to improving safety performance. The changes that have been made in the fire service with regard to safety in the past would be classified as Engineering approaches to improving safety performance. The development of safety management systems is an example of an Administrative approach, and the targeting of critical safety related behaviors for change or improvement is an example of a Behavioral approach.

This study will involve the development of safety management systems that are targeted at critical safety related behaviors, resulting in a study that applies both the administrative and behavioral approach to improving safety performance. This approach is based on a model developed by Cooper called the Reciprocal Determinism Model of safety culture. Changes and improvements in safety management systems and safety related behaviors are expected to results in improvements in organizational safety climate, which in the long term, result in improved safety performance.

Although extensive research has been conducted in regard to the influence of safety culture on safety performance, several gaps remain in the field. Clearly, there has been very little research conducted using the fire service as the field of study. Several studies have examined the effect of changes in safety management systems on safety performance, while other studies have examined the effect of changes in safety related behaviors on safety performance. These studies have examined the impact of safety management systems and safety behaviors on safety performance independently of one another. Few research studies have used an integrated framework using all three elements of the RDM model to evaluate the effect of changes in all three elements of safety culture on safety performance (Cooper, 2000).

Although the issues involving the implementation of safety culture assessments have been studied in other high risk industries, they are not clearly understood (Wiegmann et al, 2004). This study will contribute to a greater level of understanding of the implementation of a safety performance improvement intervention from the perspective of safety culture because the factors that influence successful implementation will be examined as part of the study. These factors include the level of cooperation and conflict, the level of trust, whether the response to the intervention is supported or resisted, and whether the changes are perceived to fall within a range of acceptance. This study will also contribute to a greater understanding of the factors that influence the implementation of a quality management innovation in a public sector organization because the model for safety management systems is based on the principles of continuous quality improvement and total quality management.

The construct or model used in this study has the potential to be used for improving organizational performance in other areas in addition to safety. Because the model is grounded in the principles of quality management and continuous improvement, it is possible that the basic construct could be used to improve the quality or performance of other services and programs provided by public organizations. If the model is shown to be successful in demonstrating that changes in management practices that are focused on specific behaviors result in changes in values, beliefs, and attitudes, and that such an integrative framework results in improved performance, then researchers in other fields may find this project valuable for improving other areas of organizational performance.

It is also important as a national policy goal. In 2004, the United States Fire Administration established a goal to reduce firefighter fatalities by 25% within 5 years, and 50% within 10 years. Results from this study have the potential to help make a major contribution toward these national policy goals.

III. Preliminary Studies/Progress Report: Three fire departments have agreed to participate in the full study. These include Anchorage, Alaska; Shreveport, Louisiana; and Tulsa, Oklahoma.

