FIRE FIGHTER SAFETY AND DEPLOYMENT STUDY

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MULTI-PHASE STUDY ON FIREFIGHTER SAFETY AND THE DEPLOYMENT OF RESOURCES

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Year 1 Final Report

MULTI-PHASE STUDY ON FIREFIGHTER SAFETY AND THE DEPLOYMENT OF RESOURCES

Year 1 Final Report

Abstract

Over the past three decades, fire department response has expanded from fire prevention and fire suppression to include multiple other community risks such as emergency medical services, hazardous materials response, and special rescue. Today, service demands and public expectations placed upon local fire departments continue to rise as threats to communities from both natural and man-made disasters including terrorism reach new highs. A Multi-Phase Study on firefighter safety and the deployment of resources is being conducted under a grant from the Department of Homeland Security's Assistance to Firefighters grant program.

During year 1, the project team performed a comprehensive literature review, assembled an expert technical panel, developed a robust theoretical model, designed and tested the survey instrument, and developed and implemented a statistically significant fire department sampling strategy. Over four hundred fire departments across the country have been invited to participate, have registered their participation in the study, and have submitted a completed departmental background survey. The goal of year 2 of this research is to collect data with adequate variance to be useful as a technical basis for modeling regression equations and to conduct field experiments that will provide a depth-of-understanding in deployment analysis. Year 3 of this research will be the capstone effort of the project focused on delivery of the results to the fire service community. Year three work will consist of software development, model verification and testing, model validation, documentation, and dissemination. The completion of this project will enable fire departments, cities, counties, and fire districts to plan resource deployment based upon community risks and service provision commitment.

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Background

The fire service in the United States has a proud tradition of service to community and country dating back over 400 years (Hashagan 1998). While the nature of the fire service has changed dramatically in sophistication, techniques, and scope over the years, the fire service always remains committed to a core mission of protecting lives and property from the effects of fire. In 2007, U.S. municipal fire departments responded to an estimated 1,557,500 fires. These fires killed 3,430 civilians (non-firefighters) and contributed to 17,675 reported civilian fire injuries. One hundred and two (102) firefighters died in the line-of-duty (Karter, 2007). Direct property damage was estimated at $14.6 billion dollars. In 2006, the total cost of fire in the United States was approximately $280 billion (Hall, 2006). Every statistical analysis of the fire problem in the United States identifies residential structure fires as a key component in firefighter and non-firefighter deaths, as well as direct property loss.

It is a primary goal of the United States Fire Administration to achieve a 25% reduction in firefighter deaths by 2009 and a 50% reduction in firefighter fatalities in ten years (USFA, 2004). Firefighter fatalities occur during varied areas of the job including on scene operations, responding or returning from a call, training and other assigned tasks. Inherent to each of these arenas are notable risks that may be identifiable and preventable.

Further, the scope of fire service activity has increased in recent years. Notably, more fire department resources are committed to emergency medical service (EMS) calls every year. Though not considered in the current study, the fire service is often tasked to lead or contribute to the mitigation of natural disasters, hazardous materials incidents, and terrorism. Whether current resource allocations match existing service commitments remains unclear, due primarily to a lack of scientifically-based analytical tools.

Despite the magnitude of the fire problem in the United States, there are no scientifically-based tools available to community and fire service leaders to assess the effects of prevention, deployment, and staffing, decisions. Presently, community and fire service leaders have a qualitative understanding of the effect of certain resource allocation decisions. For example, as decision to double the number of firehouses, apparatus, and firefighters would likely result in a decrease in community fire losses, while cutting the number of firehouses, apparatus, and firefighters would likely yield an increase in the community fire losses. However, decision-makers lack a sound basis for quantifying the total economic benefit of more fire resources or the number of firefighter and non-firefighter lives saved or injuries prevented.

Studies on a deployment of resources are needed to enable fire departments, cities, counties, and fire districts to design an acceptable level of resource deployment based upon community risks and service provision commitment. These studies will assist with strategic planning and municipal and state budget processes. Additionally, as resource studies refine data collection methods and measures, subsequent research and improvements to resource deployment models will have a sound scientific basis. Annual cost assessment indicates that the cost benefit for this project will be $33 per department or $.88 per firefighter, based on fire department data from Karter (2006).

Purpose of the Study

This project in firefighter safety and deployment of resources seeks to enable fire departments and city/county managers to make sound decisions regarding optimal resource allocation and service based upon scientifically-based community risk assessment; safe, efficient and effective emergency response system design; and the local government's service commitment to the community.

Scope of Research

The scope of year one research on this project was focused on producing a scientifically-based resource allocation model based upon an international search of the published literature and expert elicitation. The model is useful for analysis of the impact of existing and alternative prevention and mitigation strategies at the station or fire department level. Model development was followed by the production and testing of web-based fire department surveys designed to collect data at the department level, the station level, and the incident level. Participating departments were selected using a two-stage stratified probability sampling methodology. Selected departments have signed onto the study and completed a department level survey.

The reader should note that this report is a status report covering year one of a three-year, multi-phase study. As year two and year three research progresses, it is likely that some of the information contained within this report will change. The focus of year two is to generate survey data to provide the technical basis for modeling equations and to conduct field experiments to develop an in-depth understanding of deployment analysis. Year three will deliver the results to the fire service through software development, model verification and testing, documentation and dissemination.

Methods for Year 1 Research Overview of Methods

The Center for Public Safety Excellence subcontracted with three research organizations including the International Association of Fire Fighters (IAFF), the National Institute of Standards and Technology (NIST), and Worcester Polytechnic Institute (WPI) to conduct the study. These three organizations each committed a principal investigator to the study. Principal investigators conduct the fundamental study activities. In addition, the International Association of Fire Chiefs (IAFC) was brought in as an industry partner. These five partner organizations worked collaboratively to establish the technical basis for risk assessment and deployment of resources by local fire departments. A list of the partner organizations and individual council representatives is shown in Table 1. The ultimate goal of this project is to create tools the departments can use to:

- better assess the risks and hazards in their communities,
- plan adequate resource deployment to assure safe efficient and effective mitigation of emergency events, and
- measure effectiveness in responding to and handling of events.

In addition to the partners, project technical experts have been identified in each major area of the project, expanding upon the expertise of the principle investigators. Commitments have been made by each individual expert. Fourteen experts have provided invaluable time and talent to the study in fields that include fire ground operations, fire ground strategy and tactics, consensus standards and codes, fire engineering, emergency medical services, economics, decision analysis, risk assessment, statistics and geographic information system mapping. Each individual's name, affiliation, and area of technical expertise is shown in Table 2. A project orientation meeting was held on May 31, 2006, at NIST for principal investigators and technical experts. The meeting was an orientation for the team about the scope and purpose of the project. Subsequent to the meeting, each technical expert or group of experts were engaged multiple times via email, teleconference, and in-person as appropriate based on their expertise and its relevance to a particular phase of the study. A second meeting was held with the full technical expert group in March of 2007. The meeting provided the opportunity to update the group on the status of the project, to conduct discussion of key points, and to obtain further input and review.

A stakeholder group was identified and engaged. Stakeholders are fire industry representatives or end-users, who serve as a direct connection to the field for dissemination of study results. Stakeholders are briefed on the project regularly, represent the project to their respective organizations, and provide principal investigators with project input and review. Table 3 shows each of the stakeholder groups and the individual(s) appointed to represent that group. The first meeting of the stakeholder group was held on September 13, 2006. The stakeholders were briefed on the project and stakeholders provided with information in hard copy form to share with their respective organizations along with a copy of a press release on the project. Many stakeholder representatives requested further opportunity for input and were provided contact information for all partner representatives. Subsequent stakeholder briefings have occurred in February 2007, August 2007, and February 2008. To complement the stakeholder outreach, press releases were generated to industry journals and web sites quarterly in conjunction with study reports. An example of a study press release is included in Appendix C.

In addition to expert elicitation, a comprehensive literature review was performed. The objective of the literature review was to develop a state-of-the-art understanding of the correlations and causal links between factors which correspond to variation in community outcomes. Historic and contemporary literature was compiled on a diverse group of subject matters related to the study. The search included articles in refereed journals from a variety of disciplines, industry publications, textbooks, and relevant web sites. Several hundred related studies, articles, expert opinions, standards, codes and academic papers were reviewed and compiled into (a) an executive summary (below) which synthesizes the findings (including consistent findings and conflicting findings) as appropriate to the study, and (b) an annotated bibliography which includes all resources were considered during model development (Appendix A).

VISION ™, a previously developed community risk analysis tool, was originally intended to be used in this study. VISION ™ was evaluated by the principal investigators for scope, method, and technical foundation. The predictor variables were found to be consistent with the intended scope of the model. The ultimate dependent variable (a non-dimensional quantitative score for community risk) produced by the model, however, was found to lack an independent measurement basis or provide sufficient foundation for model validation and verification. Upon evaluation of the existing VISION ™ calculations (mathematical relationships between the variables), significant error was discovered. This error warranted that the technical approach specified in the original proposal as steps B4-B6, be modified to include development of a risk assessment model from the ground-up using currently available scientific knowledge. Modifications are shown in the Year 1 progress report as steps C1–C6. Both the original year 1 proposal and the Year 1 progress report are shown in Appendices B and B.1. The final product of the current project will provide a technical basis for screening and eliminating non-predictive concepts, as well as assessments of the statistical significance/power of the final product.

Based on the literature review and input from technical advisors, a formal model structure was developed. The model contains decision variables, objective variables, and boundary variables. Decision variables within the model are variables with levels that can be determined by the fire service and include prevention programs, apparatus and staffing levels, first alarm (initial) response levels, dispatch protocol, training, and mutual aid, among others. Objective variables were selected to reflect the primary measurable concepts which correspond to the actual risks observed in the community under consideration including the number of firefighter injuries and deaths per year; the number of civilian injuries and deaths per year; total annual direct economic losses; firefighter work hours lost per year and total firefighter work hours spent on work restriction per year. Boundary variables were identified as predictors of community risk which are outside the routine decision set of the fire department. Examples include characteristics of the built environment (number and type of buildings), characteristics of the population (population, socioeconomic factors, etc), community loss history, and elements of critical infrastructure which require unique consideration. Variables were evaluated for inclusion in stochastic data collection, inclusion in field testing (Phase 2) or inclusion in both formats as a test of robustness and consistency.

Historic data were collected from participating fire departments to assess the usability of the model interface, as well as data availability and ease of data entry for the fire departments. Additionally, the mathematics and model structure for the current version of the model were tested with these data. During data collection, optimization of the levels of the dependent variables will be conducted in order to reflect the fact that priorities of economic and life safety concepts may be variable across otherwise similar communities.

Data Synthesis

Data collection will be completed via stochastic methods using a series of online surveys. The U.S. Office of Management and Budget (OMB) approved the Paperwork Reduction Act submission (Control Number 0693-0047). A representative sample of approximately 400 fire departments will provide incident response data using a secure, web-based data entry portal.

The web-based surveys were compiled using technical experts to formulate questions based on the study model. Surveys were then assessed for correlation with data typically available in most fire departments. Data specialists from three geographically diverse metropolitan departments assisted in the preliminary assessment. Based on these findings, three separate but related surveys were formulated. Each survey was designed to target a specific level of operation within a fire department. The surveys were designed to collect data at 1) the department level, 2) the station level, and 3) the incident level. Once the verbiage for each question in each survey was determined, the surveys were edited and prepared for web design.

Web page development and survey design were handled by technical experts from a division of ACS Governmental Services known as Fire House Software. Web designers formatted the questions, the user-friendly data entry and the resultant reporting features of the survey. All aspects of the surveys were pilot and beta tested by data entry specialists from two metropolitan fire departments. These two departments differed from those used to design the surveys. Final surveys will be completed by department respondents via the study web site at www.firereporting.org using a user name and password assigned to the departments during participant solicitation.

Participant departments were selected using a two-stage stratified probability sampling methodology (see Sampling Methodology, page 50). Prior to providing the surveys to the selected departments, it was necessary to identify a contact in each department and to acquire a list of department mobile and personnel resources. These data were solicited via an introductory letter accompanied by a form for completion, profiling the department's response capacity including available mobile and personnel resources. Letters were customized for each department and were sent to both the chief of the department and the president of the local affiliate labor union if available. A recognizable logo was designed and used on letterhead developed for the study. The letterhead also included the logo from the five partner organizations and the signatures of three of the organizations' current presidents were used to encourage department participation. An example of the letter and station form is included in Appendix F.

Each recipient was given a deadline for return of the station form. One week following the mailing of the letter and form, a telephone and/or email follow up was made to the chief of each department. Verbal commitment to return the form was acquired when possible. Additional telephone and email follow up was conducted with departments deemed delinquent based on their respective deadlines. The overall return rate for the station form was 36%. For the metropolitan departments, deemed to be self representing and vital to the study, the return rate was much higher at 83%. Telephone and email follow-up continues in an effort to increase the level of commitment for departments of all sizes to submit data via the online surveys.

Data Analysis

Once data are collected and compiled, regression analyses will be performed to determine which variables have significant impact on the dependent variables (community outcomes). The regression analyses will form the basis for development and testing of a predictive computer model for risk assessment and deployment of resources.

Preliminary Conclusion

A scientific foundation for the assessment of community risk by fire and city officials will ensure efficient expenditure of public resources and raise the bar for technical discussion of the community impact of changes to resource levels.

Articles summarizing the literature review, describing model structure, capabilities, assumptions, limitations and project progress are being written for publication in the archival literature.

Table 1: Partner organization council representatives
Kathy A. Notarianni, Ph.D, P.E. Head, Department of Fire Protection Engineering Worcester Polytechnic Institute
Lori Moore-Merrell, DrPH, MPH Assistant to the General President International Association of Fire Fighters
Jason D. Averill Group Leader, Engineered Fire Safety Group National Institute of Standards and Technology
John Drago Executive Director Center for Public Safety Excellence, Inc.
Chief Randy Bruegman Chairman, Center for Public Safety Excellence, Inc.
William Grosshandler Deputy Director, Building and Fire Research Laboratory National Institute of Standards and Technology
Ed Plaugher Director of National Programs International Association of Fire Chiefs

Table 2: Project technical experts	
Sanjay Kalasa Vice President ACS – Firehouse Software Expertise: Software Programming and Web Development	William Guthrie NIST Expertise: Regression, Experiment Design, Robust Statistics, Data Analysis
Chief Dennis Compton City of Mesa, Arizona Expertise: Fire Department/Fire Ground Procedures/Tactics	Bob Chapman, Ph.D. NIST Expertise: Economics
Chief William "Shorty" Bryson Miami Fire Department Expertise: Fire Ground Operations	Dan Madrzykowski NIST Expertise: Field Experimentation
Russ Sanders National Fire Protection Association Expertise: Consensus Standards and Codes	John A. Granito Fire Consultant Expertise: Operational Performance; Deployment and Staffing
Phil Pommerening Fairfax County Fire Department Expertise: EMS	Jonathan Moore International Association of Firefighters Expertise: Fire & EMS Operations; GIS
Mike McAdams Montgomery County Fire Department Expertise: EMS and Quality Measurement	Ronny J. Coleman Fire Service Consultant Expertise: Standards of Cover and Fire Department Risk Assessment
James J. Corbett, Jr., Ph.D. University of Delaware Expertise: Technology Policy; Decision Analysis	Russ Johnson ESRI/GIS Expertise: GIS

Table 3: Stakeholder Representatives	
Stakeholder Group	**Representative**
Fire Department Accreditation	Rick Black, Program Manager Commission on Fire Accreditation
Less than 25,000 Population	Chief William F. Jenaway King of Prussia Volunteer Fire Company
100,000 – 249,999 Population	Assistant Chief Paul D. Brooks, Greensboro Fire Department
Over 250,000 Population	Chief Robin Paulsgrove Arlington Fire Department
County Manager	Max H. Baker, County Administrator County of Los Alamos
City Manager	Mr. Jeffrey A. Pomeranz City of West Des Moines
Consensus Standards	Frank E. Florence National Fire Protection Association
Insurance Industry Representative	Ralph Dorio Insurance Services Office
Federal Representative	Fire Chief Ernst Piercy USAF Academy
Labor Representative	Jim Lee International Assoc. of Fire Fighters

Core Values of the Fire Service

Protect lives, property, and the environment through preparedness, prevention, public education, and emergency response with an emphasis on quality services, efficiency, effectiveness, and safety.

Figure 1: Core Values of the Fire Service

A key outcome of the expert elicitation was to generate a statement of the core values of the fire service (Figure 1). Core values are an expression of fundamental objectives towards which efforts and resources are directed. The purpose of developing a statement of the core values of the fire department was to ensure that the results of the computer model support the stated values of the fire service.

The core values statement has two key components: what and how. First, the fire service is focused on the "what:" protection of lives (both civilian and fire service), property, and the environment.* The second clause addresses the "how:" preparedness, prevention, public education, and emergency response with an emphasis on quality services, efficiency, effectiveness, and safety. The first part describes specific programs which are considered fundamental to fire service success and the second part describes expectations for performance of those programs. Each of the programs (how) will be evaluated as part of the final model as they correlate with successful outcomes (what).

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* While protection of the environment is an important consideration for the fire service, it was determined to be an area for future model enhancement and therefore beyond the scope of the current study.

Literature Review

Background

Each and every day, community and fire service leaders make tough decisions on how to fulfill increasing responsibilities for fire prevention, fire suppression, and emergency medical response under tight budgetary conditions. An extensive review of the archival literature was conducted to determine what parameters have been shown to impact community outcomes such as civilian and fire fighter fatalities, injuries and property loss. Several hundred publications were identified, categorized, and reviewed. A technical analysis of findings in the areas of community demographics; response capacity of the fire service; prevention programs; notification; emergency medical response; and community outcome was conducted. The results are summarized below. For this study, community outcome was the term chosen to represent a measure of the personal and economic consequences expressed as:

1) Total annual direct economic losses
2) Firefighter fatalities per year
3) Firefighter injuries per year
4) Firefighter work hours lost per year
5) Firefighter hours on work restriction per year
6) Civilian fire related injuries per year
7) Civilian fire fatalities per year

In 2007, U.S. municipal fire departments responded to an estimated 1,557,500 fires. These fires killed 3,430 civilians (non-firefighters) and contributed to 17,675 reported civilian fire injuries. Direct property damage was estimated at $14.6 billion. One hundred and two (102) firefighters died in the line-of-duty, an increase over the 89 firefighter fatalities that occurred in 2006 (Karter, 2007). During 2007, the 530,500 reported structure fires accounted for 34% of reported fires. These 530,500 reported structure fires caused 3,000 civilian fire deaths, 15,350 civilian fire injuries, and $10.6 billion in direct property damage, not accounting for losses from the California Fire Storm. In other words, structure fires accounted for 34% of fires, 87% of both civilian fire deaths and civilian fire injuries, and 73% of the direct property loss (Ahrens, 2008).

Syntheses of findings from the archival literature from around the world, and as appropriate to the study, are presented below. This analysis along with the annotated bibliography (included as Appendix A) which included relevant resources considered during model development, will aid in the development of a state-of-the-art understanding of the correlations and causal links between factors which correspond to variation in community outcomes.

The Impact of Community Demographics

Both community-building fire research and emergency medical research provide evidence of a strong link between the demographics of a community and that community's experience of death, injury and property loss. This review identified over twenty demographic descriptors that are either qualitatively or quantitatively linked to community outcome. Descriptors of community demographics can be subdivided into three groups: (1) descriptors of individuals or family groups living together; (2) descriptors of buildings; and (3) descriptors of the demographic profile of the station's coverage area.

Individual Descriptors of Community Demographics

Descriptors of individuals that impact outcome from fire or emergency medical response include factors such as age, race, disabilities, income, smoking, education, gender, and inebriation from alcohol or drugs. Descriptors of individuals or family units also include culture and home ownership.

Age

There is general agreement that in the United States, preschoolers and the elderly have an elevated risk of fire death. The National Fire Protection Association report, "Characteristics of Home Fire Victims," reports that children under age 5 and older adults age 65 and older are more than twice as likely to die in home fires as the average person (Hall, 2005). A study of the probability of survival based upon severity of injury using national standards and norms showed that in adult populations, there is a negative correlation between increasing age and probability of survival. The Hall report also pointed to other factors, such as alcohol or other drugs, disabilities, race, less education, poverty, and property vacancy as highly correlated with fire death rates (Hall, John, 2005).

Race

The literature for both fire and emergency medical risk point to correlations between race and outcome, however, studies differ in reporting if race is independent from income. Most studies, especially on cardiac arrest, show race as significant apart from income.

Race and Fire Risk

Researchers studying, "The Truly Disadvantaged and the Structural Covariates of Fire Death Rates" concluded that fire death rates were significantly influenced by both median income and the proportion of African-American population. Areas of low income with a high proportion of African-American population exhibited extremely high fire rates. The researchers conclude that race is the stronger variable (58% vs. 19% for median income).

Race and Cardiac Arrest

The Becker, Han, Meyer, and Associates study, "Racial Differences in the Incidence of Cardiac Arrest and Subsequent Survival" reported that the incidence of cardiac arrest was significantly higher for African Americans than for whites in every age group. Likewise, the survival rate after cardiac arrest was 2.6 percent in whites, as compared with 0.8 percent in African Americans. Becker also reported that African Americans were significantly less likely to have a witnessed cardiac arrest and/or bystander-initiated cardiopulmonary resuscitation. When admitted to the hospital, African Americans were half as likely as whites to survive. This important association between race and survival persisted even when other recognized risk factors were taken into account. Casual differences were not found to exist in the response times of the emergency medical services to either group, however, the African American community in this study was at higher risk for cardiac arrest and subsequent death than the white community, even after controlling for other variables (Becker, 1993).

In another study, Becker examined outcomes of CPR in a large metropolitan area and noted that survival was significantly greater with bystander-witnessed arrest and bystander-initiated CPR then in unwitnessed arrests (Becker, Ostrander, et.al). This is a particularly relevant finding given that his earlier study showed that African Americans were significantly less likely to have bystander-witnessed cardiac arrest or a bystander-initiated cardiopulmonary resuscitation. Another study published in the Annals of Emergency Medicine entitled, "Do Blacks get Bystander Cardiopulmonary Resuscitation as Often as Whites?" reports that African American victims were less likely to receive CPR when suffering cardiac arrest than were white victims. Furthermore, African American victims received bystander CPR 9.8% of the time as compared to white victims who received bystander CPR 21.4% of the time (Brookoff, 1994).

A study published in the American Journal of Public Health argues that race is important in determining the risk of cardiac arrest within a community. Data collected over a 26-month period showed the age-adjusted incidence of out-of-hospital cardiac arrest was twice as great in African Americans as in white (3.4 vs. 1.6 per 1000 aged 20 and over). Also, the initial resuscitation rate was markedly poorer in the African American cardiac arrest victims (17.1% vs. 40.7%), and rates of survival to hospital discharge were also lower in African Americans (9.4% vs. 17.1%) (Cowie, 1993).

A separate study published in the Annals of Emergency Medicine controlled for income, using two groups which were affluent by national standards. The study population did not vary for witnessed arrest (57% for African Americans and 61% for whites). Unlike similar studies, this study concluded that race was not a predictor of out-of-hospital outcomes in an affluent population (Chu, 1998).

Income/Socioeconomic Status

A paper entitled “Moral Hazards, Social Catastrophe,” made the argument that in America, social vulnerability, a measure of one’s susceptibility to the impacts of hazards, is not evenly distributed among social groups or between places. Some regions may be more socially vulnerable than others, based on the characteristics of the people residing within them. The article points to the lessons learned from Hurricane Katrina, that when coupled with residencies in high-risk areas, differential vulnerabilities can lead to catastrophic results. In this study, the variable most responsible for increasing social vulnerability is socioeconomic status. Other variables include community development density, population age, race/ethnicity, and gender (Cutter, 2006).

A population-based, retrospective study conducted in Ontario, Canada looked at the relationship between childhood injuries and socioeconomic status. The study population was divided into socioeconomic grades based upon percentages of area residents living below the poverty line. Injuries for children 0-19 years of age were included. A consistent relation between poverty and injury was evident. Data on nearly 6,000 childhood injuries demonstrated that children living in areas of severe poverty had the highest injury rates or a 1.67 higher risk of injury in areas of lesser poverty (Faelker, 2000).

A study on the incidence of residential fires in London looked at what role tenancy and living standards had on the incidence of fire. It noted a high degree of correlation between non-owner occupancy and incidence of fire. There was also a high degree of correlation between the lack of basic household amenities (such as hot water) and a high incidence of fire.

Building Descriptors

Descriptors of the building that impact outcome from fire include factors such as occupancy type, building height, building age, and whether the building is vacant.

Occupancy Type

A study by Brennan and Thomas entitled "Victims of Fire? Predicting Outcomes in Accidental Fires," analyzed fire fatalities in different building occupancies. The number of fatalities per 1000 fires was presented as a range with the high end of the range being 13.3 fatalities per 1000 fires in chemical, plastic, and petroleum manufacturing facilities. Manufacturing facilities total experienced 2.7 fatalities per 1000 fires. The value for all other occupancies ranged from 0.3–1.2 fatalities per 1000 fires (Brennan, 2001). However, for a more accurate picture it is important to remember that most fires occur in residential structures. The U.S. National Fire Protection Association reports that out of over 530,500 fires occurring in structures in 2007, 414,000 fires or 78% of all structure fires occurred in residential properties. Also, 14,000 of all civilian injuries occurred in residential properties (Karter, 2007).

Flynn (2007) looked at fires in industrial and manufacturing properties including utility, defense, agriculture and mining properties. The study analyzed data from 2000–2004. During this time period, fire departments responded to about 12,000 fires per year in these properties resulting in 17 civilian deaths, 365 civilian injuries, and $747 million in direct property loss. Ten percent of fires were caused by flammable or combustible liquids; however, these fires resulted in a high proportion of civilian deaths and injuries (28% and 35%, respectively). It is noteworthy that in these properties, it was determined that property loss was lowered 65% when automatic suppression was present.

A study of Hong Kong, a densely populated urban city, showed that as in the United States, residential buildings constituted the majority (75%) of the total number of building fires. Furthermore, as in the U.S., more fires due to carelessness occurred in buildings where the occupants were less educated. (Hui, 2005)

Descriptors of the demographic profile of the station's coverage area

Descriptors of the demographic profile of the station's coverage area included: total population, population density, coverage area of the station in square miles, annual call volume of the station, and region of the country. Population density is a common term referring to the number of residents per square mile and is used as a factor in determining whether a locale is urban, suburban, rural, or wilderness.

Population/Population Density

Fire

In the study, "Acute Traumatic Injuries in Rural Populations," published in the American Journal of Public Health, it is shown that rural populations exhibit disproportionately high injury mortality rates. Data shows that the fire fatality rate per capita is 36% higher in rural areas. A government study of rural and non-rural (defined as areas with populations less than or greater than 2500) civilian residential fire fatalities in twelve states revealed that rural areas have fire fatality rates of 2.5 times those of non-rural areas. Misuse of solid fueled heating equipment was found to be the most significant rural fire problem (Gomberg, 1982).

Another study published in the Journal of Policy Analysis and Management reported that the fire fatality rates were the lowest for "medium-sized" communities. Medium-sized was defined as a population between 25,000 and 50,000. Residents in these medium-sized communities were half as likely to die in fires as those in large cities or rural towns. The research presented a U-shaped curve that related community size and fire fatality rates.

Cardiac Arrest

A 1991 study by Becker, Ostrander, Barrett, and Kondos published in the Annals of Emergency Medicine evaluated outcomes of CPR in a large metropolitan city with a 1987 population of more than 3 million living within an area of 228 square miles. The overall survival rates from cardiac arrest were significantly lower than those reported in studies of smaller communities, but they were consistent with the rates reported in a comparable study of a larger city. The single most important factor was the relatively long interval between collapse and defibrillation. Additionally, logistical, demographic, and other special characteristics of large cities may have affected the rates. A similar study conducted in Victoria, "Out-of-Hospital Cardiac Arrest in Victoria: Rural and Urban Outcomes" and published in the Medical Journal of Australia, showed a very different result. This study found that urban patients were more likely to arrive at an emergency facility with a cardiac output and to be discharged from the hospital alive than rural patients (Jennings, 2006).

Traumatic Brain Injury

The relationship between population density and the outcomes from traumatic brain injuries were evaluated in the study, "Urban and Rural Traumatic Brain Injuries in Colorado" published in the Annals of Epidemiology. This study reported the average annual age-adjusted rates of hospitalized and fatal traumatic brain injury varied significantly from 97.8 per 100,000 population for the most urban group to 172.1 per

100,000 population for the residents of rural, remote counties. Similarly, total mortality rates and pre-hospital mortality rates also were higher in rural areas by nearly two-fold (Gabella, 1997). A separate study, "Urban-Rural Differences in Pre-hospital Care of Major Trauma" published in the Journal of Trauma-Injury Infection & Critical Care, compared differences in response times, scene times, and transport times by advanced life-support-trained paramedics with trauma incidents in urban and rural locations. The mean response time for urban locations was 7 minutes vs. 13.6 minutes for rural locations. The mean scene time in rural areas was slightly longer than in urban areas (21.7 minutes vs. 18.7 minutes). Mean transport times from the scene to the hospital were also significantly longer for rural incidents (17.2 minutes vs. 8.2 minutes). The study concluded that rural trauma victims can be up to 7 times more likely to die than urban trauma victims (Grossman, 1997).

Area of the Country/Age of Housing

Both the rate of occurrence of fire and the level of magnitude of negative consequences from fire vary across the United States. A study by the National Fire Protection Association (NFPA) reported the numbers of unintentional fire fatalities by state, over a five year period. Mississippi had the highest fire fatality rate, and states of the southeast accounted for 11 of the 13 highest rates, with Rhode Island and Oklahoma as exceptions. It was determined that race accounted for 49% of the variation, while poverty 34%, rural/urban 30%, smoking 29%, and education 26% as relevant predictors also. It is noteworthy that "age of housing" is a poor predictor of fire death rates by itself and is rather a proxy often used for areas of poverty and less educated households. It was determined that states with older, high-quality structures, like Connecticut, had low fire death rates.

A separate NFPA study reported U.S. Fire Experience by Region of the Country. This study found that the South had the highest average number of fires per thousand population and the highest rate of civilian deaths per million people, an average of 17.3 deaths/1 million people. The West had the lowest rates each of the years studied. The Northeast had the highest civilian injuries per million population, an average of 107, 30% higher than the national average (Karter, 2003).

Coverage Area of the Station

A Rand Institute study, "Fire Severity and Response Distance" demonstrated a relationship between the distance the responding companies travel and physical damage. The study showed that fire severity increased with response distance and thus dollar value of loss increased proportionally. A longer response distance typically correlates with a longer response time. Longer response times are highly correlated to losses from fire.

Response Capacity of the Fire Service

Important measures of the capacity of the fire service to respond to an emergency can be divided into two categories: (1) operational response variables which account for the type and amount of personnel and equipment available and (2) operational readiness variables which measure the degree to which the fire service is ready to respond. Operational response variables include such measures as: ambulance crew size; engine and ladder crew size; total response/deployment to scene; and available equipment while operational readiness variables include firefighter fitness; training; pre-incident planning; and mutual/automatic aid.

Operational Response

The literature documented a clear relationship between the staffing level per fire department apparatus and variables such as the mean on-scene time; the incidence of injury of fire service personnel; the time it takes to complete various tasks; the tasks that cannot be completed before arrival of additional crews; the cost incurred as a result of on-scene injuries; and the cost-benefit of adding additional crew vs. accepting a higher injury rate. The literature also presents discussion of the level of emergency medical certification of the staff responding on emergency apparatus, comparing outcomes for EMT-D staffed apparatus with EMT-D plus ALS staffed responses and ALS only responses.

Ambulance Crew Size vs. Mean On-scene Time

Brown (1996) studied on-scene times for two and three person EMS crews by evaluating an EMS agency in Greenville, North Carolina that converted from three-person to two-person EMS crews. Two-person EMS crews responded to seizure calls; two-person EMS crews accompanied by a fire department engine (pumper) with additional personnel responded to chest pain calls. The study noted no significant differences in total number or types of procedures performed. Mean on-scene time for patients with seizures was 11.0 minutes for three-person crews and 19.4 minutes for two-person crews. Mean on-scene time for patients with chest pain was 13.6 minutes for three-person crews and 15.4 minutes for two-person crews assisted by fire department personnel. It is noted that two-person EMS crews without the assistance of additional responders may have even longer on-scene times.

Engine and Ladder Crew Size vs. Injury Rate

A FEMA report from 1982 that looked into existing crew sizes and response protocols for cities in the U.S. with populations greater than 100,000 reported that 40% of departments had engine crews of three or fewer and 43% had ladder crews of three or fewer (Centaur Associates, 1982). Cushman reported that the rate of firefighter injuries expressed as total hours of disability per hours of fire ground exposure were 54% greater for engine companies staffed with three personnel when compared to those staffed with four personnel. Companies staffed with five personnel had an injury rate that was only one-third that associated with four-person companies (Cushman, 1981). A separate study of fire fighter injuries and minimum staffing levels in a number of cities showed that jurisdictions having crew sizes of fewer than four firefighters suffered a benchmark injury rate of nearly twice the percentage rate of jurisdictions that maintained crew sizes of four or more firefighters (IAFC, 1991).

Engine and Ladder Crew Size vs. Effectiveness/Efficiency

Roberts (1993) also evaluated whether companies staffed with four firefighters were safer and more effective than three-person companies. As part of this study, the Austin Fire Department conducted drills consisting of a series of common fireground tasks. These simulations revealed that firefighter effectiveness significantly improved when a company was increased from three to four personnel. Efficiency (defined as time improvement) was increased 73% for a residential fire, 66% for aerial ladder evolution, and 35% for a high-rise fire. The study also reviewed injury reports and reported that the injury rate for four- or five-person crews was 5.3 per 1000 fire fighters compared to 7.77 per 1000 for three-person crews, i.e., consistent with previous studies, the injury rate for three-person companies was 46% higher.

In Ontario, crew size was evaluated relative to tasks which three- and four-person crews could safety accomplish. It was determined that until additional assistance arrived, the following tasks could not be accomplished safely by three-person crews: deployment of back-up lines; conducting interior suppression or rescue operations; ventilation operations requiring access to the roof of the involved structure; the use of large hand-held hose lines; and the establishment of a water supply from a static source within the time limits. It was reported that three-person crews were overworked due to an inability to take sufficient breaks; therefore, they were more at risk for exhaustion (Office of the Fire Marshall, 1993).

Cost of Injuries/Cost vs. Crew Size

A government sponsored study on the economic consequences for firefighter injuries and their prevention looked at the cost involved with firefighter injuries. The costs included workers compensation, long-term medical care, lost productivity, etc. It was determined that these costs amount to between $2.8 and $7.8 billion annually. The report addressed commonly occurring minor injuries (sprains, strains, falls, slips, back problems, etc.) and the less frequent, but severe injuries (burns, major falls, etc.) that cost more on an annual basis. The report recommended a scientific study on the relationship between the number of firefighters per engine and the incidence of injuries to investigate the relationship between staffing and safety (TriData, 2005).

Varone (1994) determined that the costs of adding a fourth person to three-person companies could be offset by lower injury costs. The Providence's Fire Department database was queried to determine pertinent injury information. The study data showed that four-person staffing led to a 23.8 percent reduction in injuries, a 25 percent reduction in time the number of lost injuries and a 71 percent decrease in time lost due to injury when compared to three-person staffing.

Total Response/Deployment to Scene

Several articles in the literature pointed to the staffing level of firefighting apparatus as an important measure of firefighter safety, many due to the fact that an increase in physical stress may lead to increases in heart problems. Clark (1994) quoted an earlier study that showed that firefighter injuries occurred more often when the total number of personnel on the fire ground was less than 15 at residential fires and less than 23 at large-risk fires.

Level of Qualification of Staffing and Equipment for Emergency Apparatus

Some work has been done to quantify the effects of different levels of EMS care as provided by qualified staff. Cummins (1991) noted that the average rate of survival from cardiac arrest in EMT-D only systems was about 16%. This rate referred to witnessed victims in ventricular fibrillation. Comparatively, the survival rate in combined EMT-D and ALS systems was 29%. In ALS only systems, the corresponding survival rate was about 17%. In this study, the similar survival rates between EMT-D only and ALS systems is attributed to a difference in response time and intervention methods in each. EMT-D systems have small response times but lack the advanced intervention methods; on the other hand, ALS only systems have longer response times, but include the advanced intervention methods.

Kellermann, et al, (1992) studied the effectiveness of automatic external defibrillators (AED) compared to CPR performed by first responders in a busy, urban EMS system. The study concluded that patients who were treated with the AED vs. CPR alone were not significantly more likely to be resuscitated (32% vs. 34%), survive to hospital admission (31% vs. 29%), or to survive to hospital discharge (14% vs. 10%) in this fast-response urban system.

Operational Readiness

It has been shown that the capacity of a fire department to respond to an emergency is a function of the number of personnel and apparatus/equipment sent to the scene. The literature also demonstrated a link between the readiness of the personnel deployed and good outcomes. The term readiness is measured by both personnel and mobile resources, response personnel physical fitness, fire department training for responders and officers, and the degree of pre-incident planning available.

Fitness

How fit is today's fire service? A study by Campbell, et al, (1998) where researchers tested a group of 65 firefighters in several fitness areas showed that from 45% to 68% of firefighters did not meet national standards. Many firefighter deaths are attributable to cardiac arrest. Fahy and LeBlanc (2005) summarized deaths due to cardiac arrest over a 10-year period. The authors found 440 deaths from cardiac arrest, making up close to 44% of total firefighter fatalities. The report concluded that fitness programs need to be instituted, stating that 73% of career and 88% of volunteer fire departments polled in 2001 did not have such programs. A follow-up study of firefighter fatalities occurring in 2005 (Fahy, 2006), showed similar results with 46% of firefighter fatalities attributed to stress and overexertion, leading to heart attacks or other sudden cardiac events. This study also documented that responding and returning from alarms accounted for a large share of firefighter deaths.

Deaths Due to Cardiac Arrest and Underlying Risk

A report of the International Association of Fire Fighters and the International Association of Fire Chiefs (1997) describes the Fire Service Joint Labor Management Wellness/Fitness Initiative formed to address the need for a holistic and non-punitive approach to wellness and fitness in the fire service. A task force recommended performing physical ability tests for firefighting candidates, along with fitness and wellness programs for all firefighters (IAFF, IAFC, 1999). Kales, et al, (2003) studied on-duty deaths of firefighters, seeking to identify occupational and personal risk factors associated with on-duty coronary heart disease(CHD) death. Emergency duties such as fire suppression, training, and alarm response carried elevated risk of CHD death.

Compared to active firefighters, the CHD victims had a significantly higher prevalence of cardiovascular risk factors including: age over 45 years; currently smoking; hypertension; and a prior diagnosis of arterial-occlusive disease. Findings strongly supported that most on-duty CHD fatalities are work precipitated and occur in firefighters with underlying CHD. It was suggested that improved fitness promotion, medical screening and medical management could prevent many of these premature deaths.

A study by Moore-Merrell et al. (2006) analyzed retrospective data from six years to identify and quantify the major factors that contributed to firefighter line-of-duty death (LODD). Frequency analysis revealed that the dominant contributing factors to LODD are health/fitness/wellness (54%), personal protective equipment (19%), and human error (19%).

Potential Impact of Fitness Programs

The Orange County Fire Department (2006) undertook a fitness/wellness program in which 90% of firefighters in the department participated. Results after two years were reported qualitatively and included lower body fat percentage, increased aerobic capacity, lower worker's compensation costs despite higher payrolls, and lower hours of work missed due to injury. A separate study by Roberts (2002) observed respiratory activity of firefighter recruits before and after a 16-week training program. Prior to the program, the aerobic capacity was 20% below minimum standards for suppression duties. Results showed that the program improved aerobic capacity by 28% as well as decreasing body fat and increasing muscle.

A National Institute for Occupational Health and Safety (NIOSH, 2007) study evaluated 304 firefighter sudden cardiac deaths. Of the fire departments where these deaths occurred, only 8% had mandatory fitness programs.

Training

How does training affect a firefighter's capacity to respond? In one study (Cohen, 1998) that performed a multi-dimensional evaluation of firefighter training for hazardous materials response, it showed that the majority of participants judged the course to have a beneficial impact.

Although training is a vital part of fire department operations, it can also result in deaths and injuries. Each year, approximately 10% of all on-duty firefighter deaths occur while firefighters are engaged in training related activities. A study by Fahy (2006) stated that although the number of fire-scene deaths has decreased over the years, the same is not true for training deaths as it has stayed more or less constant. Of the 100 firefighter deaths over a 10 year period, 53 were the result of sudden cardiac arrest. Forty-four (44) out of the 53 deaths showed previous heart conditions.

Pre-incident Planning

Klaene and Sanders (2000) believed that having a pre-incident plan was essential to the incident commander when making strategic and tactical decisions at the scene. The authors argue that pre-incident planning effectively removed an initial step at the fire ground during the first few important minutes. Another study by Klaene and Sanders (2002), discusses the specific need for pre-incident planning at industrial facilities, due to the specific and high-hazard scenarios. NFPA statistics between 1996 and 2000 showed that industrial facilities fires resulted in 6 firefighter deaths per 100,000 structure fires as compared to 3.7 firefighter deaths per 100,000 residential fires.

Mutual-Aid/Automatic Aid

When the response capacity of a single department is not sufficient, mutual aid arriving from surrounding departments expands capacity. The literature documented the escalation of an event requiring mutual aid, starting at the local level, progressing to the state and finishing with a national level response. A paper by the International Association of Fire Chiefs (2006) makes recommendations for a national level mutual aid system.

Prevention

In this study, prevention refers to either the prevention of a fire or emergency medical event or the prevention of major loss from either, through early interventions. Prevention encompasses educational programs such as teaching children not to play with matches or educating adults on proper maintenance of smoke alarm systems. Prevention also includes training programs such as adult instruction on proper CPR techniques or the use of public access defibrillators. Some prevention programs stress the importance of early fire detection and the widespread use of suppression equipment such as smoke alarms and fire extinguishers. Another key component of prevention stresses the importance of regular fire code inspections and code enforcement of structures by trained fire service professionals.

Educational Programs

Categories of educational programs discussed in the literature included comprehensive, community-wide programs; school programs; programs aimed at specific fire causes or target groups; juvenile fire setter programs; smoke detector programs; and nationwide programs using a known figure such as 'Sparky the Fire Dog'. Despite the wide range and types of educational programs, it is well documented that historically in the United States emphasis has been on the response to an emergency event more so than the prevention of one.

Teaching Laypeople CPR and Use of Defibrillators

The published literature addressed multiple concerns regarding the training of laypersons for emergency intervention. Some concerns included: 1) Who needs to be trained and at what level? 2) Are enough people being trained in CPR? 3) Are there particular demographic groups with insufficient training? and 4) Should laypersons be trained in the use of defibrillation? Other concerns address the level of training and the best means for evaluation. Are public health and community-based interventions adequate? Are programs properly evaluated according to settings, goals, and purpose?

CPR Training

The literature showed that CPR training is very important to increasing survival rates from cardiac arrest. Becker reported in a study of outcomes of CPR in a large metropolitan area that survival was significantly greater with bystander witnessed arrest and bystander initiated CPR (Becker, 1991). Ritter (1985) quantified the increase in survival rates for patients who received bystander CPR. In Ritter's study, published in the American Heart Journal, 2,142 emergency medical service cardiac arrest runs were used to determine the role of bystander CPR on survival. For cardiac arrest patients that received bystander CPR, it showed survival rates of 22.9% to hospital admission and 11.9% to hospital discharge. Those patients that did not receive bystander CPR had survival rates of 14.6% to hospital admission and 4.7% to hospital discharge. Ventricular fibrillation occurred more often in patients who had received bystander CPR when emergency personnel arrived; this was seen as a major contributor to higher survival rates.

Beyond identifying the need and benefit of public health prevention programs, Brennan and Braslow (1998) identify the need for improvement in the effectiveness of CPR training. Trained observers evaluated 226 individuals following public CPR classes provided by the American Red Cross or the American Heart Association. The trained observers found almost half of the 226 individuals "not competent," having made four or more errors during the evaluation.

Goldberg, et al, (1984) addressed layperson CPR asking the question, "Are we training the right people?" The study showed that those surrounded by people at higher risk of cardiac arrest, such as family members of people with heart disease are not being trained at higher rates. A study by Swor, et al (2003) delved deeper into this issue, comparing cardiac arrest in private vs. public locations. The results showed that many important characteristics of cardiac arrest patients and the bystander differ in public vs. private locations. Swor argued that a tremendous amount of public resources are focused on improving out-of-hospital cardiac arrest (OHCA) survival in public places, yet most OHCAs occur in private residences. A prospective, observational study of patients transported to seven urban and suburban hospitals and the individuals who called 911 showed that of all arrests, 80.2% arrested in homes. Patients who arrested in public places were significantly younger, more often had an initial rhythm of VF, were seen or heard to have collapsed by a bystander, received bystander CPR, and survived to discharge (17.5 vs. 5.5%). Patients who contested at home were older and had an older bystander. The bystander was less likely to be CPR trained, less likely to be trained within the last five years, and less likely to perform CPR if trained. Thus, fundamentally different strategies are needed to improve survival from cardiac arrests in private homes.

This finding agreed with an earlier study of the location of collapse from cardiac arrest as inside or outside the home. Litwin (1987) found that of patients who were documented with having cardiac arrest at home, 13% survived to hospital discharge. This compares to patients who suffered cardiac arrest outside the home who survived to hospital discharge (27%). Similar trends were observed where cardiac victims outside the home were younger, more often men, a larger percentage of arrests were witnessed, bystander CPR occurred more frequently, and prior symptoms occurred less often. Also noteworthy, the data showed that average time to CPR was shorter.

Public-Access Defibrillation

A study by Hallstrom, et al (2004) published in The New England Journal of Medicine showed that training and equipping layperson to attempt early defibrillation within a structured response system can increase the number of survivors. Units assigned to have laypersons trained in CPR plus the use of AEDs had 30 survivors among 128 cardiac arrests (23.4% saved) compared to units assigned to have volunteers trained only in CPR had 15 survivors among 107 cardiac arrests (14.0% saved). The authors feel that trained laypersons can use AEDs safely and effectively.

Public Fire Education

Schaenman, et al, (1990) provided data showing that public fire education improves fire safety in a community. The paper argued that evaluations are most useful when bottom-line effectiveness can be quantified (fires, deaths, injuries, property loss, etc.). This can be achieved by comparing statistics before and after program implementations. If statistical collection is not feasible, program evaluation should include pre- and post-testing, along with retention testing. The impact of prevention programs can also be seen vis-à-vis an international perspective. The focus of fire protection in the U.S centers on response rather than mitigation. One example, goal response times in some foreign countries might be as high as 20 to 30 minutes. This would be unacceptable in the U.S. and yet, despite these statistics, fire death rates are lower in some countries than the U.S., due largely to the fact that foreign countries focus more resources on prevention programs. The countries cited spend between four and ten percent of their total firefighting budget on prevention measures whereas U.S. departments tend to allocate an average of three percent for such programs.

Teaching Children about Fire Safety

It is possible to effectively teach children not to play with fire and what to do in case of a fire. Rashbash, et al, (2004) reviewed statistics for the U.S., Japan, and the UK. The statistics showed that although the number of fires is not decreasing substantially, the number of fire deaths are. Multiple references are made to previous studies of the effectiveness of prevention programs. Nonetheless, U.S. preschoolers have a fire death rate four times that of Japanese preschoolers.

Gamache (2001) studied the implementation methods and success of the NFPA's Learn Not to Burn (LNTB) program in Portland, Oregon. In this study, the total number of fires and youth-caused fires were recorded for the 10-year period from 1990–2000. In the years following the implementation of the LNTB program, youth caused fires decreased steadily. In states (North Carolina and West Virginia) where pre- and post-tests were used, scores also reflected significant improvement.

The effectiveness of educational programs can be improved by considering the cultural characteristics of the targeted audience. An interesting study published by Bertrand (1976) identified socio-economic, socio-cultural, and socio-demographic variables related to fire occurrence in high risk urban residential locations. These factors are important in tailoring fire prevention programs to specific targeted groups. For example, many children in a high risk area of New Orleans considered fire as a "play" method, a habit not deterred by adult intervention. Other cultural characteristics that contributed to the high fire rate in this area were: lack of community spirit, lack of fire safety training, lack of practiced fire precautions; and an attitude of fatalism towards fire.

Public Education as Continuing Education

This study evaluated the effectiveness of the "FireEd" fire safety education program in primary school children in Australia (Satyen, 2004). This study showed that one-time training is not an effective method by which to teach fire safety. Children's knowledge was tested at the conclusion of the program and again five weeks later. A significant decline in fire-safety knowledge was seen after five weeks. This demonstrated that children require periodic training that matches their cognitive development.

It has also been shown that adults need continuing cardiopulmonary resuscitation education. Kalmouth (1985) analyzed 166 laypeople and evaluated their ability to perform CPR according to the American Heart Association standards. Prior to the course, no participant could perform resuscitation. After completion, 65% of participants could properly compress and ventilate. After six months, 44% could still perform CPR properly. This study supported other studies that argue continued education is necessary to maintain the ability to perform proper CPR.

Fire Code Inspections

A study by Hall, Karter, et al (1978) is one of the few studies examining the importance of fire code enforcement. Data from seventeen cities and one county were analyzed to determine whether certain specific fire-code inspection practices resulted in fewer fires, lower fire loss, and fewer civilian casualties in properties covered by fire codes than do other fire-code inspection practices. The research involved (1) identifying the fires and civilian fire casualties that are potentially preventable by inspection and measuring the proportion of fires and casualties which are of that type; (2) relating differences in characteristics of fire code inspection practices to differences in fire rates for a representative group of cities. The study concluded that in cities that conducted annual inspections in all, or nearly all, properties revealed significantly lower fire rates than those cities that do not.

Smoke Alarms and Fire Extinguishers

The American experience with smoke alarms and other fire detection and alarm equipment is a positive one (Ahrens, 2007). Almost all households in the U.S. have at least one smoke alarm. However, in 2000-2004, smoke alarms were either not present or non-operational in almost half (46%) of all reported home fires. During the same time period, 43% of all home fire fatalities resulted from fires in homes with no smoke alarms, 22% resulted from homes in which smoke alarms were present but did not operate, and 65% of fire fatalities occurred in homes with no smoke detectors or no working detectors. Ahrens estimated that if all homes had working smoke alarms, an estimated 890 lives could be saved annually, or just under one-third of the U.S. annual fire fatality rate. Fatalities resulting from home fires with working smoke alarms were more likely to have occurred in the area of origin, to those who tried to fight the fire themselves, or to those who were at least 65 years old.

Ahrens (2007) estimated the causes of smoke alarm failures, based upon data from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual fire department experience survey. Almost three-quarters (73%) of the smoke alarm failures were due to missing, disconnected, or dead batteries. Furthermore, the study re-iterates the importance of public education in the area of smoke detector testing and maintenance.

A study by Mallonee, et al, (1996) examined the effectiveness of a smoke-alarm giveaway program in Oklahoma City over a four year period. The metric used to measure effectiveness was the number of burn injuries. During this study, smoke alarms were handed out door-to-door in a high risk target area. Results showed that four years after the program, burn injury rates decreased 80% in the target area.

Voelkert (2007) showed that fire extinguishers were effective based on the percentage of fires extinguished, the number of deaths and injuries per 100 fires, and the average dollar loss per fire. National Fire Incident Reporting System (NFIRS) statistics over a five-year period indicated that 94% of the time when a fire extinguisher is discharged, the fire is put out and the fire is extinguished usually within two minutes. Donovan (2006) agrees with Voelkert, stating that the role of fire extinguishers should not be underestimated. A survey carried out by the Fire Extinguishing Trades Association and the Independent Fire Engineering and Distributors Association in 2002 showed that fire extinguishers put out more workplace fires every year than the fire service. The point is made that fires extinguished by this means are virtually a "black hole" in the fire statistics, as successful extinguishment via this method typically goes unrecorded.

Residential Sprinklers

A report by Ford (2001) provided statistics 15 years after a residential sprinkler ordinance took effect in 1986 in Scottsdale, Arizona. During the 15 years, the civilian fire fatality rate fell by at least 50%. Fire officials predict that the sprinklered properties have saved at least thirteen lives during the 15 years. Additionally, property losses due

to fire in the area have decreased dramatically. The average property loss for a fire incident in a sprinklered building was over 90% less than that for a nonsprinklered building. This report showed the positive effects of sprinkler intervention on civilian lives and property saved during the study period.
Although the number of fatalities and injuries caused by residential fires has declined gradually over the past several decades, many residential fire-related deaths remain preventable and continue to pose a significant public health problem (CDC, 2008).

Notification

One- vs. Two-Tiered System for Emergency Medical Response

Braun, et al, (1990) described EMS system configuration and performance for systems in 25 mid-sized cities (population 400,000–900,000). Responding cities provided either one- or two-tier systems. In a one-tier system, an advanced life support (ALS) unit responded to and transported all patients who used 911 to activate the system. Three types of two-tiered systems are identified:

System (A) ALS units responded to all calls; on the scene, an ALS unit can turn a patient over to a basic life support (BLS) unit for transport.

System (B) ALS units do not respond to all calls. BLS units may be sent for noncritical calls.

System (C) A non-transport ALS unit is dispatched with a transporting BLS unit. For ALS calls, ALS personnel join BLS personnel for transport.

Overall, cities staffed an average of one ambulance per 50,000 people. In the two-tiered system B, the average ALS unit serves approximately 199,000 people. In a majority of one-tier systems, one ALS unit serves approximately 58,000 people. The average response time for two-tiered systems is 5.9 minutes versus 7.0 minutes for one-tiered systems. This research suggested that the two-tiered system B allows for a given number of ALS units to serve a much larger population while it maintained a rapid response time for most calls.

BLS-D vs. ALS Performance Outcomes

Another dispatch option discussed in the literature is dispatching BLS-D units, which are BLS trained personnel with the aid of on-board defibrillators. A study with a large population base was conducted by Ma, et al, (2007) in Taipei, an Asian metropolitan city with an area of 272 km2 and a population of 2.65 million. The study was conducted to evaluate the impacts of ALS versus BLS-D services. Among 1423 patients included in the analysis, 73% received BLS-D service, and 386 (27%) received ALS services. Compared to BLS-D, ALS patients had similar age, sex, witness status, rate of bystander

CPR, and response timeliness. Patients treated by ALS were more likely to result in significantly higher rates of return of spontaneous circulation and survival to emergency department/intensive care unit admission, but there was no difference in the rate of survival to hospital discharge. The study concluded that the implementation of ALS services improved the intermediate, but not the final outcomes. The study recommended further studies to configure the optimal care model for combating cardiac arrest.

These results agreed with a previous study by Cummins (1991) who reported that the average rate of survival from cardiac arrest in EMT-D only systems was about 16% compared to ALS only systems, which had a survival rate of 17%. Cummins went one step further and evaluated survival in combined EMT-D and ALS systems which demonstrated a survival rate of 29%, significantly higher than BLS-D or ALS only responses.

A study of EMT Defibrillation by Sweeney, et al, (1998) disagrees. This study's findings were that EMT defibrillation does not increase survival from sudden cardiac death in a two-tiered urban-suburban EMS system. This study evaluated a total of 627 patients and found that 4.6% patients with witnessed cardiac arrest with AED use survived to hospital discharge as opposed to 5.3% when AEDs were not used. The authors made the argument that optimization of bystander CPR and EMS dispatching may be more critical than equipping first responders with AEDs. The justification for this argument is that if ALS arrival is already timely, there is no point in the addition of defibrillation capabilities for first responders. Thus if EMS dispatching is optimized then the total time for ALS intervention may be reduced.

Advanced Medical Priority Dispatch Systems

The Advanced Medical Priority Dispatch System (AMPDS) is a medically approved, unified system used to dispatch appropriate aid to medical emergencies including systematized caller interrogation and pre-arrival instructions. AMPDS is developed and marketed by Priority Dispatch Corporation which has similar products for police and fire.

The output gives a main response category - A (Immediately Life Threatening), B (Urgent Call), C (Routine Call). This may well be linked to a performance targeting system where calls must be responded to within a given time period. For example, in the United Kingdom, calls rated as 'A' on AMPDS are targeted to receive a responder on scene within 8 minutes.

The software is used widely but its validity is constantly questioned by first responders in the pre-hospital care environment. For cost effectiveness AMPDS does not generally use medically qualified and experienced call takers. It uses call takers trained to use the software rather than those experienced in the pre-hospital care environment.

A study of AMPDS dispatch by Heward, et al (2004), published in the Journal of Emergency Medicine, compared the percentage of cases coded as cardiac arrest at dispatch using AMPDS with the code reported by the responder in the London ambulance service. The relationship between compliance with the AMPDS protocol and patient cardiac arrest identification was also evaluated. These results were compared with similar statistics prior to AMPDS implementation. Results for this study reported that AMPDS resulted in patients being accurately identified as suffering cardiac arrest twice as often. The second part of the study reported that as compliance with AMPDS protocol increased, so did the accuracy of dispatched coding.

Priority and Scripted Dispatch Systems

How accurate is a type of dispatching in deploying resources? A two-tiered dispatch system relies on the ability of a priority dispatch system to safely limit the need for advanced life support (ALS). Curka, et al (1993), applied a methodology where a retrospective review of incidence reports was conducted to determine what percentage of the time a dispatched basic life support (BLS) unit actually required ALS intervention. Records for over 35,000 events were analyzed to determine how often ALS procedures were used. BLS units were dispatched to over 40% of calls. This allowed for ALS units to be in-service for more serious calls. Of the non-ALS dispatched events only 0.3% were administered drugs, 0.2% received resuscitative interventions. It was determined, after review, that the presence of an ALS unit would have only provided potential advantage in five or six patients out of the total 14,000 of BLS dispatched events.

A study by Garza, et al (2003) showed much less accurate results, reviewing 506 tapes originally coded as cardiac arrest and reporting a system sensitivity of 68.3% for accurately assigning calls as cardiac arrest emergencies. The authors felt that there was an effect on the correct coding of a call based on the type of person instituting the call. They looked at four caller types: victim experiencing cardiac arrest, bystander, person transferring the call to dispatch, and other dispatchers. They also commented that it is possible that dispatchers with more medical training are better at acquiring key information or processing verbal cues from the caller than non-medically trained dispatchers relying solely on a scripted dispatch format.

An earlier study by Wilson, et al, (1992) discussed the value of a single-tier system based upon the unexpected ALS procedures needed on what were initially non-emergency ambulance calls. The study population was an urban community of 475,000 populations with an annual response of 45,000 calls. The results of this study were based retrospectively on 6,363 non-emergency calls. Of these, 309 (5%) were upgraded to emergency while the responding unit was on route. Of the remaining 6,053 calls, 11% resulted in one or more ALS interventions. Calls that were upgraded by dispatch resulted in one or more interventions in 144 out of the 309 (47%) calls. This study shows that despite strict dispatch protocols, 11.7% of non-emergency patients ended up needing ALS care.

Standard Practice for Emergency Medical Dispatch

The American Society for Testing and Materials International (ASTMI) publishes ASTM F1560 (2006), Standard Practice for Emergency Medical Dispatch Management. This document discusses metrics such as: primary intake center, secondary answering point, level of training of call takers and level of training of the dispatchers. The standard discusses telephone aid which is defined as experienced-based aid relying on the experience of the dispatcher vs. scripted aid.

Fire Dispatch Standards

The National Academies of Emergency Dispatch (NAED) is a non-profit standard-setting organization promoting safe and effective emergency dispatch services world-wide. Comprised of three allied Academies for medical, fire and police dispatching, the NAED supports first-responder related research, unified protocol application, legislation for emergency call center regulation, and strengthening the emergency dispatch community through education, certification, and accreditation.

Emergency Responses References

A report from the National Fire Academy (1981) summarized a 1977 test conducted by the Dallas Fire Department, which consisted of a simulated fire involving several rooms at the rear of the third floor of an old school. This simulation was conducted to determine how long it took a three-, four-, or five-person crew to advance its line to this area and get water on the fire. Immediately following those tasks, each individual's physical condition was assessed. Timing began as each engine company entered the schoolyard. The average time for the engine companies to complete the tasks is revealing. The three-person crew average was 18.8 minutes. All personnel were exhausted, "rubber legged", had difficulty standing up and were unfit for further fire fighting. The four-person crew, conducting the very same test, averaged 10.29 minutes and upon completion, was nearing exhaustion. The five-person crew averaged 6.15 minutes (less than 1/3 the time of the three-person crew, and showed little evidence of fatigue at the end of the exercise.

Response Time

Becker (1991) found that the single factor that most likely contributed to poor overall survival was a relatively long interval between collapse and intervention. Benichou, et al, (1999) evaluated the Impact of Fire Department Response and Mandatory Sprinkler Protection on Life Risks in Residential Communities. The National Research Council of Canada's risk-cost assessment model, FiRECAM (Fire Risk Evaluation and Cost Assessment Model), was used to assess whether an apartment building with sprinkler protection, but with longer fire department response time, provides a level of fire safety for the occupants equivalent to that in a building without sprinkler protection, but with a faster fire department response time. Five new development areas in Canada were studied. A three-story apartment building was used as a model building to represent the normal range of buildings in a residential community. The expected risk to life to the occupants was assessed with and without added sprinkler protection, and with two levels of fire department response: with and without new fire stations. The results of this study showed that the provision of sprinkler protection and the existing fire department response time (i.e., no new fire stations) provided a level of fire safety that is better than the case without sprinkler protection but with a shorter fire department response time (i.e., with new fire stations).

Emergency Medical Services

A study by DeMaio, et al (2005) attempted to quantify the role of ALS response time on cardiac arrest survival. In doing so, it identified EMS care level, time and calls as dispatched and patient status on scene as metrics to be evaluated. The study conducted between 1998 and 2002, involved 17 communities. Using data from 3,545 cardiac arrests managed by ALS paramedics, faster response time to ALS care was reported to be influential in survival rates:
6 minutes (5.0%), 5 minutes (6.4%), 4 minutes (8.1%), 3 minutes (8.2%). Mean response for ALS and BLS were 7.7 and 5.9 minutes, respectively; ALS units arrived first in 32% of cardiac arrests. Advanced intervention methods were not studied but it was observed that the results were similar to those of BLS studies regarding time to intervention.

In an attempt to enable prediction of potential for survival from out-of-hospital cardiac arrest based on response time and time to various patient interventions, Eisenberg, et al (1993) used data from a cardiac arrest surveillance system in King County, Washington that had been in place since 1976. From this, 1,667 cardiac arrest patients were selected that had a high likelihood of survival. For each of these patients, time intervals from collapse to CPR were collected. The result of this work was a multiple linear regression model. The following were the findings: survival rate = 67% - 2.3% per minute to CPR - 1.1% per minute to defibrillation - 2.1% per minute to ALCS. If no treatment is given, the survival rate declines 5.5% per minute. The effectiveness of emergency medical technician-defibrillators (EMT-Ds) in various pre hospital settings was investigated by Olsen (1989). The community types for this study ranged from rural to city suburbs. In total, 64 ambulance services took part in the data collection that spanned 18 months. During data collection, 566 patients were included. Of these, 36 (6.4%) survived. Response time (as defined by EMS activation until arrival) in this study was seen to be a good predictor of survival. Those that survived had an average arrival time of 3.7 plus or minus 2.0 minutes, while those that did not survive had an average arrival time of 7.3 plus or minus 5.8 minutes. T he researchers reported that for this study, there were no survivors when response time eclipsed eight minutes.

The association between ambulance response time and survival from out of hospital cardiopulmonary arrest was also evaluated by Pell et al (2001). Data were gathered from all out of hospital cardiopulmonary arrests due to cardiac disease attended by the Scottish Ambulance Service from May 1991 to March 1998. The main outcome measures of the study were the survival rate to hospital discharge and potential improvement from reducing response times. Results: Of 13,822 arrests not witnessed by ambulance crews but attended by them within 15 minutes, complete data were available for 10,554 (76%). Of these patients, 653 (6%) survived to hospital discharge. After other significant covariates were adjusted for, shorter response time was significantly associated with increased probability of receiving defibrillation and survival to discharge among those defibrillated. Reducing the 90th percentile for response time to 8 minutes increased the predicted survival to 8%, and reducing it to 5 minutes increased survival to 10-11% (depending on the model used). Reducing ambulance response times to 5 minutes could almost double the survival rate for cardiac arrests.

Outcomes

Residential Fire Losses

The National Fire Protection Association (NFPA) estimates losses due to fire from a combination of data from the National Fire Incident Reporting System (NFIRS) and data from a survey that they conduct of fire departments throughout the United States. Ahrens (2007) reports for the NFPA specifically on home structure fires. Ahrens reports an annual average of 375,000 home structure fires resulting in 2,970 (92%) of the 3,240 civilian structure fire deaths. Of the 16,170 civilian structure fire injuries, 14,390 (86%) occurred in residential fires. Also, residential fires result in $5.6 billion in direct property damage per year.

Effect of Size of Emergency Response/Deployment

The effectiveness of the fire service in rapidly extinguishing a fire thus minimizing flame spread, property damage and injury is shown in the literature to be a function of having more or less than a predetermined threshold number of personnel on the fireground. Backoff (1980) evaluated the relationship between the number of initial firefighters originally deployed vs. the proportion of incidents in which dollar losses exceeded $5,000 and the proportion of fires with flame spread greater than 25 square feet. The paper concluded that the magnitude of the initial deployed force will affect the efficiency of fire suppression. Clark (1994) found that firefighter injuries occurred more often when the number of personnel on the fire ground was less than 15 at residential fires and less than 23 at large-risk fires.

Firefighter Fatalities

Firefighter Fatalities due to Structural Collapse

Structural collapse is an insidious problem within the fire fighting community. It often occurs without warning and often results in multiple fatalities. The National Institute of Standards and Technology examined records (Brassell, 2003) to determine if trends or patterns could be detected in records of firefighter fatalities due to structural collapse. Between the years 1979 and 2002, there were over 180 firefighter fatalities due to structural collapse, not including those firefighters lost in 2001 in the collapse of the World Trade Center Twin Towers. The data showed that 65% of structural collapse fatalities occurred during the fire attack and, although the total number of collapse fatalities has decreased since 1979, the percentage of collapse fatalities in residential occupancies has increased.

Fire Fatality Rates by Occupancy Type

This study analyzed NFIRS data on fatalities in both residential and other occupancies as a rate of fatalities per 1,000 fires. Data used was based on NFIRS. The study showed that the death rate per 1,000 fires was relatively low for both residential and non-residential fires. Manufacturing facilities experienced the greatest number of fatalities per 1,000 fires (2.7). This was due to the large value of 13.3 fatalities per 1,000 fires in chemical, plastic, and petroleum manufacturing facilities. The values for all other occupancies ranged from 0.3–1.2 fatalities per 1,000 fires.

Firefighter fatalities from Cardiac Arrest

In 2007, there were a total of 102 on-duty firefighter deaths in the U.S. As with previous years, the most fire deaths (36) occurred on the fire ground. The leading cause continues to be sudden cardiac arrest. Of 40 stress related deaths, 38 were considered to be SCAs. The second leading cause was coming into contact with or being struck by an object. The report mentioned that although the number of SCAs has decreased from 70 in 1977 to 38 in 2007, this number still makes up approximately 40% of firefighter deaths. NFPA Standards 1500, 1582 and 1583 are referenced because they emphasize the importance of medical screening and firefighter fitness programs.

The Effect of Automatic Fire Sprinklers in Reducing Losses

Ramachandran (1995) used a probability-based methodology to quantify the effectiveness of sprinklers in reducing the amount of loss caused by fires by minimizing property damage and lives lost. This paper estimates damage by total floor area of building (square meters) for sprinkled and non-sprinkled buildings. According to the calculations, “sprinklers would reduce the maximum damage to 1,000 square meters and 1,200 square meters in buildings of 8,000 square meters and 10,000 square meters, respectively.” Also, Ramachandran found that sprinklers would reduce the probability of fire spreading beyond the room of origin to 0.02.

Data from Factory Mutual Research Corporation for a 10-year period, 1980–1989, show that the average loss where adequate sprinkler protection is provided is only 23% of the average loss where sprinkler protection was either incomplete or not provided. This paper also included data on the number of sprinkler heads necessary to provide sufficient coverage. Twenty-eight percent of recorded fires were controlled by only one sprinkler head, 69% of fires were controlled by 5 or less, and 89% were controlled by 15 heads or less Rees (1991).

According to Rohr and Hall (2005), the chances of dying in a fire in a sprinkled property are reduced by one-half to three-fourths (compared to a property without fire sprinklers) and the average property loss is cut by one-half to two-thirds. It was also shown that sprinklers dramatically affected civilian fire deaths. Public assembly and education occupancies reported no fire deaths in sprinkled properties during this time period. According to this report, direct property loss averted by sprinklers is as follows: 53% for stores and offices, 64% for manufacturing properties, 66% for healthcare facilities for the aged or sick, and 70% for public assembly occupancies.

The effect of a mandatory residential sprinkler ordinance in Prince George's County, Maryland twelve years after mandatory implementation is shown by Siarnicki (2001). In this county, all new residential construction requires sprinklers. During the time period of the study, there were 117 residential sprinkler reported fire incidents. Total fire losses for these events were $401,220. According to predictions in the report, the estimated losses would have exceeded $38 million if these buildings were not sprinkled. Sprinklers also were estimated to have saved 154 lives during the 12-year time period. Seven injuries occurred in sprinkled properties, all of which were minor in nature.

Firefighter injuries

Details about firefighter injuries that occurred in 2005 are given by Karter and Molis (2006). The report includes injury details in the following sections: overall results, injuries by type of duty, number of exposures to infectious diseases, injury trends and rates, injuries by cause, vehicle accident injuries, fires and fireground injuries relative to population protected. In 2005 there were 80,100 injuries.

Costs of Injury

A proposal was made to quantify the total economic cost of injury (Goodchild, 2002). The elements that should be included in total economic cost of injury are broken down into three categories: Direct costs, indirect costs and intangible costs. Direct Costs include: accident, medical and non-medical costs. Indirect Costs are said to be: absenteeism, productivity losses, family worker substitution, worker replacement substitution, and taxation. Intangible Costs are defined as: loss of life, loss of life expectancy, loss of quality of life, physical suffering, and mental suffering. Multiple modern methods are suggested for how to quantify a value for each aforementioned cost.

Total Cost of Fire

The total cost of fire in the United States for the year 2005 (Hall, 2006) is observed by its constituents and summed. The costs observed are: estimates of economic loss, costs of fire departments, net fire insurance, building construction for fire protection, other fire protection costs, estimates of human loss and value of donated time of volunteer firefighters. The complete total cost of fire estimated in this report is $267-$294 billion.

Meade (1991) attempted to characterize the cost of fires losses on society. The relevant findings include: 1) Fires are becoming less acceptable as U.S. and foreign competitors will capture the market if business interruption is considerable, 2) 40% of small businesses with a major fire never reopen, 3) Business interruption loss is estimated to be three to four times greater than business property loss and 4) Product liability costs of fire ($3.5 billion).

TriData Corporation (2005) investigated the cost of firefighter injuries annually. The costs involved included workers compensation, long-term medical care, lost productivity, administrative costs of insurance, etc. It was determined that these costs amount to between $2.8 and $7.8 billion annually. The term firefighter in this report is all-encompassing for this study: career, volunteer, combination departments, special operations, paramedics, training officers, etc. Data collection for this work used NFIRS. Some of the key points included that “more fire departments need to take physical fitness seriously and adopt a formal program that monitors progress against goals and goals met against number and severity of injuries.” Also, “a scientific study on the relationship between the number of firefighters per engine and the incidence of injuries would resolve a longstanding question concerning staffing and safety.” This paper addresses the inquiry whether it is the commonly occurring but minor injuries (sprains, strains, falls, slips, back problems, etc.) or the less frequent, but severe injuries (burns, major falls, etc) that cost more on an annual basis.

Theoretical Model

The theoretical model is the backbone of the entire multi-phase project. The model synthesizes existing knowledge, structures working hypotheses, forms the basis of the survey instrument, and guides the data analysis and conclusions. The literature review, discussed in the previous section, formed the technical basis of the theoretical model by establishing which concepts have been shown to impact the dependent variable (community vulnerability). Expert elicitation was also critical to understanding and evaluating fire service industry rules-of-thumb. In other words, the model should also evaluate the effectiveness of common fire service practices, independent of whether any literature has previously evaluated the concepts.

Once concepts which correlate with changes in community outcomes are identified, objective measures must be developed. Some concepts have obvious measures which are familiar to the respondents (such as recent civilian injuries and deaths due to fire), while other concepts must use newly developed or proxy measures to estimate the magnitude and direction of the concept (such as prevention efforts which have no broadly accepted measure).

Overview

Figure 2 is an overview of the theoretical model. At the most aggregated level, the model can be summarized as a temporal progression of risk factors (moving from left to right in Figure 2), from background data, to incident data, to outcomes. Background data is the context, decisions, and outcomes which have occurred prior to an incident. Context (such as socioeconomics of the response area), decisions (response capacity and prevention efforts, for example) and outcomes (fire and EMS loss history) influence future outcomes through incidents and responses.

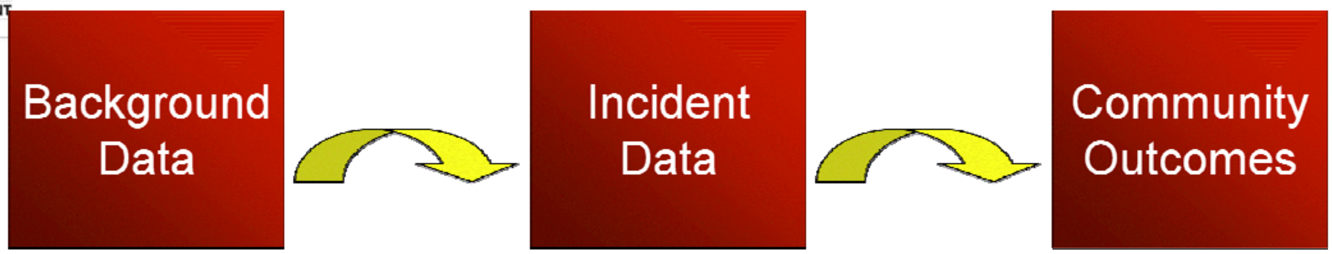

Figure 2: Overall Progression of Risk in Theoretical Model

Incident data is the sequence of response to a fire or EMS event. Incident data includes the dispatch, the response, characterization of the responding units, and external mitigation. Finally, the community outcomes are measured. Community outcomes reflect the core values of the fire service as discussed previously, and include the protection of civilians and firefighters from injury and death and protection of property. Each of these steps is described in greater detail below.

Model Development

The process of model development consists of three steps, each adding further specificity and clarity to the model. The first step is to identify which high-level concepts predict variance in community outcomes (e.g., response time of the first due engine). The second step is to determine which dimensions of the concept adequately characterize the concept in a distinct and measurable manner (e.g., turnout time and travel time). The final step is to develop a measure for each dimension (e.g., a time stamp such as wheels stopped at scene). Figure 3 shows each of these steps.

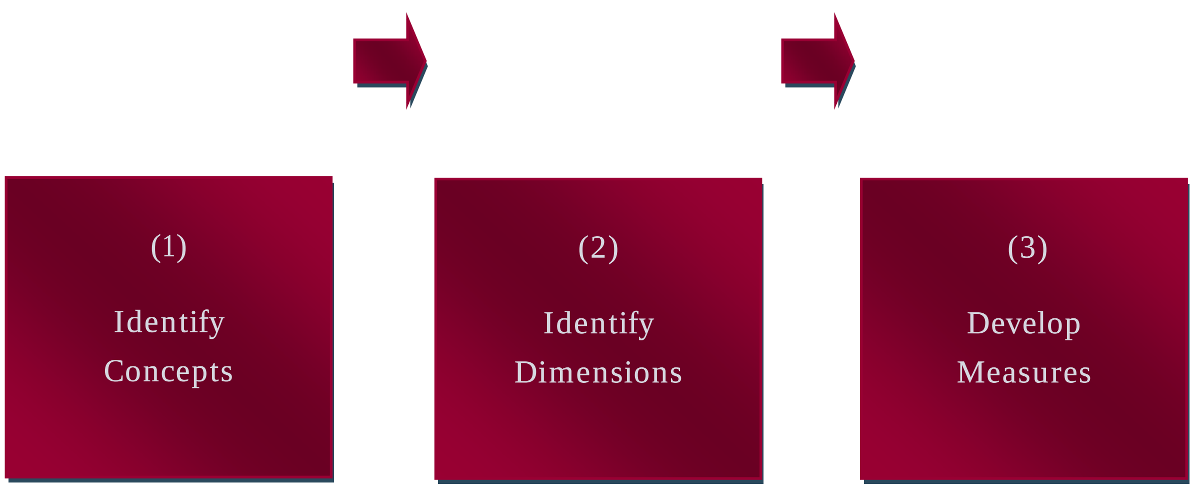

Figure 3: Model Development Process

Concepts

Identifying the universe of concepts is performed largely through literature review and expert judgment. If the universe of concepts is incomplete, the model will have unexplained variance or potentially misleading conclusions. To characterize a complex system, everything that may have an effect on the system should be included.

Figure 4 shows the concepts for assessing community risk. The first box on the left in Figure 4 shows the background concepts. These concepts occur prior to an event. The concept of prevention captures the efforts of the fire service to prevent fires or EMS events and may include public education or distribution of smoke detectors. Prior events are the local fire loss or EMS call volume history for the community. Demographic profile is the collection of socioeconomic factors which correlate with increased fire and EMS activity. Finally, a community has established a response capacity made up of mobile apparatus and trained personnel which stands ready to respond to a future event.

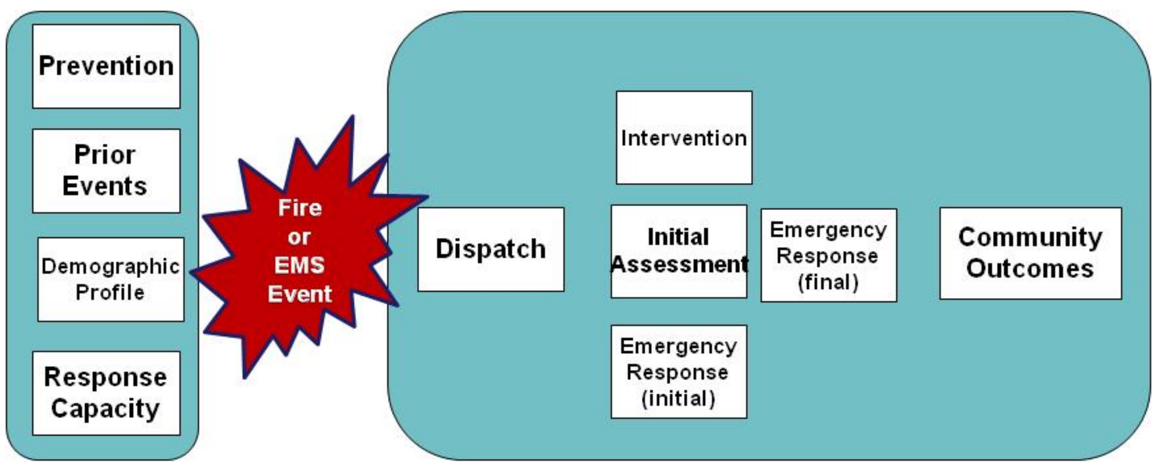

Figure 4: Schematic of model concepts

Once an event (fire or EMS) occurs, the event will be mitigated to a greater or lesser degree depending on the resources deployed by the fire service. The concept of dispatch characterizes the nature and severity of the event. Based on the dispatch assessment, the initial emergency response is deployed. Prior to or concurrent with fire department arrival, non-fire service intervention (such as sprinklers or civilian CPR) may have occurred. On-scene, the first arriving unit assesses the situation to compare to the dispatch assessment. The nature of the event may require additional or fewer resources (captured by the final emergency response concept). Finally, the concept of community outcomes captures the nature of the losses to property or injuries or death to people.

Dimensions and Measures

Once the concepts are identified, each concept must be defined and measured. Additionally, multiple dimensions for a concept help to ensure robustness. Table 4 shows the dimensions and measures for each concept in the background section. Table 5 and Table 6 show the dimensions and measures for each concept in the fire incident data and outcomes section, and EMS incident data and outcomes section, respectively.