IV. Research Methods: Summary of Study Rationale

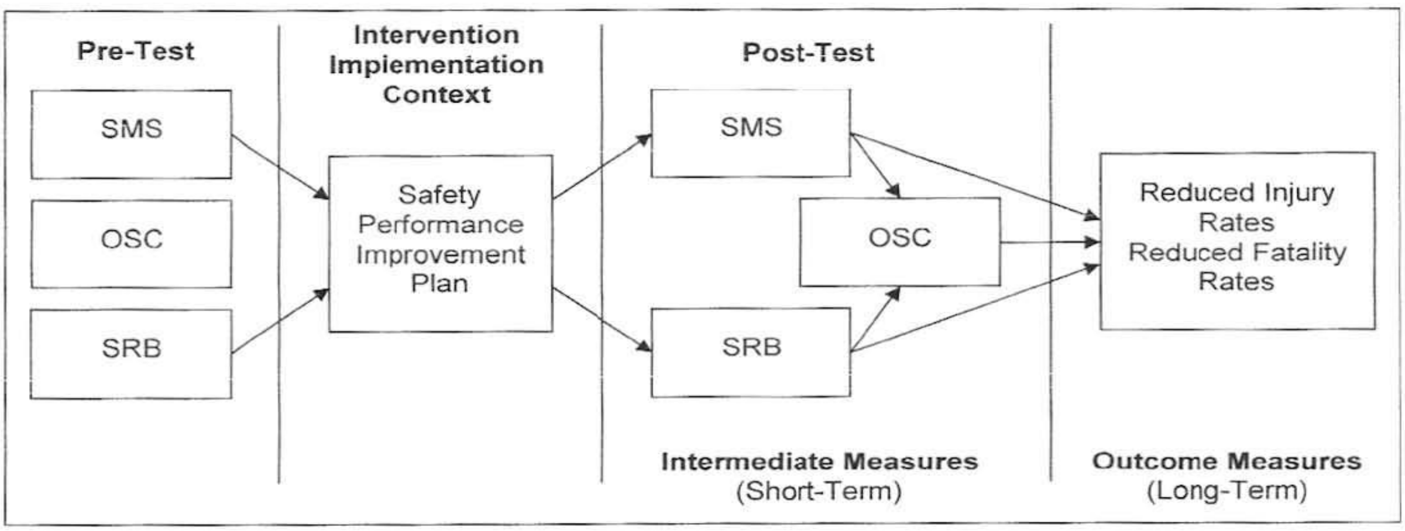
A. **Primary Outcome(s):** This study involves short term outcomes and long term outcomes. The short term outcomes of the study are anticipated to include improvement in scores for questionnaires on safety management systems, safety related behaviors, and organizational safety climate. These questionnaires are attached for review. The long term outcomes of the study are expected to include a reduction in the rates of accidents, incidents, injuries and deaths for those fire departments participating in the study. If the study is successful in improving safety performance, it is anticipated that more departments from around the US will use the model presented in the study to improve safety performance in their organization. Over time, it is anticipated that this study will help to significantly reduced the rates of firefighter deaths and injuries in the US.

B. **Secondary Outcome(s):** Secondary outcomes resulting from this study are anticipated to include an improved capacity for participating departments to use the concepts and principles of quality management for other issues and problems; a reduction in the use of medical leave resulting from injuries and accidents; and lower health care costs resulting from fewer injuries.

C. **Summary of Research Methods and Study Design:** This study will involve a mixed methods approach using a qualitative comparative case study component and a quantitative pre-test, intervention, post-test component. The pre and post test variables will be consist of quantitative measures of safety management systems, safety behaviors, and safety climate. The intervention will include both qualitative and quantitative measures of both intervention and implementation variables. In addition, variables associated with the context of implementation will be measured quantitatively and compared between the participating organizations.

Measures of the intervention and implementation are the independent variables. The process and content of the intervention and the implementation of the intervention make up the Safety Performance Improvement Plan. The dependant variables are the scores on the Safety Management System, Safety Related Behaviors, and Organizational Safety Climate questionnaires.

The principle hypothesis for the study is that the Safety Performance Improvement Plan will result in improvements in the scores for safety management, safety behaviors, and safety climate. Comparisons will be made between participating organizations to determine whether and how the process and content of the intervention and the implementation of the intervention directly influences scores in the management systems and safety behavior variables, and how changes in these variables influences scores in the organizational safety climate variable. A comparison will also be made between the departments with regard to the organizational context of the implementation of the intervention to determine which how the variables associated with the context of implementation influence the success of the implementation. A basic diagram of the study is provided in the following figure.



Safety Management Systems are comprised of four elements, most of which contain a number of sub-elements, which are also identified:

1) Policy
2) Organizing
   a) Structure
   b) Cooperation
   c) Communication
   d) Competence
3) Planning and Implementation
   a) Performance Standards
   b) Risk Assessment and Control
   c) Hazard Identification
   d) Planning
4) Measuring and Reviewing Performance
   a) Active Monitoring
   b) Reactive Monitoring

c) Remedial Action
d) Reviewing Performance

Safety Management Systems will be operationalized through the development of a questionnaire based on these four elements of safety management. A similar approach has been used in a study of safety culture in aviation (Flannery, 2001). A Likert scale will be used for rating the questions associated with the Safety Management System questionnaire. The rating scale used will include five ratings ranging from 1 to 5 (No Evidence, Little Evidence, Reasonable Evidence, Significant Evidence, Full Evidence). In order to assist participants in scoring the elements of the Safety Management System questionnaire, a numerical percentage will be provided below the rating description. The purpose of this percentage score is to provide numerical comparison for each response.