Table 4: Background concepts with dimensions and measures

Concept	Dimension	Measure
Prior Events	Property loss	Dollars
	Fire service injuries	Number
	Lost fire service labor	Hours
	Fire service work restriction	Hours
	Fire service lives lost	Number
	Civilian injuries due to fire	Number
	Civilian lives lost due to fire	Number
Department Profile	Fitness program	Dummy
	Training program	Dummy
	Scripted dispatch	Dummy
	Call processing	Fire service, civilian, none
Prevention	Public health program effort	Hours
	Public health program type	CPR, AED, first aid
	Fire safety program effort	Hours
	Fire safety program type	Smoke detectors, presentations, fire drills
	Code enforcement	Percent inspected annually
Community Demographics	Building density	Percent urban, suburban, rural, and wilderness
	Building height	Percent higher than 3 stories
	Construction type	Percent single family residential, multi-family residential, industrial, commercial, vacant, and multi-use
	Station coverage area	Square miles
	Annual call volume	Number
	Community median income	Higher or lower than region
	Age	Percentage by range
	Race demographic	Percent race by census categories

Table 5: Concepts dimensions and measures for fire incident data and outcomes

Concept	Dimension	Measure
Dispatch	Dispatch call type	Odor, alarm, reported fire
	Scene type	Single family residential, multi-family residential, industrial, commercial, vacant, and multi-use
	Pre-plan	Dummy
	Mutual aid	Dummy
	Automatic aid	Dummy
Initial Assessment	Call type	ALS: medical, trauma, or cardiac
	Scene type	Single family residential, multi-family residential, industrial, commercial, vacant, and multi-use
Emergency Response (initial)	Response level dispatched (initial)	Number of units (engine, truck, ambulance, supervisor, officer)
Intervention	Call pickup time	Time stamp
	Dispatch pickup time	Time stamp
	Dispatch time	Time stamp
	Enroute time	Time stamp
	Arrival time	Time stamp
	Early intervention	Dummy
Emergency Response (final)	Response level deployed (final)	Number of units (engine, truck, ambulance, supervisor, officer)
Community Outcomes	Property loss	Dollars and percent of structure damaged
	Worker injuries	Number and work loss hours
	Worker deaths	Number
	Civilian injuries	Number
	Civilian deaths	Number

Table 6: Concepts, dimensions, and measures for EMS incident data and outcomes

Concept	Dimension	Measure
Dispatch	Dispatch call type	BLS, ALS, public service
	Scene type	High-rise, skilled nursing, residence, public assembly, business, outdoor
	Mutual aid	Dummy
	Automatic aid	Dummy
Initial Assessment	Call type	ALS: cardiac, trauma, other
	Scene type	High rise, skilled nursing facility, residential, public assembly, outside property, vehicle, other
	Patient assessment (initial)	BP, pulse, respiratory sounds, skin color, pulse oximeter, EKG, pain level
Emergency Response (initial)	Response level dispatched (initial)	Number of units (engine, truck, ambulance, supervisor, officer)
Intervention	Call pickup time	Time stamp
	Dispatch pickup time	Time stamp
	Dispatch time	Time stamp
	Enroute time	Time stamp
	Arrival time	Time stamp
	BLS arrival time	Time stamp
	ALS arrival time	Time stamp
	Time at patient side	Time stamp
	Early intervention	AED, CPR, medicine
Emergency Response (final)	Response level deployed (final)	Number of units (engine, truck, ambulance, supervisor, officer)
	Patient assessment (final)	BP, pulse, respiratory sounds, skin color, pulse oximeter, EKG, pain level
Community Outcomes	Worker injuries	Number and work loss hours
	Worker deaths	Number
	Civilian injuries	Change in patient vital signs
	Civilian deaths	number

Web-based Survey Instrument

The survey instrument translates the theoretical model into specific questions using each of the dimensions and measures. The questions were carefully constructed to maximize respondent comprehension, minimize respondent burden, and ensure rigor in the resultant model. The web-based survey questions, with survey skip patterns, is shown in Appendix D.

However, constructing questions from the theoretical model is simply the first step towards creating a usable and robust web-based survey. The answers to the questions will not yield meaningful understanding unless (a) a statistically-representative sample of fire departments are providing the answers, (b) the web site design is intuitive, reliable, and available, and (c) rigorous analytical techniques are applied to the data collection. Each of these steps is discussed below.

Collection of Fire Department Background and Incident Data

The primary technical foundation for this study is the collection of background and incident-based data from a representative sample of career fire departments in the United States. The theoretical model described in the previous section was converted into a web-based survey instrument. Rigorous sampling and survey design protocols are critical to producing a reliable and valid model for the deployment of resources.

Sampling Methodology

Design overview

The study employs a two-stage stratified probability sample of fire and EMS events. At the first stage of selection, 494 departments were sampled[†] with probabilities proportional to the population served by the department. Only fire departments that have career staff are eligible for participation. That is, volunteer fire departments are not included in this study (see the section on Limitations for additional information). At the second stage of selection, eligible fire and EMS 'events' are sampled. Detailed information on staffing, vehicle deployment and outcome measures are collected via a web survey for each sampled event. Eligible fire events must be those where the fire *at arrival was a working fire that spread beyond its point of ignition*; eligible EMS events are those that are a *confirmed ALS event at the time of arrival*. In total, we expect that data will be captured for approximately 33,000 fire events and 33,000 EMS events. We now discuss the design activity that led to our statistical design approach.

[†] We expect that 400 eligible departments will participate from this group.

Objectives

The sampling methodology for this study was driven by the project's research goals and analytic objectives. The overarching goals were to gather detailed data from a scientifically sampled collection of fire and EMS events in order to explore patterns of staffing and equipment deployment and its association with selected fire and EMS outcomes. Our specific analytic, statistical objectives called for:

- detecting a 10% relative difference when comparing two groups (i.e., two alternative staffing levels or two alternative response times) under a two-sided test of difference of means using a 5% level of significance and 80% statistical power.

This objective in combination with several design constraints motivated the development of our sample design and data collection methodology.

Design constraint

The collection of event-level data (i.e., deployment and outcome data from 911 calls) was needed to achieve the analytic objectives of this study. Moreover, due to the logistical challenge of securing cooperation and mobilizing the collection of massive amounts of data (approximately 66,000 events), a simple random sample of events was not feasible. Events would need to be sampled from a scientifically sampled set of departments. Moreover, it was impracticable to have all 4,000+ United States fire departments participate in the data collection because of the logistical challenge of securing cooperation and training personnel on data entry. A sample of departments would need to be drawn. Thus, the operational realities related to the collection of high quality data required a two-stage sample design that started with sampling departments, then the independent selection of fire and EMS events for data entry.

Implication of constraint

The multi-stage design for this study necessarily involves cluster sampling. Events are 'clustered' within departments‡. When a multi-stage cluster sample design is employed, the resulting statistical efficiency of the collected data falls below that of a simple random sample of the same sample size. This is because of the 'similarity' of information within a cluster. 'Like events' may tend to occur within towns or cities serviced by a department. As such 'similarity' increases within clusters, so too will the *loss* of statistical efficiency from cluster sampling.

The similarity of observational units (i.e., events) within a department is reflected by a measure called the *intraclass correlation*. When cluster sampling occurs, the intraclass correlation typically ranges in value between zero and one. A zero reflects perfect randomness – that is, when 'clusters' are essentially small random samples of the population. A value of 1.0 occurs when the observations from all units in a cluster are identical (so that no additional information is gleaned after observing the first element in a cluster). In this study it is highly unlikely that event outcomes will be exceedingly similar within a department. On the other hand, assuming no similarity of event outcomes within a department appeared implausible, as well. We conservatively took a middle ground in our evaluation of design options, especially as they related to sample size and statistical power analyses.

The impact of clustering on statistical efficiency can be measured via design effects – ratios of the variance of a statistic for a given design relative to that of a simple random sample of the same size. Design effects can be approximated using an estimate of the intraclass correlation and the average cluster size (in this case, the average number of events sampled per department). It was important to account for the impact of clustering on statistical efficiency when developing the sample design. We now discuss how this was accomplished.

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‡ Technically, events are further clustered within stations, but since events will be drawn from all stations within a sampled department, this level of clustering can be ignored from a statistical design perspective.

Design Development

Sample size analysis

To explore the sample sizes that were needed to meet the analytic objectives in the face of a complex sample design, we conducted several power analyses using existing survey and population data. To begin, we assumed that the principal analyses would utilize a two-tailed statistical test of hypothesis comparing either two levels of staffing (e.g., 2- vs. 3-person teams) or two levels of response time (e.g., less than vs. greater than 6 minute response time). Furthermore, we sought to detect a 10% relative difference using a difference of means test with a 5% significance level and 80% power.

For *fire events*, our power analyses used the following outcomes:

- property damage (in dollars);
- numbers of worker and civilian injury or death.

And power analyses for *ALS events* utilized:

- breathing rate;
- pulse;
- blood pressure (both systolic and diastolic).

Table 7 -Table 9 illustrate the power analyses that were conducted to determine the required sample sizes under three scenarios of clustering: (1) no clustering effects; (2) modest clustering effects, signified by roughly a 45% increase in variance relative to simple random sampling; and (3) major clustering effects, where the variance is doubled relative to simple random sampling. For instance, Table 1 shows the sample sizes required to detect a 10% relative difference in means for contrasting various levels of staffing (e.g., 2- vs. 3-person teams or 3- vs. 4-person teams). Note that the calculations rely on the expected allocation of the staffing configurations in fire response deployments (see the second column from the left). They also rely on estimates of mean values and variance across events. We used limited existing data to develop estimates of these inputs, as well as expert judgment regarding the distributions of staffing levels across departments nationally. In each table, the total sample size required for a given scenario appears in the summary column labeled 'total events.' It is this row that communicates requisite sample sizes that meet our analytic objectives.

In Table 7 we see that sample sizes ranging from 24,000 and 44,000 are needed to achieve the desired statistical efficiency. Table 8 and Table 9 (as well as all other power analyses we conducted) showed that far smaller sample sizes would be required to achieve our desired analytic objectives. In consequence we used Table 7 to determine the sample size for the study, recognizing that detectable difference goals would be exceeded for all other desired analyses (and allow from a variety of secondary subclass analyses).

Table 7: Sample sizes required to detect a 10 percent relative difference in the numbers of worker and civilian injuries or death when contrasting team sizes

		clustering effects**		
		Scenario 1	*Scenario 2*	*Scenario 3*
		no clustering	*modest*	*Major*
Staffing configuration	**expected allocation ***	**requisite n*****	**requisite n*****	**Requisite n*****
2 person	**0.15**	3600	4950	6600
3 person	**0.3**	7200	9900	13200
4 person	**0.4**	9600	13200	17600
5 person	**0.1**	2400	3300	4400
6 person	**0.05**	1200	1650	2200
	Total events	**24,000**	**33,000**	**44,000**
mean = 1.00	std dev	1.544	1.853	2.162

* estimate from project team; means & standard deviations from Montgomery County, Maryland data

** modest clustering boosts std dev by a factor of 1.2; major effects boost by 1.4

*** two-sided test of difference of means via normal distribution, 5% significance and 80% power

Table 8: Sample sizes required to detect a 10 percent relative difference in the numbers of worker and civilian injuries or death when contrasting response time

		clustering effects**		
		Scenario 1	*Scenario 2*	*Scenario 3*
		no clustering	***modest***	***major***
Response Time	**expected allocation***	**requisite n*****	**requisite n*****	**requisite n*****
<6 minutes	**0.38**	535	775	1050
6+ minutes	**0.62**	873	1264	1713
	Total events	**1,408**	**2,039**	**2,763**
mean = $963K	std dev	$624	$749	$874

* based on Fairfax County, Virginia data

** modest clustering boosts std dev by a factor of 1.2; major effects boost by 1.4

*** two-sided test of difference of means via normal distribution, 5% significance and 80% power

Table 9: Sample sizes required to detect a 10 percent relative difference in the pulse of ALS patients when contrasting response times

		clustering effects**		
		Scenario 1	*Scenario 2*	*Scenario 3*
		no clustering	*modest*	*major*
Response Time	**expected allocation***	**requisite n*****	**requisite n*****	**requisite n*****
<6 minutes	**0.68**	378	542	712
6+ minutes	**0.32**	178	255	335
	Total events	**556**	**797**	**1,047**
mean = 80	std dev	31.1	37.3	43.5

* based on Fairfax County, Virginia data

** modest clustering boosts std dev by a factor of 1.2; major effects boost by 1.4

*** two-sided test of difference of means via normal distribution, 5% significance and 80% power

http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1403631&blobtype=pdf

We rejected Scenario 1 for determining sample sizes because it is implausible to expect a complete lack of similarity in both fire and EMS event outcomes within districts. At the other extreme, we expected that the larger cluster effects were not that likely. In consequence, we allowed the sample sizes suggested by Scenario 2 (modest cluster effects) to guide the selection of our sample size target. We concluded that a sample size of 33,000 for fire events would suffice to meet all of our analytic goals. We further chose to maintain equal sample sizes for EMS and fire events in order to minimize complexity for the fire departments staff that would have to implement the event sampling protocols.

First stage of selection

The sample of departments employed a stratified sample design with probabilities proportional to the population served by the department. A sample of 494 departments was desired, from which – after accounting for ineligibility and voluntary participation rates – we expect 400 departments to participate in this study.

We began this stage of selection by identifying an appropriate sampling frame. The 2007 National Directory of Fire Chiefs & EMS Administrators (2008) was obtained from the National Public Safety Information Bureau for use in departmental sampling. The sampling frame contains contact information as well as the total population served by the department.

Volunteer and other ineligible departments and offices were removed prior to processing (although inevitably some ineligible listings remained and were sampled and removed after selection). Volunteer and other ineligible departments represented about

4/5 of all departments in the 2007 National Directory; the Directory data suggest that this group of departments represented about 25% of the population served by the departments.

We then conducted an assessment of the approximately 6,200 departments that made up our sampling frame. These departments serve 75% of the U.S. population. Table 10 presents the distribution of departments by percentile ranking of department population served (as shown in Column B). The green shaded rows show that departments serving small communities (with populations ranging 2,000 to 6,200) represent a total of 2.2% of the population served by our non-volunteer departments (Column E), yet comprise a quarter of all departments in the frame (Column D). Moreover, the estimated six-month volume of eligible fire and EMS events that these smaller departments respond to is sufficiently low that if selected they would fall way short of our sample size target. Finally we felt that the cost associated with selecting and processing the low volume of data from these departments would not be as beneficial as that of sampling the larger departments (and we note that covering departments serving communities with as few as 9,000 population would adequately reflect small department activity). In consequence, we removed from our sampling frame all departments serving 6,200 and less population served. As a result, a total of 4,656 departments in the 50 states plus Washington, DC remained in sampling frame.

Next, we considered the identification of a measure of size to use in sampling departments with probabilities proportional to size. Annual numbers of fire and EMS events would have been ideal as a measure of size for sampling departments. Unfortunately, those data were not available on the department sampling frame. Instead we used *population served* as a proxy for the annual number of fire/EMS events. Our analyses of the IAFF 2006 survey data suggested that this was a good proxy for fire/EMS events.

Table 10: Distribution of Fire Departments by Percentile Ranking of U.S. Population Served

A	B	C	D	E	F	G	H
Pop Served per Dept percentile (RHS of range)	Percentile range	Number of records	Percent of departments	Percent of population served	Population served	6 mo. Average # ***eligible fire events*** for a dept*	Insufficient # events @ 1station = 1dept
2,000	0 - 5%	370	6%	0.2%	460,682	8	**X**
3,000	5.1 - 10%	277	4%	1%	2,045,533	12	**X**
6,200	10.1 - 25%	912	15%	1%	3,041,800	25	**(X)**
9,000	25.1 - 35%	628	10%	2%	4,845,448	36	
10,000	35.1 - 40%	403	6%	2%	4,013,739	40	
14,000	40.1 - 50%	575	9%	3%	7,082,165	55	
30,000	50.1 - 75%	1570	25%	15%	33,039,167	119	
115,000	75.1 - 90%	866	14%	17%	38,909,813	455	
400,000	90.1 - 99%	553	9%	33%	76,081,269	1584	
8,000,000	99.1 - 100%	62	1%	26%	58,318,074	31680	
	Total	**6216**	**100%**	**100%**	**227,837,690**	*33% elig events	
						24 total fires/yr per 1K	
						goal: 28 elig fires/sta	

The sample of departments was determined in two steps – (a) identification of ‘self-representing’ departments, and (b) the selection of the remaining “non-self-representing” departments. Self-representing departments are those whose populations served (and thus annual fire/EMS event volume) is so large that they would appear in the sample with certainty. To understand why self-representing departments are unavoidable in our probability-proportional-to-size (pps) sample, note that a sample of 494 departments would cover in aggregate the 227 million population served. Accordingly, each sampled department will “represent” (227 million)/494 or about 460,000 population. Thus, any department whose population served exceeds 460,000 would be sampled with certainty. It is conventional in survey sampling to use 75% of this ratio as a threshold for determining self-representing selections. We used this approach to identify 76 self-representing departments, all with ‘population served’ exceeding 350,000.

The remaining 418 non-self-representing departments were stratified by *population served* and sampled with probabilities proportional to population served. Combined with the 79 self-representing departments, this yielded our total desired sample size of 494.

Second stage of selection

The final stage of sampling involves the selection and entry of data for eligible events occurring at each sampled department during a pre-specified field period. Departments will be fielded sequentially in replicates (i.e., random subsamples) over a three- to four - month data period, starting with a release of a subsample of departments comprising about 10 percent of the total sample. A single sworn staff person from each department will be trained on identification and entry of eligible events. A web-based data entry protocol will be used.

Ideally, we seek about 83 events sampled per department per event type (i.e., fire and EMS). The actual sample sizes from departments will depend on the department stratum (self-representing vs. non-self-representing), and the volume of eligible events.

Eligible events

Data will be collected only for *eligible* events. Eligible fire events are those that, upon initial assessment *at arrival,* involve a working fire that has spread beyond its point of ignition. Eligible EMS events must involve an actual ALS event *at first arrival.* The project team carefully chose the eligibility definition for this study. A key issue was the timing of the eligibility determination. Using the determination at the point of initial dispatch would result in an extremely large number of events with little information of value (e.g., false alarms). Waiting to determine eligibility after the event had been brought to conclusion (e.g., EMS responses resulting in death) would seriously bias the sample because the sample would be defined on the outcome and fail to capture variation on possible outcomes. We chose to define event eligibility based on an assessment prior to the administration of an intervention – the assessment upon first arrival.

Expected sample size

We have assumed that 400 participating departments and an average of 82.5 events of a specific type (of which there are two – fire and EMS) per department. This should yield data for a total of (400 x 82.5) = 33,000 fire and an equal number of EMS events.

DEPARTMENT Information									
Department ID (Name)									
Chief Name									
Contact Name									
Address									
Street address									
City, State, Zip									
Telephone									
Email									
Station Information									
Numeric listing	**STATION ID or Station Name**	**STATION APPARATUS (List all i.e. - Engine, Ladder, Quint, Ambulance, Heavy Rescue, Boat, Hazmat, Chief, Other)**	**REGULAR (OR TYPICAL) CREW SIZE FOR EACH APPARATUS**	**CREW TYPE FOR EACH APPARATUS (Fire, EMS, Fire/EMS, Other)**	**NUMBER OF ANNUAL RESPONSES FOR EACH UNIT for 2007**	**ANNUAL STATION INCIDENT VOLUME for 2007 (This should be the 'total incidences' NOT the accumulation of the total responses from the units in the station)**	**COMMUNITY TYPE (Circle or check one per station that best describes the neighborhood surrounding the station)**		
Example Station	Station #4	Engine / Pumper 1	3-4	Fire/EMS	2400	4200	Residential	X	
		Engine / Pumper 2	3-4	Fire/EMS	1800				
		Ladder / Truck	4	Fire/EMS	2000		Nonresidential		
		Quint	3		Reserve				
		Ambulance / Medical Unit	2	EMS	3600				
		Chief	1	Fire/EMS	2200		Mixed		
		Other (Air Unit)	3	EMS	1500				

Table 11: Station Listing Form

Web Site Development

Once the survey content was developed and the sampling plan identified, the respondents, the web site was developed in order to capture the data. The web site has been developed to be accurate, secure, available, and reliable. Further, help text was developed and tested in order to provide the respondent with additional clarification and context during data entry. Finally, after each survey response is completed via the web site, the data will be archived and delivered to the study team for subsequent analysis and model building.

ACS FIREHOUSE Software (ACS) is the technical web-based data collection consultant for this project. ACS is responsible for executing and maintaining the online survey instrument. ACS has extensive experience with deploying applications to thousands of customers nationwide and assisting their customers with collection, analysis and reporting of fire department data.

FireReporting.org Infrastructure

ACS converted the survey questions into a reliable web-based data entry portal. The effort has involved 10 personnel, including three project managers and seven developers and over 300 hours of development and project support effort. The data collection web site (www.firereporting.org) is running on a Linux/Apache[§] server and data is stored in a secure MySQL table. The MySQL table can be exported in a number of different formats for subsequent statistical analysis and model development. Since data security is important to the success of the study, individual user names and passwords are encrypted. Finally, PHP language was used in the development of pages and rules.

The web site is divided into two sections: a development site and live site. The development site is a secure environment created for testing purposes only. The live site is accessible to the public but requires a name and password to interact with the survey. The advantage of having both sites is that any changes or improvements can be thoroughly tested prior to posting to the public site.

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§ Use of this product or any other product identified in this report does not imply endorsement by any agency of the U.S. Government or any other organization affiliated with the project team.

Home Page

As shown on the left side of Figure 5, there are seven different options from the project home page. The sections are: Home, Apply to Participate, Complete Surveys, Sponsors/Links, Contact Us, Technical Support, and FAQ's. Each of these sections are discussed below.

The home page is the primary gateway to the study. For visitors who are not affiliated with the study or new study participants, the home page is an introduction to the study, the partner organizations, and the Assistance to Firefighter Grant program. The home page also serves as the first stop for departments to conduct official business with the study, such as enter data or report problems or questions.

Figure 5: Screen capture of the welcome screen for web survey

The 'apply to participate' link allows departments who were not randomly selected for the statistically representative portion of the data collection to participate as part of the validation phase. By comparing data from departments who were not part of the model development analysis, the accuracy and applicability of the model can be assessed.

'Complete surveys' is the link which allows participating departments to securely log in to the study and enter data. The 'sponsors/links' section of the web site provides additional information about the project partners and the DHS Assistance to Firefighters grants program. The 'contact us' link allows the public to ask questions about the study directly to the partners. The 'technical support' section is designed specifically for study participants to obtain technical assistance related to the web site from ACS or technical assistance with the content of the survey from the study partners. Finally, the 'FAQs' section lists questions about the survey and study which have been asked repeatedly of ACS or the study team.

Survey Structure

The background section of the survey is filled out once for each department and once for each station in that department for which data is entered into the study. The survey questions for each section are shown in Appendix D. The incident survey will be the most frequently visited link since every department will provide a significant number of fire and EMS incidents (see section on Sampling Methodology for more information about the number of incidents reported for each department).

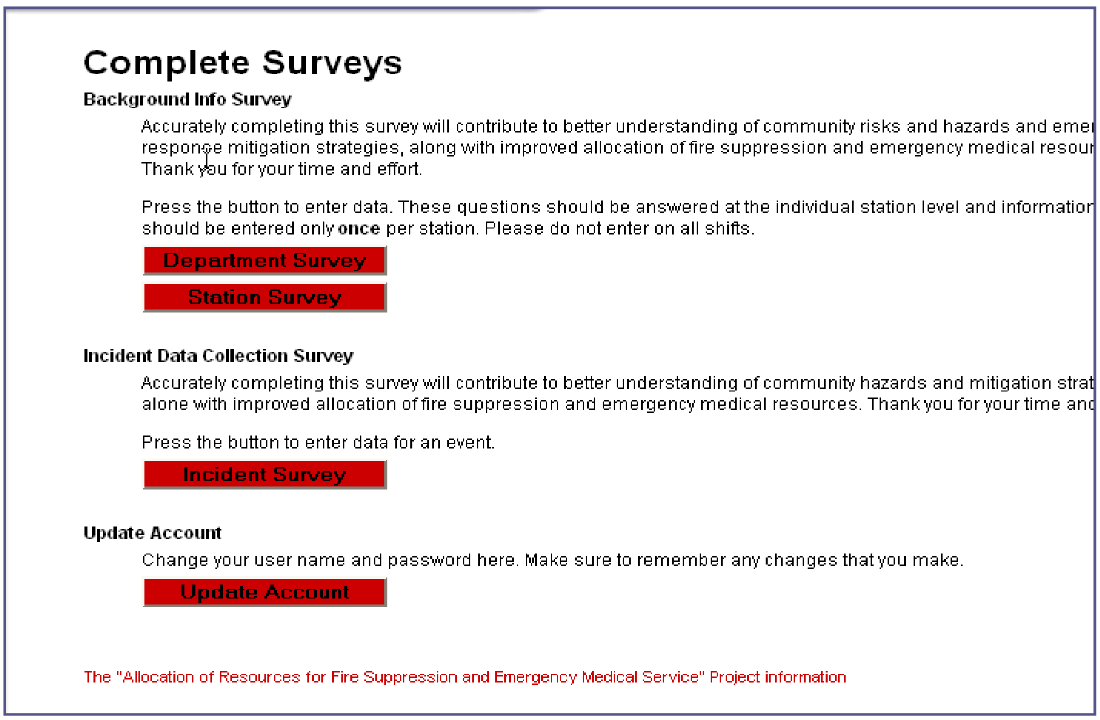

Figure 6: Screen capture of main data entry page

Finally, after the user logs in, they may update their account information if there are necessary changes.

Sample Incident Survey Screen

The incident survey is a chronological record of the important incident factors, ranging from call intake through total assets deployed and incident outcome. Figure 7 shows the notification portion of the incident web site. Responses have drop-down boxes for multiple choice answers, radio buttons for dummy variables (yes/no), and text boxes for numerical or text string answers. For every question, a red circled-question mark indicates a help screen, which appears on mouse-over (rather than having to go to a remote help page). Each portion of the survey is completed by answering all questions on a tab (top of screen) and completing all tabs from left to right (notification to outcome) in Figure 7.

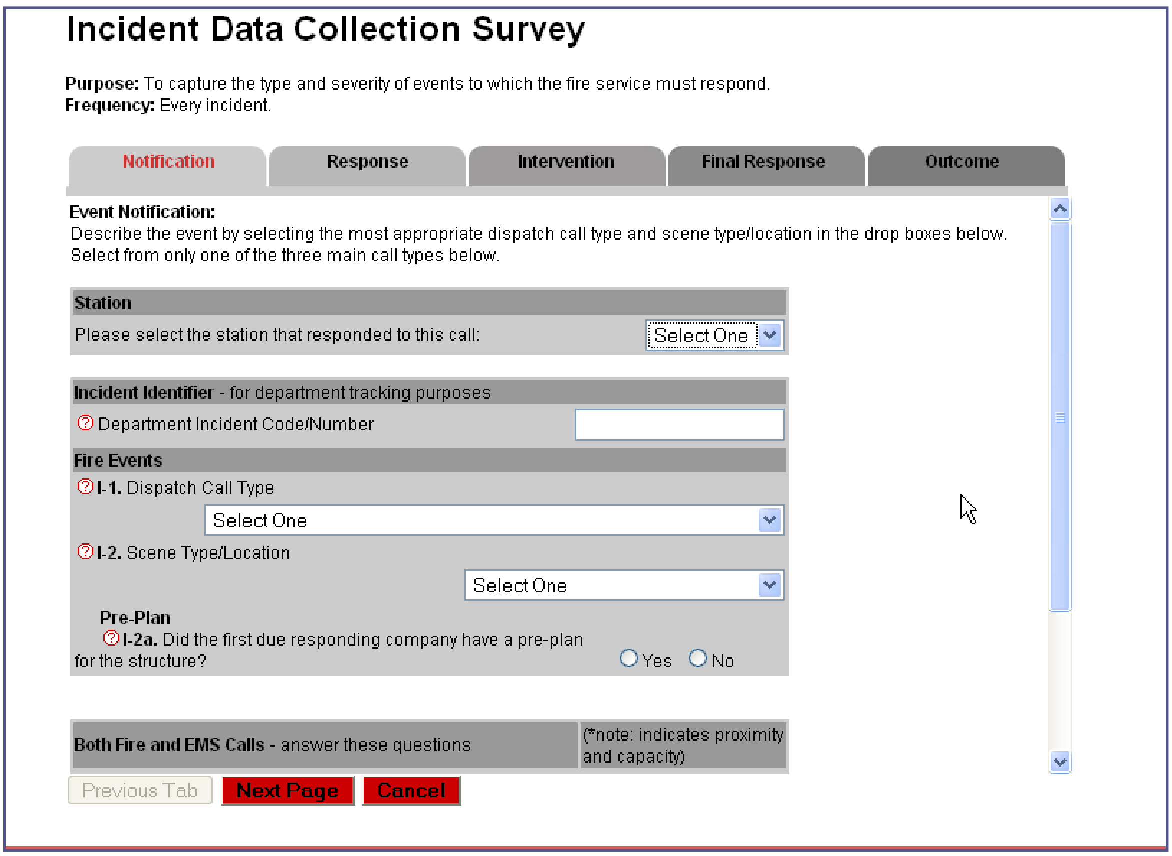

Figure 7: Sample interface for data entry

In the event that a field is left blank or completed with an out-of-range or inappropriate response, error text identifying the problem is returned to the respondent in order to maximize the accuracy and completeness of every response. This error text appears either at the question level, when the respondent attempts to move to a new tab, or completes the survey (depending on the appropriate time).

In conclusion, ACS has implemented a reliable and intuitive web-based survey portal. However, database and web site infrastructure are insufficient to ensure quality study outcomes if the purpose and format of the questions are not readily comprehended by the respondents. The next section describes the pretesting program used to evaluate the implementation of the web site and comprehension of the questions by a variety of respondents.

Pretesting

Pretesting the survey instrument is critical to ensuring the quality of the results. Dillman (2000) addresses the many reasons for conducting pretests, including the identification and correction of cognitive and motivational errors, typographical and implementation errors, and database and programming errors. Identifying and eliminating these errors prior to public release of the survey instrument will produce a higher quality project output. The procedures for pretesting are described below.

Selecting Pretest Participants

Individuals who pretested the survey were selected based on several criteria designed to ensure a broad spectrum of respondent types. The first criterion was that the respondent should have knowledge of the sources and quality of data available within their department from which to provide answers to the survey questions. The second criterion was that the respondent did not have any knowledge about the study prior to the pretest. This would help to ensure that the respondent was not biased by prior information. Finally, the respondents were selected to ensure a diversity of perspectives: geographic (east or west of the Mississippi) and size of department (urban or suburban).

Pretest Procedures

Each pretest nominally followed the same procedures. A member of the project team provided a short (less than five minute) overview of the project. The respondent was asked to begin to fill out the survey starting at the login screen and talk out loud to the research team about what he thinks the question is asking, whether he has ready access to that data, and then to input realistic (though not necessarily accurate) answers into the web application. In most circumstances, help menus were utilized to answer questions rather than have the study team give verbal guidance in order to assess the utility of the help options.

Prior to conducting the next pretest of the instrument, each of the problems identified in the previous pretest were corrected. This would ensure that the changes were adequate solutions to the identified problems.

Pretest Results

The survey pretests resulted in numerous improvements to the survey.

- Language was clarified in both the survey questions and the help text to better communicate the intent of the question as well as what constituted an acceptable answer.
- A small number of questions were removed due to an unreasonable data collection burden on the respondent. For example, the study team was originally interested in evaluating the impact of firefighter certifications on community outcomes. However, to report the relevant certifications for every firefighter on the fireground was determined to be a significant burden to the respondents and the question was eliminated.
- Programming errors were identified and fixed. A common error was the length of a numerical string too short to accommodate large (though reasonable) answers.
- Automated error checking logic was instituted to ensure quality data input. An example of error checking logic is checking for negative numbers or numbers too big to be reasonable answers to a question. Some fields can only be numbers while others can only be text.
- Formatting of input options was improved to ease the data entry process. In particular, the structure for entering the fire service apparatus and personnel deployed to the scene was improved.

Pretesting is presently ongoing and will continue until the survey instrument and training manual have been improved such that respondents consistently demonstrate high-quality and consistent data reporting.

Training Manual for Participating Departments

The training manual was developed in partnership with the survey instrument. Immediately prior to full-scale web-based survey data collection, each responding department will have responsible personnel trained by a member of the study team. The current version of the training manual is included in Appendix E.

Limitations

Given the nearly unlimited number of potential possibilities facing the modern fire service for preventing and mitigating community risks, it is necessary to limit the data collection. The first significant limitation is to evaluate only the most prevalent techniques (i.e., the model would not consider seven-person apparatus staffing as these are relatively rare and therefore consideration of these alternatives would provide little insight). Second, the model focuses on those asset allocation strategies which have been shown or are expected to result in significant impact on the community outcomes. The specific manifestations of these limitations are discussed further below.

First, the scope of this project will evaluate only career fire departments in the United States. Career fire departments protect approximately 76% of the United States population (see the section on Sampling Methodology for more information about the U. S. population included in the scope of this study). While volunteer fire departments make important and valuable contributions to many jurisdictions in the United States, the team considered evaluation of both career and volunteer departments as impractical within the given time and resource constraints. This decision was weighed considerably as the volunteer fire service (and the population served by those firefighters) would greatly benefit from the results of this study since volunteer departments often lack the financial and technical resources to conduct sophisticated hazard assessment and deployment analysis. However, the project team determined that the majority of the public would be best served by conducting a more rigorous analysis of the career departments. It is recommended that a follow-up study be conducted to provide an equivalent tool for the volunteer fire service.

Second, the data collection can only consider existing prevention and mitigation strategies which are broadly applied throughout the country. Unusual or unique strategies lack sufficient variation from which to develop statistically significant conclusions. Examples of deployment strategies which were not considered by the proposed model include:

- New or emerging technologies,
- Highly unusual staffing levels (i.e., greater than 6 personnel per apparatus),
- Communities with unusual hazards (i.e., nuclear power plant),
- Technical rescue activities (i.e., swift water, high angle)
- Response to terrorism or natural hazards, and
- Vehicular incidents.

Third, the scope of events deemed eligible for inclusion in the study was narrowed to those which required the presence of the fire service to determine the outcome of the event (in this case working structure fires and advanced life support (ALS) medical responses). In other words, the nature of the event must exhibit variance in the community outcomes. Therefore, a fire which either self-extinguished or was suppressed by the occupants would not be eligible for inclusion in the study because the effectiveness of the fire service would play no role in determining the outcome of the fire. Further, a medical call which was dispatched as an ALS call but was determined to be a BLS call upon arrival would not be eligible for inclusion in the study.

Future Work

Year 1 of the multi-phase study on firefighter safety and the deployment of resources developed a model and an accompanying survey instrument from the available literature and the combined expertise of approximately two dozen industry leaders. The instrument was converted to a web-based survey and pretested with several potential respondents.

Year 2 (underway) will involve large-scale data collection using two protocols: survey and experimental. The survey data collection will be completed during Year 2 and the data will be transferred to the study's principal investigators to begin in-depth analysis and model development. In order to maximize the time available for data analysis, preliminary regression will be conducted to establish working hypotheses and understanding. As further data are reported the results of the analyses will be updated and the conclusions modified to reflect the new data as necessary. As the sample size increases, the solutions should move towards firm and consistent conclusions.

The second component of data collection is a series of field experiments. The field experiments will provide for a controlled parametric study of the relative influence of fire service response time, crew size, and fire growth rate on the observed fire/smoke damage and occupant tenability in a typical residential structure. In order to ensure firefighter safety, the procedures prescribed in NFPA 1403 (the national standard for conducting live firefighter training burns) will be observed. In order to both satisfy NFPA 1403 and ensure realistic images during the fire evolution the experiments have been divided into two components: NIST Large Fire Laboratory experiments and field experiments. The NIST Large Fire Laboratory experiments, completed in early 2008, measured the progression of two 'typical' family room fires, one with a slow fire growth rate and one with a fast fire growth rate. Both fires burned freely until a standard fire suppression hose line was sprayed at pre-determined intervention times onto the fire using a robotic nozzle controller. Conducting the experiments in this fashion clearly captured the tenability conditions as a function of fire growth rate and time to water application without unnecessarily subjecting firefighters to an elevated IDLH (immediately dangerous to life and health) environment.

The Large Fire Laboratory completed experiments results will be used to safely design the field experiments. Wood pallets will be substituted for the 'typical' family room furnishings (ensuring that the heat release rate will be roughly equivalent) and localized fixed suppression systems will be installed to maintain a 'realistic looking' fire condition, while the tenability conditions will be controlled to minimize threat to the firefighters. The main objectives will be to produce a parametric analysis of the impact of response time, crew size, and fire growth rate on observed building damage and interior tenability conditions for occupants at various locations throughout the structure.

Finally, a parametric series of EMS response experiments will be conducted. The EMS experiments measure time to task for combinations of response time, crew training levels, and crew size. The response incident types will be a series of basic system and extremity trauma and cardiac arrhythmia and arrest. Intervention effectiveness will be recorded using an interactive/responsive 'Harvey' manikin.

Year 3 of this project is the capstone effort which will bear the fruit of the efforts of Years 1 and 2. Whereas Year 1 established the technical and theoretical foundation for the model and Year 2 generated the necessary data to build the model, Year 3 will deliver the results to the fire service community. To accomplish these objectives, Year 3 work has five distinct components: software development, model verification and testing, model validation, documentation, and dissemination. Each component is discussed in greater detail below.

Software Development

In Year 2, the results of the fire station data collection [will be] analyzed to produce regression equations and beta coefficients for the final model. The results of the analysis will be delivered to ACS Governmental Services, Inc. (Firehouse Software) for software development. Tasks associated with software development include computer programming of the regression equations, development of an intuitive user-interface for (a) entering data, (b) running the model, (c) visualizing and interpreting the results, (d) storing and retrieving data and results, (e) help and explanatory menus, and (f) error checking.

First, the regression equations will be converted to computer code using robust and efficient numerical algorithms. Standard checks for numerical stability will be included to ensure that results are returned in a reasonable time period, anticipated not to exceed several minutes. Finally, data storage structures will be developed to minimize storage requirements.

The graphical user interface (GUI) for entering data will ensure that the users of the software can easily enter the profile of their community and fire station(s) in a standard, Windows®-based or similar program. The software development element will be integrated with the help and error checking elements described above. In other words, if a user is unsure of what form of data is required for model input, dynamic help menus will be readily available to define the necessary requirements and give examples. Further, if a user enters a data element which is outside the range of either model applicability or is otherwise outside a valid range, an error message will immediately flag the input error. This will help minimize improper uses of the model.

The visualization routines will be designed in order to efficiently communicate multivariate optimization decisions in the proper context. In other words, the dependent variable of community outcome has three distinct measures: firefighter injuries and deaths, civilian injuries and deaths, and economic losses. Each of these three measures will be visualized simultaneously, including specific on-screen notations of the input parameters used to generate the output. Further the visualization routines will deliver the ability for fire department officers (users) to compare changes to resource allocation and the resulting changes in the community outcome measures. Therefore, the visualization routine will maximize insight for the user into the dynamics of prevention and mitigation strategies in their particular community.

Finally, an electronic user's manual will be delivered integral to the software package. It is the goal of the user's manual that any fire service or public official with a fundamental working knowledge of fire service operations and access to the relevant input data should be able to run the model and interpret the results after reading the user's manual.

Model Verification and Testing

Model verification ensures that the model performs as it was designed to perform. (Model validation (described later) compares the results of the model with the actual phenomena being modeled to evaluate the accuracy and quality of the model.) Model verification and testing will evaluate both the precision of the software, as well as the ability of users to use the model as it was designed to be used. Therefore, Year 3 verification effort will verify that (a) the code is working as designed, (b) users understand the input, output, and limitations, and (c) users evaluating the same problem arrive at similar conclusions.

The first step of verification will check that the software is working as it was designed to work. Multiple independent checks will ensure that the regression equations were converted into computer code correctly. This will involve both visual inspection, as well as numerical checks using standard debugger software.

The next step of verification will evaluate the repeatability and precision of the use of the model. Using identical scenarios, multiple independent users will be asked to run the model and interpret the results. If substantial differences are observed between users, procedures, help menus, and the user's manual will be modified in order to minimize inter-user errors (Inter-rater reliability methods). Finally, some users will be asked to run the model for several scenarios, including some which are identical, to ensure that the user will produce consistent results (intra-user error evaluation - Test-retest methods).

Model Validation

Model validation is a critical element of development in order to provide important context and understanding to both model users, as well as anyone to whom the results may be presented as a basis for allocation decision-making. Validation will assess both the aspects of the problem that the model evaluates adequately (along with a multiple measures of the accuracy), as well as define what aspects of the problem are either not appropriate for evaluation by the model or which have significant uncertainty. ASTM E1355, "Standard Guide for Evaluating the Predictive Capability of Deterministic Fire Models," while not directly applicable to the fire department deployment model, outlines principles and methods which apply to the Year 3 validation and verification effort. Specifically, the ASTM guide outlines four parts of model validation:

- defining the model and scenarios for which the evaluation is to be conducted,
- assessing the appropriateness of the theoretical basis and assumptions used in the model,
- assessing the mathematical and numerical robustness of the model, and
- validating the model by quantifying the accuracy of the model results in predicting the course of events for specific community outcomes.

For the Year 3 project, validation will entail a priori prediction of community vulnerability of an unidentified community. The predictions of the model will be compared to data collected for that community which was held in reserve from the Year 2 data collection expressly for the purpose of model validation. The ability of the model to replicate the observed vulnerability measure provides a level of confidence in the model accuracy.

Additionally, a 'side-by-side' evaluation of community risk and resource assessment projections will be performed by industry experts proficient in staffing and deployment assessment methodologies. The evaluator will perform both manual and automated assessment of risks and resources for a Class A city using identical spatial, resource and demographic data. In principle, both methods should derive the same results; risk valuation based on jurisdiction specific data – identifying resources required for safe effective and efficient mitigation of pre-existing and/or expected risks to firefighters or civilians alike. Both manual and automated models will be expected to recognize and evaluate compliance with NFPA Standard 1710 *Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* and NFPA Standard 1720 *Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments* stated performance objectives as well as compliance with operational best practices as promulgated by other existing standards, regulations or guidelines, outputting identical risk information for the users review.

If necessary, the model will be modified based upon the findings of the validation exercise. The results of the model validation will be documented in the user's guide and published in the open literature.

Documentation

As discussed several times throughout this study or report, thorough documentation is a critical component of this project. There are three primary components of documentation: software documentation, DHS grant documentation, and scientific documentation for the purpose of disseminating the findings of the study. The principal component of software documentation is the electronic user's guide. Along with clear and specific examples of how to operate the product software, the user's guide will summarize the model objectives, scope, theoretical foundation, and validation work.

As part of the completion of the overall three-year project, the project team will produce a final report, summarizing in one document all the work from years one through three. Highlights of the document will include model theory, literature review, data collection methods, including sampling procedures, analysis of the field experiments, summary of the statistical analysis and model regression, and verification and validation results, significant project conclusions, and recommendations for future research. All relevant data will be provided as either appendix or supplementary CD/DVD, depending on the size of the files.

Dissemination

One of the primary objectives of Year 3 is to make the findings of this multi-year project as widely available as possible, including software, scientific findings, verification and validation exercises, field experiments, and recommendations for future research. Modes of publication include scientific, peer-reviewed journals, industry journals for the fire service and public officials, and web site publication of documents on partner organization web sites (CPSE, IAFC, IAFF, NIST, and WPI). Finally, stakeholder organizations will also be delivered copies of relevant reports and findings for further dissemination.

Finally, the model will be used in the Fire Department Accreditation process as administered by CPSE through the Commission on Fire Accreditation International (CFAI). This process assures delivery and use of the product at the local fire department level.

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Appendix A. Annotated Bibliography

Community Demographics

Ahrens, M.
Home Structure Fires
National Fire Protection Association, Quincy, MA, 2007

NFPA estimated that U.S. fire departments responded to an average of 377,100 reported home structure fires per year during the four-year-period of 2002-2005. These fires caused an estimated average of 2,870 civilian deaths, 13,360 civilian injuries, and $5.9 billion in direct property damage per year. Almost three-quarters (72%) of the reported home structure fires and 85% of the fatal home fire injuries occurred in one- and two-family dwellings (including manufactured homes). The remainder occurred in apartments or similar properties. Cooking equipment is the leading cause of home structure fires and home fire injuries, while heating equipment and smoking materials are the leading causes of home fire deaths. Among the major fire causes, smoking materials have the highest rate of deaths per 100 reported fires. More than half of all home fire deaths resulted from incidents reported between 11:00 p.m. and 7:00 a.m. Twenty-four percent of all home fire deaths were caused by fires that started in the living room, family room or den; 24% also resulted from fires originating in the bedroom. Although smoke alarms operated in 49% of the reported home fires, no working smoke alarm was present in 65% of the home fire deaths. These estimates are based on data from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual fire department experience survey.

This report identified the importance of occupancy as a demographic metric. Statistics are also presented regarding types of residence (1-2 family dwellings, manufactured home), fire causes, the time of fire occurrence and presence of smoke detectors. This document provided the reader with information about the frequency of fires in residential occupancies as well as greater detail that describes type of residence. Because of the information about fire cause and smoke detector presence, this document helped to argue the importance of prevention programs.

Association of State and Territorial Health Officials

Injury Prevention Fact Sheet, July 2003

Association of State and Territorial Health Officials, Arlington, VA, 2003

Injuries cause significant suffering and death among the elderly population in the U.S. Elderly injuries are a serious public health concern that affects millions nationally each year. As vision, balance, strength, and other abilities diminish, the potential for injury increases. Common injury mechanisms among older adults include: falls, motor vehicle accidents, abuse/maltreatment, and suicide.

Age is recognized as important to civilian risk of injury & death. The report provides some statistics that quantify age risk such as approximately 13,000 Americans 65 and older died from fall related injuries in 2003.

Becker, L. B.; Han, B. H.; Meyer, P. M.; Wright, F. A.; Rhodes, K. V.; Smith, D. W.; Barrett, J.

Racial Differences in the Incidence of Cardiac Arrest and Subsequent Survival

The New England Journal of Medicine, Vol. 329, No. 9, Pg. 600, 1993

Differences between African Americans and whites have been reported in the incidence of several forms of cardiovascular disease, including hypertension and stroke. Racial differences were examined in terms of incidence of cardiac arrest in a large urban population and in subsequent survival. Data was collected on all non-traumatic, out-of-hospital cardiac arrests in Chicago from January 1, 1987, through December 31, 1988, and was compared to the incidence and survival rates for African Americans and whites. The association between survival and race and seven other known risk factors was examined by logistic-regression analysis. Incidence rates were completed by coupling study data with U.S. Census population data. The study population comprised 6,451 patients: 3,207 whites, 2,910 African Americans, and 334 persons of other races. The incidence of cardiac arrest was significantly higher for African Americans than for whites in every age group. The survival rate after cardiac arrest was 2.6 percent in whites, as compared with 0.8 percent in African Americans. African Americans were significantly less likely to have a witnessed cardiac arrest, bystander-initiated cardiopulmonary resuscitation, or a "favorable" initial rhythm or to be admitted to the hospital. When they were admitted, African Americans were half as likely as whites to survive. The association between race and survival persisted even when other recognized risk factors were taken into account. Important differences were not found between African Americans and whites in the response times of the emergency medical services, however the African American community in this study was at higher risk for cardiac arrest and subsequent death than the white community, even after controlling for other variables.

Becker, L. B.; Ostrander, M. P.; Barrett, J.; Kondos, G. T.
Outcome of CPR in a Large Metropolitan Area - Where are the Survivors?
Annals of Emergency Medicine, Vol. 20, No. 4, Pg. 355, 1991

Survival from out-of-hospital cardiac arrest in cities with populations of more than 1 million has not been studied adequately. This study was undertaken to determine the overall survival rate for Chicago and the effect of previously reported variables on survival, and to compare the observed survival rates with those previously reported. Consecutive pre-hospital arrest patients were studied prospectively during 1987. Chicago's population was more than 3 million inhabitants in 228 square miles. The emergency medical services system, with 55 around-the-clock ambulances and 550 paramedics, is single-tiered and responds to more than 200,000 emergencies per year. The study comprised 3,221 victims of out-of-hospital cardiac arrest on whom paramedics attempted resuscitation. Ninety-one percent of patients were pronounced dead in emergency departments, 7% died in hospitals, and 2% survived to hospital discharge. Survival was significantly greater with bystander-witnessed arrest, bystander-initiated CPR, paramedic-witnessed arrest, initial rhythm of ventricular fibrillation, and shorter treatment intervals. The overall survival rates were significantly lower than those reported in most previous studies, all based on smaller communities; they were consistent with the rates reported in the one comparable study of a large city. The single factor that most likely contributed to the poor overall survival was the relatively long interval between collapse and defibrillation. Logistical, demographic, and other special characteristics of large cities may have affected the rates. To improve treatment of cardiac arrest in large cities and maximize the use of community resources, further study of comparable metropolitan areas using standardized terms and methodology was recommended. Detailed analysis of each component of the emergency medical services systems will aid in making improvements to maximize survival of out-of-hospital cardiac arrest.

This article provided an analysis of cardiac arrest and intervention time intervals in a large metropolitan area (Chicago). By doing this, the article implies the importance of studying response area, total population and population density. The article stated that the survival rates are lower in comparison to the rates reported by smaller communities but consistent with other large communities. The single factor that most likely contributed to the poor overall survival was the relatively long interval between collapse and defibrillation. The paper mentions that demographics need to be studied in future analysis to improve the emergency medical service.

Bertrand, A. L.; McKenzie, L. S.
The Human Factor in High Risk Urban Areas: A Pilot Study in New Orleans, Louisiana, US
U.S. Department of Commerce, Washington DC, 1976

The goal of the study was to determine the socio-economic, socio-cultural, and socio-demographic variables related to fire occurrence in a high risk urban residential location. This study supports the theory that poor, urban areas are at a higher risk of fire loss, injuries, and deaths; i.e., the socioeconomics of a community play a role in the determination of the risk. The fires in the study area were determined to be similar to those in other high fire risk cities. Many children in the area considered fire as a "play" method, a habit not deterred by adult intervention. The following were found to be cultural characteristics that lead to the high fire rate: lack of community spirit, lack of fire safety training, lack of practiced fire precautions, lack of fire fighting facilities, and an attitude of fatalism toward fire.

Boyd, C. R.; Tolson, M. A.; Copes, W. S.
Evaluating Trauma Care: The TRISS Method
The Journal of Trauma, Vol. 27, No. 4, Pg. 370, 1987

Evaluation of trauma care is an integral part of any system designed for care of seriously injured patients. Outcome review should offer comparability to national standards or norms. This paper studies the "TRISS" method, a standard approach for evaluating outcome of trauma care. The role of anatomic, physiologic, and age characteristics are employed to quantify the probability of survival based on the severity of the injury. Used in this article are Trauma Scores which are based upon systolic blood pressure, capillary refill, respiratory rate, and respiratory expansion. This journal article states that there is a correlation between increasing age and probability of survival. For instance, Trauma Scores and Injury Severity Scores for patients under 55 with 10% predicted mortality rates have a predicted mortality of about 40% in patients over 55 years old.

Brennan, P.; Thomas, I.
Victims of Fire? Predicting Outcomes in Accidental Fires
Second International Symposium on Human Behaviour in Fire, Boston
Interscience Publications

This paper analyzed fire fatalities in different building occupancies. Data used was based on the National Fire Incident Reporting System (NFIRS). The results showed that frequency of fatal fires for both residential buildings and non-residential buildings were comparably low. Manufacturing facilities experienced the greatest number of fatalities per 1,000 fires (2.7 fatalities per 1000 fires). Specifically, this number is so high due to the large risks inherent to chemical, plastic, and petroleum manufacturing (13.3 fatalities per 1000 fires). The number of fatalities per 1,000 fires for all other occupancies ranged from 0.3-1.2 fatalities per 1000 fires.

Brookoff, D.

Do Blacks Get Bystander Cardiopulmonary Resuscitation as Often as Whites?
Annals of Emergency Medicine, Vol. 24, No. 6, Pg. 1147, 1994

This research reviewed 1,068 consecutive cases of non-traumatic out-of-hospital cardiac arrest in Memphis, Tennessee from 1989 to 1992. Every adult to which emergency medical services responded was used in the data collection. Results showed that African American victims received bystander CPR 9.8% of the time as opposed to white victims who received it 21.4% of the time. This study determined that African American victims were less likely to receive CPR when suffering cardiac arrest than white victims. As a result, this research suggests that a patient's condition prior to responder arrival could be based on representative demographic information. Also, this study concluded that training programs should be targeted towards susceptible populations, indicating the need for prevention programs.

Chandler, S. E.

The Incidence of Residential Fires in London - The Effect of Housing and Other Social Factors
Building Research Establishment, Fire Research Station, UK, 1979
Information Paper IP 20/79

Data from London in 1972 was examined to determine what role housing and social conditions had on fire incidence and fire deaths. Housing was looked at with metrics of tenancy, density of population, lack of basic amenities (hot water), shared households, and ratable (arbitrary quantity) value per person. The social aspects were socioeconomic group, unemployment, country of birth, age groups, and family stability. The results of the study showed the following:

1. Owner occupation: those communities with high percentages of non-owner occupancy had higher fire incidences (correlation coefficient = 0.91)

2. Residential Density: the most densely populated boroughs all appear on the list of highest residential fire per thousands (correlation coefficient = 0.86)

3. Lack of basic household amenities: this factor was a decent predictor of fire incidence, but not overwhelmingly strong (correlation coefficient = 0.82)

4. Children in care: very good indicator of fire incidence (correlation coefficient = 0.94)

5. Country of birth: Slight predictor of fire incidence as only those born in the Caribbean or Africa saw significantly higher levels (correlation coefficient = 0.64). Direct causal relationships were not possible, but this study gives possible socioeconomic factors that affect fire risk in a community.

Chang, C. Huang, H

A Water Requirements Estimation Model for Fire Suppression: A Study Based on Integrated Uncertainty Analysis

Fire Technology, Vol. 41, No. 1, Pg. 5, 2005

This study used firefighting cases in Taoyuan County in Taiwan and the corresponding field data to conduct a quantitative analysis. The results of the research concluded that the type of land uses (commercial, business, hospitals, and education) have a significant impact on water volume necessary. The quantity of water applied on-scene doubled when the fire department response increased by ten minutes. The authors found that different types of land use require different amounts of water because the fires associated with each had varying severity. It could be implied that coverage area is an important metric as well, as this is directly related to response times. Emergency response is also relevant because of the implication that total response time is related to fire severity.

Chu, K.; Swor, R.; Jackson, R.; Domeier, R.; Sadler, E.; Basse, E.; Zaleznak, H.; Gitlin, J.

Race and Survival after Out-of-hospital Cardiac Arrest in a Suburban Community

Annals of Emergency Medicine, Vol. 31, No. 4, Pg. 478, 1998

The purpose of this study was to establish whether race was a predictor of survival leading to hospital discharge after suffering out-of-hospital cardiac arrest. Income was controlled for in this study. This study used prospective data of out-of-hospital cardiac arrests from 1991 - 1994 for 1,690 patients transported to hospitals in three suburban communities. 223 (13%) were African-American and 1,467 (87%) were Caucasian.

Although average household income varied slightly for African-Americans and Caucasians ($40,225 versus $46,193) both groups were affluent by national standards. The populations varied slightly for witnessed arrest (57% for African Americans and 61% for whites). African-Americans were found to receive bystander CPR less frequently than Caucasians (11% and 20%, respectively). African-Americans had shorter ALS call-response interval compared to Caucasians (median of 4 minutes versus 6 minutes). This study concluded that race was not a predictor of out-of-hospital outcomes in an affluent population.

Clark, George E.; Moser, Susanne C.; Ratick, Samuel J.; Dow, Kirstin; Meyer, William B.; Emani, Srinivas; Jin, Weigen; Kasperson, Jeanne X.; Kasperson, Roger E.; Schwarz, Harry E.

Assessing the Vulnerability of Coastal Communities to Extreme Storms: The Case of Revere, MA., USA

Mitigation and Adaptation Strategies for Global Change, Vol. 3, No. 1, Pg. 59, 1998

Climate change may affect the frequency, intensity, and geographic distribution of severe coastal storms. Concurrent sea-level rise would raise the baseline of flooding during such events. Meanwhile, social vulnerability factors such as poverty and disability hinder the ability to cope with the foreseeable future, the ability to mitigate potential impacts from coastal flooding may be fostered by better understanding the interplay of social and physical factors that produce human vulnerability. This study does so by integrating the classic causal model of hazards with social, environmental, and spatial dynamics that lead to the differential ability of people to cope with hazards.

The paper used Census data, factor analysis, data envelopment analysis, and floodplain maps to understand the compound social and physical vulnerability of coastal residents in the city of Revere, MA, USA. This paper used causal modeling to determine the risk associated with the community of Revere, MA. The metrics that were considered to be of concern to “vulnerable groups” were age, disabilities, housing and the built environment, family/social structure, income, lifelines, occupation, and race. Although this report is not about fire or EMS events, it provides useful insight into metrics that affect the resiliency of a community. In other words, this report considers the metrics that will be significant predictors of the magnitude of damage caused by a negative community event.

Cobb, L. A.; Fahrenbruch, C. E.; Olsufka, M.; Copass, M. K.
Changing Incidence of Out-of-Hospital Ventricular Fibrillation, 1980-2000.
Journal of the American Medical Association, Vol. 288, No. 23, Pg. 3008, 2002

This work looked to determine the relationship of gender, race, age, and first identified rhythm in cardiac arrests in Seattle. The data in this study was taken from advanced life support responses from Seattle Fire Department emergency services from 1979 to 2000. This data was supplemented with U.S. census data to adjust for age and sex. During this period, the incident rate of ventricular fibrillation (VF) as the initial rhythm decreased from 0.85 per 1000 to 0.38 per 1000 (56%). Decreased VF rhythms were seen in African Americans (54%), whites (53%) and men in general (57%). When all treated arrests with presumed cardiac etiology were considered, that incidence decreased by 43% in men but negligibly in women, for whom a relatively low incidence of VF also declined but was offset by more cases with asystole or pulseless electrical activity. VF is a common cause of cardiac arrest and thus the paper shows a reduction in the rate of cardiac arrests over the time period. Most importantly the paper points out demographic indicators of the risk of VF.

Cowie, M. R.; Fahrenbruch, C. E.; Cobb, L. A.; Hallstrom, A. P.
Out-of-Hospital Cardiac Arrest: Racial Differences in Outcome in Seattle
American Journal of Public Heath, Vol. 83, No. 7, Pg. 955, 1993

This study argues that race is important in determining the risk of cardiac arrests in a community. Out-of-hospital sudden cardiac arrest is a key area in which to study the dual problem of the poorer health status of minority populations and their poorer access to the health care system. This study examined the relationship between race (African American/white) and survival, including the incidence and outcome of cardiac arrests in Seattle for which medical assistance was requested. Over a 26-month period, the age-adjusted incidence of out-of-hospital cardiac arrest was twice as great in African Americans than in whites (3.4 vs. 1.6 per 1000 aged 20 and over). The initial resuscitation rate was markedly poorer in the African American victims (17.1% vs. 40.7%), and rates of survival to hospital discharge were also lower in African Americans (9.4% vs. 17.1%). Both effective initial resuscitation and survival were significantly related to white race following adjustment for other covariates. The differences in outcomes were not fully explained by features of the collapse or relevant service factors. Possible explanations included delays in instituting therapy, less bystander-initiated cardiopulmonary resuscitation, poorer levels of health, and differences in the underlying cardiac disorders.

Cutter , Susan L.; Emrich, Christopher T.
Moral Hazards, Social Catastrophe: The Changing Face of Vulnerability along the Hurricane Coasts
The ANNALS of the American Academy of Political and Social Science, Vol. 604, No. 102, Pg. 102, 2006

The social vulnerability of the American population is not evenly distributed among social groups or between places. Some regions may be more susceptible to the impacts of hazards than other places, based on the characteristics of the people residing within them. As observed with Hurricane Katrina, when coupled with residencies in high-risk areas such as the hurricane coasts, differential vulnerabilities can lead to catastrophic results. The geographic discrepancies in social vulnerability also necessitate different mitigation, post response, and recovery actions. Given temporal and spatial changes in social vulnerability in the future, a one-size-fits-all approach to preparedness, response, recovery, and mitigation may be the least effective in reducing vulnerability or improving local resilience to hazards.

This journal article addressed the vulnerability and risk associated with coastal communities for hurricane situations by looking at a community's demographic profile. A large list of variables (based on past data) was developed and narrowed down through statistical analysis. The variable most responsible for increasing the vulnerability in a community was socioeconomic status. Other variables also responsible for the variation in social vulnerability among the counties investigated were development density, population age, race/ethnicity, and gender.

Engdahl, J.; Bang, A.; Lindqvist, J.; Herlitz, J.
Time Trends in Long-Term Mortality After Out-of-hospital Cardiac Arrest, 1980 to 1998, and Predictors for Death.
American Heart Journal, Vol. 145, No. 5, Pg. 826, 2003

This article identified demographic metrics that affect survival of out of hospital cardiac arrests. The study took place in Goteborg, Sweden and used data from 1980 to 1998. This span of time was split into two periods so that time-dependent changes could be observed. In collecting age, sex, cardiovascular co-morbidity (presence of additional conditions with the initially diagnosed illness), resuscitation and hospital complications, no time dependent changes occurred and the study did not reflect higher survival rates with time. Final metrics associated with survival were concluded to be age, cardiac history, history of smoking and worsened cerebral performance at hospital discharge.

Faelker, T.; Pickett, W.; Brison, R. J.

Socioeconomic Differences in Childhood Injury: A Population Based Epidemiologic Study in Ontario, Canada
Injury Prevention, Vol. 6, No. 3, Pg. 203, 2000

This population-based, retrospective study attempted to determine whether childhood injuries are affected by socioeconomic status. The study population was divided into socioeconomic grades based upon percentages of area residents living below the poverty line. Injuries for children 0-19 years were included. A consistent relation between poverty and injury was evident. Results for 5,894 childhood injuries showed that children in the areas of most severe poverty (determined using census data) showed the highest injury rates. The rate in the most severe area of poverty was 1.67 times higher than areas of lesser poverty. These patterns were observed within age/sex strata; for home, recreational, and fall injuries; and for injuries of minor and moderate severities. It was concluded that socioeconomic differences in childhood injury parallel mortality and morbidity gradients identified in adult populations. This study confirms that this health gradient is observable in a population of children using emergency department data. Given the population based nature of this study, these findings are likely to be reflected in other settings. The results suggest the need for targeted injury prevention efforts among children from economically disadvantaged populations, although the exact requirements of the optimal prevention approach remain elusive.

Frank, R. L.; Raush, M. A.; Menegazzi, J. J.; Rickens, M.
The Locations of Nonresidential Out-of-Hospital Cardiac Arrests in the City of Pittsburgh over a Three-year Period: Implications for Automated External Defibrillator Placement
Prehospital Emergency Care, Vol. 5 , No. 3, Pg. 247, 2001

The goal of this study was to identify areas of high risk for cardiac arrest in Pittsburgh for the purpose of achieving effective placement of automated external defibrillators. A total of 971 OHCAs occurred in the City of Pittsburgh from January 1, 1997, to December 31, 1999. Of these, 575 (59%) occurred in private residences, and 396 (41%) occurred in nonresidential locations. Fifteen locations had at least one cardiac arrest per year for three years, accounting for 166 (43%) of the total nonresidential OHCAs. Twelve locations had two arrests during the three-year period, accounting for 24 (6%) of the total nonresidential OHCAs. One hundred ninety-four locations had a single episode of cardiac arrest, accounting for 51% of the OHCAs. Nursing homes and dialysis centers accounted for 178 (94%) OHCAs in the 27 locations that had two or more cardiac arrests. A local sports/events complex (Three Rivers Stadium) was the only other single location to have more than two cardiac arrests in the three-year study period, with a total of three. However, events at this complex are routinely staffed by paramedics equipped with defibrillators. The study concluded that the majority of nonresidential OHCAs occur as singular, isolated events. Other than nursing homes and dialysis centers, there were no identifiable high-risk locations for nonresidential OHCA within the City of Pittsburgh.

Gabella, B.; Hoffman, R. E.; Marine, W. W.; Stallones, L.

Urban and Rural Traumatic Brain Injuries in Colorado

Annals of Epidemiology, Vol. 7, No. 3, Pg. 207, 1997

The purpose of this study was to compare and contrast the epidemiology of traumatic brain injury among urban and rural residents of Colorado. Cases of traumatic brain injury for 1991 and 1992 from the Colorado surveillance system of hospitalized and fatal traumatic brain injuries were used. Urban cases resided in counties designated by the U.S. Census Bureau as metropolitan statistical areas (MSA). Rural cases were divided into two groups: "rural, non-remote" if the county of residence was adjacent to an MSA county or if it had a population of 2500, and "rural, remote," if not. Average annual age-adjusted rates of hospitalized and fatal traumatic brain injury varied significantly from 97.8 per 100,000 population for the most urban group to 172.1 per 100,000 population for the residents of rural, remote counties. Similarly, total mortality ranged from 18.1 per 100,000 population among residents of the most urban counties to 33.8 among residents of rural, remote counties. Pre-hospital mortality ranged from 10.0 to 27.7 traumatic brain injuries per 100,000 population. These results provide justification for expanding efforts to prevent traumatic brain injury to include the small, but high-risk group of residents in rural areas.

Galea, S.; Blaney, S.; Nandi, A.; Silverman, R.; Vlahov, D.; Foltin, G.; Kusick, M.; Tunik, M.; Richmond, N.

Explaining Racial Disparities in Incidence of and Survival from Out-of-Hospital Cardiac Arrest

American Journal of Epidemiology, Vol. 166, No. 5, Pg. 534, 2007

A prospective observational study of 4,653 consecutive cases of out-of-hospital cardiac arrest (OOHCA) occurring in New York City from April 1, 2002, to March 31, 2003, was used to assess racial/ethnic differences in the incidence of OOHCA and 30-day survival after hospital discharge among OOHCA patients. The age-adjusted incidence of OOHCA per 10,000 adults was higher among African Americans than among persons in other racial/ethnic groups, and age-adjusted survival from OOHCA was higher among whites compared with other groups. In analyses restricted to 3,891 patients for whom complete data on all variables were available, the age-adjusted relative odds of survival from OOHCA among African Americans were 0.4 (95% confidence interval) as compared with whites. A full multivariable model accounting for demographic factors, prior functional status, initial cardiac rhythm, and characteristics of the OOHCA event explained approximately 41 percent of the lower age-adjusted survival among African Americans. The lower prevalence of ventricular fibrillation as the initial cardiac rhythm among African Americans relative to whites was the primary contributor. A combination of factors probably accounts for racial/ethnic disparities in OOHCA survival. Previously hypothesized factors such as delays in emergency medical service response or differences in the likelihood of receipt of cardiopulmonary resuscitation did not appear to be substantial contributors to these racial/ethnic disparities.

Gomberg, A.; Clark, L. P.
Rural and Non-Rural Civilian Residential Fire Fatalities in Twelve States
National Bureau of Standards, Gaithersburg, MD, 1982
NBSIR 82-2519

The results of an analysis of fire causal factors in over 1,600 fire fatalities were presented. The primary emphasis was on the identification of fire causes leading to demonstrated high fatality rates in rural areas. It was found that the most significant rural fire fatality cause was heating equipment, with improper installation and misuse of solid fueled heating equipment predominating. Other fire causes making significant contributions to high rural fatality rates were also investigated and documented. Additional data are currently being collected to enable further evaluation of rural fire problems.

This paper identified population density and total populations as important metrics because it focused on the difference between rural and non-rural fire death rates. The study used data on 1,797 fire deaths from twelve states - both rural (<2500) and non-rural (>2500) representations, during a one year time period. Results revealed that rural areas have fire fatality rates of 2.5 times those of non-rural areas. Misuse of solid fueled heating equipment was found to be the most significant rural fire problem. Also, the study concluded that the elderly and non-white populations are at a higher risk, though specific data is not given. Finally socioeconomics are identified as having an obvious effect on the risk of fires and having metrics that, at the point of the study, required further data collection.

Grossman, D. C.; Kim, A.; Macdonald, S. C.; et.al.
Urban-Rural Differences in Prehospital Care of Major Trauma
Journal of Trauma-Injury Infection & Critical Care, Vol. 42, No. 4, Pg. 723, 1997

The objective of this study was to compare differences in response times, scene times, and transport times by advanced life-support-trained paramedics to trauma incidents in urban and rural locations. This report was a prospective cohort study of professional emergency medical services conducted in a five-county area in the state of Washington. Ninety-eight percent of trauma transports are provided by professional paramedics trained in advanced life support. Subjects were included in this study if they qualified as a major trauma victim and were transported or found dead at the scene by one of the region's advanced life support transport agencies between August 1, 1991, and January 31, 1992. The severity of injury was rated using the Pre-hospital Index. Incident locations were defined as "rural" if they occurred in a US Census division (a geographic area) in which more than 50% of the residents resided in a rural location. During the 6-month data collection period, advanced life support agencies responded to a total of 459 major trauma victims in the region. A geographic location was determined for 452 of these subjects. Of these, 42% of subjects were injured in urban areas and the remainder in rural areas. The severity of injuries, as determined both by the triage classification and the distribution of Pre-hospital Index scores, was similar for urban and rural major trauma patients. Twenty-six (5.7%) subjects died at the scene. About one quarter of both groups had a severe injury, as indicated by Pre-hospital Index score of more than 3. The mean response time for urban locations was 7.0 minutes (median = 6 minutes) compared with 13.6 minutes (median = 12 minutes) for rural locations. The mean scene time in rural areas was slightly longer than in urban areas (21.7 vs. 18.7 minutes). Mean transport times from the scene to the hospital were also significantly longer for rural incidents (17.2 minutes vs. 8.2 minutes). Rural victims were over seven times more likely to die if the emergency medical services' response time was more than 30 minutes.

This journal article provided a rural vs. urban comparison of survival from major trauma, which served to justify a population breakdown within the demographic profile. The results showed that response, on-scene and transport times were longer for rural areas. This indicates the need to record these time stamps as metrics.

Gunther, P.
Fire-Cause Patterns for Different Socioeconomic Neighborhoods
Fire Journal, Vol. 75, May, Pg. 52, 1981

This research in 1981 used five census tracts in Toledo, Ohio, observing income and race. This study determined that family income was a strong predictor of residential fire rates. Specifically, it was found to be more powerful for fire causes such as arson, careless smoking, cooking, and children playing with fires.

Hall, Jr., John R.
Characteristics of Home Fire Victims
National Fire Protection Association, Quincy, MA, 2005

Children under age 5 are nearly twice as likely to die in home fires as the average person, but their relative risk has been declining, and by 2002 was down to only 56% over the average. Adults age 65 and older are more than twice as likely to die in home fires as the average person. Alcohol or other drugs, disabilities and age-related limitations are all factors in home fire risk.

This is an excellent source that suggests metrics that are important as well as unimportant to the demographic profile. Primarily the article focuses on age, providing a breakdown of risk of fire death for different age ranges (under 5, over 65, 20-34, etc.). Hall also suggested that race, lower education, poverty and property vacancy highly correlate with fire death rates. Statistical breakdowns for these metrics are given in detail in the report as well as statistics for sprinkler systems.

Hall, Jr., John R.
U.S. Unintentional Fire Death Rates by State
National Fire Protection Association, Quincy, MA, 2006

This NFPA document reported the numbers of unintentional fire deaths by U.S. state for the years between 1998 and 2002. The long-term trend in fire death rates per million population has been sloping substantially downward for nearly every state since 1980. In the five most recent years analyzed (1999-2003), Mississippi had the highest fire death rate, and states of the southeast accounted for 11 of the 13 highest rates, with Rhode Island and Oklahoma as exceptions. There were several correlations obtained by the data in this study that are important to justifying the demographic profile. It was determined that race (49% of statistical variation), poverty (34%), rural/urban (30%), smoking (29%), and education (26%) were relevant predictors. Also, it is noteworthy that "age of housing" is a poor predictor of fire death rates by itself and is rather a proxy often used for areas of poverty and less educated households. It was determined that states with older, high-quality structures, like Connecticut, had low fire death rates. Additionally, climate was found to be a poor predictor of fire death rates.

Hannon, L.; Shai, D.
The Truly Disadvantaged and the Structural Covariates of Fire Death Rates
The Social Science Journal, Vol. 40, No. 1, Pg. 129, 2003

This journal article provides more justification for the inclusion of race and median income into the demographic profile. CDC 1990 data was used for 199 "large metropolitan counties." Results indicated that that fire rates were significantly influenced by both median income and the proportion of African-American population. Areas of low income with a high proportion of African-American population exhibited extremely high fire rates. The researchers conclude that race is the stronger variable (58% vs. 19% for median income).

Hemenway, D.
The Smoldering Issue of Fire Fatalities
Journal of Policy Analysis and Management, Vol. 4, No. 4, Pg. 593, 1985

This 1985 publication provides justification for the collection of population size in the demographic profile. Fire fatality rates were the lowest for "medium-sized" communities; medium-sized was defined as a population between 25,000 and 50,000. Residents in these medium-sized communities were half as likely to die in fires as those in large cities or rural towns. The research addresses this as a "U-shaped" curve with respect to community size and fire death rates.

Hui, M. C.; Tsui, F. S. C.; Luo, M. C.
Fire Incident Characteristics of a Densely Populated Oriental Urban City Beijing, China
Fire Safety Science - Proceedings of the Eighth International Symposium, September 18-23, 2005
International Association of Fire Safety Science

Hong Kong is a small but densely populated Asian city with limited natural resources. The fire engineering approach to formulating fire safety strategies for buildings requires information on the number and characteristics of fires that occurred in different types of buildings. In this paper, fire incident statistical data collected by the Hong Kong Fire Services Department for years 1991 to 2001 is analyzed. It is found that residential buildings constituted 75% of the total number of building fires; however, fire risk appears to be the highest in buildings classified as Places of Public Assembly, using the number of fatalities and injuries per fire as an indicator. The statistical data seems to imply that quality of maintenance of equipment and power supply in privately built shopping arcades, commercial premises and residential buildings is lower than the same buildings owned by the government. Apart from the fire engineering perspective, the fire statistics seem to also reflect to some degree the social make-up and work pattern of the society of Hong Kong. For example, more fires due to carelessness occurred in buildings with lesser educated occupants, and relatively uniform temporal distribution of fires in most parts of the day in private commercial buildings due to significant amount of overtime and overnight work.

Ignall, E.; Rider, K. L.; Urbach, R.

Fire Severity and Response Distance: Initial Findings
The Rand Institute, Santa Monica, CA, 1978

Rational decisions about the number of fire companies a community should have require reliable estimates of the fire losses that would result. Such estimates were not available. One building block in their development is a relationship between the distance the responding companies travel and physical damage. Response distance is a primary focus of this research which shows that fire severity increases with response distance. The researchers predicted that one minute of response time was worth $100 to $10,000.

Jennings, C.

Socioeconomic Characteristics and Their Relationship to Fire Incidence: A Review of the Literature
Fire Technology, Vol. 35, No. 1, Pg. 7, 1999

This article presented a literature review of the socioeconomic modeling of fire incidence, with an emphasis on urban residential fires. The development and history of socioeconomic models of fire incidence are reviewed from the perspectives of ecology and location economics within the urban planning discipline, which encompasses sociological, economic, epidemiological, and interdisciplinary approaches. The predominant methodology used was a thematic type of qualitative analysis, and detailed information on variables selected and results are offered where appropriate.

This literature review is important to the demographic profile section of the model because it serves to summarize the metrics to determine community fire risk in previous studies. The review covers the majority of studies from 1943 to 1992, focusing on urban residential fires. The metrics previously identified were: structure age, unit vacancy, occupancy, age, race, education, population density and poverty rate.

Jennings, P. A.; Cameron, P.; Walker, T.; et al
Out-of-Hospital Cardiac Arrest in Victoria: Rural and Urban Outcomes
Medical Journal of Australia, Vol. 185, No. 3, Pg. 135, 2006

The objective of this study was to compare the survival rate from out-of-hospital cardiac arrest in rural and urban areas of Victoria, and to investigate the factors associated with these differences. Data consisted of a retrospective case series using data from the Victorian Ambulance Cardiac Arrest Registry. All out-of-hospital cardiac arrests occurred in Victoria and were attended by Rural Ambulance Victoria or the Metropolitan Ambulance Service. The study population consisted of 1790 people who suffered a bystander-witnessed cardiac arrest between January 2002 and December 2003. Results showed that bystander cardiopulmonary resuscitation was more likely in rural (65.7%) than urban areas (48.4%). Urban patients with bystander-witnessed cardiac arrest were more likely to arrive at an emergency department with a cardiac output, and to be discharged from the hospital alive than rural patients. Major factors associated with survival to hospital admission were distance of cardiac arrest from the closest ambulance branch, endotracheal intubation, and the presence of asystole or pulseless electrical activity on arrival of the first ambulance crew. The study concluded that survival rates differ between urban and rural cardiac arrest patients. This is largely due to a difference in ambulance response time.

Jermyn, B. D.
Cost-Effectiveness Analysis of a Rural/Urban First-Responder Defibrillation Program
Prehospital Emergency Care, Vol. 4, No. 1, Pg. 43, 2000

The value of gathering demographic data regarding population density can be seen through this article's research. This study from 2000 served to determine the cost-effectiveness of first-responder defibrillation in a small rural area compared to an urban center in Ontario. The data was collected in Waterloo (urban) and Wellesley (rural). The results shows that the project cost per life saved are $49,274 in the rural area compared to $6,776 in the urban center. Additionally, this study cited studies completed by Ornato et al 1984, Ornato et al 1988, and Valenzuela et al 1990 that discussed the rural versus urban cost per life saved using different methodologies.

Karter, Jr., Michael
U.S. Fire Loss for 2005
NFPA Journal, September/October, Pg., 2006

This report provided quantifiable information that supported the inclusion of building occupancy into the demographic profile. Specifically this report focused on the percentage of fires in 2005 occurring in residential properties. Also included are the numbers of deaths and injuries occurring in these fires. Out of a total of 511,000 structure fires, 396,000 occurred in residential properties (78%). 290,000 fires occurred in vehicles. Also, 3,030 out of 3,080 structure fire civilian deaths occurred in the home (98%). A total of 3,675 civilian deaths occurred, of which 82% were in residential occupancies. A total of 13,825 out of 15,325 civilian structure injuries occurred in residential properties.

Karter, Jr., Michael
Fire Loss in the United States During 2006
National Fire Protection Association, Quincy, MA, 2007

In 2006, U.S. fire departments responded to an estimated 1,642,500 fires. These fires resulted in 3,245 civilian fire fatalities, 16, 400 civilian fire injuries and an estimated $11,307,000,000 in direct property loss. There was a civilian fire death every 162 minutes and a civilian fire injury every 32 minutes in 2006. Home fires caused 2,580, or 80%, of the civilian fire deaths. Fires accounted for seven percent of the 24,470,000 total calls. Nine percent of the calls were false alarms; sixty-two percent of the calls were for aid such as EMS.

Karter, Jr., Michael
U.S. Fire Experience by Region
National Fire Protection Association, Quincy, MA, 2003

Data for this report were taken for the years between 1997 and 2001. For purposes of this study the country was broken up into four regions: the South, Northeast, North central, and West. The South had the highest average number of fires per thousand population during the study time period with 7.6. This was followed by the Northeast with 6.9. The West had the lowest during all five years. Excluding the events of September 11th, 2001, the South had the highest rate of civilian deaths per million people for four of the five years (an average of 17.3). The West had the lowest rates each of the five years. The Northeast had the highest civilian injuries per million each of the five years with an average value of 107, 30% higher than the average national rate. The property loss rates per capita varied year by year and showed no consistent trend.

Killien, S. Y.; Geyman, J. P.; Gossom, J. B.; Gimlett, D.

Out-of-Hospital Cardiac Arrest in a Rural Area: A 16-Year Experience with Lessons Learned and National Comparisons

Annals of Emergency Medicine, Vol. 28, No. 3, Pg. 294, 1996

This report highlighted age and response distance as important EMS related demographic metrics. The objective of this study was to evaluate the effectiveness of the emergency medical services (EMS) system in a rural island community in resuscitating victims of out-of-hospital cardiac arrest over the past 16 years. A retrospective analysis of all EMS responses to cardiac arrests on San Juan Island, a rural island community of 5,000 people in the Pacific Northwest was conducted. Data were collected between January 1977 and July 1994. From these data, survival rates were calculated and compared with published data from other rural and non-rural areas in the United States. Results showed that during this study, 22% of all the patients who sustained a cardiac arrest of cardiac origin on the island survived to hospital discharge. The survival rate for witnessed cases of ventricular fibrillation and ventricular tachycardia was 43%. The report concluded that the combined paramedic/emergency medical technician system used on San Juan Island has yielded survival rates comparable to those of urban areas. This system may serve as a model for other rural communities, especially those with well-defined geographic areas and established 911 central dispatching.

Leff, M.; Stallones, L.; Keefe, T. J.; Rosenblatt, R.; Reeds, M.

Comparison of Urban and Rural Non-Fatal Injury: The Results of a Statewide Survey

Injury Prevention, Vol. 9, No. 4, Pg. 332, 2003

This study compared the epidemiology of non-fatal injury among urban and rural residents of Colorado. A stratified probability sample with random digit dial methods was used to survey Colorado residents by telephone regarding injuries experienced in the last 12 months. Questions on the cause of the injury, the activity at the time of the injury, and the place of injury were based on the Nordic Medico Statistical Committee's (NOMESCO) classification of external causes of injuries. Subjects: A total of 1425 urban and 1,275 rural Colorado residents aged 18 and older were interviewed. Results: Age, gender, marital status, and rural residency were found to increase the odds of self reported injury. The adjusted odds ratio for self reported injury was 1.3 for rural compared with urban residents. Rural residence was not a risk factor for injury among the highest risk group, those who were single and never married. No differences in injury characteristics were found by urban-rural status. The increased odds of self reported injury among rural residents were not explained by differences in the causes of injury or other injury characteristics. The differences in the importance of rural residence in increased odds of injury by marital status warrants further understanding and may be important in the development of injury prevention programs. Based on comparison with a similar survey, the NOMESCO coding system appears to be a viable alternative survey tool for gathering information on injury characteristics.