Safety Related Behaviors examined in this study will include the key or critical behaviors within four domains of fire service practices. These domains and safety behaviors include the following:

1) Health, Wellness, Fitness and Medical
   a) Fitness Program
   b) Medical Evaluation
2) Vehicle Safety
   a) Seat Belt Use
   b) Response Policy and Procedures
   c) Training
   d) Supervision
3) Structural Firefighting
   a) Command and Control
   b) Communications
   c) Accountability
   d) Operational Risk Management
4) Training
   a) Instructors
   b) Planning
   c) Facilities
   d) Safety Requirements

Development of the Safety Related Behavior questionnaire will be based on the critical behavioral elements within each of these domains. These domains will be operationalized through a review and assessment of several sources. These will include the National Fire Protection Association standards on health, fitness, medical examinations, and vehicle operations, as well as the FEMA Emergency Vehicle Safety Initiative and the Health and Safety Guidelines for Firefighter Training developed by the University of Maryland.

The same Likert scale use for the Safety Management System questionnaire will be used for rating the questions associated with the Safety Related Behavior questionnaire. This rating scale will include five ratings ranging from 1 to 5 (No Evidence, Little Evidence, Reasonable Evidence, Significant Evidence, Full Evidence).

The Health and Safety Climate Survey Tool (CST) has been selected as the method for operationalizing the Organizational Safety Climate variable. This tool is considered to be well developed and has been used extensively in other occupations (HSE, 1999). Several broad elements of organizational safety climate are measured with this tool. These are the Organizational Context, Social Environment, Individual Appreciation, and Work Environment. Each of these dimensions consists of a number of specific elements as listed below.

1) Organizational Context

a) Management Commitment: perceptions of management overt commitment to health and safety issues.
b) Communications: the nature and efficiency of health and safety communications within the organization.
c) Priority of Safety: the relative status of health and safety issues within the organization.

2) Social Environment
   a) Supportive Environment: the nature of the social environment at work, and the support derived form it.
   b) Involvement: the extent to which safety is a focus for everyone and all are involved.
3) Individual Appreciation
   a) Personal Priorities and Need for Safety: the individuals view of their own health and safety management and need to feel safe.
   b) Personal Appreciation for Risk: how individuals view the risk associated with work.
4) Work Environment.
   a) Physical Work Environment: perceptions of the nature of the physical environment.

An evaluation of the effectiveness of the safety climate measurement survey tool was conducted by the Health and Safety Executive in 2002. Results from that evaluation indicate that the CST enables organizations to gain a greater understanding of existing levels of safety culture and areas in need of improvement (HSE, 2002).

The rating scale for the Organizational Safety Climate questionnaire is similar to those used for the Safety Management System and Safety Related Behavior questionnaires in that it is a five point Likert scale. However, the CST uses a different form of descriptors for each of the ratings. Descriptors for the Organizational Safety Climate questionnaire are: Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, Strongly Agree.

Pre-test variables include Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate. These variables will be measured using a questionnaire for each of the three variables. Additional data will be collected through interviews with a random selection of organizational members of various ranks, and by a review of safety related documents, such as safety policies and procedures.