Lerner, E. B.; Fairbanks, R. J.; Shah, M. N.

Identification of Out-of-Hospital Cardiac Arrest Clusters Using a Geographic Information System

Academic Emergency Medicine, Vol. 12, No. 1, Pg. 81, 2005

Objectives: To locate all out-of-hospital cardiac arrests (OHCAs) in Rochester, New York, and identify clusters of OHCAs, as well as clusters of patients who did not receive bystander cardiopulmonary resuscitation (CPR), in order to identify locations that may benefit from prevention efforts. Methods: The locations of all adult OHCAs of cardiac etiology occurring in the study city over a four-year period were plotted on a map using ArcGIS. Location information was obtained from the emergency medical services (EMS) medical record and included street address and zip code. Descriptive data related to patient treatment and transport were also abstracted. Kernel analysis was used to identify areas with the highest density of OHCAs. Census-defined block groups were used to calculate OHCA incidence in order to determine the effect of population density. Patients with OHCAs who did not receive bystander CPR were selected and kernel analysis was repeated to identify areas with the highest density of no bystander CPR. Results: A total of 537 OHCAs that met the inclusion criteria occurred during the study period. Ninety-four percent had sufficient location information to be plotted. Two clusters of OHCAs were identified. One cluster covered two block groups that were found to have the highest incidence of OHCA in the city (142 and 105 per 10,000 people). EMS providers or first responders started CPR (i.e., no bystander CPR) for 80% of patients. Kernel analysis revealed three areas with a high density of no bystander CPR; these areas coincided with the OHCA cluster sites. Cluster communities were found to have a lower median household income and a larger percentage of people living below the poverty level, to have more residents of African American race, and to have more residents without a high school diploma compared with the city's population in general. Conclusions: Out-of-hospital cardiac arrest can be plotted by geographic location. Clusters of OHCAs can be identified which could be used to guide resource allocation. Clusters of OHCAs in which the patients did not receive bystander CPR can also be identified and could be used to direct educational programs. Census data can be superimposed on this information to identify characteristics of cluster locations and were used to demonstrate that the identified clusters were not simply the result of population density.

Marshall, S.W.; Runyan, C.W.; Bangdiwala, S.I.; Linzer,M.A.; Sacks, J.J.; Butts, J.D.
Fatal residential fires: Who dies and who survives?
Journal of the American Medical Association, Vol. 279, No. 20, Pg. 1633, 1998

The United States has one of the highest fire fatality rates in the developed world, and three quarters of these deaths are in residential fires. The objective of this study was to compare characteristics of those who die and those who survive in the same residential fire. Data on fatal residential fires were collected from the medical examiner and interviews with local fire officials. The subjects of this study were persons in residential fires with at least one fatality in a one-year period. T he main outcome measure of this study was dying versus surviving a fatal residential fire that occurred with more than one person at home.

The results of the study showed that of the 190 decedents, 124 (65%) were male, 78 (41%) were home alone, and 69 (53%) of 130 adults who had blood alcohol measured were intoxicated (blood alcohol content >22 mmol/L [100 mg/dL]). Of the 254 persons present during fires in which more than one person was at home, 112 died. Individuals more likely to die (high-vulnerability group) were younger than 5 years or 64 years or older, had a physical or cognitive disability, or were impaired by alcohol or other drugs. The presence of an adult with no physical or cognitive disabilities who was unimpaired by alcohol or other drugs (a potential rescuer) reduced the risk of death in the high-vulnerability group but not the low-vulnerability group. Overall, a functioning smoke detector lowered the risk of death. The study concluded that smoke detectors were equally effective in both low- and high-vulnerability populations. The high-vulnerability group was more likely to survive if, in addition to a smoke detector, a potential rescuer was present. Further research should seek to identify prompts that facilitate speedy egress from a burning structure and that can be incorporated into residential fire alarm systems.

National Fire Protection Association
Educational Properties
National Fire Protection Association, Quincy, MA, 2006

During 2001, an estimated 7,100 reported fires in educational properties caused 76 civilian injuries and $127.7 million in estimated direct property damage. Educational properties include: public, private and parochial schools from preschool through high school where students attend during the day only; daycare facilities; public, private or parochial boarding schools; trade or business schools; and colleges or universities. Dormitories are considered residential and therefore are not included in this report. Fires in the educational occupancy group fell 53% from 15,100 in 1980 to 7,100 in 2001. In comparison, structure fires of all types declined 48% from 1980 to 2001. From 2000 to 2001, fires in these occupancies increased by less than 1%.

North, M. A.
The Estimated Risk of Various Occupancies
Fire Research Station, UK, 1973
Fire Research Note No 989

The relevance of this study comes from the main focus of determining the role of building occupancy type in predicting the risk of fire deaths, injuries and direct property loss. The data used in this study came from a collection of resources ranging from UK Fire and Loss statistics to censuses and surveys. The data is broken down into aggregate values and rate-per values. North considers deaths and injuries on a scale of exposed hours (annually). Although homes had the greatest number of total fires, the fire rate and fire loss per establishment were the lowest. The coal and chemical industries had the highest mean values for deaths/injuries. Increased life risk also occurs in hotels/motels, forestry and fishing, and agriculture. The manufacturing industry (namely coal and petroleum, chemicals, and metals) had the highest fire loss annually.

Notake, H.; Sekizawa, A.; Kobayashi, M.; Mammoto, A.; Ebihara, M.
How to Save the Lives of Vulnerable People from Residential Fires?
Belfast, UK
Third International Symposium on Human Behaviour in Fire, September 1-3, 2004
Interscience Publications

This study presented results from an analysis of fire fatalities in Japan from 1995-2001. Construction type is identified as an important metric, along with age and physical ability of occupant.

Pappas, G.; Queen, S.; Hadden, W.; Fisher, G.
The Increasing Disparity in Mortality Between Socioeconomic Groups in the United States, 1960 and 1986
The New England Journal of Medicine, Vol. 329, No. 2, Pg. 103, 1993

There is an inverse relation between socioeconomic status and mortality. Over the past several decades, death rates in the United States have declined, but it is unclear whether all socioeconomic groups have benefited equally. Records from the 1986 National Mortality Followback Survey (n = 13,491) and the 1986 National Health Interview Survey (n = 30,725), were used to calculate direct standardized mortality rates and indirect standardized mortality ratios for persons 25 to 64 years of age according to race, sex, income, and family status. Results were compared to a 1960 study by Kitagawa and Hauser. The inverse relationship between mortality and socioeconomic status persisted in 1986 and was stronger than in 1960. The disparity in mortality rates according to income and education increased for men and women, whites and African Americans, and family members and unrelated persons. Over the 26-year period, the inequalities according to educational level increased for whites and African Americans by over 20 percent in women and by over 100 percent in men. In whites, absolute death rates declined in persons of all educational levels, but the reduction was greater for men and women with more education than for those with less. Despite an overall decline in death rates in the United States since 1960, poor and poorly educated people still die at higher rates than those with higher incomes or better educations, and this disparity increased between 1960 and 1986.

Peek-Asa, C.; Zwerlinng, C.; Stallones, L.

Acute Traumatic Injuries in Rural Populations

American Journal of Public Health, Vol. 94, No. 10, Pg. 1689, 2004

In the United States, injuries are the leading cause of death among individuals aged one to 45 years and the fourth leading cause of death overall. Rural populations exhibit disproportionately high injury mortality rates. Deaths resulting from motor vehicle crashes, traumatic occupational injuries, drowning, residential fires, and suicide all increase with increasing rurality. This study demonstrated differences in rates and patterns of injury among rural and urban populations and discussed factors that contributed to these differences. Injuries and fatalities are said to be more than twice as high in rural areas than urban areas in this document. Data of 1998 show that the fire death rate per capita was 36% higher in rural areas.

Pulley, S.; Ferko III, J. G.

Defibrillation - EMT Style

Emergency, July, 1989

This journal article is a discussion of defibrillator effectiveness studies. Eisenberg's study in King County, Washington showed that out of 301 out-of-hospital patients given basic life support, only 4.7% survived. Also, ALS supported patients survived at higher rates than those supported by EMTs (7.1% difference). In rural Iowa, a study showed that early defibrillation had an effect on the number of patients saved (11% versus 2%).

In a similar study in rural Wisconsin, it was found that no one survived when the response times were greater than eight minutes; furthermore, it was found that the response and defibrillation time for survivors was half of that of non-survivors. In rural Minnesota the following was found: Bachman reported that no survivors lived if ACLS was started after 30 minutes, CPR after four minutes, call for help after two minutes, or distance to the hospital from the scene greater than 10 miles. Additionally, a model in Nebraska found that the cost per life saved was $566 for urban demographics with a population of 50,000 or more. The cost per life saved with rural populations less than 10,000 was $4,785. Training and practice is also an issue as it is estimated that in a rural setting a technician working in a town of 5,000 will be asked to defibrillate a patient once every seven years.

Reiner, K.; Stecker, E. C.; Vickers, C.; et al
Incidence of Sudden Cardiac Arrest is Higher in Areas of Low Socioeconomic Status: A Prospective Two Year Study in a Large United States Community
Resuscitation, Vol. 70, No. 2, Pg. 186, 2006

A potential effect of socioeconomic status on occurrence of sudden cardiac arrest in the community is likely, but has not been evaluated fully. All cases of sudden cardiac arrest in Multnomah County Oregon (population 660,486; February 2002-January 2004) were identified prospectively and categorized by census tract based on the address of residence and specific geographic location of occurrence of cardiac arrest. Each census tract was assigned to quartiles of median income, poverty level, median home value, and educational attainment.

Of 714 cases (annual incidence 54 per 100,000), 697 (98%) had residential addresses that matched a county census tract successfully. For each socioeconomic status measure, the incidence of cardiac arrest was 30-80% higher in the lowest compared to the highest socioeconomic status census tracts. Annual incidence in census tracts in the lowest compared to the highest quartiles of median home value was 60.5 vs. 35.1 per 100,000. This gradient was exaggerated significantly for age< 65 years (34.5 vs. 15.1 per 100,000). Identical trends were observed for sudden cardiac arrest based on location, with 60% of all cases and 66% of cases age<65 years occurring in the two quartiles with lowest socioeconomic status.

Low neighborhood socioeconomic status was associated with a significantly higher incidence of sudden cardiac arrest based on address of residence as well as location of cardiac arrest. For effective deployment of strategies for community-based prevention such as the automated external defibrillator, neighborhood socioeconomic status is likely to be an important consideration.

Relethford, J.; Mahoney, M.

Relationship Between Population Density and Rates of Injury Mortality in New York State (Exclusive of New York City), 1978-1982

American Journal of Human Biology, Vol. 3, No. 2, Pg. 111, 2005

The relationship between population density and rates of mortality from unintentional and intentional injuries is examined using mortality data from New York State (exclusive of New York City), 1978-1982. Records for 26,118 individuals with an underlying cause of death due to injury were assigned to population density quintiles based on residence of decedent at time of death. Mortality rates for each population density quintile were examined separately by sex and for 11 causes of injury death. Overall, injury mortality is highest in the most rural and most urban populations. For both sexes, there is an inverse relationship between mortality from motor vehicle incidents and population density, and a positive relationship between homicide and population density. Male mortality from unintentional poisoning deaths shows a positive relationship with population density. Male mortality from fires shows a U-shaped relationship with population density, with the highest mortality in the most rural and most urban populations. The relationships observed here between injury mortality and population density are most likely due to accompanying variation with aspects of the physical and cultural environments, such as socioeconomic status, ethnicity, and individual risk behaviors.

Rogers, F. B.; Shackford, S. R.; Hoyt, D. B.; et al

Trauma Deaths in a Mature Urban vs. Rural Trauma System: A Comparison

Archives of Surgery, Vol. 132, No. 4, Pg. 376, 1997

The objective of this study was to compare the timing, severity, and injury characteristics of patients dying from trauma in an urban versus a rural setting. The study design was a retrospective review of autopsy database (urban) and medical examiner database (rural), with selected medical chart review. The setting was an organized urban trauma system with six trauma centers and a rural state with no formal trauma system and one trauma center. The patients were all trauma fatalities occurring in an urban (n=612) and a rural (n=143) setting during a one-year period.

In the urban system, 248 patients (40.5%) died at the scene of injury compared with 103 (72%) patients in a rural environment. During the first 24 hours of hospitalization 243 (39.7%) urban patients died compared with 23 (16%) rural patients. Eighty-nine urban patients (14.5%) and 17 rural patients (11.8%) survived for more than 24 hours but later died in the hospital. The mean age of those who died was significantly greater in the rural trauma system than in the urban trauma system, and the Injury Severity Score was significantly less in the rural trauma system than in the urban trauma system. In the patients who died after being admitted to the hospital for more than 24 hours there was a significantly higher rate of preexisting comorbidity in the rural patients than in the urban patients. The most frequent cause of death in the rural setting was multisystem organ failure; head injury was the most common cause of death in the urban setting.

Patients who die in a rural area without a formal trauma system are more likely to die at the scene, are less severely injured, and are older. Rural trauma patients who are admitted to a hospital and who survived for at least 24 hours before dying are older, less severely injured, have significantly more comorbidities, and are more likely to die of multisystem organ dysfunction than their urban counterparts. These differences reflect the different patient populations and injury patterns that confront urban and rural trauma centers. The higher proportion of on-scene deaths in the rural environment may reflect the longer discovery and transport times that occur in a rural setting.

Scholer, S. J.; Mitchel Jr., E. F.; Ray, W. A.
Predictors of Injury Mortality in Early Childhood
Pediatrics, Vol. 3, No. 3, Pg. 342, 1997

OBJECTIVE: To study the association between maternal/infant characteristics and mortality from injury for children 0 through 4 years of age. DESIGN: Historical cohort. SETTING: State of Tennessee. PARTICIPANTS: Children zero through four years of age at any time between January 1, 1985 and December 31, 1994. The study linked birth certificates and U.S. census data to obtain information on maternal age, race, education, neighborhood income, parity, use of prenatal care, residence location, infant's gender, and gestational age. MAIN OUTCOME MEASURES: The outcome was death from injury, as determined from linked death certificates. The incidence density rates for each stratum (defined by maternal/child characteristics) were calculated by dividing the number of injury deaths by child years in the stratum. We used multivariate analysis to assess the independent contribution of each characteristic to risk of injury death.

There were 1,035,504 children zero through four years of age who contributed 3,414,436 child years. There were 803 deaths from injury (23.5 deaths per 100,000 child years). In the multivariate analysis, children had at least a 50% increased risk of injury mortality if they were born to a mother who had less than a high school education compared with a college education, was < 20 years of age compared with > 30 years, or had two or more other children compared with no other children. Neither race nor income was significantly associated with childhood injury mortality in the multivariate analysis. Classification of children by maternal education, age, and parity defined a pronounced risk gradient in which high-risk children had an injury mortality rate >15 times that of low-risk children. The steep risk gradient was present for both infants (24-fold increase for high-risk children) and children 1 through 4 years of age (13-fold increase for high-risk children). If the injury mortality rate for all children were equal to that of the low-risk group, 614/803 (76.3%) of injury deaths would not have occurred.

For young children, maternal education, age, and parity are strongly and independently associated with injury mortality. These factors define a steep gradient of risk, suggesting that many injury deaths could be prevented.

Sekizawa, A.

Care of the Vulnerable Populations: Who are Vulnerable to Fires and what Care is Needed for their Fire Safety?
Third International Symposium on Human Behaviour in Fire, September 1-3, 2004
Interscience Publications, Belfast, UK

The results given by this study are relevant to the demographic profile because they justify the inclusion of occupancy type, age, and population. All data in this study was obtained from Fire and Disaster Management (Japan). This paper provides graphical representations of the physical conditions of fatalities at the time of fire by occupancy type in Japan. It shows that contrary to popular belief, most vulnerable groups (disabled, bed-ridden, etc.) die in residential properties. They also make up a large percentage of fatalities given their small fraction of the total population. A graphical representation also shows the causes of fire death by type of physical condition in residential fires in Japan. Finally, the fire causes of fatal residential fires are broken down by age group brackets. Depending on the age bracket, the resulting likelihood of cause varied.

Sekizawa, A.

Statistical Analyses on Fatalities: Characteristics of Residential Fires
Edinburgh, UK
Fire Safety Science - Proceedings of the Third International Symposium,
Elsevier Applied Science

Pre-school children in the U.S. have a fire death rate twice that of Japanese children in the 0-5 age group. This might be due to the fact that there are a higher number of single-parent families in the U.S. than Japan, which may lead to more children being left alone.

Sekizawa, A.
Study on Potential Alternative Approach to Fire Death Reduction
University of Poitiers, France
Fire Safety Science - Proceedings of the Sixth International Symposium, July 5-9, 1999
International Association of Fire Safety Science

This paper explored methods to lower fire death numbers by determining the factors that affect fire incidence. Statistical trends by age group, types of home structure, and causes of fire were explored. The study determined that the popularization of safer heating appliances and fire-resistive houses and/or fireproof wooden houses provide a good prospect for reducing fire deaths in the future as an alternative approach. This research concluded that fire death rates of older people has declined with time, which is promising, as the number of people in this older age group is growing in Japan and other developed nations.

Swor, R. A.; Jackson, R. E.; Compton, S.; et al
Cardiac Arrest in Private Locations: Different Strategies are Needed to Improve Outcome
Resuscitation, Vol. 58, No. 2, Pg. 171, 2003

Though the article focused on CPR training and bystander CPR, an analysis of cardiac arrest locations was given. This analysis showed that about 80% of cardiac arrests occur in residential properties. The bystanders who witnessed cardiac arrest were interviewed after the incident. Results showed that bystanders in residential occupancies were less likely than bystanders in public places to be trained in CPR, trained within the last five years, and less likely to perform CPR if trained.

TriData Corporation
An NFIRS Analysis: Investigating City Characteristics and Residential Fire Rates
Federal Emergency Management Agency, Arlington, VA, 1998

The purpose of this study was to define relationships between city characteristics and fire rates. Data collection for this study involved 27 cities reporting to NFIRS. Results from this study showed that there was no evidence that race had an effect on fire incidence rates, independent of its effects on income and poverty. An extensive literature review was also performed. This report cites previous work by Gunther (1981) and Jennings (1996) who found similar results regarding race and poverty levels.

United States Fire Administration
A Profile of the Rural Fire Problem in the United States
United States Fire Administration, Emmitsburg, MD, 1998

While there are many similarities between fires in rural and non-rural areas, there are also many differences. Some of the differences, such as the higher incidence of heating fires in rural areas, point to issues that need to be considered when designing public education programs to reduce the number of fires and the deaths, injuries, and property loss associated with rural fires. For the purposes of this report, "rural" is defined as all counties that have populations of fewer than 20,000 persons and that are generally not adjacent to metropolitan areas.

United States Fire Administration
The Rural Fire Problem in the United States
United States Fire Administration, Emmitsburg, MD, 1997

This study, being the predecessor to the 1998 report, "A Profile of the Rural Fire Problem in the United States," found similar results. NFIRS data was used for the analysis. The report identified age, race and gender as metrics. Although the greatest number of fire deaths in rural areas is among the white, the largest number of fire deaths per capita is among African-Americans and Native Americans. For gender, the report states that nearly twice as many men die in fires as women. In rural settings, fire deaths "tended to affect a larger portion of the younger population than non-rural fire deaths."

Vukmir, R. B.
The Influence of Urban, Suburban, or Rural Locale on Survival from Refractory Prehospital Cardiac Arrest
The American Journal of Emergency Medicine, Vol. 22, No. 2, Pg. 90, 2004

This 2003 study sought to determine the role of rural, suburban, and urban locales on the outcome of pre-hospital cardiac arrest; this was the secondary endpoint, as the study also sought to evaluate the effect of bicarbonate on patient survival. Rural, suburban, and urban were classified as 0-399 people per square mile, > 400 people per square mile, and > 2,000 people per square mile, respectively. All the patients underwent standard ALS care intervention. The metric of time was measured from collapse until onset of medical intervention. Survival was measured as the presence of ED vital signs on arrival. Survival rates varied for rural (9%), suburban (14%), and urban (23%); the overall survival rate was 13.9% for the entire study (110 of 793). It is noteworthy that there was no difference in time to bystander cardiac resuscitation for the various groups.

However, BLS response time was better in urban and suburban communities than rural. Also, intervention and transport times for ALS were less for suburban communities only. This study found that although response times can be predicted based on demographic community type, those response times were not necessarily predictive of survival.

Zheng, Z. J.; Croft, J. B.; Giles, W. H.; Mensah, G. A.

Sudden Cardiac Death in the United States, 1989 to 1998

Circulation, Vol. 104, No. 18, Pg. 2158, 2001

Sudden cardiac death (SCD) is a major clinical and public health problem. United States (U.S.) vital statistics mortality data from 1989 to 1998 were analyzed. SCD is defined as deaths occurring out of the hospital or in the emergency room or as "dead on arrival" with an underlying cause of death reported as a cardiac disease (ICD-9 code 390 to 398, 402, or 404 to 429). Death rates were calculated for residents of the U.S. aged >/= 35 years and standardized to the 2000 U.S. population. Of 719,456 cardiac deaths among adults aged >/= 35 years in 1998, 456,076 (63%) were defined as SCD. Among decedents aged 35 to 44 years, 74% of cardiac deaths were SCD. Of all SCDs in 1998, coronary heart disease (ICD-9 codes 410 to 414) was the underlying cause on 62% of death certificates. Death rates for SCD increased with age and were higher in men than women, although there was no difference at age >/=85 years. The African American population had higher death rates for SCD than white, American Indian/Alaska Native, or Asian/Pacific Islander populations. The Hispanic population had lower death rates for SCD than the non-Hispanic population. From 1989 to 1998, SCD, as the proportion of all cardiac deaths, increased 12.4% (56.3% to 63.9%), and age-adjusted SCD rates declined 11.7% in men and 5.8% in women. During the same time, age-specific death rates for SCD increased 21% among women aged 35 to 44 years.

SCD remains an important public health problem in the U.S. The increase in death rates for SCD among younger women warrants additional investigation.

Death due to sudden cardiac arrest was investigated between 1989 and 1998. Deaths were observed as occurring out of hospital, in the emergency room, or as "dead on arrival." Residents of the U.S. with cardiac arrest as the cause of death and who were over 35 years old were included in the data collection. Results showed that the African American population had higher rates of sudden cardiac death than all other ethnicities. Hispanics had the lowest death rate for sudden cardiac arrest of all ethnicities. Death rates were higher in males than females. Rate of SCD also increased with age; 85 years old was determined as the line where gender no longer was a relevant factor.

Response Capacity

Brown, L. H.; Owens Jr., C. F.; March, J. A.; Archino, E. A.
Does Ambulance Crew Size Affect On-Scene Time or Number of Prehospital Interventions?
Prehospital and Disaster Medicine, Vol. 11, No. 3, Pg. 214, 1996

While large cities typically staff ambulances with two emergency medical services (EMS) professionals, some EMS agencies use three people for ambulance crews. The Greenville, North Carolina, EMS agency converted from three-person to two-person EMS crews in July 1993. There are no published reports investigating the best crew size for out-of-hospital emergency care. Two-person EMS crews perform the same number and types of interventions as three-person EMS crews. Data for the two most common advanced life support calls in this system-seizures and chest pains-were collected for the months of June and August 1993. Three-person EMS crews responded to both types of calls in June. In August, two-person EMS crews responded to seizure calls; two-person EMS crews accompanied by a fire department engine (pumper) with additional staffing responded to chest pain calls. The frequency of specific interventions, number of total interventions, and scene times for the August calls were compared to their historical control groups, the June calls. One hundred twenty-six patient contacts were included in the study. There were no significant differences in total number or types of procedures performed for the two patient groups. Mean on-scene time for patients with seizures was 11.0 ± 4.2 minutes for three-person crews and 19.4 ± 8.3 minutes for two-person crews. Mean on-scene time for patients with chest pain was 13.6 ± 4.9 minutes for three-person crews, and 15.4 ± 3.2 minutes for two-person crews assisted by fire department personnel. Two-person EMS crews perform the same number of procedures as do three-person EMS crews. However, without the assistance of additional responders, two-person EMS crews may have statistically significantly longer on-scene times than three-person EMS crews.

Campbell, M. H.; Ritter, G. N.; Lee, D. J.; Garcia, A. A.; Rosenberg, D.-G.
Comprehensive Fitness Assessment in Firefighters
Medicine & Science in Sports and Exercise, Vol. 30, No. 5, 1998

This article identified the importance of the metrics that fall under fitness programs. The study showed negative results from fitness tests. Researchers tested a group of 65 firefighters in several fitness areas; they included push-ups, sit and reach, sub maximal bike test, along with others. Results showed that from 45% to 68% of firefighters did not meet national benchmarks.

Centaur Associates
Report on the Survey of Fire Suppression Crew Size Practices, 1982

Crew size is a metric identified within this source. The information gleaned from this source is that a large percentage of non-rural fire departments are understaffed. This source states that staffing on apparatus is an issue and should be captured. The report was conducted for FEMA and looked into the existing crew sizes and response protocols for cities in the U.S. with populations greater than 100,000. In 1982, 40% of departments had engine crews and 43% had ladder crews of 3 or fewer. The remaining were 4 and 5-person crews. This document also provided the standard initial response for various occupancies (single family, multiple dwelling, high-rise, commercial/mercantile, hospital).

Clark, Bill
Is There Safety In Numbers?
Fire Engineering, No. 147, Pg. 24, 1994

This journal article identifies the staffing level of firefighting apparatus as an important measure of firefighter safety. According to one nationwide study, "Survey of Fire Suppression Crew Practices, Centaur Associates, Wash., D.C. 1982," engine and truck companies in cities with populations of 100,000 and over were staffed with an average of 3.8 people per apparatus, including officer and driver. It was also shown that increase in physical stress leads to increase in heart problems. The article also cites the 1980 Ohio State University study, which showed that firefighter injuries occurred more often when the total number of personnel on the fire ground was less than 15 at residential fires and 23 at large-risk fires.

Cohen, A.
A Multidimensional Evaluation of Fire Fighter Training for Hazardous Materials Response: First Results from the IAFF Program
American Journal of Industrial Medicine, Vol. 34, No. 4, Pg. 331, 1998

The International Association of Fire Fighters (IAFF) course on hazardous materials training was analyzed in this journal article. Metrics that fall under training were shown to be important to record as a result. In order to measure the effectiveness of the course, trainee appraisals, shifts in task competencies, improved quiz score and self reports of actions reflecting lessons learned were used. Results showed that more than 60% judged the course to be highly favorable. Qualitative judgment of the training by the participants showed that the training had a beneficial impact.

Coleman, Ronny J.

Pride Can Come from More than Run Numbers
Fire Chief, Vol. 48, No. 7, Pg. 30, 2004

The expert opinion of Ronny J. Coleman argued that metrics falling under training, fitness, prevention and staffing are critical. He identified four components of “fire company productivity”: operational readiness (personnel hours spent on physical fitness and training), community readiness (fire prevention and public education efforts), operational response (the ability to respond to calls assigned), and standby (not doing any of the first three).

Cummins, R. O.; Ornato, J. P.; Thies, W. H.; Pepe, P. E.

Improving Survival from Sudden Cardiac Arrest: The "Chain of Survival Concept"
Circulation, Vol. 83, No. 5, Pg. 1832, 1991

More people can survive sudden cardiac arrest when a particular sequence of events occurs as rapidly as possible. This sequence is:

1) recognition of early warning signs

2) activation of the emergency medical system

3) basic cardiopulmonary resuscitation

4) defibrillation

5) intubation

6) intravenous administration of medications

The descriptive device, "chain of survival," communicates this understanding in a useful way. While separate specialized programs are necessary to develop strength in each link, all of the links must be connected. Weakness in any link lessens the chance of survival and condemns the efforts of an emergency medical services (EMS) system to poor results. The chain of survival concept has evolved through several decades of research into sudden cardiac arrest. Effective system interventions have been identified that will allow survivors to remain neurologically intact. While a few urban systems may have approached the current practical limit for survivability from sudden cardiac arrest, most EMS systems, both in the United States and other countries, have defects in their chain. Poor resuscitation rates have been the rule. This statement described the research supporting each link and recommended specific actions to strengthen the chain of survival.

This document thoroughly summarized previous research. In order to record the event, it is necessary to record the call as dispatched and as found as metrics. This work quantified the effects of different levels of EMS care as provided by qualified staff. Analyzing prior research, Cummins found that average rate of survival from cardiac arrest in EMT-D-only systems was about 16%. This rate referred to witnessed victims in ventricular fibrillation. Comparatively, Cummins found that rate of survival in combined EMT-D and ALS systems was 29%. In ALS only systems, the corresponding survival rate was about 17%. The similar survival rates between EMT-D only and ALS-only systems is attributed to a difference in response time and intervention methods. EMT-D systems have small response times but lack the advanced intervention methods; on the other hand, ALS-only systems have longer response times, but include the advanced intervention methods. These statistics show that a combined system may be the most effective in improving survival rates. As it obvious that community resources may prevent the implementation of two-tiered systems, the researchers recommend that it may be beneficial to use first-responder defibrillation rather than paramedics alone.

Curka, P. A.; Pepe, P. E.; Ginger, V. F.; Sherrard, R. C.; Ivy, M. V.; Zachariah, B. S.

Emergency Medical Services Priority Dispatch

Annals of Emergency Medicine, November, Pg. 45, 1993

STUDY OBJECTIVE: To test the ability of a locally designed priority dispatch system to safely exclude the need for advanced life support (ALS). DESIGN: Retrospective review of emergency medical services (EMS) incident records to determine how often the lone dispatch of basic life support (BLS) units, staffed with basic emergency medical technicians, subsequently required or involved ALS care. SETTING: A large centralized municipal EMS system with a tiered ALS/BLS ambulance response. All BLS units carry automated defibrillators. MEASUREMENTS: Consecutive EMS records (35,075) were reviewed by computerized search for ALS procedures. Records indicating ALS procedures were tabulated and then manually reviewed for the nature of, and probable indication for, ALS intervention. INTERVENTION: Brief sequences of computer-stored questions that help dispatchers identify (or exclude) signs and symptoms indicating the need for ALS.

The dispatch triage system spared ALS units from initial dispatch in 14, 100 of the EMS incidents (40.2%), increasing their availability and use for more serious calls. Among these 14, 100 cases, only 41 patients (0.3%) later received drugs such as nitroglycerin and naloxone; another 27 patients (0.2%) received resuscitative interventions such as epinephrine or defibrillation. Furthermore, on closer analysis, the immediate presence of a paramedic might have provided a true potential for advantage in outcome for only five or six patients (less than 0.04 of the 14,100 BLS dispatches). Meanwhile, many important operational, fiscal, and cost-effective patient care benefits were realized with this system.

A computer-aided dispatch triage algorithm can facilitate improvements in both EMS system operations and pre-hospital patient care by safely and reliably identifying EMS incidents requiring only BLS.

Cushman, J.
Report to Executive Board, Minimum Staffing as Health & Safety Issue
Seattle, WA Fire Department, Seattle, WA, 1981

This analysis indicated that the rate of firefighter injuries expressed as total hours of disability per hours of fire ground exposure were 54% greater for engine companies staffed with three personnel when compared to those staffed with four personnel, while companies staffed with five personnel had an injury rate that was only one-third that associated with four-person companies

De Maio, V. J.; Stiell, I. G.; Nesbitt, L.; Wells, G. A.
Faster Advanced Life Support Response Intervals May Improve Cardiac Arrest Survival
Academic Emergency Medicine, Vol. 12, No. 5, Pg. 16, 2005

This study quantified the role of ALS response time on cardiac arrest survival. In doing so, it identified EMS care level, time and calls as dispatched and found as metrics. The study involved 17 communities of Phase III of the OPALS study and was conducted between 1998 and 2002. Using data from 3,545 cardiac arrests managed by ALS paramedics, faster response time to ALS care was found to be influential in survival rates: 6 min (5.0%), 5 min (6.4%), 4 min (8.1%), 3 min (8.2%). Also mean response for ALS and BLS were 7.7 and 5.9 minutes, respectively; ALS units arrived first in 32% of cardiac arrests. Advanced intervention methods were not studied and it was observed that the results were similar to those of BLS studies regarding time to intervention.

Eisenberg, M. S.; et al
Predicting Survival from Out-of-Hospital Cardiac Arrest: A Graphic Model
Annals of Emergency Medicine, Vol. 22, No. 11, Pg. 1652, 1993

The purpose of this work was to create a graphical model that described survival from out-of-hospital cardiac arrest as a function of time intervals to critical pre-hospital interventions. The metrics identified were level of care, time, and prior medical interventions. This study used data from a cardiac arrest surveillance system in King County, Washington that had been in place since 1976. From this, 1,667 cardiac arrest patients were selected that had a high likelihood of survival. For each of these patients, time intervals from collapse to CPR were collected. The result of this work was a multiple linear regression model. The study found that survival rate = 67% - 2.3% per minute to CPR - 1.1% per minute to defibrillation - 2.1% per minute to ALCS; this was significant to $P < 0.001$. Assuming that no treatment is given, the survival rate declines 5.5% per minute. This model coincided with published reports of EMS systems.

Eisenberg, M. S.; Horwood, B. T.; Cummins, R. O.; Reynolds-Haertle, R.; Hearne, T. R.

Cardiac Arrest and Resuscitation: A Tale of 29 Cities

Annals of Emergency Medicine, Vol. 19, No. 2, Pg. 179, 1990

This study highlighted the importance of including level of EMS care and dispatching protocols as metrics. The study reviewed previously published studies from 1967 to 1988 on 39 emergency medical services programs from 29 different locations. These programs were broken up into five groups for purposes of this study: EMT, EMT-D, paramedic, EMT & paramedic, and EMT-D & paramedic. There were three single responses and two double responses. For the reviewed studies, discharge rates varied from 2%-25% for all cardiac rhythms and 3%-33% for ventricular fibrillation. Survival was higher for the double response than single response. It was predicted that earlier CPR initiation is a primary method to this higher success rate.

Fahy, R. F.; LeBlanc, P. R.; Molis, Joseph L.

Firefighter Fatalities in the United States - 2007

National Fire Protection Association, Quincy, MA, 2007

In 2007, there were a total of 102 on-duty firefighter deaths in the U.S. This is a slight increase over the 87 firefighter fatalities that occurred in 2005. It was the second consecutive year, and the fifth out of the last 10 years, that the total number of deaths has been below 100. The largest share of deaths (38 deaths) occurred on the fire ground. Stress, exertion, and other medical-related issues, which usually result in heart attacks or other sudden cardiac events, continued to be the leading cause of fatal injury. Of the 38 stress-related fatalities in 2006, 34 (38%) were classified as sudden cardiac deaths. The second leading cause was coming into contact with or being struck by an object. The report mentions that although the number of sudden cardiac arrests (SCAs) has decreased from 70 in 1977 to 38 in 2007, this number still makes up approximately 40% of firefighter deaths. Also mentioned in the report are the importance of NFPA 1500, 1582 and 1583. These are all documents that stress the importance of medical screening and firefighter fitness programs. This report demonstrated the importance of metrics that describe first responder outcomes as well as scene type where the injury occurred and whether the department had any fitness/wellness programs.

Fahy, Rita F.
U.S. Firefighter Deaths Related to Training, 1996-2005
National Fire Protection Association, Quincy, MA, 2006

Training is a vital part of fire department operations, but it too often results in deaths and injuries. Between 1996 and 2005, 100 firefighters in the U.S. died while engaged in training related activities (ten percent of all on-duty firefighter deaths). The deaths occurred during a broad range of activities, including apparatus and equipment drills; physical fitness; live fire training; underwater/dive training; and while attending classes or seminars.

This report reflected the importance of wellness programs and, most importantly, the report showed that training is not a risk-free component of firefighting. Although, the number of fire-scene deaths has decreased over the years, training deaths stayed more or less constant. Of the 100 deaths during the ten year period, 53 were the result of sudden cardiac arrest. All but nine had medical records available, all of which showed previous heart conditions.

Fahy, Rita F.
U.S. Firefighter Fatalities Due to Sudden Cardiac Death, 1995-2004
National Fire Protection Association, Quincy, MA, 2005

This report summarized deaths due to cardiac arrest in the ten year period from 1995-2004. It looked into various characteristics of the firefighters such as age, prior medical history and type of duty performed prior to arrest. Over the study period, there were 440 deaths from cardiac arrest, making up 43.7 of total firefighter fatalities during the study. It also pointed out that over 50% of deaths during training were due to cardiac arrest. In the conclusion, it recommended that fitness programs be instituted, stating that 73% of career and 88% of volunteer fire departments polled in 2001 did not have such programs.

Fahy, Rita F.; LeBlanc, Paul R.
Firefighter Fatalities in the United States - 2005
National Fire Protection Association, Quincy, MA, 2006

In 2005, a total of 87 on-duty firefighter deaths occurred in the United States. Responding and returning from alarms accounted for the largest shares of firefighter deaths, with 26 deaths. Fire ground operations accounted for 25 deaths. This continued the trend that deaths on the fire ground account for less than one third of the deaths each year. Stress and overexertion, which usually precedes heart attacks or other sudden cardiac events, continued to be the leading cause of fatal injury. Of the 47 stress-related deaths in 2005, 40 (46%) were classified as sudden cardiac deaths.

The authors cited the NFPA 1582 and the Fire Service Joint Labor Management Wellness-Fitness Initiative and their importance in preventing these types of outcomes. This report shows the importance of capturing responder outcomes and establishment of wellness and fitness programs.

Fratus, J. M.
High-Reliability Organization Theory and the San Bernadino City CA Fire Department
San Bernardino City CA Fire Department, San Bernardino City, CA, 2006

The San Bernardino City Fire Department (SBFD) was experiencing errors and near-miss incidents at a troubling rate. Research showed that certain organizations, called High Reliability Organizations (HROs), consistently maintain low error rates in operations similar to those undertaken by the SBFD. The purpose of this research was to identify the characteristics of HROs, determine SBFD's strengths and weaknesses in these characteristics, and identify how the SBFD could develop as a HRO. Descriptive methods were used to analyze each of these elements. A questionnaire was given to SBFD members to assess HRO factors in the department. The research found that the SBFD had moderate to strong HRO tendencies. Recommendations were made to enhance HRO characteristics in the SBFD.

The goal of this research was to reduce the number of errors and near-miss incidents in the SBFD in order to make their operations as safe and reliable as possible. The researchers analyzed the operations of the SBFD and determined that to best improve them, SBFD should adapt behaviors from HRO (high reliability organizations). Recommendation #7 stated that the SBFD should defer decisions to the most experienced and knowledgeable individual at hand. This implied that the chain of command be used. This recommendation justified the importance of capturing qualifications and staffing sent to fire calls. Recommendation #10 is directly related to pre-incident planning. The angle of the argument is well beyond whether or not pre-incident planning should or should not be carried out.

Gerard, John C.; Jacobsen, A. Terry

Reduced Staffing: At What Cost?
Fire Service Today, Pg. 15, 1981

This report identified the fire company as the fire department's basic working unit. T he paper called for accurate performance measurements to determine effectiveness and ultimately to better utilize staffing and equipment.

Live experiments were performed in a one-family residential home with modern apparatus and equipment. The results were provided in a graphical figure labeled Loss Probability as a Function of Knockdown Time (21). Results showed that larger units performed tasks more quickly, and thus lowered the percentage of loss associated with the fire house.

International Association of Fire Chiefs

A National Mutual Aid System for the Fire Service: A Strategic Plan
International Association of Fire Chiefs, Fairfax, VA, 2006

This document demonstrated the need for data collection regarding mutual aid programs. The escalation of an event requiring mutual aid is described, starting at the local level, progressing to the state and finishing with a national level response. The purpose of the project related to this document was to make recommendations for a national level mutual aid system.

International Association of Fire Fighters / Johns Hopkins University

Analysis of Fire Fighter Injuries and Minimum Staffing Per Piece of Apparatus in Cities With Populations of 150,000 or More

International Association of Fire Fighters, Washington, DC, 1991

This study provided a comprehensive analysis of firefighter injuries and minimum staffing levels in a number of cities. The study found that 69% of jurisdictions that maintained crew sizes of fewer than four firefighters had firefighter injury rates of 10 or more per 100 firefighters, while only 38.3% of jurisdictions maintaining crew sizes of four or more firefighters had comparable injury rates. In other words, jurisdictions having crew sizes of fewer than four firefighters suffered a benchmark injury rate at nearly twice the percentage rate of jurisdictions that maintained crew sizes of four or more firefighters.

International Association of Fire Fighters; International Association of Fire Chiefs

The Fire Service Joint Labor Management Wellness/Fitness Initiative
International Association of Fire Fighters, Washington, D.C., 1997

The formation of the Fire Service Joint Labor Management Wellness/Fitness Initiative resulted in the realization that it is necessary to perform physical ability tests for firefighting candidates to establish a baseline performance. "The Task Force successfully developed the Fire Service Joint Labor-Management Wellness-Fitness Initiative in 1997 to address the need for a holistic and non-punitive approach to wellness and fitness in the fire service. The Task Force then discovered that municipalities were hiring people who would not be physically capable of a successful career in the fire service." The IAFF/IAFC developed the Candidate Physical Ability Test (CPAT) in 1999.