Development of a Safety Performance Improvement Plan includes the development of an intervention plan and a plan for implementation of the intervention. Several variables will be used to measure the overall success of the safety improvement plan. These include the commitment of top management, which will be measured by a qualitative evaluation of how the commitment of top management is demonstrated and communicated. Participation will be measured by the number and characteristics of the members of the Safety Performance Improvement Committee, as well as the number of meetings of the committee and the level of attendance. Communications are another essential element of a successful safety performance improvement plan. This variable will be measured by comparing the frequency, content, channel and form of communications from the committee to the members of the department. The resources provided for the development of the intervention and for the implementation of the intervention is the last element required for a successful improvement plan. This variable will be measured through the human and financial resources allocated to the development of the intervention and the implementation of the intervention, which will include the number of personnel hours and the amount of funding allocated to both.

The process of developing the intervention will be measured as a qualitative comparison. A comparison will be made between the process used by each of the participating departments to develop their intervention and recommended best practices for developing an intervention. The best practices recommendations are derived from the BS 8800 standards used in the UK. These include the following elements:

- Initial review of findings
- Develop goals and objectives for improvement

- Criteria for selection of goals/objectives
  - Description statements for goals/objectives
- Determine how achievement of goals/objectives will be measured
- Prioritize goals/objectives

Measurement of the content of the intervention will also be based on a qualitative and quantitative comparison of the variables between the participating departments. The content of the intervention will consist of the following variables:

- Goals and objectives: which ones selected for improvement
- Total number of goals and objectives: how many selected for improvement
- Goal differential: how much improvement is desired
- Duration of the intervention: within what time frame is this to take place
- Performance measures: how will achievement of each goal/objective me measured

As in the case of measuring the intervention process, the variables used to measure the process of developing the implementation plan will consist of a qualitative comparison. A comparison will be made between the process used by each of the participating departments to develop their implementation plan and recommended best practices for developing an implementation plan. These best practices recommendations are also derived form the BS 8800 standard, and include the following:

- Prepare a plan for achieving the goals/objectives
  - Assign responsibility for achieving objectives
  - Allocate resources
- Communicate the plan
- Implement the plan
- Measure and review implementation progress

The content of the implementation plan will be measured by making a qualitative and quantitative comparison between the participating departments and the elements of implementation that have been determined to make up the best practices as described in the research on safety interventions. These have also been derived from the BS 8800 Standard, and include the following:

- Training
- Incentives and constraints
- Concerns and complaints
- Performance measures for implementation success

Measures for training include the number of classes, the hours of training, participation in the training program, content of the training classes, and the method of delivery. Incentives and constraints are expected to be developed for the purpose of encouraging compliance and participation, and to increase the use of the tools, techniques and practiced identified in the performance improvement plan. These will be compared qualitatively, as will the method that each of the departments develops to deal with concerns and complaints about the Safety Performance Improvement Plan from members of their respective departments.

Probably the most important measure associated with implementation is the actual use of the tools, techniques, and practices identified in the performance improvement plan. These will include some or all of the following:

- Risk Control Systems
- Preventive Action Plans
- Corrective Action Plans
- Active Performance Monitoring

Templates for these tools will be provided for the participating departments. As a measure of implementation success, comparisons between the participating departments will be made as to the number of Risk Control System elements completed, the number of preventive and corrective action plans developed, and the what measures are developed and used for active performance monitoring.

The measures that will be used to evaluate the context of implementation have already been described, but include the following: cooperation, conflict, trust, resistance/support, and change acceptance. For each of these elements, a simple five level Likert scale will be developed to rate each element from low to high.

The Post-Test variables will be a repeat of the Pre-Test questionnaires on Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate. Additional data will be collected through interviews with a random selection of organizational members of various ranks, and by a review of safety related documents, such as safety policy and procedures.

Two separate phases are planned for this study. The first phase is intended to develop and then test the surveys that will be used as the measures for the Safety Management System, Safety Related Behaviors, and Organizational Safety Climate variables. Three departments from around the United States will be asked to participate in this phase. Participation will involve three elements: distribution, completion and return of the Safety Management System, Safety Related Behavior, and Organizational Safety Climate surveys; the participation of various members of the department in personal interviews; and the submission of safety related documents for review. The purpose of this phase will be to determine if the RDM model is a useful heuristic for the construct of safety culture in the participating fire departments, and to develop and test the operational measures of the variables included in the model within the fire service context.

Phase Two will involve the application of all three stages of the research design, including the Pre-Test, the development of a Safety Performance Improvement Plan, and Post-Test. The development of a Safety Performance Improvement Plan will include the development of the intervention and implementation of the intervention. This design has been used in several other safety culture studies (Zohar & Luria, 2003; DeJoy, 2005; Cooper & Phillips, 2004; Lind & Aaro, 2004). The Pre-Test stage involves a review of safety related documents, distribution and completion of a set of questionnaires on the Safety Management System, Safety Related Behaviors, and Organizational Safety Climate variables, and interviews with department personnel. This stage concludes with the input of the data from the questionnaires into a Pre-Test data base.

The next stage of the study is the development and implementation of the safety intervention. A set of recommended best practice for this stage will be provided to the participating organizations. Recommended practices will include the establishment of a Safety Performance Improvement Committee (SPIC) for the purpose of providing the participation and involvement necessary for a successful intervention. It will be the responsibility of the SPIC to develop the intervention plan, a plan for implementation of the intervention, and to measure and review both of these components throughout the course of the initial intervention period.

Development of the safety intervention will be based on the scores on the Safety Management System and Safety Related Behaviors surveys, as well as supplemental information provided by the interviews and document review. This is equivalent to recommendations for what has been previously described as the multiple intervention approach, which includes elements of both an Administrative and Behavioral intervention. The SPIC will make decisions about which elements of the Safety Management System and Safety Related Behavior variables will be selected for improvement, how many total elements will be selected for improvement given the limitations of resources, and how much improvement is established as the goal for each element. In addition, they will develop the implementation plan for the making the changes and improvements identified in the intervention plan.

The implementation plan will include decisions about what process should be used to develop the implementation plan, how much time will be required to implement the intervention recommendations, and what resources will be required for successful implementation. As previously explained, successful implementation also requires the development of a positive climate for implementation and removal or reduction of the obstacles that limit successful implementation. Recommendations for developing a positive climate will include a program for providing knowledge to organizational members about the model and associated variables, about what incentives and constraints on behaviors will be included in the plan, how concerns and complaints will be dealt with, and what steps will be taken to monitor and review results of the safety performance improvement plan.

Recommendations for removing obstacles will include a program to identify what obstacles may be present in the organization. These include melioration bias rare event bias, optimism bias, the cost of safety, normalization of risk, intervention/values fit, and whether the need and value of the change is recognized. Recommended practices to remove or limit these variables will include high levels of participation, the visible commitment of top leaders, development of clear goals through the Safety Management System, high levels of communication between members, clearly defined control practices, and training. Training will include generalized training for all members of the department, and specialized training for first line supervisors.

It is anticipated that the three departments participating in the study will develop different interventions and different implementation plans. Every attempt will be made to fully document the intervention and implementation phase, since this phase represents the independent variable in the study.

In summary, the intervention and implementation phase will begin after the baseline measures for the Safety Management Systems, Safety Related Behaviors, and Organizational Safety Climate are completed. This phase will include the development of the intervention plan and the implementation plan, and will conclude when the plan is fully implemented as planned. This is expected to require from three to six months.

The Post-Test stage of this phase is expected to begin when the end of the time frame developed for implementation has been reached. It may begin earlier under two conditions: after the intervention is considered to be fully implemented and operating as planned; or when the participating organization decides that the program is operating as well as possible, and that further improvements are unlikely. The Post-Test stage will involve the distribution and completion of the Safety Management System, Safety Related Behaviors, and Organizational Safety Climate surveys used in the Pre-Test. The context of implementation will also be assessed during the Post-Test stage.

D. **Description of Population to be enrolled:** Firefighters working in the participating departments are the target population for this study. They are typically between the ages of 21 and 60. Minimum educational requirements for most fire departments include graduation from high school, but the general population of firefighters includes a large population with undergraduate degrees. Most of the population will be male, since the largest proportion of firefighters is male, but some female firefighters are expected to be included in the study. Because of the hiring requirements for municipal fire departments, no high risk populations are anticipated to be included in the study.