Kales, S. N.; Soteriades, E. S.; Christophi, C. A.; Christiani, D. C.

Emergency Duties and Deaths from Heart Disease among Firefighters in the United States
The New England Journal of Medicine, Vol. 356, No. 12, Pg. 1207, 2007

The value of this article is that it identified and quantified the risk of cardiac arrest associated with various firefighting activities. The research reviewed summaries from FEMA for all on-duty deaths of firefighters between 1994 and 2004; deaths during September 11, 2001 were excluded. Results provided statistics for how often various on-duty activities were responsible for deaths. The risk breakdown provided showed that these deaths correspond to stress related activities. One statistic of interest was the risk associated with training. The breakdown: "suppressing a fire (32.1% of all such deaths), responding to an alarm (13.4%), returning from an alarm (17.4%), engaging in physical training (12.5%), responding to non-fire emergencies (9.4%), and performing nonemergency duties (15.4%)."

Kales, S. N.; Soteriades, E. S.; Christoudias, S. G.; Christiani, D. C.

Firefighters and On-Duty Deaths from Coronary Heart Disease: A Case Control Study
Environmental Health: A Global Access Science Source, Vol. 2, No. 14, 2003

Coronary heart disease (CHD) is responsible for 45% of on-duty deaths among United States firefighters. This study sought to identify occupational and personal risk factors associated with on-duty CHD death. A case-control study was performed, selecting 52 male firefighters whose CHD deaths were investigated by the National Institute for Occupational Safety and Health. Two control populations were used: 51 male firefighters who died of on-duty trauma; and 310 male firefighters examined in 1996/1997, whose vital status and continued professional activity were re-documented in 1998. The circadian pattern of CHD deaths was associated with emergency response calls: 77% of CHD deaths and 61% of emergency dispatches occurred between noon and midnight. Compared to non-emergency duties, fire suppression (OR (Odds Ratio)= 64.1); training (OR= 7.6) and alarm response (OR = 5.6) carried significantly higher relative risks of CHD death. Compared to the active firefighters, the CHD victims had a significantly higher prevalence of cardiovascular risk factors in multivariate regression models: age 45 years (OR 6.5), current smoking (OR 7.0), hypertension (OR 4.7), and a prior diagnosis of arterial-occlusive disease (OR 15.6). Findings strongly support that most on-duty CHD fatalities are work precipitated and occur in firefighters with underlying CHD. Improved fitness promotion, medical screening and medical management could prevent many of these premature deaths.

Karter Jr., Michael
A Needs Assessment of the Fire Service: Massachusetts
National Fire Protection Association, Quincy, MA, 2004

This report quantifies several response capacity related metrics. Identified are: staffing, training (fire and EMS), fitness/wellness and mutual aid. The report gives a detailed analysis of the capabilities of fire departments in MA: 34% of departments deliver four or fewer firefighters to a mid-day house fire (towns with pop <2500), 20-89% of towns with greater than 10k population deliver less than four firefighters (depending on population interval), estimated 19% of firefighters involved with suppression lack formal training, 14% delivering EMS care lack training and 89% of firefighters served in a department with no fitness/wellness programs. Additionally, the report gives statistics regarding the approximate percentages of departments that have written mutual aid agreements for various types of incidents.

Kass, L. E.; Eitel, D. R.; Sabulsky, N. K.; Ogden, C. S.; Hess, D. R.; Peters, K. L.
One-Year Survival after Prehospital Cardiac Arrest: The Ustein Style Applied to Rural-Suburban Systems
American Journal of Emergency Medicine, Vol. 12, No. 1, Pg. 17, 1994

To evaluate the recently published Utstein algorithm (Ann Emerg Med 1991;20:861), the authors conducted a retrospective review of all advanced life support (ALS) trip sheets and hospital records of patients with pre-hospital cardiac arrests between January 1988 and December 1989. Telephone follow-up was used to determine one-year survival rates. Of 713 arrests in the 24-month study period, 601 were of presumed cardiac etiology. Approximately 599 of these charts were available for analysis. One hundred ninety-three (32.2%) of these had return of spontaneous circulation (ROSC), 36 (6.0%) survived to hospital discharge, and 24 were alive at one-year follow-up (4.0% of total or 67% of survivors to discharge). The Utstein style was found to be a useful algorithmic format for reporting prehospital cardiac arrest data in a manner that should allow direct comparison between emergency medical service (EMS) systems. Existing prehospital record-keeping practices (trip sheets) are easily adapted to this style of data collection, although certain data for the template (e.g., resuscitations not attempted and alive at one-year) are more difficult to ascertain. Additionally, the authors report their own experience during a two-year period, including data that suggest that the majority of patients with cardiac arrest who survive to hospital discharge are still alive at one year.

Kellermann, A. L.; Hackman, B. B.; Somes, G.; Kreth, T. K.; Nail, L.; Dobyns, P.

Impact of First Responder Defibrillation in an Urban EMS System
Annals of Emergency Medicine, Vol. 21, No. 14, Pg. 1708, 1992

This goal of this study conducted in 1992 was to determine the effectiveness of automatic external defibrillators (AED). The methodology used incorporated forty engines from the Memphis Fire Department. For the first 75 days, half of the companies used the AEDs and the other half performed CPR. After the 75 days, the roles were reversed. Finally, all patients who were successfully resuscitated were followed to the hospital discharge. During the study time period, 431 patients (49%) were found in ventricular fibrillation.

This source identified several metrics: apparatus staffing, response time intervals, bystander CPR and AED intervention. Bystander CPR was only found in 12% of cases. Firefighters arrived to the scene a mean of 2.5 minutes faster than dispatched paramedics. In this fast-response urban system, patients treated by an AED were not more likely to be resuscitated (32% versus 34%), survive to hospital admission (31% versus 29%) or survive to hospital discharge (14% versus 10%) than CPR controls. It was concluded that AEDs cannot increase the likelihood of survival enough to account for lack of bystander CPR.

Klaene,B. J.;Sanders,R. E.
Structural Fire Fighting
Jones and Bartlett Publishers, Sudbury, Massachusetts, 2000

This text focused on fire fighting in structures. Relevant to response capacity is the discussion of the importance of pre-incident planning. The authors believe that it is an asset to any fire department. I t is agreed that pre-incident planning is essential to the incident commander when making strategic and tactical decisions at the scene. It is mentioned that pre-incident plans effectively remove an initial step at the fireground during the first few important minutes.

Klaene, B. J.; Sanders, R. E.
Expert Advisors Provide Strategic Support
NFPA Journal, November/December 2002

In this journal article, Klaene and Sanders both gave their opinion on why training and pre-incident planning are very important to the fire service. The article mentioned that although firefighter on-duty deaths have decreased since the late 1970s, the probability of a firefighter death at a single fire has not decreased much. The authors believed that more frequent and realistic training along with better education would provide one means to lower firefighter death rates. Also, the authors state the importance of pre-incident planning. The need for pre-incident planning at industrial facilities due to specific and high-hazard scenarios is also mentioned. NFPA statistics between 1996 and 2000 showed that industrial facility fires resulted in 6 firefighter deaths per 100,000 structure fires as opposed to 3.7 firefighter deaths per 100,000 residential fires.

Leroy, Tonya; Rozenek, Ralph; Wann, Terri; Schroeder, Jan
Prevalence and Trends in Coronary Artery Disease Risk Factors in Southern California Fire Fighters
Medicine & Science in Sports & Exercise, Vol. 36, No. 5, 2004
This article provided insight to the importance of fitness/wellness programs by showing the prevalence of coronary artery disease (CAD) in firefighters. Over 10 years, the program recorded several heart health related metrics in order to track the cardiac conditions of 96 firefighters. They concluded that firefighters have a similar risk of developing CAD, but because of the demands of their job, should take steps to reduce the risk of cardiac arrest. In other words, they are as likely as anybody else to encounter heart disease, but more likely to encounter cardiac arrest due to the stress put on them at work.

McManis Associates; John T. O'Hagan and Associates
Dallas Fire Department Staffing Level Study
McManis Associates, Washington, DC, 1984

This 1984 study sought to determine the effect of the number of firefighters on task performance. Three different simulations were used: apartment house fire, high-rise office fire, and private residential fire. Each of the simulations was run ninety-one times to provide accurate results. Results showed that increased staffing levels improved results. The 5-person crews showed a very coordinated and effective attack and the 4-person crew was capable of performing satisfactorily. The 3-person crews were not able to complete all tasks during the given time span.

Moore-Merrell, Lori Lynn; McDonald, Sue; Zhou, Ainong; Fisher, Elise; Moore, Jonathan
Contributing Factors to Firefighter Line-of-Duty Death in the United States
TBD, 2006

The objective of this study was to analyze retrospective data from the years 2000-2005 (six years) to identify and quantify the major factors that contribute to firefighter line-of-duty deaths (LODD) in the United States. The identified contributing factors were examined for frequency of occurrence and clustering with other factors. Results were to be used to develop risk management programs for fire departments. A retrospective study was conducted using data compiled from six years of verified firefighter LODD from four reputable industry sources. Sources include the National Fire Protection Association (NFPA), the National Institute for Occupational Safety and Health (NIOSH), the United States Fire Administration (USFA) and the International Association of Fire Fighters (IAFF). For each LODD, factors contributing to the death were recorded from federal investigations and eyewitness reports. The contributing factors were then analyzed for frequency of occurrence and clustering with other factors. Factors mentioned in less than 5% of the LODD cases were excluded from the cluster analysis. Factors and clusters were stratified according to department type, age of firefighter, scene type, population density of the jurisdiction (proxy for department size) and census region. Results: There were 644 cases with sufficient information to be included in the study. Frequency analysis revealed that the dominant contributing factors to LODD are health/fitness/wellness (54%), personal protective equipment (19%) and human error (19%). Cluster analysis was performed revealing contributing factors frequently occurring together.

Four main clusters were identified with these contributing factors:

1. Incident command, training, communications, SOP, and pre-incident planning
2. Vehicles, personal protective equipment, equipment failure, and human error
3. Private owned vehicle accidents, and civilian error
4. Company staffing, operating guidelines, and health/fitness/wellness

Cluster 4 alone (regardless of other clusters) was shown to be responsible for more than 44.72% of all firefighter on duty deaths during the years studied. Cluster 4, in conjunction with other clusters, was shown to be responsible for an additional 16% of all firefighter line-of-duty deaths during the years studied.

Ninety-seven and one half percent of all firefighter LODD occurring between the years of 2000-2005 were attributable to an identifiable cluster of contributing factors. Approximately half of all firefighter LODD that occurred between these years were attributable to a cluster of three factors that were under the direct control of the individual firefighter and chief officers. This study implied a considerable burden on decision makers and fire service leaders, as well as firefighters themselves, by offering substantial guidance for shaping local fire department policy decisions and operational priorities.

Morrison, R. C.
Manning Levels for Engine and Ladder Companies in Small Fire Departments
National Fire Academy, Emmitsburg, MD, 1990

Using standard fire fighting tactics, the results of the Westerville Fire Department report showed that four firefighters could perform rescue of potential victims 80% faster than a three firefighter crew.

National Institute for Occupational Health and Safety
Preventing Fire Fighter Fatalities Due to Heart Attacks and Other Sudden Cardiovascular Events
Department of Health and Human Services, Washington, D.C., 2007

This report cited the need for fire departments to incorporate fitness and wellness training in their operations. From 1998 to 2004, the National Institute for Occupational Safety and Health (NIOSH) investigated 131 (43%) of the 304 firefighter sudden cardiac death fatalities. Fifty-one (39%) of the 131 fire departments where a sudden cardiac death fatality occurred had voluntary fitness programs. However, only 11 (8%)

departments had mandatory programs. This report recommended that comprehensive fitness/wellness programs be established with a concentration on cardiovascular health.

Office of the Deputy Prime Minister

Operational Physiological Capabilities of Firefighters: Literature Review and Research Recommendations
Queen's Printer and Controller of Her Majesty's Stationery Office, Kew, Richmond, Surrey, UK, 2004
Fire Research Technical Report 1/2005

The purpose of this paper was to review the published literature on the physiological capability of firefighters and to provide insight on where future research should be focused. It is helpful because it identified the importance of gathering data about firefighter training and fitness. The future areas of research identified also help to justify possible uses of the data collected by the community risk model. This report had the following outcomes in mind: reduce risk; improve guidance for practices and training; improve risk assessment; modify procedures for building design; and elicit improvements to the building regulations. The study identified the following research needs: quantify physiological requirements and limiting factors to performance; establish fitness norms; quantify the extent to which Personal Protective Equipment (PPE) limits firefighters; quantify thermal environments (in actual environments as opposed to training); determine the effectiveness of physical training; establish thermal tolerance limits; develop a thermal intolerance test, etc.

Office of the Fire Marshall of Ontario

Fire Ground Staffing and Delivery Systems within a Comprehensive Fire Safety Effectiveness Model
Ministry of the Solicitor General, Toronto, Ontario, Canada, 1993

The Fire Marshal of Ontario completed a study in 1992 to examine the tasks which 3- and 4- person crews could safely accomplish. This study is a sub-section of a larger "Comprehensive Fire Safety Effectiveness Model." The purpose of this sub-section was to determine how staffing levels affect certain fire ground tasks. It was determined that until additional assistance has arrived, the following cannot be accomplished safely by 3-person crews:

-Deployment of back-up protection lines.
-Conducting interior suppression or rescue operations

-Ventilation operations requiring access to the roof of the involved structure.
-The use of large hand-held hose lines.
-The establishment of a water supply from a static source within the time limits

The study found that 3-person crews were overworked due to an inability to take sufficient breaks; therefore, they were more at-risk for exhaustion. The study also recommended minimum staffing required for suppression and rescue related tasks.

Orange County Fire Authority
Orange County Fire Authority Firefighter Wellness and Fitness Program Report
Orange County Fire Department, Orange County, CA, 2006

This document described the fitness program undertaken by the Orange County Fire Authority. The outcome of this report reflected the benefits predicted by other studies that recommend the establishment of fitness/wellness programs. Results after the first two years showed successes. About 90% of firefighters in the department participated in the program. Some of the outcomes included improved firefighter fitness and health, enhanced quality of service to the community and cost savings. Examples are given only qualitatively but include: lower body fat percentage, increased aerobic capacity, lower worker's compensation costs despite higher payrolls and lower hours of work missed due to injury.

Phoenix Fire Department
Fire Department Evaluation System - Benchmark Structure Fire (FIREDAP)
Phoenix Fire Department, Phoenix, AZ, 1992

This Phoenix Fire Department report goes through the protocol on responding to structure fires. This report looked at the staffing, objectives, task breakdowns, and times for evaluations for structure fires. The responsibilities of the responding fire department members are also outlined in the order that they should be accomplished. Although there were discrepancies between department protocols, this report gave a solid basis from which to evaluate 'typical' actions in a structure fire. For full-scale simulation of firefighter activities this resource is a very effective starting point from which to construct experimental focuses.

Roberts, B.
Austin Fire Department Staffing Study
Austin Fire Department, Austin, TX, 1993

In 1993, the Austin Fire Department conducted a study to determine whether companies staffed with four firefighters were safer and more effective than the three-person companies. In order to compare the effectiveness of fire companies, the physiological impact on firefighters and injury rates at various staffing levels, Austin Fire Department conducted drills consisting of a series of common fireground tasks. These simulations revealed that regardless of the experience, preparation or the training of firefighters, loss of life and property increases when a sufficient number of personnel are not available to conduct the required tasks efficiently. The Austin Fire Department concluded that firefighter effectiveness significantly improves when a company is increased from three to four personnel. In the two-story residential fire, the efficiency or time improvement between the three-person and four-person crew was 73%. In the aerial ladder evolution, the efficiency improvement between three-person and four-person crews was 66%. In the high-rise fire, the efficiency improvement between the three-person and four-person engine company crew was 35%. In addition to the fireground simulations, the Austin Fire Department also reviewed injury reports involving 136 emergency incidents from 1989 to 1992 to which 1,938 firefighters responded. The analysis revealed that the injury rate for four or five-person crews was 5.3 per 100 firefighters while the three-person companies experienced an injury rate of 7.77 injuries per 100 firefighters. The injury rate for three-person companies was 46% higher than the rate for larger crews.

Roberts, M. A.; O'Dea, J.; Boyce A.; Mannix E.T.

Fitness Levels of Firefighter Recruits Before and After a Supervised Training Program

Journal of Strength and Conditioning Research, Vol. 16, No. 2, Pg. 271, 2002

This 2002 study observed respiratory activity of firefighter recruits before and after a 16-week training program. Prior to the program, the authors determined that aerobic capacity was 20% below minimum standards for suppression duties. Results showed that the program improved aerobic capacity by 28% as well as decreasing fat and increasing lean muscle. The researchers hoped that the results of this study would encourage those overseeing firefighters to take the initiative and mandate physical ability assessment of new hires and mandate participation in fitness programs for those that do not meet standards.

Stiell, I. G.; Wells, G. A.; Spaite, D. W.; et al

OPALS Study Phase III: What is the Impact of Advanced Life Support on Out-of-Hospital Cardiac Arrest?

Academic Emergency Medicine, Vol. 10, No. 5, Pg. 423, 2003

This study compared a community's cardiac arrest victims during 12 months of BLS-D rapid defibrillation and 36 months of ALS. This process was conducted in 17 communities. The primary outcome was survival to hospital discharge. The results showed that the difference in survival rates between BLS-D and ALS did not change (5.0% vs. 5.1%). This study showed that ALS measures did not improve patient survival, compared to a previously optimized rapid defibrillation BLS system.

Tennessee Municipal League

Mandatory Fire Training

Tennessee Municipal League, Nashville, Tennessee, 2006

Using a 2006 survey conducted by the Tennessee State Fire Marshal, this study indicated that only about 21% (7,073) of the 34,000 firefighters in the state are required by law to complete a minimum level of training. This number represents only career firefighters. There is no such requirement for the approximately 79% of part-time and volunteers. The Tennessee Firefighter Commission’s records showed that approximately 4,000 of the 26,900 part time and volunteers had any formal training whatsoever. The author states that “many have suggested there is a direct correlation between the death rate from fire and the fact that a very large percentage of Tennessee firefighters are either untrained or under-trained.” This lack of training may explain that Tennessee had the second highest death rate in the U.S. due to fire in 2005.

TriData Corporation

The Economic Consequences of Firefighter Injuries and Their Prevention. Final Report

National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, 2005

This report investigated the cost of firefighter injuries annually. The costs involved included workers compensation, long-term medical care, lost productivity, administrative costs of insurance, etc. It was determined that these costs amount to between $2.8 and $7.8 billion annually. The term firefighter in this report is all-encompassing for this study: career, volunteer, combination departments, special operations, paramedics, training officers, etc. Data collected for this work was obtained from NFIRS.

The report concluded that "more fire departments need to take physical fitness seriously and adopt a formal program that monitors progress against goals and goals met against number and severity of injuries.” Further, "a scientific study on the relationship between the number of firefighters per engine and the incidence of injuries would resolve a long-standing question concerning staffing and safety." This paper addressed the inquiry whether it is the commonly occurring, yet minor, injuries (sprains, strains, falls, slips, back problems, etc.) or the less frequent, but severe, injuries (burns, major falls, etc) that cost more on an annual basis.

U.S. Fire Administration
Four Years Later - A Second Needs Assessment of the U.S. Fire Service
National Fire Protection Association, Quincy, MA, 2007

This extensive document on the needs of the fire service was created through surveys mailed to 15,545 departments. The response rate was about 30% which was deemed sufficient for reliable results. This document is nearly identical to the needs assessment document that specifically addressed Massachusetts. The relevant topics covered in this report include personnel and their capabilities, fire prevention and code enforcement, facilities, apparatus and equipment, and mutual aid for different call types. This report contained numerous pieces of information useful for understanding a resource allocation.

Varone, J. C.
Providence Fire Department Staffing Study
National Fire Academy, Emmitsburg, MD, 1994

The Providence Fire Department Staffing Study, conducted from 1990-1991, determined that the costs of adding a fourth person to three-person companies was offset by lower injury costs. The department's Injury/Exposure Database was queried to determine pertinent injury information. The study data showed that four-person staffing led to a 23.8 percent reduction in injuries, a 25 percent reduction in time lost injuries and a 71 percent decrease in time lost due to injury when compared to three-person staffing. These results led to the conclusion that four-person staffing substantially reduced the number and the severity of injuries compared with three-person staffing. The recommendations were that the Providence Fire Department continue working toward staffing all companies with four persons. Additional research was recommended to analyze injuries in the years subsequent to the study to determine if the trend continued; attempt to validate the results of the Providence study; identify factors causing injuries in three-person versus four person companies; and help resolve labor disputes pertaining to staffing in other departments.

FIRE FIGHTER SAFETY AND DEPLOYMENT STUDY

Williford, H. N.; Duey, W. J.; Olson, M. S.; Howard, R.; Wang, N.
Relationship Between Fire Fighting Suppression Tasks and Physical Fitness
Ergonomics, Vol. 42, No. 9, Pg. 1179, 1999

This study sought to determine the most accurate predictors of physical performance in fire suppression activities by testing 91 firefighters. Firefighters performed many different activities during a physical performance assessment (stair climb, hoist, forcible entry, hose advance, etc). Multiple regression analysis results showed that the 1.5 mile run and pull-ups were the best predictors of performance for the aforementioned fire suppression activities. The researchers concluded that physical fitness is an important component in the performance of firefighting suppression activities.

Ahrens, M.

U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment
National Fire Protection Association, Quincy, MA, 2007

This document is the seminal report on smoke detectors and other alarm equipment in the United Stated. The study demonstrated the importance of equipping homes with functional smoke detectors. Almost all households in the U.S. have at least one smoke alarm, yet in 2000-2004, no smoke alarms were present or none operated in almost half (46%) of the reported home fires. (Homes include one- and two-family dwellings, apartments, and manufactured housing.) During the same period, 43% of all home fire deaths resulted from fires in homes with no smoke alarms, while 22% resulted from homes in which smoke alarms were present but did not operate. The death rate per 100 reported fires was twice as high in homes without a working smoke alarm as it was in home fires with this protection. If all homes had working smoke alarms, an estimated 890 lives could be saved annually, or just under one-third of the annual fire death toll. Fatalities resulting from home fires with working smoke alarms were more likely to have been in the area of origin, to instances where people have tried to fight the fire themselves, or to occupants who have been at least 65 years old. Two-thirds of the smoke alarms in reported non-confined home fires were powered solely by batteries. The rest split evenly between hardwired only and hardwired with battery backup. More than half (54%) of the smoke alarm failures were due to missing or disconnected batteries; 19% were due to dead batteries. Nuisance alarms were the leading cause of disabled alarms. Hardwired devices accounted for 29% of the smoke alarms in non-confined fires but problems with the hardwired power source caused only 7% of the smoke alarm failures. These estimates are based on data from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual fire department experience survey.

Bahr, J.; Klinger, H.; Panzer, W.; Rode, H.; Kettler, D.

Skills of Lay People in Checking the Carotid Pulse
Resuscitation, Vol. 35, No. 1, Pg. 23, 1997

This study was undertaken to contribute to the discussion on the ability of health professionals to check the carotid pulse. Checking the carotid pulse is a requirement, according to the American Heart Association (AHA) and the European Resuscitation Council, to determine whether CPR should be performed. 449 volunteers were used to check the pulse of a young, healthy person. T he majority of these volunteers had just undergone a CPR course. The results of this work showed that only 48% of volunteers were able to detect a pulse within 5 seconds and 74% within 10 seconds. The AHA recommends that the carotid pulse should be able to be obtained within 5 - 10 seconds. This study showed that the intervals established for carotid pulse check may be too short and that the value of pulse check within the scope of CPR may need to be reconsidered.

Bertrand, A. L.; McKenzie, L. S.
The Human Factor in High Risk Urban Areas: A Pilot Study in New Orleans, Louisiana, U.S.
U.S. Department of Commerce, Washington, DC, 1976

The goal of the study was to determine the socio-economic, socio-cultural, and socio-demographic variables related to fire occurrence in a high risk urban residential location. The value of this reference is that it identifies characteristics that are typically the targets of fire prevention/safety programs. As a result the need for prevention programs is justified. While this does not show any directional effects of prevention efforts, it does strengthen the case for including prevention related metrics in the model so we are able to measure their value. The fires in the study area were determined to be similar to those in other high fire risk cities. Many children in the area considered fire as a "play" method, a habit not deterred by adult intervention. The following were found to be sub cultural characteristics that lead to the high fire rate: lack of community spirit, lack of fire safety training, lack of practiced fire precautions, lack of fire fighting facilities, and an attitude of fatalism toward fire. This study supports the theory that poor, urban areas are at a higher risk of fire loss, injuries, and deaths; the socioeconomics of a community play a role in the determination of the risk.

Brennan, R. T.; Braslow, A.
Skill Mastery in Public Cardiopulmonary Resuscitation Classes
American Journal of Emergency Medicine, Vol. 16, No. 7, Pg. 653, 1998

It has been argued that CPR training should be targeted at those people most likely to be on the scene when a cardiac arrest occurs. This study looked at the effectiveness of CPR on a manikin directly following public CPR classes provided by the American Red Cross or American Heart Association. Beyond indentifying the need and benefit of public health prevention programs, this source identified the need for the improvement. Almost half of the 226 subjects made four errors or more during the evaluation. The trained observers found almost 52% of the subjects "not competent." Furthermore, they found that only about 3% of the subjects were able to effectively perform all skills "very well with no errors." This was not reflected in individuals' assessment of their performance as 56% deemed themselves "very confident" and the remainder deemed themselves "somewhat confident." CPR training does not reach the right people and more research needs to be done to determine how to better reach them.

Bukowski, R. W.; Peacock, R. D.; Averill, J. D.; Cleary, T. G.; Bryner, N. P.; Walton, W. D.; Reneke, P. A.; Kuligowski, E. D.

Performance of Home Smoke Alarms: Analysis of the Response of Several Available Technologies in Residential Fire Settings
National Institute of Standards and Technology, Gaithersburg, MD, 2003

This report presented the response of a range of residential smoke alarm technologies in a controlled laboratory test and in a series of real-scale tests conducted in two different residential structures. The data included measurement of temperature and smoke obscuration in addition to gas concentrations for a range of fire scenarios and residences. Smoke alarms of either the ionization type or the photoelectric type consistently provide time for occupants to escape from most residential fires. Consistent with prior findings, ionization type alarms provided somewhat better response to flaming fires than photoelectric alarms, and photoelectric alarms generally provided earlier response to smoldering fires than ionization type alarms. Available escape times in this study were shorter than those found in a similar study conducted in the 1970's. The authors theorized that this was due to a combination of faster fire development times for today's home furnishings (which provided the main fuel sources), as well as use of different criteria for time to untenable conditions.

Center for Disease Control and Prevention

Fire Deaths and Injuries: Fact Sheet
Department of Health and Human Services, Washington, D.C., 2008

This document pulls together a number of different facts from recent reports addressing demographic risk factors and outcomes associated with residential fires. The facts are organized by 1) Occurrence and Consequences, 2) Costs, 3) Groups at Risk and 4) Risk Factors. The majority of these facts are gathered from NFPA and CDC reports but other sources include medical journal articles. A major observation offered is that although the number of annual fire deaths has steadily decreased from previous decades, many of the fire deaths occurring today are preventable and continue to pose a public health problem. To put this in perspective, it is mentioned that the U.S. mortality rate from fires ranks sixth out of twenty five for developed nations for which statistics are available.

Coleman, Ronny J.

Managing Fire Services, Second Edition

International City/County Management Association, Washington, DC, 1988

This literature provided a comparison of different staffing levels and task outcomes. As firefighting tactics were conducted for comparative purposes, five-person fire suppression companies were judged to be 100 percent effective in their task performance, four-person companies 65 percent effective, and three-person companies 38 percent effective; six person companies are judged 20 percent faster than four person companies. Data gathering examples for evaluation of the fire service are given in chapter 5. A significant number of metrics are given on pages 107-111. Notables include dollar property loss per building fire; response time; fire-related deaths and injuries; work load; EMS staffing and training; and presence of prevention programs. Also provided is a walkthrough on how an analysis of changing staffing levels can effect response times and other factors. Finally, Chapter 14, "Emergency Medical and Rescue Services," provided background information on integration of EMS and special operations.

Demby, K.; Mathis, J.

Annual Report: January 1, 2007 - December 31, 2007

University of North Carolina Injury and Prevention Research Center, Chapel Hill, NC, 2007

This annual report by the Injury and Prevention Research Center is excellent for justifying the capture of prevention metrics that are related to injury. In the beginning of the report is a detailed description of the "injury problem" affecting all people, worldwide. Many different statistics are given that illustrate the severity of this problem. This document forms a good basis for justification of prevention programs. It identified the types of injuries that programs should be developed for. According to this report, these injuries have common risk factors and "protective factors" that may identify effective interventions to reduce the risk of injuries. The report calls on policy makers, scientists, stakeholders and other professionals to collaborate to implement intervening actions that reduce injuries. The report described the need for prevention programs and encouraged further research.

Gamache, S.; Porth, D.
The Development of an Education Program Effective in Reducing the Fire Deaths of Preschool Children
Second International Symposium on Human Behaviour in Fire
Interscience Publications, Boston, MA

This study focused on the implementation methods and success of the NFPA's Learn Not to Burn program in Portland, Oregon. Unlike previous analysis of the success of prevention programs, this study did not focus solely on pre- and post-tests. Rather, the number of total fires and youth caused fires were recorded for the years of 1990-2000. In the years following the implementation of the LNTB program, youth caused fires decreased steadily. Furthermore, the statistics showed that youth fires due to "curiosity" also decreased dramatically. In states (North Carolina and West Virginia), where pre- and post-tests were used, scores also reflected significant improvement. Capturing metrics that relate to the types and hours of prevention programs offered will allow similar analyses to be conducted. This report may provide future direction for the model to provide more detailed analyses of the effectiveness of prevention programs.

Glascow, R. E.; Vogt, T. M.; Boles, S. M.
Evaluating the Public Health Impact of Health Promotion Interventions: The RE-AIM Framework
American Journal of Public Health, Vol. 89, No. 9, Pg. 1322, 1999

Progress in public health and community-based interventions has been hampered by the lack of a comprehensive evaluation framework appropriate to such programs. Multilevel interventions that incorporate policy, environmental, and individual components should be evaluated with measurements suited to their settings, goals, and purpose. In this commentary, the authors proposed a model (termed the RE-AIM model) for evaluating public health interventions that assesses 5 dimensions: reach, efficacy, adoption, implementation, and maintenance. These dimensions occur at multiple levels (e.g., individual, clinic or organization, community) and interact to determine the public health or population-based impact of a program or policy. The authors discuss issues in evaluating each of these dimensions and combining them to determine overall public health impact. Failure to adequately evaluate programs on all 5 dimensions can lead to a waste of resources, discontinuities between stages of research, and failure to improve public health to the limits of our capacity. The authors summarize strengths and limitations of the RE-AIM model and recommend areas for future research and application.

Goldberg, R. J.; Gore, J. M.; Love, D. G.; Ockene, J. K.; Dalen, J. E.
Layperson CPR - Are We Training the Right People?
Annals of Emergency Medicine, Vol. 13, No. 9 Pt. 1, Pg. 701, 1984

This study addressed the recipients of CPR training. The focus was to determine whether CPR training among family members with heart disease was more common than those without such a family member. The study looked at percentages of CPR-trained people with a family member with heart disease, family members of patients seen in a primary care clinic, and in randomly selected neighborhood controls. The percentages of people with CPR training for the previous categories were 22.0%, 25.6%, and 28.7%, respectively. The study concludes that those surrounded by higher risk people to cardiac arrest were not being trained at higher rates and that the people that most needed the training were not receiving it.

Hall, J.; Karter, M.; Koss, M.; Schainblatt, A.; McNerney, T.
Fire Code Inspections and Fire Prevention: What Methods Lead to Success?
The Urban Institute, Washington, DC, 1978

Research was undertaken to determine whether some fire-code inspection practices resulted in fewer fires, lower fire loss, and fewer civilian casualties in properties covered by fire codes (excluding one and two-family residences) than do other fire-code inspection practices. The research involved (1) identifying the fires and civilian fire casualties that are potentially preventable by inspection and measuring the proportion of fires and casualties which are of that type; (2) relating differences in characteristics of fire-code inspection practices to differences in fire rates for a representative group of cities; and (3) examining the circumstances of major casualty incidents across the country to determine the relative preventability of those incidents.

This study qualitatively reflected the importance of code enforcement. This study involved measuring data from fires that were "relatively preventable" by inspections per 1,000 occupancies. The study used data from seventeen cities and one county. The study concluded that cities that conducted annual inspections in all or nearly all inspectable properties had lower fire rates than those cities that do not.

Hallstrom, A. P.; Ornato, J. P.; Weisfeldt, M.; Travers, A.; Christenson, J.; McBurnie, M. A.; Zalenski, R.; Becker, L. B.; Schron, E. B.; Proschan, M.
Public-Access Defibrillation and Survival after Out-of-Hospital Cardiac Arrest
The New England Journal of Medicine, Vol. 351, No. 7, Pg. 637, 2004

The rate of survival after an out-of-hospital cardiac arrest is low. It is not known whether this rate will increase if laypersons are trained in defibrillation with the use of automated external defibrillators (AEDs). A clinical trial was conducted in which community units (e.g., shopping malls and apartment complexes) were randomly assigned to a structured and monitored emergency-response system involving laypersons trained in cardiopulmonary resuscitation (CPR) alone or in CPR and the use of AEDs. The primary outcome measured was survival to hospital discharge.

More than 19,000 layperson responders from 993 community units in 24 North American regions participated. The two study groups had similar unit and layperson characteristics. Patients with treated out-of-hospital cardiac arrest in the two groups were similar in age (mean, 69.8 years), proportion of men (67 percent), rate of cardiac arrest in a public location (70 percent), and rate of witnessed cardiac arrest (72 percent). No inappropriate shocks were delivered. There were more survivors to hospital discharge in the units assigned to have laypersons trained in CPR plus the use of AEDs (30 survivors among 128 arrests) than there were in the units assigned to have laypersons trained only in CPR (15 survivors among 107 arrests); there were only 2 survivors in residential complexes. Functional status at hospital discharge did not differ between the two groups. The study concluded that training and equipping laypersons to attempt early defibrillation within a structured response system can increase the number of survivors to hospital discharge after out-of-hospital cardiac arrest in public locations. The study concluded that trained laypersons can use AEDs safely and effectively.

Long, W. J.
Fire Prevention Program Planning in a Social Action Perspective: An Exploratory Study of Knowledge, Attitudes and Leaders in a High Fire Risk Area of New Orleans, Louisiana (prepared for National Fire Prevention and Control Administration)
Planning and Research Associates, Inc, Baton Rouge, 1977

This follow-up study determined what "social action could be initiated at the local level to reduce the rate of fires and fire losses in residential areas with high-risk characteristics.” One-third of the subjects interviewed had experienced a fire in their residence. One-half of those interviewed experienced a fire in the previous ten years. The author reported that although those surviving a fire learned a lesson about that particular fire, there was little appreciation for more general fire prevention.

Mallonee, S.; Istre, G. R.; Rosenberg, M.; Reddish-Douglas, M.; Jordan, F.; Silverstein, P.; Tunell, W.
Surveillance and Prevention of Residential-Fire Injuries
The New England Journal of Medicine, Vol. 355, No. 1, Pg. 27, 1996

This study evaluated the effectiveness of a smoke-alarm giveaway program in Oklahoma City between 1987 and 1990. The metric used to measure effectiveness was number of burn injuries. As part of the study, smoke alarms were handed out door-to-door in a high risk target area. Results showed that four years after the program, fire injury rates decreased by 80% in the target area and that the injury rate per 100 fires decreased by 74% in the target area. The study concluded that smoke detector giveaway programs are an effective means by which to lower residential fire injury rates.

Moore, L.
Emergency Medical Services: Adding Value to a Fire-Based EMS System
International Association of Fire Fighters, Washington, DC, 1997

This document provided methods by which a fire-based EMS system can be evaluated and improved. The study investigated "Injury Prevention and Public Education," citing the Mueller studies on seat belt legislation and the Tucson, Arizona fire department injury prevention program that lowered child drownings in that city by more than 50%. Other injury prevention opportunities cited include "Child Health Month," “National Child Passenger Safety Awareness Week,” the National Highway Traffic Safety Administration's “Safety Advice from EMS (SAFE): A Guide to Injury Prevention.” Finally, CPR classes, AEDs, and public health vaccines are cited as methods to increase public safety.

National Center for Injury Prevention and Control
U.S. Fall Prevention Programs for Seniors: Selected Programs Using Home Assessment and Modification
National Center for Injury Prevention and Control, Atlanta, Georgia, 2000

This document provided programs for senior citizens to prevent injury from falls. Specifically, it cited the Tucson Fall Prevention Project in Tucson, Arizona for persons aged 60 years and older. Fire prevention officers conducted home safety assessments coupled with a clinical assessment of fall risk. Effectiveness was recorded and in the six months following the pilot project, of the 100 participants, two people fell but sustained no injuries, two called 911 for emergencies unrelated to falls, one was admitted to a skilled nursing facility, and one person died. The inclusion of detailed metrics for prevention programs targeted at specific populations, such as the young and the elderly are justified.

Rasbash, D. J.; Ramachandran, G.; Kandola, B.; Watts, J. M.; Law, M.
Fire Safety
John Wiley & Sons, England, 2004

This book was a compilation of literature on fire safety and the fire service. Noteworthy was Chapter 8, which discussed Life Loss. The U.S., Japan, and the UK have similar fire deaths according to age group. A major difference was in Japan, where there was a high number of incendiary suicides in the 31-50 age group. Were it not for this factor, the U.S. rate would have been three times that of Japan in the group 31 - 50. Also worth noting was that U.S. preschoolers had a fire death rate four times that of Japanese preschoolers. Based on statistics from the UK between 1978 and 1991, half of all fire deaths in single family residences occurred in the room of fire origin. It was found that burns caused the highest number of injuries in the room of origin; in other areas, gas or smoke inhalation was the primary injury and death factor, accounting for 50% of fatalities overall. Statistics showed that for the U.S., Japan, and the UK, the number of fires were not decreasing substantially but the number of fire deaths were. Multiple references were made to previous studies of prevention programs. Property Damage (Chapter 9) contained an explanation of methods to characterize building fire risk. A significant account of the prevention efforts and ways to measure their effectiveness was presented. Section 10.4.2 discussed the effectiveness of sprinklers in property protection. Rasbash, et al. state that the fatality rate for multi-occupancy dwellings could be lowered significantly.

Satyen, L.; Barnett, M.; Sosa, A.
Effectiveness of Fire Safety Education in Primary School Children
Third International Symposium on Human Behaviour in Fire, September 1-3, 2004, Interscience Publications, Belfast, UK

The purpose of this research was to determine the effectiveness of the "FireEd" program in Melbourne, Australia. Although it was assumed that the program benefited the young children, it had not been previously evaluated. Sixty children from six primary schools were included in the study. Results showed improvements in fire safety knowledge three weeks later. However, when re-tested after five weeks, a significant decline was noted. This study demonstrated that one-time training was not the most effective method of teaching fire safety. Rather, periodic training matching the child's cognitive development should be utilized.

Schaenman, P.; Stambaugh, H.; Rossomando, C.; et al
Proving Public Education Work
TriData Corporation., Arlington, VA, 1990

This document provided data demonstrated that public fire education improved fire safety in a community. It described a methodology used for determining public education effectiveness, claiming that evaluations are most effective when bottom-line effectiveness can be measured (fires, deaths, injuries, property losses, etc). This is best achieved by comparing statistics before and after program implementations. If this statistical collection is not feasible, the next best means of evaluating a program is through pre- and post-tests, along with retention tests. Additionally, this program described 77 fire education programs that were completed throughout the U.S. The categories of programs included "comprehensive, community wide programs," "school programs," "specific fire causes or target groups," "juvenile fire setter programs," "smoke detector programs," "national programs," and "special topics."