E. **Description and Justification of Procedures, Measures, and Data Collection Tools:** The procedures, measures and data collection tools are typical for studies involving safety performance that have been conducted in other occupations. The organizational climate survey and the safety management system survey questionnaires have been used extensively in other occupations and industries. The development of the survey questionnaire on safety related behaviors is based on data from the National Fire Protection Association on firefighter deaths and injuries, and on information from a study conducted by the National Fallen Firefighters Foundation on the causes of firefighter deaths and injuries.

Data collection using questionnaires, interviews and document reviews are a common methodology for studies involving safety interventions and efforts to improve safety performance (Cooper, 2000; Zohar & Luria, 2003; DeJoy, 2005 Cooper & Phillips, 2004).

F. Potential Scientific Problems:

Due to budgetary constraints, the number of organizations that can participate in the project is limited to three departments. Each department has approximately 200 members, so the maximum number of questionnaires that can be expected is around 800. Depending on the total number of questions to be used in the three questionnaires, and the completion rates for each of the participating departments, this may result in a problem with the sample size.

The ideal methodological approach for this study would be to include a control group in the research. Consideration was given to the possibility of administering the intervention to two of the three shifts of firefighters within each of the participating departments, but was rejected on both ethical and methodological grounds. Increasing safety for some firefighters and not others in a department simply was not considered an ethical option for the study. Using one shift as a control group was also rejected because it is unlikely that the integrity of individual shifts would have been maintained over the course of the intervention phase, given the propensity for shift exchanges and overtime. Individuals assigned to the control shift would be likely to work numerous shifts on the experimental shifts during the course of the intervention phase, confounding the desired effect of having a control group.

Although the Reciprocal Determinism Model will be used for this study, the purpose of this study is not to test the reciprocal nature of the relationship between the variables. In addition, it is not the intention of this study to evaluate the impact of any potential change in the variables on the outcome measures of organizational safety performance, which would be actual reductions in injury and death rates. Again because of limitations of time and funding, this study will limit the examination of safety performance to the intermediate performance measures, which are the changed in scores for safety management systems, safety related behaviors, and organizational safety climate.

G. Data Analysis Plan:

Analysis of the data from this study will begin with descriptive statistics and exploratory data analysis of the variables. Factor analysis will be conducted on the questionnaires used on the first phase of the study. The purpose of this statistical analysis is to determine if it is possible and appropriate to reduce the number of questions in the Safety Management System and Safety Related Behavior questionnaires. In addition, factor analysis will be used to evaluate the validity of the various sub-elements of the Safety Management System and Safety Related Behavior questionnaires.

Several hypotheses will be used to guide the analysis of the data. These have been put into the form of a series of null hypotheses, and include the following:

H1 – The development and implementation of a Safety Performance Improvement Plan will have no significant effect on changes in the scores for Safety Management Systems or Safety Related Behaviors.

> H1a – The process and content of the intervention will have no significant effect on changes in scores for Safety Management Systems or Safety Related Behaviors.
>
> H1b – The process and content of implementation will have no significant effect on the scores for Safety Management Systems or Safety Related Behaviors.
>
> H1c – The process and content of implementation will have no significant effect on implementation success.

H1d – The context of implementation will have no significant effect on implementation success.

H2 – Changes in scores for Safety Management Systems and Safety Related Behaviors will have no significant effect on changes in scores for Organizational Safety Climate.

Based on these hypotheses, additional statistics will include correlation and multiple regression, which will be used to describe the relationship between the variables in the model. Factorial ANOVA will be used to determine the individual effect of the independent variables on the dependant variable, as well as the interaction effects between the two independent variables. Reliability of the scales used in the Safety Management System and Safety Related Behavior questionnaires will be tested using Cronbach's Alpha.

H. Summarize Knowledge to be Gained: link with instruction and guidance

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