Swor, R. A.; Jackson, R. E.; Compton, S.; et al
Cardiac Arrest in Private Locations: Different Strategies are Needed to Improve Outcome
Resuscitation, Vol. 58, No. 2, Pg. 171, 2003

A tremendous amount of public resources are spent on improving cardiac arrest (Out of Hospital Cardiac Arrest - OHCA) survival in public places, yet most OHCAs occur in private residences. A prospective, observational study of patients transported to seven urban and suburban hospitals and the individuals who called 911 at the time of a cardiac arrest (bystander) was performed. Bystanders (N = 543) were interviewed via telephone beginning two weeks after the incident to obtain data regarding patient and bystander demographics, including cardiopulmonary resuscitation (CPR) training. Of all cardiac arrests, 80.2% were in homes. Patients who arrested in public places were significantly younger (63.2 vs. 67.2), more often had an initial rhythm of ventricular fibrillation (VF) (63.0 vs. 37.7%), were seen or heard to have collapsed by a bystander (74.8 vs. 48.1%), received bystander CPR (60.2 vs. 28.6%), and survived to discharge (17.5 vs. 5.5%). Patients who contested at home were older and had an older bystander (55.4 vs. 41.3). The bystander was less likely to be CPR trained (65.0 vs. 47.4%), less likely to be trained within the last 5 years (49.2 vs. 17.9), and less likely to perform CPR if trained (64.2 vs. 30.0%). Collapse to shock intervals for public versus home VF patients were not different. Conclusions: Many important characteristics of cardiac arrest patients and the bystander differ in public versus private locations. Fundamentally different strategies are needed to improve survival from these events.

U.S. Fire Administration
Four Years Later - A Second Needs Assessment of the U.S. Fire Service
National Fire Protection Association, Quincy, MA, 2007

This document on the needs of the fire service was created using surveys mailed to 15,545 departments. The response rate was about 30%. The relevant topics covered in this report included personnel and their capabilities, fire prevention and code enforcement, facilities, apparatus and equipment, and mutual aid for different call types. For instance, the report mentions statistics such as 40% of U.S. citizens are protected by fire departments that do not conduct permit approval and 23% are protected by departments that do not provide plans review.

U.S. Fire Administration
Fire Death Rate Trends: An International Perspective
Federal Emergency Management Association, Emmitsburg, MD, 1997

A comparison is presented between the U.S. fire death rate and the fire death rates in other industrialized nations. Globally, the U.S. had one of the highest fire death rates, based on the data obtained from 1979-1992. Specifically, this report stated that the focus of fire protection in the U.S. was on response instead of mitigation. For example, goal response times in foreign countries for fire personnel might be as high as 20 to 30 minutes. Such times in the U.S. would be unacceptable. Despite these statistics, fire death rates are lower in these countries than the U.S. This was attributed to the fact that foreign countries focus more of their resources on prevention programs. Other industrialized countries spend between four and ten percent of total firefighting budget on prevention measures; U.S. departments tend to allocate three percent for such programs.

Vaillancourt, C.; Stiell, I. G.; Wells, G. A.; De Maio, V. J.
Mathematical Model Predicting the Potential Impact of Various Community Bystander CPR Rates on Overall Survival from Cardiac Arrest
Academic Emergency Medicine, Vol. 10, No. 5, Pg. 503, 2003

Survival from cardiac arrest remains low. Bystander CPR is a crucial yet weak link of the chain of survival for cardiac arrest. This study sought to determine the potential impact of various community bystander CPR rates on overall survival from cardiac arrest. The method employed was a descriptive analysis and mathematical modeling of data collected within the Ontario Prehospital Advanced Life Support Study. This study has the largest population-based cohort of adult out-of-hospital cardiac arrests in 20 communities with BLS-D and ALS paramedics.

Van Kalmouth, P. M.; Speth, P. A.; Rutten, J. R.; Vonk, J. T.
Evaluation of Lay Skills in Cardiopulmonary Resuscitation
British Heart Journal, Vol. 53, No. 5, Pg. 562, 1985

This study analyzed 166 lay people on their ability to perform cardiopulmonary resuscitation according to the American Heart Association standards. Prior to the course, no participant could perform resuscitation. After completion, 65% of participants could properly compress and ventilate. After six months, 44% could still perform CPR properly. This study supports later works that show that continued education is necessary to maintain the ability to perform proper CPR.

Voelkert, J. C.
Fire Extinguishers: A Necessary Component in Balanced Fire Protection
National Institute of Standards and Technology, Gaithersburg, MD, 2007

This presentation stated that fire extinguishers are an essential method by which to lower civilian deaths and property losses. The NIST workshop cites NFIRS data from 1991 - 1995 that showed fire extinguishers were effective based on percentage of fires extinguished, number of deaths and injuries per 100 fires, and average dollar loss per fire. NFIRS statistics for that time period showed that 94% of the time a fire extinguisher is discharged, the fire is put out. Furthermore, this extinguishment usually occurs within two minutes.

Notification

American Society for Testing and Materials

ASTM F1560 - 00(2006) Standard Practice for Emergency Medical Dispatch Management

American Society for Testing and Materials, West Conshohocken, PA, 2006

This document is the standard practice authored by the American Society for Testing and Materials for the operation of an emergency medical dispatching center. This document discusses metrics such as: primary intake center, secondary answering point, who are the call takers and who are the dispatchers. The importance of the first two metrics is illustrated in the section concerning performance evaluation. Primary intake centers and secondary answering points are identified as necessary entities in a performance review because of their involvement in the emergency medical dispatch program. The importance of the second two metrics is implied in the section discussing telephone aid (non-scripted aid based on the experience of the dispatcher). Since telephone aid is experience based, this implies that dispatchers more familiar with the emergency medical field will be able to interpret emergencies better and provide more effective aid instructions in non-scripted situations and/or systems.

Braun, O.; McCallion, R.; Fazackerley, J.

Characteristics of Midsized Urban EMS Systems

Annals of Emergency Medicine, Vo. 19, No. 5, Pg. 536, 1990

Emergency medical services (EMS) systems in 25 midsized cities (population, 400,000 to 900,000) are described. Information describing EMS system configuration and performance was collected by written and telephone surveys with follow-ups. Responding cities provide either one- or two-tier systems. In a one-tier system, an advanced life support (ALS) unit responds to and transports all patients who use 911 to activate the system. Three types of two-tier systems are identified. In system A, ALS units respond to all calls. Once on scene, an ALS unit can turn a patient over to a basic life support (BLS) unit for transport. In system B, ALS units do not respond to all calls; BLS units may be sent for noncritical calls. In system C, a non-transport ALS unit is dispatched with a transporting BLS unit. For ALS calls, ALS personnel join BLS personnel for transport. Overall, cities staff an average of one ambulance per 51,223 population. One-tier systems average one ambulance per 53,291 compared with two-tier systems, which average one ambulance per 47,546. In the two-tiered system B, the average ALS unit serves 118,956 population. In the 60% of cities that use a one-tier system, one ALS unit serves 58,336. Overall, the code 3 response time for all cities is an

average of 6.6 minutes. The average response time of two-tier systems is 5.9 minutes versus 7.0 minutes for one-tier systems. These data suggest that the two-tiered system B allows for a given number of ALS units to serve a much larger population while maintaining a rapid code 3 response time.

Compton, Dennis; Beck, Harry; Segebarth, Darryl
Fire Department Evaluation System Phoenix Fire Department: FIREDAP Medical Assignment-CODE
Phoenix Fire Department, Phoenix, AZ, 1992

This Phoenix Fire Department report goes through the protocol on responding to various EMS calls. An explanation of the necessary actions are described for the various "Medical codes" (both BLS and ALS). The responsibilities of the responding fire department members are also outlined in the order that they should be accomplished. This report gives a solid understanding of what the protocol is for an EMS event.

Cummins, R. O.; Ornato, J. P.; Thies, W. H.; Pepe, P. E.
Improving Survival from Sudden Cardiac Arrest: The "Chain of Survival Concept"
Circulation, Vol. 83, No. 5, Pg. 1832, 1991

See Response Capacity for abstract.

Curka, P. A.; Pepe, P. E.; Ginger, V. F.; Sherrard, R. C.; Ivy, M. V.; Zachariah, B. S.
Emergency Medical Services Priority Dispatch
Annals of Emergency Medicine, November, Pg. 45, 1993

See Response Capacity for abstract.

Davis, Jennie
Study Results Show Feasibility of 911 Consolidated Dispatch Center
(2007). Retrieved 12 September 2008 from:
http://www.charlestoncounty.org/handheld/www/News/archives/2007/2791.htm

Consultants hired by Charleston County, SC presented the results of their Consolidate Dispatch Feasibility Study. The study concluded that not only is consolidation feasible, but that the county would benefit through improved efficiency, better coordination of responding agencies, and improved operational safety.

De Lisi, S. M.
Responding to Hazardous-Materials Incidents at Fixed Facilities
Fire Engineering, November, Pg. 75, 2006

This article summarized the importance of a fire department conducting emergency planning for facilities that contain hazardous materials. Essentially the whole article is a qualitative argument for the necessity of pre-planning. This justified the capture of pre-planning on the notification tab of the incident survey.

Fratus, J. M.
High-Reliability Organization Theory and the San Bernadino City CA Fire Department
San Bernardino City CA Fire Department, San Bernardino City, CA, 2006

See Response Capacity for abstract.

Garza, A. G.; Gratton, M.C.; Chen, J. J.; Carlson, B.
The Accuracy of Predicting Cardiac Arrest by Emergency Medical Services Dispatchers : The Calling Party Effect
Academic Emergency Medicine, Vol. 10, No. 9, Pg. 955, 2003

The accuracy of dispatchers in recognizing and appropriately assigning calls as cardiac arrest emergencies was the focus of this study. Five hundred six tapes originally coded as cardiac arrest were reviewed from a Midwestern dispatch center that had an annual call volume of approximately 90,000 with about 60,000 hospital transports. The reporting parties were broken into 4 categories: individual having cardiac arrest, bystander, person transferring the call to dispatch and other dispatchers. Statistics are given for the effect of the caller type on the correct coding of the call. Statistics are also given for the field diagnosis for calls coded as cardiac arrest and for the dispatch code of patients given a field diagnosis of cardiac arrest. The researchers conclude that this system had a sensitivity of 68.3% in predicting cardiac arrest with a Positive Pressure Ventilation (PPV) of 65%. The study also pointed out that there is very little literature in the way of previous studies in the accuracy of dispatch coding: "To date, there are few studies describing the accuracy of predicting and dispatching CA calls by EMS dispatchers." It does offer up this insight theory. It is possible that dispatchers with more medical training are better at acquiring key information or processing verbal cues from the caller than non–medically trained dispatchers relying solely on a scripted dispatch format."

Heward, A.; Damiani, M.; Hartley-Sharpe, C.
Does the use of the Advanced Medical Priority Dispatch System affect cardiac arrest detection?
Journal of Emergency Medicine, Vol. 21, No. 1, Pg. 115, 2004

This study was completed in 2004. The purpose of this work was to determine the impact that the Advanced Medical Priority Dispatch System had on identifying patients in cardiac arrest in the London Ambulance Service. The relationship between compliance with the AMPDS protocol and patient cardiac arrest identification was also evaluated. The study first compared the percentage of cases coded as "cardiac arrest" at dispatch using AMPDS with the code found by the responder; these results were compared with similar statistics prior to AMPDS implementation. Results for this study found that AMPDS resulted in patients being accurately identified as suffering cardiac arrest twice as often. The second part of the study found that as compliance with AMPDS protocol increased, so did the accuracy of dispatched coding. This study showed that similar findings can be possible if including the scene type/location as dispatched, the scene type/location as found and whether the fire department dispatch uses a scripted/priority dispatching system.

International Association of Fire Chiefs
A National Mutual Aid System for the Fire Service: A Strategic Plan
International Association of Fire Chiefs, Fairfax, VA, 2006

See Response Capacity section for abstract.

Jones, Jillian
Grand Jury: County Must Improve Protocol at Dispatch Center
(2008). Retrieved 12 September 2008 from:
http://www.napavalleyregister.com/articles/2008/05/21/news/local/doc4833b2a6d3506232767932.txt

A Napa Valley Grand Jury issued a report highly critical of county emergency communications center, citing lack of even basic quality assurance measures, lack of record keeping and reliance on California Highway Patrol to handle all cellular 911 calls.

Karter, Jr., Michael
A Needs Assessment of the Fire Service: Massachusetts
National Fire Protection Association, Quincy, MA, 2004

This report identified mutual aid as an important notification related metric. The report gave statistics regarding the approximate percentages of departments that have written mutual aid agreements for various types of incidents. Some examples of these incidents are technical rescue with EMS at a structural collapse with 50 occupants; HazMat and EMS incidents involving chemical/biological agents and ten injuries; wildland/urban interface fires affecting 500 acres; and/or mitigation of a developing major flood. The important thing to understand is that these are just representative of many different types of possible incidents that require mutual aid.

Karter, Jr., Michael; Molis, Joseph L.
Firefighter Injuries for 2004
NFPA Journal, November/December, Pg. 50, 2005

This report provided a statistical breakdown of the 75,840 reported firefighter injuries in 2004 by injury type, fireground (or not), year-over-year trends in injuries, and injuries per hundred fires. Years 1988-2004 yielded about 25 fireground injuries per 1,000 fires and a steady decline in non-fire injuries to less than one per 1,000 incidents. About half of injuries occurred on the fireground. This report justified the collection of the initial and final scene types/locations in order to conduct such an analysis.

Karter Jr., Michael; Molis, Joseph L.
U.S. Firefighter Injuries - 2005
NFPA Journal, 2006

This report held the same value in justifying the collection of initial and final scene type/location as the previous year's report, which is found above. This report provided statistical breakdowns of firefighter injuries: whether they were fire-related, types, injuries per department by population of community, etc. A total of 80,100 firefighter injuries occurred in 2005. 41,950 (49%) occurred during fireground operations, 13,325 occurred during other on-duty activities, and 12,250 occurred at non-fire emergency incidents. The main injury type was strain/sprain/muscle pain (44%). It is interesting to note that since 1988-2005, the rate of "injuries per 1,000 fires at the fireground" have remained more or less level. However, the "injuries per 1,000 incidents at non-fire emergencies" has decreased steadily. The breakdown of the injuries sustained is reasonably comprehensive.

Klaene, B. J.; Sanders, R. E.
Structural Fire Fighting
Jones and Bartlett Publishers, Sudbury, Massachusetts, 2000

This text focused on fire fighting in structures. It discussed the importance of pre-incident planning. The authors believed that it is an asset to any fire department. It is agreed that a pre-incident plan is essential to the incident commander when making strategic and tactical decisions at the scene. It is mentioned that pre-incident plans effectively remove an initial step at the fireground during the first few important minutes.

Klaene, B. J.; Sanders, R. E.

Expert Advisors Provide Strategic Support
NFPA Journal November/December, 2002

Klaene and Sanders gave their opinion on why training and pre-incident planning are very important to the fire service. The article mentioned that, although firefighter on-duty deaths have decreased since the late 1970s, the probability of a firefighter death at a single fire has not decreased much. The authors believed that more frequent and realistic training, along with better education, will provide a means to lower fire death rates. Also, the authors state the importance of pre-incident planning. Specifically, it is stated the need for pre-incident planning at industrial facilities due to specific and high-hazard scenarios. This was due to NFPA statistics between 1996 and 2000 that showed that industrial facilities result in 6 firefighter deaths per 100,000 structure fires as opposed to 3.7 firefighter deaths per 100,000 residential fires.

Ma, M.H., Chiang, W.C., Ko, P.C., Huang, J.C., Lin, C.H., Wang, H.C., Chang, W.T., Hwang, C.H., Wang, Y.C., Hsiung, G.H., Lee, B.C., Chen, S.C., Chen, W.J., Lin, F.Y.

Outcomes from out-of-hospital cardiac arrest in Metropolitan Taipei: Does an advanced life support service make a difference?

Resuscitation, Vol. 74, No. 3, Pg. 461, 2007

Out-of-hospital cardiac arrest (OHCA) is of major medical and public health significance. It also serves as a good indicator in assessing the performance of local emergency medical services system (EMS). There have been arguments for and against the benefits of advanced life support (ALS) over basic life support with defibrillator (BLS-D) for treating OHCA. The study was conducted to characterize the outcomes of cardiac arrest victims in an Asian metropolitan city; to evaluate the impacts of ALS versus BLS-D services; and to explore the possible patient and arrest factors that may be associated with the observed differences in the outcomes between the two pre-hospital care models. Taipei, an Asian metropolitan city with an area of 272 square kilometers and a population of 2.65 million, served as the study population. The fire-based BLS-D EMS system was in the process of phasing in ALS capability. While there were 40 BLS-D teams in the 12 city districts, two ALS teams were set up in the central part of the city. In this prospective study, all adult non-traumatic OHCA from September 2003 to August 2004 were included. Patient, arrest, care, and outcome variables for OHCA victims were collected from pre-hospital run sheets, automatic defibrillators, and emergency department and hospital records. Among 1423 OHCA included in the analysis, 1037 (73%) received BLS-D service, and 386 (27%) received ALS services. The initial shockable rhythms and early bystander CPR were strongly associated with better survival for victims of cardiac arrests. Compared to BLS-D, ALS patients had similar age, sex, witness status, the rate of bystander CPR, and response timeliness but more patients in asystole (84% versus 72%). Patients treated by ALS were more likely to result in significantly higher rates of return of spontaneous circulation and survival to emergency department/intensive care unit admission, but there was no difference in the rate of survival to hospital discharge. The outcome difference from ALS services was more pronounced among patients in asystole and without bystander CPR. Conclusions: In this metropolitan EMS system in Asia, the implementation of ALS services improved the intermediate, but not the final, outcomes. Communities with larger populations and lower incidence of initial shockable rhythms than the OPALS study should also prioritize their resources in setting up and optimizing systems of basic life support and early defibrillations. Further studies are warranted to configure the optimal care model for combating cardiac arrest.

National Fire Protection Association
Fire Department Calls and False Alarms
National Fire Protection Association, Quincy, MA, 2008

In 2006, U.S. fire departments responded to 2,119,500 false alarms. This was a very slight decrease of 0.7%. This means that one out of ten calls responded to by fire departments were false alarms. This source is particularly valuable in justifying the final use of on-scene resources. Because 10% is a significant quantity of fire department calls, it makes sense to include a metric that will give a clearer picture of the demands on a fire department with a resolution at the station level.

National Fire Protection Association
NFPA 1061: Standard for Professional Qualifications for Public Safety Telecommunicator
Quincy, MA, 2007

This standard identifies the minimum job performance requirements for public safety telecommunicators. The purpose of this standard is to ensure that persons meeting the requirements of this standard are qualified to serve as public safety telecommunicators.

A duty description for telecommunicators is to process any request for public safety services. They are also to establish communications with the requester, using a communication device, a means of collecting information, operating procedures, and a work station, so that a communication link with the requester is achieved. They are also to extract pertinent information, given a request for public safety service, so that accurate information regarding the request is obtained. Next, they should establish nonverbal communications, given a request for public safety service through a communications device, so that accurate information regarding the request is obtained. Then, they are to prepare data for dispatch or referral by evaluating, categorizing, formatting, and documenting the incident per established policies, procedures, or protocols. Next they should analyze information provided by a service requester, given the policies, procedures, and guidelines of the agency, so that the request is accurately categorized and prioritized. Then, evaluate a categorized and prioritized service request, given available resources, so that an allocation of resources is determined. Next they are to initiate the timely addition, deletion, and correction of data, given agency policies, procedures, guidelines, and protocols, so that documents, files, databases, maps, and resource lists are accurately maintained. Convey instructions, information, and directions to the service requester, given agency policies, procedures, guidelines, and protocols, so that information appropriate to the incident is consistent with agency policies, procedures, guidelines, and protocols, and results in resolution, referral, or response. Finally, they are to relay information to other telecommunications personnel or entities, given processed data, so that accurate information regarding the request for service is provided to the responders.

National Fire Protection Association
NFPA 1221: Standard for the Installation, Maintenance, and use of Emergency Services Communications Systems
Quincy, Massachusetts, 2007

This standard covers the installation, performance, operation, and maintenance of public safety emergency services communications systems and facilities. The 2002 edition continued to enhance the capabilities of personnel assigned to communications centers as well as the interoperability of systems. The standard notes that the mission of the communications center should be to serve as a conduit between those requesting services and those providing those services.

The purpose of this standard is:

1) To specify operations, facilities, and communications systems that receive alarms from the public

2) To provide requirements for the retransmission of such alarms to the appropriate emergency response agencies

3) To provide requirements for dispatching of appropriate emergency response personnel

4) To establish the required levels of performance and quality of installations of emergency services communications systems

This standard identifies minimum job performance requirements for public safety telecommunicators.

National Institute for Occupational Health and Safety

Death in the Line of Duty: Career Fire Fighter Dies for Fire in a Restaurant/Lounge - Missouri
National Institute for Occupational Health and Safety, Washington, DC, 2004.

This investigative report highlighted the importance of pre-incident planning. NIOSH investigators concluded that pre-incident planning would minimize the risk of similar occurrences. Specifically, the investigators found that a lack of pre-planning concerninginterior construction information created an unsafe environment for the firefighters. Particular hazards, such as truss construction, are mentioned. The report also mentioned that NFPA 1500 stresses the importance of building assessment.

National Fire Protection Association

NFPA 1620: Recommended Practice for Pre-Incident Planning (2003 Edition)
National Fire Protection Association, Quincy, MA, 2003

This NFPA practice qualitatively justifies pre-incident planning. The document is a guide for departments looking for help on how to carry out pre-incident planning.

Expert opinion complied in this document formed a qualitative argument that pre-incident planning needs to be studied further in order to quantify the beneficial effects on community outcomes.

Northern Middlesex Council of Government

Pre-Disaster Mitigation Plan for the Northern Middlesex Region
Northern Middlesex Council of Governments, Lowell, MA, 2006

This paper presented an approach for developing a methodology for public assets risk mitigation. While this type of pre-planning is different from the typical type of site pre-plan conducted by fire departments, it is representative of the benefits recognized by pre-planning. The pre-plans discussed in this document are aimed at types of disasters rather than the hazards at specific locations. The authors took the various disasters and developed the frequency and severity of several events (flood, dam failure, hurricane, etc) in past history (page 108). This methodology is effective when past historical events are considered in model development. The core of the methodology is useful as the report follows a similar scoring system to the other literature. They define occurrences as very low, low, medium, or high frequency. These values are determined from past history.

Sweeney, T. A.; Runge, J. W.; Gibbs; et al

EMT Defibrillation Does Not Increase Survival from Sudden Cardiac Death in a Two-Tiered Urban-Suburban EMS System
Annals of Emergency Medicine, Vol. 31, No. 2, Pg. 234, 1998

This study collected data prospectively between 1992 and 1995 in Charlotte, North Carolina. The metrics that it identified were CPR, AED intervention and type of dispatching. A total of 627 patients were included in the study. Results found that five of 110 (4.6%) patients of witnessed cardiac arrest with AED use survived to hospital discharge as opposed to 7 out of 113 (5.3%) when AEDs were not used. The authors conclude that AEDs did not improve cardiac arrest outcomes, which disagrees with typical AED intervention study results. They also make the argument that optimization of bystander CPR and EMS dispatching may be more critical than equipping first responders with AEDs. The justification for this argument is that if ALS arrival is already timely, there is no point in the addition of defibrillation capabilities for first responders. Thus if EMS dispatching is optimized then the total time for ALS intervention may be reduced.

U.S. Fire Administration
FEMA Reviews Two Major Apartment Fire That Affected Elderly Residents for Lessons Learned
Federal Emergency Management Association, Emmitsburg, MD, 2003

This publication reviewed two high-rise apartment fires that resulted in deaths and injuries to elderly residents. The point of the article was to identify "lessons" that have been learned by these fires. The recommendations are pre-incident planning to secure necessary resources for potentially large scale events, the installation of sprinkler systems, the presence of an incident management system and public education programs for the elderly.

U.S. Fire Administration
Four Years Later - A Second Needs Assessment of the U.S. Fire Service
National Fire Protection Association, Quincy, MA, 2007

See Response Capacity for abstract.

Valenzuela, T.; Roe, D.; Nichol, G.; et al
Outcomes of Rapid Defibrillation by Security Officers after Cardiac Arrest in Casinos
The New England Journal of Medicine, Vol. 343, No. 17, Pg. 1206, 2000

The purpose of this 1997 work was to develop a predictive model for survival in out-of-hospital cardiac arrest due to ventricular fibrillation. The research stressed the importance of bystander intervention and especially the time dependence of these interventions. It also provided some quantification of the quality of care offered by two-tier EMS systems. A regression analysis of retrospective cardiac arrest data was done using a Southwestern city with a population of 415,000 and Northwestern county with a population of 1,038,000. Both of these communities had two-tiered EMS systems in place. Those measures tested for association with patient survival likelihood included: "patient age, initiation of CPR by bystanders, interval from collapse to CPR, interval from collapse to defibrillation, bystander CPR/collapse-to-CPR interval interaction, and collapse-to-CPR/collapse-to-defibrillation interval interaction." This model determined that the best predictors for survival were collapse-to-CPR and collapse-to-defibrillation intervals. Death occurred 1.1 times more frequently with each passing minute from the point of collapse to CPR or defibrillation. Also, it was noted that a delay of more than 10 minutes for CPR causes defibrillation to be ineffective; both methods have serious time sensitivity implications.

Van Dusen, Eric L.

Mutual Aid for Major Emergencies
Fire Engineering, Vol. 156, No. 7, Pg. 143, 2003

This 2003 journal article cited the success of mutual aid agreements in Glendale, California; Burbank, California; and Pasadena, California. The mutual aid success was enhanced by the fact that these departments are dispatched from a central location, train together, and can use similar radio frequencies when working together at an emergency scene. Although data collection regarding mutual aid effectiveness for these communities has not been completed, six other cities have joined the original three during the past five years.

Wilson, B.; Gratton, M. C.; Overton, J.; Watson, W.
Unexpected ALS Procedures on Non-Emergency Ambulance Calls: The Value of a Single-Tier System
Prehospital and Disaster Medicine, Vol. 7, No. 4, Pg. 380, 1992

This study analyzed the frequency of originally dispatched BLS calls resulted in ALS calls at the scene or in transport to the hospital. The study was conducted retrospectively during 1989 in an urban community of 475,000 with an annual response of 45,000 calls. The results for this are based on 6,363 non-emergency calls; of these 309 (5%) were upgraded to emergency while the responding unit was on route. Of the remaining 6,053 calls remaining, 11% resulted in one or more ALS interventions. Calls that were upgraded to emergency by dispatch resulted in one or more interventions in 144 out of the 309 (46.6%) calls. This study shows that despite strict protocols for dispatch, 11.7% of non-emergency patients ended up needing ALS care. These results tend to favor a single-tier EMS system although these types of systems may have evolved into more efficient/effective systems since and should be studied.

Aghababian, R. V.; Mears, G.; Ornato, J. P.; Kudenchuk, P. J.; Overton, J.

Cardiac Arrest Management
Prehospital Emergency Care, Vol. 5, No. 3, Pg. 237, 2001

Approximately 1,000 people in the United States suffer cardiac arrest each day, most often as a complication of acute myocardial infarction (AMI) with accompanying ventricular fibrillation or unstable ventricular tachycardia. Increasing the number of patients who survive cardiac arrest, and minimizing the clinical sequelae associated with cardiac arrest in those who do survive, are the objectives of emergency medical personnel. In 1990, the American Heart Association (AHA) suggested the chain of survival concept, with four links—early access, cardiopulmonary resuscitation (CPR), defibrillation, and advanced care—as the way to approach cardiac arrest. The recently published International Resuscitation Guidelines 2000 of the AHA have addressed advances in our understanding of the chain of survival. While the chain of survival concept has withstood a decade of scrutiny, there are only a few scientifically rigorous research studies that support changes in pre-hospital patient care. Additional research efforts carried out in the pre-hospital setting are needed to support the concepts included in the chain of survival for cardiac arrest patients. Participants at the second Turtle Creek Conference, a meeting of experts in the field of emergency medicine held in Dallas, Texas, on March 29-31, 2000, discussed these and other issues associated with pre-hospital emergency care in the cardiac arrest patient. This paper addressed a number of the issues associated with each of the links of the chain of survival, the evidence that exists, and what should be done to achieve the clinical evidence needed for true clinical significance. Also included in this paper are the consensus statements developed from small discussion groups held after the main presentation. These comments provide another perspective to the problems and to possible approaches to deal with them.

National Fire Academy

Fire Engines are Becoming Expensive Taxi Cabs: Inadequate Manning
United States Fire Administration, 1981

This report illustrates the King of analysis that will be possible by capturing the resources sent, and final scene resources utilized, at a scene. This NFA report summarizes a 1977 test conducted by the Dallas Fire Department, which consisted of a simulated fire involving several rooms at the rear of the third floor of an old school. This simulation was conducted to determine how long it took a three-, four-, or five-person team to advance its line to this area and get water on the fire. Immediately following those tasks, each individual's physical condition was assessed. Timing began as each engine company entered the schoolyard. The average time for the engine companies to complete the tasks is revealing. The three-person team average was 18.8 minutes. All personnel were exhausted, "rubber legged", had difficulty standing up and were unfit for further fire fighting. The four person team, conducting the very same test, averaged 10.29 minutes and upon completion, were nearing exhaustion. The five-person team averaged 6.15 minutes, and showed little evidence of fatigue at the end of the exercise.

Backoff, R. W.; et al
Firefighter Effectiveness - A Preliminary Report
Columbus Fire Division, The Ohio State University, 1980

This paper investigated the role of staffing resources for emergency service delivery. It was found that the three effectiveness measures (metrics) which were significant were: "firefighter injuries, dollar value of property loss, and square feet of fire spread after arrival of the fire suppression units." Results showed that the elapsed time from dispatch to situation contained was most commonly 18 minutes after the alarm was sounded. Most fires investigated in the study were contained in less than one hour. "A" and "B" studies were defined as the presence of more or less than a predetermined threshold number of personnel on the fireground. For both A and B studies, the number of initial firefighters originally deployed (more or less than the design number) were not found to affect firefighter injuries. The relationship between the initial number deployed and the proportion of incidents in which dollar losses exceeded $5,000 was investigated. For the A response, a $5,000 loss occurred in 43% of the cases when deployment was 14 or fewer; for 15 or more people deployed, the proportion was 46%. However for the B response, the proportions for the 23 or fewer and 24 or more were 59% and 34%, respectively. The horizontal fire spread was also investigated. It was found that for the A response, the proportion of spread greater than 25 square feet were 35% for 14 or fewer and only 29% for 15 or greater. The B response showed a similar trend in that spread occurred for 35% of fires involving 22 or fewer firefighters and 29% for 23 or more. The paper concluded that the magnitude of the initial deployed force will affect the effectiveness of fire suppression.

Bahr, J.; Klinger, H.; Panzer, W.; Rode, H.; Kettler, D.
Skills of Lay People in Checking the Carotid Pulse
Resuscitation, Vol. 35, No. 1, Pg. 23, 1997

For abstract, see Prevention.

Becker, L. B.; Ostrander, M. P.; Barrett, J.; Kondos, G. T.

Outcome of CPR in a Large Metropolitan Area - Where are the Survivors?

Annals of Emergency Medicine, Vol. 20, No. 4, Pg. 355, 1991

See Community Demographics section for abstract.

This article provides an analysis of cardiac arrest and intervention time intervals in a large metropolitan area (Chicago), implying the importance of studying response area, total population and population density. The article states that the survival rates in Chicago are lower in comparison to the rates reported by smaller communities but consistent with other large communities. The single factor that most likely contributed to the poor overall survival was the relatively long interval between collapse and defibrillation. Ninety-one percent (91%) of patients were pronounced dead in emergency departments (patients may have died prior to arrival at emergency dept.), 7% died in the hospital and 2% survived to discharge.

Benichou, N.; Yung, D.; Hadjisophocleous, G.

Impact of Fire Department Response and Mandatory Sprinkler Protection on Life Risks in Residential Communities

Scotland, UK

8th International Interflam Fire Science & Engineering Conference, June/July 1999

Interscience Communications

The National Research Council of Canada's risk-cost assessment model, FiRECAM (Fire Risk Evaluation and Cost Assessment Model), was used to assess whether an apartment building with sprinkler protection, but with longer fire department response time, provided a level of fire safety for the occupants equivalent to that in a building without sprinkler protection, but with a faster fire department response time. Five new development areas in Canada were studied. A 3-story apartment building was used as a model building to represent the normal range of buildings in a residential community. The expected risk to life to the occupants is assessed with and without added sprinkler protection, and with two levels of fire department response: with and without new fire stations. The results of this study showed that the provision of sprinkler protection and the existing fire department response time (i.e., no new fire stations) provided a level of fire safety that is better than the case without sprinkler protection but with a shorter fire department response time (i.e., with new fire stations).

Boyd, C. R.; Tolson, M. A.; Copes, W. S.
Evaluating Trauma Care: The TRISS Method
The Journal of Trauma, Vol. 27, No. 4, Pg. 370, 1987

See Community Demographics section for abstract.

Braun, O.; McCallion, R.; Fazackerley, J.
Characteristics of Midsized Urban EMS Systems
Annals of Emergency Medicine, Vo. 19, No. 5, Pg. 536, 1990

See Notification section for abstract.

Brown, L. H.; Owens Jr., C. F.; March, J. A.; Archino, E. A.
Does Ambulance Crew Size Affect On-Scene Time or Number of Prehospital Interventions?
Prehospital and Disaster Medicine, Vol. 11, No. 3, Pg. 214, 1996

This study was conducted to compare the effectiveness of a two-person ambulance crew versus a three-person ambulance crew. The metrics included in this work were staffing and on-scene/transport times. The hypothesis being tested was that two person crews did not have longer on scene times. There were no significant differences in total number or types of procedures performed for the two patient groups. Mean on-scene time for patients with seizures was 11.0 +/- 4.2 minutes for three-person crews and 19.4 +/- 8.3 minutes for two-person crews. Mean on-scene time for patients with chest pain was 13.6 +/- 4.9 minutes for three-person crews, and 15.4 +/- 3.2 minutes for two-person crews assisted by fire department personnel.

Bukowski, R. W.; Peacock, R. D.; Averill, J. D.; Cleary, T. G.; Bryner, N. P.; Walton, W. D.; Reneke, P. A.; Kuligowski, E. D.
Performance of Home Smoke Alarms: Analysis of the Response of Several Available Technologies in Residential Fire Settings
National Institute of Standards and Technology, Gaithersburg, MD, 2003

See Prevention section for abstract.

Centaur Associates
Report on the Survey of Fire Suppression Crew Size Practices 1982

See Response Capacity section for abstract.

Chugh, S. S.; Jui, J.; Gunson, K.; et al

Current Burden of Sudden Cardiac Death: Multiple Source Surveillance Versus Retrospective Death Certificate-based in a Large U.S. Community

Journal of American Cardiology, Vol. 44, No. 6, Pg. 1,268, 2004

This study conducted in 2003 and published in 2004 sought to accurately determine the incidence of sudden cardiac death (SCD) annually in Multnomah County, Oregon (population of 660,486). A prospective evaluation of SCD was coupled with a retrospective, death-certificate-based determination of SCD. The study concluded that 53 of 100,000 residents (a total of 353) suffered SCD between February 1, 2002 and January 31, 2003. Resuscitation was attempted in 67% of the cases and successful in 8%. The accompanying study using death certificate-based data generated 1,007 cases. This work concluded that sudden cardiac death accounts for about 6% of annual mortality. This clearly indicated the need to capture the occurrence of bystander CPR, in order that effectiveness is quantified.

Cobb, L. A.; Fahrenbruch, C. E.; Walsh, T. R.; et al

Influence of Cardiopulmonary Resuscitation Prior to Defibrillation in Patients with Out-of-Hospital Ventricular Fibrillation

Journal of the American Medical Association, Vol. 281, No. 13, Pg. 1,182, 1999

Due to the addition of AEDs to the emergency medical system in Seattle, Washington, this study was undertaken to determine the effectiveness of providing 90 seconds of CPR to victims with out-of-hospital ventricular fibrillation prior to AED shock by first-arriving EMTS. The results showed that survival improved from 24% to 30% in the post-intervention time period; those patients with response intervals of 4 minutes or longer saw the greatest improvement (17% survival to 27% survival). This study showed that about 90 seconds of CPR prior to AED use increased survival rates, especially when response times were greater than 4 minutes. This supported the inclusion of bystander CPR and bystander defibrillation as intervention metrics.

Coleman, Ronny J.

Pride Can Come from More than Run Numbers

Fire Chief, Vol. 48, No. 7, Pg. 30, 2004

Ronny J. Coleman argued that metrics falling under training, fitness, prevention and staffing are critical. He identified four components of “fire company productivity”: operational readiness (personnel hours spent on physical fitness and training), community readiness (fire prevention and public education efforts), operational esponse (the ability to respond to calls assigned), and standby (not doing any of the first three).

Cummins, R. O.

The Origins of Utstein

Journal of Emergency Medical Services, Pg. 74, 1994

The Utstein method is one of the accepted methods by which to collect cardiac arrest data according to specific guidelines. This is performed by clearly defining summary definitions for emergency care and resuscitation. This method is vital because it allows different communities to compare survival rates and other statistics on the same baseline. This journal article provided the “Utstein Style Template” for data collection. Some of the data collected included population served, confirmed cardiac arrests considered, resuscitations attempted, arrests witnessed, and status of patient at hospital. Also in the template are whether the patient is discharged alive and whether the patient is alive one year later.

Cummins, R. O.; Ornato, J. P.; Thies, W. H.; Pepe, P. E.

Improving Survival from Sudden Cardiac Arrest: The “Chain of Survival Concept”

Circulation, Vol. 83, No. 5, Pg. 1832, 1991

More people can survive sudden cardiac arrest when a particular sequence of events occurs as rapidly as possible. This sequence is 1) recognition of early warning signs, 2) activation of the emergency medical system, 3) basic cardiopulmonary resuscitation, 4) defibrillation, 5) intubation, and 6) intravenous administration of medications. The descriptive device "chain of survival" communicates this understanding in a useful way. While separate specialized programs are necessary to develop strength in each link, all of the links must be connected. Weakness in any link lessens the chance of survival and condemns the efforts of an emergency medical services (EMS) system to poor results. The chain of survival concept has evolved through several decades of research into sudden cardiac arrest. Effective system interventions have been identified that will allow survivors to remain neurologically intact. While a few urban systems may have approached the current practical limit for survivability from sudden cardiac arrest, most EMS systems, both in the United States and other countries, have defects in their chain. Poor resuscitation rates have been the rule. This statement described the research supporting each link and recommended specific actions to strengthen the chain of survival.

This document thoroughly summarized previous research. From this document the importance of capturing the level of qualification staffing emergency apparatus as a metric can be deduced. In order to record the event, it will be necessary to record the call as dispatched and as found as metrics. This work quantified the effects of different levels of EMS care as provided by qualified staff. Analyzing prior research, Cummins found that average rate of survival from cardiac arrest in EMT-D only systems was about 16%. This rate referred to witnessed victims in ventricular fibrillation. Comparatively, Cummins found that rate of survival in combined EMT-D and ALS systems was 29%. I n ALS only systems, the corresponding survival rate was about 17%. The similar survival rates between EMT-D only and ALS only systems is attributed to a difference in response time and intervention methods in each. EMT-D systems have small response times but lack the advanced intervention methods; on the other hand, ALS only systems have longer response times, but include the advanced intervention methods. These statistics show that a combined system may be the most effective in improving survival rates. Although community resources may prevent the implementation of two-tiered systems, the researchers recommend that it may be beneficial to use first-responder defibrillation rather than paramedics alone.

De Maio, V. J.; Stiell, I. G.; Nesbitt, L.; Wells, G. A.

Faster Advanced Life Support Response Intervals May Improve Cardiac Arrest Survival

Academic Emergency Medicine, Vol. 12, No. 5, Pg. 16, 2005

See Response Capacity section for abstract.

Donovan, S.

Credit Rating

Fire Prevention Fire Engineers Journal, 2006, December, Pg. 50, 2006

This article stated that the role of fire extinguishers should not be underestimated. A survey carried out by the Fire Extinguishing Trades Association and the Independent Fire Engineering and Distributors Association in 2002 showed that extinguishers put out more workplace fires every year than the fire service. The point is made that fires extinguished by this means are virtually a “black hole” in the fire statistics, as successful extinguishment via this method typically goes unrecorded.

Eisenberg, M. S.; et al

Predicting Survival from Out-of-Hospital Cardiac Arrest: A Graphic Model

Annals of Emergency Medicine, Vol. 22, No. 11, Pg. 1,652, 1993

See Response Capacity section for abstract.

Eisenberg, M. S.; Horwood, B. T.; Cummins, R. O.; Reynolds-Haertle, R.; Hearne, T. R.
Cardiac Arrest and Resuscitation: A Tale of 29 Cities
Annals of Emergency Medicine, Vol. 19, No. 2, Pg. 179, 1990

See Response Capacity section for abstract.

Fahy, R. F.; LeBlanc, P. R.; Molis, Joseph L.
Firefighter Fatalities in the United States - 2007
National Fire Protection Association, Quincy, MA, 2007

In 2007, there were a total of 102 on-duty firefighter deaths in the U.S. This is a slight increase over the 87 firefighter fatalities that occurred in 2005. It was the second consecutive year, and the fifth out of the last 10 years, that the total number of deaths has been below 100. The largest share of deaths (38 deaths) occurred on the fire ground. Stress, exertion, and other medical-related issues, which usually result in heart attacks or other sudden cardiac events, continued to be the leading cause of fatal injury. Of the 38 stress-related fatalities in 2006, 34 (38%) were classified as sudden cardiac deaths. The second leading cause was coming into contact with or being struck by an object. The report mentions that although the number of sudden cardiac arrests (SCAs) has decreased from 70 in 1977 to 38 in 2007, this number still makes up approximately 40% of firefighter deaths. Also mentioned in the report are the importance of NFPA 1500, 1582, and 1583. These are all documents that stress the importance of medical screening and firefighter fitness programs. As a result, this report demonstrated the importance of metrics that describe first responder outcomes as well as scene type where the injury occurred and whether the department had any fitness/wellness programs.

Feero, S.; Hedges, J. R.; Simmons, E.; Irwin, L.
Does Out-of-Hospital EMS Time Affect Trauma Survival?
American Journal of Emergency Medicine, Vol. 13, No. 2, Pg. 133, 1995

To determine if out-of-hospital emergency medical services (EMS) time intervals are associated with unexpected survival and death in urban major trauma, a retrospective review was conducted of major trauma cases entered into an urban trauma system by an EMS system during a one-year period. Patients with unexpected death or unexpected survival were identified using TRISS methodology. The EMS response, on-scene time, transport time, and total EMS out-of-hospital time intervals were compared for the two groups. Of 848 major trauma cases, there were 13 (1.5%) unexpected survivors and 20 (2.4%) unexpected deaths. Of those patients with complete EMS times, the mean out-of-hospital response time interval was significantly shorter for the unexpected survivors (3.5 +/- 1.2 minutes v 5.9 +/- 4.3 minutes). The mean EMS on-scene time interval (7.8 +/- 4.1 minutes v 11.6 +/- 6.5 minutes) and the mean transport time interval (9.5 +/- 4.4 minutes v 11.7 +/- 4.0 minutes) also favored the unexpected survivor group. Overall, the total EMS time interval was significantly shorter for unexpected survivors (20.8 +/- 5.2 minutes v 29.3 +/- 12.4 minutes). It was concluded that a short overall out-of-hospital time interval may positively affect patient survival in selected urban major trauma patients.

Ford, J.

15 Years of Built-In Automatic Fire Sprinklers: The Scottsdale Experience
Scottsdale Rural/Metro Fire Department, Scottsdale, AZ, 2001

This report provided the statistics 15 years after a residential sprinkler ordinance took effect in 1986 in Scottsdale, Arizona. During the 15 years, the civilian fire fatality rate fell by at least 50%. Fire officials estimated that the sprinklered properties have saved at least thirteen lives during the 15 years. Additionally, property losses due to fire in the area have decreased dramatically. The average property loss for a fire incident in a sprinklered building was over 90% less than that for a non-sprinklered building. This report shows the positive effects of sprinkler intervention on civilian lives and property saved during the study period.

Gallagher, E. J.; Lombardi, G.; Gennis, P.

Effectiveness of Bystander Cardiopulmonary Resuscitation and Survival Following Out-of-Hospital Cardiac Arrest
Journal of the American Medical Association, Vol. 274, No. 24, Pg. 1922, 1995

The objective of this study was to examine the independent relationship between effectiveness of bystander cardiopulmonary resuscitation (CPR) and survival following out-of-hospital cardiac arrest. A total of 2071 consecutive out-of-hospital cardiac arrests occurring in New York City were evaluated. Trained pre-hospital personnel assessed the quality of bystander CPR on arrival at the scene. Satisfactory execution of CPR required performance of both adequate compressions and ventilations in conformity with current American Heart Association guidelines. The main outcome measure of the study was adjusted association between CPR effectiveness and survival. Survival was defined as discharge from hospital to home. Outcome was determined on all members of the inception cohort-none were lost to follow-up. After adjustment for witness status, initial rhythm, interval from collapse to CPR, and interval from collapse to advanced life support, effective CPR remained independently associated with improved survival. During the research time period, 662 individuals received bystander CPR; 46% (305)

had it performed correctly. Furthermore, 4.6% of those that received proper bystander CPR survived compared to only 1.4% of those that received improper CPR. It was concluded that the association between bystander CPR and survival in out-of-hospital cardiac arrest appears to be confounded by CPR quality.

Grossman, D. C.; Kim, A.; Macdonald, S. C.; et al

Urban-Rural Differences in Prehospital Care of Major Trauma

Journal of Trauma-Injury Infection & Critical Care, Vol. 42, No. 4, Pg. 723, 1997

See Community Demographics section for abstract.

Hallstrom, A. P.; Ornato, J. P.; Weisfeldt, M.; Travers, A.; Christenson, J.; McBurnie, M. A.; Zalenski, R.; Becker, L. B.; Schron, E. B.; Proschan, M.

Public-Access Defibrillation and Survival after Out-of-Hospital Cardiac Arrest

The New England Journal of Medicine, Vol. 351, No. 7, Pg. 637, 2004

See Prevention section for abstract.

Halpern, J.

Fire Loss Reduction: Fire Detectors vs. Fire Stations

Faculty of Management of the University of Calgary, Alberta, Canada, 1979
Working Paper No. WP-08-79

This 1979 study looked into the cost-benefit analysis of fire detectors versus that of additional fire stations in reducing fire losses. This study applied to single and multi-family occupancies. The data for this study was from Calgary, Canada. The assumption was made that 10 detectors per home were enough. In this manner, the paper concluded that this was a cost-effective alternative to additional fire stations in shortening the response time of critical resources or time to fire department intervention.

Herlitz, J.; Engdahl, J.; Svensson, L.; Anqquist, K. A.; Young, M.; Holmberg, S.

Factors Associated with an Increased Chance of Survival Among Patients Suffering from an Out-of-Hospital Cardiac Arrest in a National Perspective in Sweden

American Heart Journal, Vol. 149, No. 1, Pg. 61, 2005

The basis of this study showed the relative importance of metrics that capture bystander CPR, scene location and response time intervals. This study used out-of-hospital cardiac arrest patients in Sweden who were registered in the Swedish Cardiac Arrest Registry;

about 85% of the Swedish population is registered and has been in place since 1990. Included in the experimental phase were 33,453 patients who suffered cardiac arrest in which CPR was attempted. The study determined that the following variables were predictors of increased survival rates, in order of magnitude: patient found in ventricular fibrillation (odds ratio of 5.3); response time from call to arrival less than the median (3.6); cardiac arrest outside the home (2.2); cardiac arrest witnessed (2.0); bystander CPR (2.0); and age less than or equal to the media (1.6). For out-of-hospital arrests for this study, the survival rate when none of these predictors were present was about 0.4%; when all these predictors were present survival was 23.8%.

Hogg, J.

Losses in Relation to the Fire Brigade's Attendance Times
Scientific Advisory Branch, London, England, 1971

This UK report attempted to predict the value of one minute of fire department response time to property damage. Using 1971 monetary values, the estimate was made that one minute of response time was worth between $25 and $250 for residential occupancies; for industrial and commercial properties, a minute was worth about $2500.

International Association of Fire Fighters/Johns Hopkins University

Analysis of Fire Fighter Injuries and Minimum Staffing Per Piece of Apparatus in Cities With Populations of 150,000 or More
International Association of Fire Fighters, Washington, DC, 1991

The metric of apparatus staffing is identified in this report. This study was a comprehensive analysis of firefighter injuries and minimum staffing levels in a number of cities. The study found that 69% of jurisdictions that maintained crew sizes of fewer than four firefighters had firefighter injury rates of 10 or more per 100 firefighters, while only 38.3% of jurisdictions maintaining crew sizes of four or more firefighters had comparable injury rates. In other words, jurisdictions having crew sizes of fewer than four firefighters suffered a benchmark injury rate at nearly twice the percentage rate of jurisdictions that maintained crew sizes of four or more firefighters.

Israel, C. W.; Hohnloser, S. H.

Automated External Defibrillation in Emergency Medical Systems: What Has Been Achieved and Where to Go?
European Heart Journal, Vol. 27, No. 5, Pg. 508, 2006

The rate of survival after out-of-hospital cardiac arrest is low. It is not known whether this rate will increase if laypersons are trained to attempt defibrillation with the use of automated external defibrillators (AEDs). A prospective, community-based, multicenter clinical trial was conducted in which random community units (e.g., shopping malls and apartment complexes) were assigned to a structured and monitored emergency-response system involving lay volunteers trained in cardiopulmonary resuscitation (CPR) alone or in CPR and the use of AEDs. The primary outcome was survival to hospital discharge. More than 19,000 layperson responders from 993 community units in 24 North American regions participated. The two study groups had similar unit and participant characteristics. Patients with treated out-of-hospital cardiac arrest in the two groups were similar in age (mean, 69.8 years), proportion of men (67 percent), rate of cardiac arrest in a public location (70 percent), and rate of witnessed cardiac arrest (72 percent). No inappropriate shocks were delivered. There were more survivors to hospital discharge in the units assigned to have laypeople trained in CPR plus the use of AEDs (30 survivors among 128 arrests) than there were in the units assigned to have laypeople trained only in CPR (15 among 107); there were only 2 survivors in residential complexes. Functional status at hospital discharge did not differ between the two groups. Training and equipping laypeople to attempt early defibrillation within a structured response system can increase the number of survivors to hospital discharge after out-of-hospital cardiac arrest in public locations. The study concluded that trained laypersons can use AEDs safely and effectively.

Jennings, P. A.; Cameron, P.; Walker, T.; et al
Out-of-Hospital Cardiac Arrest in Victoria: Rural and Urban Outcomes
Medical Journal of Australia, Vol. 185, No. 3, Pg. 135, 2006

See Community Demographics section for abstract.

Johnson, P.F.; Brown, S.K.
Smoke Detection of Smoldering Fires in a Typical Melbourne Dwelling
Fire Technology, Vol. 22, No. 4, Pg. 295, 1986

See Prevention section for abstract.

Kellermann, A. L.; Hackman, B. B.; Somes, G.; Kreth, T. K.; Nail, L.; Dobyns, P.
Impact of First Responder Defibrillation in an Urban EMS System
Annals of Emergency Medicine, Vol. 21, No. 14, Pg. 1708, 1992

This source identifies several metrics: apparatus staffing, response time intervals, bystander CPR and AED intervention. Staffing is implied by the comparison of firefighter and paramedic interventions. This study from 1992 had the purpose of trying to determine the effectiveness of automatic external defibrillators (AED). The methodology used incorporated forty engines from the Memphis Fire Department. For the first 75 days, half of the companies used the AEDs and the other half performed CPR while waiting for paramedics. After the 75 days, these interventions were swapped. Finally, all patients who were successfully resuscitated were followed to the hospital discharge. During the study time period, 431 patients (49%) were found in ventricular fibrillation. Bystander CPR was only found in 12% of cases. Firefighters arrived to the scene a mean of 2.5 minutes faster than dispatched paramedics. In this fast-response urban system, patients treated by an AED were not more likely to be resuscitated (32% versus 34%), survive to hospital admission (31% versus 29%) or survive to hospital discharge (14% versus 10%) than CPR controls. It is concluded that AEDs cannot increase the likelihood of survival enough to account for lack of bystander CPR.

Kokkala, M. A.
Extinguishment of Compartment Fires using Portable Chemical Extinguishers and Water
Fire Safety Journal, Vol. 11, No. 3, Pg. 201, 1986

This study investigated the use of fire extinguishers and water suppression. Experiments were conducted to provide data to Finnish fire officials for the recommendation of portable extinguishers for private use. The lab in which the tests were conducted was 14m x 27m x 18m. The conclusions included the following results: A post-flashover room can be extinguished with a portable fire extinguisher; a fire of almost 5 MW was put out with 1.7 - 4.7 kg of AB-powder. With halon 1211 and B-power, re-ignition occurred. Finally, the limiting factor appeared to be the safety of the extinguisher operator as putting out the fire can lead to disruption of the hot gases. This article showed excellent for showing the importance of extinguishers and gave great detail about their effectiveness in mitigating fire losses.

Litwin, P. E.; Eisenberg, M. S.; Hallstrom, A. P.; Cummins, R. O.
The Location of Collapse and its Effect on Survival from Cardiac Arrest
Annals of Emergency Medicine, Vol. 16, No. 7, Pg. 787, 1987

See Notification section for abstract.

Madrzykowski, D.; Fleming, R.P.
Review of Residential Sprinkler Systems: Research and Standards
National Institute of Standards and Technology, Gaithersburg, MD, 2002
This document provided a good summary of the successful history of residential sprinklers in protecting life and property. It discussed the fire problem, residential

sprinkler research, standards, new technology in sprinkler system designs, incentives for residential sprinklers, and case studies of communities that have had sprinklers mandated for over a decade (at the time of study).

Automatic sprinkler systems have been successfully used to protect industrial and commercial buildings and their occupants for more than 100 years. Historically, the place which has offered the least amount of fire protection to occupants, was and still is their own home. This paper presented an overview of the development of the residential sprinkler system standard, The Standard on the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, NFPA 13D. Significant testing and development of residential sprinkler systems has continued resulting in the evolution of NFPA 13D and the development of the Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height, NFPA 13R. This paper addresses the life-safety objectives of residential sprinkler systems, the differences between a residential system and those for a residential occupancy that is required to be designed in accordance with the Standard for the Installation of sprinkler Systems, NFPA 13. New developments in residential sprinkler system technology continue to be made in an effort to increase the ease of installation and reduce the cost of installation while maintaining the effectiveness and reliability of the system. In several communities, residential sprinkler systems have been required in dwellings for more than a decade. Information from these communities provided compelling data for installing residential sprinklers. These experiences, in addition to code requirements and other incentives, are increasing the numbers of sprinkler installations around the country.

Marshall, S. W.; Runyan, C. W.; Bangdiwala, S. I.; Linzer, M. A.; Sacks, J. J.; Butts, J. D.

Fatal residential fires: Who dies and who survives?

Journal of the American Medical Association, Vol. 279, No. 20, Pg. 1633, 1998

The United States has one of the highest fire fatality rates in the developed world, and three quarters of these deaths are in residential fires. The objective was to compare characteristics of those who die and those who survive in the same residential fire. Data on fatal residential fires were collected from the medical examiner and interviews with local fire officials. Subjects were persons in residential fires with at least 1 fatality in a 1-year period. The main outcome measure was dying versus surviving a fatal residential fire that occurred with more than 1 person at home. Of the 190 decedents, 124 (65%) were male, 78 (41%) were home alone, and 69 (53%) of 130 adults who had blood alcohol measured were intoxicated (blood alcohol content >22 mmol/L [100 mg/dL]).

Of the 254 persons present during fires in which more than 1 person was at home, 112 died. Individuals more likely to die (high-vulnerability group) were younger than 5 years or 64 years or older; had a physical or cognitive disability; or were impaired by alcohol or other drugs. The presence of an adult with no physical or cognitive disabilities who was unimpaired by alcohol or other drugs (a potential rescuer) reduced the risk of death in the high-vulnerability group but not the low-vulnerability group. Overall, a functioning smoke detector lowered the risk of death. It was concluded that smoke detectors were equally effective in both low- and high-vulnerability populations. The high-vulnerability group was more likely to survive if, in addition to a smoke detector, a potential rescuer was present. Further research should seek to identify prompts that facilitate speedy egress from a burning structure and that can be incorporated into residential fire alarm systems.

McManis Associates; John T. O'Hagan and Associates
Dallas Fire Department Staffing Level Study
McManis Associates, Washington, DC, 1984

This 1984 study sought to determine the effect of the number of firefighters on task performance. Three different simulations were used: apartment house fire, high-rise office fire, and private residential fire. Each of the simulations was run 91 times to provide accurate results. Results showed that increased staffing levels improved results. The 5-person crews showed a very coordinated and effective attack and the 4-person crew was capable of performing satisfactorily. However, the 3-person crews were not able to complete all tasks during the given time span.

Menker, W. K.
Predicting Effectiveness of Manual Suppression
MS Thesis, Worcester Polytechnic Institute. 1994

This thesis detailed fire operations and step-by-step actions of the firefighters. Of note are the time-to-task breakdowns for size-up, water supply, equipment selection, entry, locating the fire, advancing hose lines, etc. Also included is the comparison between the predicted times to task and actual times and resources.

Morgan, H.P.; Hansell, G.O.
Fire Sizes and Sprinkler Effectiveness in Offices: Implications for Smoke Control Design
Fire Safety Journal, Vol. 8, No. 3, Pg. 187, 1985

This paper used the UK Fire Statistics Data Base for 1978 and 1979 to compare sprinklered and non-sprinklered offices. The conclusions supported the success of sprinklers. The results from the data collection showed that 10% of fires will exceed 16 m^2 in sprinklered buildings versus 47 square meters in non-sprinklered. Also, the study found that sprinklers were useful in all office types, but were more effective in open layout spaces than cellular offices. The study suggested that sprinklers may reduce the demands on a smoke control system.

There is a trend for many new office buildings to include a smoke ventilation system. This is especially true of 'Atrium' buildings. At present, there are no clear grounds for choosing a fire size on which to base the design of such ventilation systems. This paper drew on the U.K. Fire Statistics Data Base for 1978 and 1979 to establish the proportion of reported fires exceeding any given size (the relative frequency), for both sprinklered and unsprinklered offices. Given a decision about a reasonable proportion of fires growing larger than a particular area, the paper shows how this area can be used to determine whether the fire will be ventilation or fuel-bed controlled. It further showed how the heat carried by the gases leaving the office (e.g., into an atrium) can be estimated by the ventilation system's designer, for either ventilation or fuel-bed controlled fires, whether sprinklered or not. For example, if a relative frequency of 10% is deemed reasonable, the design fire area is 16 square meters sprinklered or 47square meters unsprinklered. The design heat output will vary between 0.3 MW and 4.5 MW depending on the building's circumstances. The study suggested that fitting sprinklers in open plan offices may give a major advantage in reducing the capacity required of a smoke ventilation system, but much less of an advantage for cellular offices. It is also suggested that the British Standard for means of escape from offices is generally successful in preventing casualties.

National Fire Protection Association

Fire Department Calls and False Alarms

National Fire Protection Association, Quincy, MA, 2008

In 2006, U.S. fire departments responded to 2,119,500 false alarms. This was a very slight decrease of 0.7%. This means that one out of ten calls responded to by fire departments were false alarms. This source is particularly valuable in justifying the final use of on-scene resources and scene as found.

Nichol, G.; Stiell, I. G.; Laupacis, A.; Pham, B.; De Maio, V.; Wells, G. A.
A Cumulative Meta-Analysis of the Effectiveness of Defibrillator-capable Emergency Medical Services for Victims of Out-of-hospital Cardiac Arrest
Annals of Emergency Medicine, Vol. 34, No. 4, Pg. 517, 1999

See Notification section for abstract.

Office of the Fire Marshall of Ontario
Fire Ground Staffing and Delivery Systems within a Comprehensive Fire Safety Effectiveness Model
Ministry of the Solicitor General, Toronto, Ontario, Canada, 1993

The Fire Marshal of Ontario completed a study in 1992 to examine the tasks which three- and four- person crews could safely accomplish. This study is a sub-section of a larger "Comprehensive Fire Safety Effectiveness Model." The purpose of this sub-section was to determine how staffing levels affect certain fire ground tasks. It was determined that until additional assistance has arrived, the following cannot be accomplished safely by three-person crews:

-Deployment of back-up protection lines
-Conducting interior suppression or rescue operations
-Ventilation operations requiring access to the roof of the involved structure
-The use of large hand-held hose lines
-The establishment of a water supply from a static source within the time limits

The study found that three-person crews were overworked due to an inability to take sufficient breaks; therefore, they were more at-risk for exhaustion. The study also recommended minimum staffing required for suppression and rescue related tasks.

Olson, D. W.; LaRochelle, J.; Fark, D.; et al

EMT-Defibrillation: The Wisconsin Experience
Annals of Emergency Medicine, Vol. 18, No. 8, Pg. 806, 1989

This study quantified typical response times and their effect on survival. It also gave an upper time limit for the patient data observed. The effectiveness of emergency medical technician-defibrillators (EMT-Ds) in various prehospital settings was investigated in this study. Work previous to this study focused on rural areas and resulted in varied results. The community types for this study ranged from rural to city suburbs. In total 64 ambulance services took part in the data collection that spanned 18 months; during the duration of data collection 566 patients were included. Of these, 36 (6.4%) survived. Response time (as defined by EMS activation until arrival) in this study was seen to be a good predictor of survival. Those that survived had an average arrival time of 3.7 +/- 2.0 minutes, while those that did not survive had an average arrival time of 7.3 +/- 5.8 minutes. The authors found that for this study, there were no survivors when response time eclipsed 8 minutes.

OPALS Pre-Hospital Research Group
*OPALS Pre-Hospital Research Group Annual Statistical Report January - December (2003) (*2004)

This report provided statistics for the 2003 year OPALS cardiac arrest study communities. Relevant statistics included arrest witnessed, person who initiated CPR, defibrillator response time, etc. It provided a large amount of data concerning EMS response systems. Key data included that defibrillator response is less than 8 minutes or less 90% of the time and advanced care paramedic response is less than 11 minutes or less 78% of the time. Also, the data for the communities used showed a “discharged alive” 5.4% of the time.

Pell, J. P.; Sirel, J. M.; Marsden, A. K.; et al
Effect of Reducing Ambulance Response Times on Deaths from Out-of-Hospital Cardiac Arrest: Cohort Study
BMJ (British Medical Journal), Vol. 322, No. 7299, Pg. 1,385, 2001

The objective of this research was to determine the association between ambulance response time and survival from out of hospital cardiopulmonary arrest and to estimate the effect of reducing response times. Data was gathered from all out of hospital cardiopulmonary arrests due to cardiac disease attended by the Scottish Ambulance Service from May 1991 to March 1998. Main outcome measures: Survival rate to hospital discharge and potential improvement from reducing response times. Results: Of 13,822 arrests not witnessed by ambulance crews but attended by them within 15 minutes, complete data were available for 10,554 (76%). Of these patients, 653 (6%) survived to hospital discharge. After other significant covariates were adjusted for, shorter response time was significantly associated with increased probability of receiving defibrillation and survival to discharge among those defibrillated. Reducing the 90th percentile for response time to 8 minutes increased the predicted survival to 8%, and reducing it to 5 minutes increased survival to 10-11% (depending on the model used). The study concluded that reducing ambulance response times to 5 minutes could almost double the survival rate for cardiac arrests not witnessed by ambulance crews.

Phoenix Fire Department
Fire Department Evaluation System - Benchmark Structure Fire (FIREDAP)
Phoenix Fire Department, Phoenix, AZ, 1992

This Phoenix Fire Department report went through the protocol on responding to structure fires. This report looks at the staffing, objectives, task breakdowns, and times for evaluations for structure fires. The responsibilities of the responding fire department members were also outlined in the order that they should be accomplished. Although there will surely be discrepancies between department protocols, this report gave a solid basis from which to evaluate 'typical' actions in a structure fire. For full-scale simulation of firefighter activities this resource is a very effective starting point from which to construct experimental focus.

Ramachandran, G.
Probability-based Building Design for Fire Safety
Fire Technology, Vol. 31, 39511, Pg. 265, 1995

The paper used a probability-based methodology for safe design of buildings by minimizing property damage and lives lost. The analysis given was excellent because it quantified the effectiveness of sprinklers in reducing the amount of loss caused by fires. This reference provides a clear need to include sprinkler activation as a metric. This paper provided a figure that depicts damage (square meters) by total floor area of building (square meters) for sprinklered and non-sprinklered buildings. According to the calculations, "sprinklers would reduce the maximum damage to 1,000 square meters and 1,200 square meters in buildings of 8,000 square meters and 10,000square meters, respectively." Also, Ramachandran found that sprinklers would reduce the probability of fire spreading beyond the room of origin to 0.02.

Rees, G.

Automatic Sprinklers, their Value and Latest Developments
Fire Surveyor, Vol. 20, No. 5, Pg. 9, 1991

The data for some of this report came from Factory Mutual Research Corporation for the years 1980-1989. The results stated that "the average loss where adequate sprinkler protection is provided is $140,000, versus over $600,000 where sprinkler protection was either incomplete or not provided." The paper also gives data breakdowns on how many sprinkler heads are necessary. Twenty-eight percent (28%) of recorded fires were controlled by only one, 69% of fires were controlled by 5 or less, and 89% were controlled by 15 heads or less." Similar to Ramachandran's analysis given in the previous reference, this article justified including a sprinkler activation metric with a good quantification of the reduction of fire losses.

Ritter, G.; Wolfe, R. A.; Goldstein, S.; et al

American Heart Journal, Vol. 110, No. 5, Pg. 1, 1985

This study supported the need to capture bystander CPR. Two thousand one hundred and forty two (2,142) emergency medical service cardiac arrests runs were used to determine the role of bystander CPR on survival. Cardiac arrest patients that received bystander CPR showed survival rates of 22.9% to hospital admission and 11.9% to hospital discharge. Those patients that did not receive bystander CPR had survival rates of 14.6% to hospital admission and 4.7% to hospital discharge. Ventricular fibrillation occurred more often in patients who had received bystander CPR when emergency personnel arrived; this was seen as a major contributor to higher survival rates.

Roberts, B.

Austin Fire Department Staffing Study
Austin Fire Department, Austin, TX, 1993

In 1993, the Austin Fire Department conducted a study to determine whether companies staffed with four firefighters were safer and more effective than the three-person companies. In order to compare the effectiveness of fire companies, the physiological impact on firefighters and injury rates at various staffing levels, Austin Fire Department conducted drills consisting of a series of common fireground tasks. These simulations revealed that regardless of the experience, preparation or the training of firefighters, loss of life and property increases when a sufficient number of personnel are not available to conduct the required tasks efficiently. The Austin Fire Department concluded that firefighter effectiveness significantly improves when a company is increased from three to four personnel. In the two-story residential fire, the efficiency or time improvement between the three-person and four-person crew was 73%. In the aerial ladder evolution, the efficiency improvement between three-person and four-person crews was 66%. In the high-rise fire, the efficiency improvement between the three-person and four-person engine company crew was 35%.

Rohr, K. D.; Hall Jr., J.

U.S. Experience with Sprinklers and other Fire Extinguishing Equipment
National Fire Protection Association, Quincy, MA, 2005

According to this report, in 2005 several relevant conclusions were formed. In sprinklered properties, the chances of dying in a fire are reduced by one-half to three-fourths and the average property loss is cut by one-half to two-thirds. In 7% of sprinklered properties they failed to operate in fires large enough to activate them; of this 7%, nearly all of it was due to system shut-offs and human errors. This publication found that sprinklers dramatically affected civilian fire deaths. Public assembly and education occupancies reported no fire deaths in sprinklered properties during this time period. According to this report, direct property loss averted by sprinklers is as follows: 53% for stores and offices, 64% for manufacturing properties, 66% for healthcare facilities for the aged or sick, and 70% for public assembly occupancies. In addition, this report characterized other important extinguishing means such as dry chemical systems, foam systems, and CO_2 systems.

Sardqvist, S.; Holmstedt, G.

Correlation Between Firefighting Operation and Fire Area: Analysis of Statistics
Fire Technology, Vol. 36, No. 2, Pg. 109, 2000

The purpose of this study was to determine where fire brigade statistics could quantify the benefits of fire brigades. The article contained very useful quantifications of the effectiveness of manual suppression in stopping fire loss. This study involved 307 fires in non-residential buildings during the time period between 1994 and 1997. The main conclusions included the following:

1. "The automatic fire alarm failed in one-fifth of the fires in systems where a system was present."

2. "In half of the fires, the final fire area was equal to the area at detection. In three-quarters of the fires, the final area was equal to the area of the fire when the brigade arrived."

3. Both water flow-rate to extinguishment and water application time were determined to be proportional to the square root of the final fire area.

4. "Total water demand was proportional to fire area."

5. "An automatic sprinkler system contained or extinguished 17 of the 21 fires in which such as system was present. 14 fires were contained by one to three sprinklers. In each of the 14 fires, the system was in working order and covered the fire area, and no flammable liquids were present."

6. Sprinklers that did not effectively suppress the fire were either non-functioning or were not located over the fire.

Shuster, M.; Keller, J. L.

Effect of Fire Department First-Responder Automated Defibrillation

Annals of Emergency Medicine, Vol. 22, No. 4, Pg. 721, 1992

The objective of this study was to examine the effect of fire department first-responder defibrillation on time to defibrillation in a mid-sized community with two tiers of emergency medical services (EMS) ambulance response. The study area was the region of Hamilton-Wentworth, which has more than 445,000 inhabitants and covers 1,136 square meters (438 square miles). Two hundred ninety seven (297) victims of out-of-hospital cardiac arrest presenting to the EMS system between May 1, 1990, and April 30, 1991 were studied. The mean defibrillation interval was decreased from 11.96 minutes to 8.50 minutes by the introduction of fire first-responder defibrillation. Survival was significantly greater with bystander-witnessed arrest, initial rhythm of ventricular fibrillation, and presence of a pulse on arrival in the emergency department. In this EMS system, fire first-responders were able to provide defibrillation in significantly shorter times than ambulance attendants. Other EMS systems should review their response times and consider instituting first-responder defibrillation as one means of reducing defibrillation intervals.

Siarnicki, R. J.

Residential Sprinklers: One Community's Experience Twelve Years after Mandatory Implementation

National Fire Academy, Emmitsburg, MD, 2001

This report's purpose was to look at the effect of a mandatory residential sprinkler ordinance in Prince George's County, Maryland. In this county, all new residential construction requires sprinklers. During the time period of the study, there were 117 residential sprinkler reported fire incidents. Total fire losses for these events were $401,220. According to predictions in the report, the estimated losses would have exceeded $38 million if these buildings were not sprinklered. Also estimated, sprinklers saved 154 lives during the twelve year time period. Seven injuries occurred in sprinklered properties, all of which were minor in nature.

Spaite, D. W.; Hanlon, T.; Criss, E. A.; et al

Pre-hospital Cardiac Arrest: The Impact of Witnessed Collapse and Bystander CPR in a Metropolitan EMS System with Short Response Times
Annals of Emergency Medicine, Vol. 19, No. 11, Pg. 1,264, 1990

Numerous studies have shown initiation of bystander CPR to significantly improve survival from pre-hospital cardiac arrest. Previous emergency medical services (EMS) systems with very short response times had shown that bystander CPR had not impacted outcome. The purpose of this study was to determine the effect of bystander CPR on survival from out-of-hospital cardiac arrest in such a system. Pre-hospital, hospital, and death certificate data from a medium-sized metropolitan area were retrospectively analyzed for adult, non-traumatic cardiac arrest during a 16-month period. A total of 298 patients met study criteria. One hundred ninety-five (195) arrests (65.4%) were witnessed, and 103 (34.6%) were unwitnessed. Twenty-five (25) witnessed victims (12.8%) were discharged alive, whereas no unwitnessed victims survived. Patients suffering a witnessed episode of ventricular fibrillation/tachycardia (VF/VT) were more likely to survive (21.9%) than were other patients (2.0%). Among witnessed patients, initiation of bystander CPR was associated with a significant improvement in survival (20.0%) compared with the no-bystander CPR group (9.2%). Bystander CPR was also associated with improved outcome when witnessed patients with successful pre-hospital resuscitation were evaluated as a group; 18 had bystander CPR, of whom 13 (72.2%) survived compared with only 12 of 38 patients with no bystander CPR (31.6%). Our data revealed improved survival rates when bystander CPR was initiated on victims of witnessed cardiac arrest in an EMS system with short response times.

Steill, I.; Nichol, G.; Wells, G.; De Maio, V.; Nesbitt, L.; Blackburn, J.; Spaite, D.

Health-related Quality of Life is Better for Cardiac Arrest Survivors who Received Citizen Cardiopulmonary Resuscitation
Circulation, Vol. 108, No. 16, Pg. 1939, 2003

This study was completed prospectively involving 20 communities for out-of-hospital patients who survived one year. This reference held unique value in that the length of observation after cardiac arrest is longer than typically carried out for a survival after cardiac arrest study. Information was retrieved from these patients via telephone conversations; the study used the Health Utilities Index Mark III to evaluate the patients' health statuses. Two hundred sixty-eight (268) of 316 one-year survivors were successfully contacted. Two factors were determined to be good indicators of a very good quality life. These were "age 80 years or older" and "citizen-initiated CPR." This shows the importance of capturing age as well as bystander CPR intervention.

Stevenson, M. R.; Lee, A. H.

Smoke Alarms and Residential Fire Mortality in the United States: An Ecologic Study.

Fire Safety Journal, Vol. 38, No. 1, Pg. 43, 2003

Death and injury from residential fires remains a major public health challenge in the United States and operable smoke alarms on each level of a home have been estimated to reduce the risk of death and injuries from residential fires. A multiple-group analytic ecologic study was undertaken with ecologic data at both the group- and individual-level for each state of the United States. The age- standardized mortality rates for residential fire in the U.S. was 1.61 per 100,000, with the highest fire-mortality rates occurring in the southeastern states of the US. An estimated 93.6% of U.S. households have a smoke alarm. The findings of the analysis highlighted that smoke alarms, when represented at an ecologic-level, have a significant, negative, association with residential fire mortality. The finding of a negative ecologic association between smoke alarms and residential fire mortality reflects findings reported in studies using individual-level data, namely, that operable smoke alarms provided adequate warning and protection against death in residential fires.

Stiell, I. G.; Wells, G. A.; Spaite, D. W.; et al

OPALS Study Phase III: What is the Impact of Advanced Life Support on Out-of-Hospital Cardiac Arrest?

Academic Emergency Medicine, Vol. 10, No. 5, Pg. 423, 2003

This study compared a community's cardiac arrest victims during 12 months of BLS-D rapid defibrillation and 36 months of ALS. This study showed that staffing and final deployment of resources should be captured so that similar such analysis can be carried out to determine the effects of ALS interventions. This process was conducted in 17 communities. The primary outcome was survival to hospital discharge. The results showed that the difference in survival rates between BLS-D and ALS did not change

(5.0% vs. 5.1%). This study showed that ALS measures did not increase patient survival, compared to a previously optimized rapid defibrillation BLS system.

Sweeney, T. A.; Runge, J. W.; Gibbs; et al

EMT Defibrillation Does Not Increase Survival from Sudden Cardiac Death in a Two-Tiered Urban-Suburban EMS System
Annals of Emergency Medicine, Vol. 31, No. 2, Pg. 234, 1998

See Notification section for abstract.

U.S. Fire Administration/National Fire Data Center

Structure Fire Response Times
U.S Department of Homeland Security, Emmitsburg, Maryland, 2006
Topical Fire Research Series, Volume 5 - Issue 7

This report looked at structure fire response times across the U.S. findings are regardless of region, season, or time of day. Structure fire response times are generally less than 5 minutes half the time. The nationwide 90th percentile response time to structure fires is less than 11 minutes. Structure fires in the Northeast have the lowest response times while those in the West have the highest. Average structure fire response times show a relationship between flame spread and longer response times, but only after flames have spread beyond the room of origin. As a result of these findings, the report provided a relatively useful perspective on fairly recent response time data. This could potentially be used with other sources that address fire severity vs. time, to produce additional useful analyses.

U.S. Fire Administration

Fire Death Rate Trends: An International Perspective
Federal Emergency Management Association, Emmitsburg, MD, 1997

This document provided a comparison of the U.S. fire death rate to other industrialized nations. Globally, the U.S. has one of the highest fire death and loss rates, based on the data taken from 1979-1992. Specifically, this report stated that the focus of fire protection in the U.S. is on response instead of mitigation. For example, goal response times in foreign countries for fire personnel might be as high as 20 to 30 minutes. Such times in the U.S. would be unacceptable. Despite these statistics, fire death rates are lower in these countries than the U.S. This is largely due to the fact that foreign countries focus more of their resources on prevention programs, something the U.S. does not do. Other industrialized countries spend between four and ten percent of total firefighting budget on prevention measures; conversely, U.S. departments tend to allocate three percent for such programs. In order to make this type of useful analysis, response time related metrics must be included into the model.

Vadeboncoeur, T.; Bobrow, B. J.; Clark, L.; Kern, K. B.; Sanders, A. B.; Berg, R. A.; Ewy, G. A.

The Save Hearts in Arizona Registry and Education (SHARE) Program: Who is Performing CPR and Where are They Doing It?
Resuscitation, Vol. 71, No. 5, Pg. 68, 2007

Bystander cardiopulmonary resuscitation (CPR) decreases mortality from out-of-hospital cardiac arrest significantly. Accordingly, layperson CPR is an integral component in the chain of survival for out-of-hospital cardiac arrest victims. The objective was to determine true incidence and location of layperson CPR in the State of Arizona. The Save Hearts in Arizona Registry and Education (SHARE) program reviewed EMS first care reports submitted voluntarily by 30 municipal fire departments responsible for approximately 67% of Arizona's population. In addition to standard Utstein style data, information regarding the performance of bystander CPR, the vocation and medical training of the bystander and the location of the arrest were documented. The total number of out-of-hospital adult arrests of presumed cardiac etiology reported statewide was 1,097. Cardiac arrests occurred in private residences in 67%, extended care or medical facilities in 18%, and public locations in 15%. Bystander CPR was performed in 37% of all arrests, 24% of residential arrests, 76% of extended care or medical facility arrests, and 52% of public arrests. Bystander CPR provided an odds ratio of 2.2 for survival [95% CI 1.2-4.1]. Excluding cardiac arrests which occurred in the presence of bystanders with formal CPR training as part of their job description, layperson CPR was performed in 218 of 857 (25%) of cases. The near statewide incidence of layperson CPR is extremely low. This low rate of bystander CPR is likely to contribute to the low overall survival rates from cardiac arrest.

Vaillancourt, C.; Stiell, I. G.; Wells, G. A.; De Maio, V. J.

Mathematical Model Predicting the Potential Impact of Various Community Bystander CPR Rates on Overall Survival from Cardiac Arrest
Academic Emergency Medicine, Vol. 10, No. 5, Pg. 503, 2003

See Prevention section for abstract.

Valenzuela, T. D.; Roe, D. J.; Cretin, S.; Spaite, D. W.; Larsen, M. P.
Estimating Effectiveness of Cardiac Arrest Interventions: A Logistic Regression Survival Model
Circulation, Vol. 96, No. 10, Pg. 3,308, 1997

The study objective was to develop a simple, generalizable predictive model for survival after out-of-hospital cardiac arrest due to ventricular fibrillation. Logistic regression analysis of two retrospective series (n=205 and n=1667, respectively) of out-of-hospital cardiac arrests was performed on data sets from a Southwestern city (population, 415,000; area, 406 square kilometers) and a Northwestern county (population 1,038,000; area 1,399 square kilometers). Both were served by similar two-tiered emergency response systems. All arrests were witnessed and occurred before the arrival of emergency responders, and the initial cardiac rhythm observed was ventricular fibrillation. The main outcome measure was survival to hospital discharge. Patient age, initiation of CPR by bystanders, interval from collapse to CPR, interval from collapse to defibrillation, bystander CPR/collapse-to-CPR interval interaction, and collapse-to-CPR/collapse-to-defibrillation interval interaction were significantly associated with survival. There was not a significant difference between observed survival rates at the two sites after control for significant predictors. A simplified predictive model retaining only collapse to CPR and collapse to defibrillation intervals performed comparably to the more complicated explanatory model. The effectiveness of pre-hospital interventions for out-of-hospital cardiac arrest may be estimated from their influence on collapse to CPR and collapse to defibrillation intervals. A model derived from combined data from two geographically distinct populations did not identify site as a predictor of survival if clinically relevant predictor variables were controlled. This model can be generalized to other US populations and used to project the local effectiveness of interventions to improve cardiac arrest survival.

Valenzuela, T.; Roe, D.; Nichol, G.; et al
Outcomes of Rapid Defibrillation by Security Officers after Cardiac Arrest in Casinos
The New England Journal of Medicine, Vol. 343, No. 17, Pg. 1,206, 2000

The use of automated external defibrillators by persons other than paramedics and emergency medical technicians is advocated by the American Heart Association and other organizations. However, there is little data on the outcomes when the devices are used by nonmedical personnel for out-of-hospital cardiac arrest. A prospective series of cases of sudden cardiac arrest in casinos was studied. Casino security officers were instructed in the use of automated external defibrillators. The locations where the defibrillators were stored in the casinos were chosen to make possible a target interval of three minutes or less from collapse to the first defibrillation. Protocol called for a defibrillation first (if feasible), followed by manual cardiopulmonary resuscitation. The primary outcome was survival to discharge from the hospital. Automated external defibrillators were used, 105 patients whose initial cardiac rhythm was ventricular fibrillation. Among the 90 patients whose collapse was witnessed (86 percent), the clinically relevant time intervals were a mean (+/-SD) of 3.5+/-2.9 minutes from collapse to attachment of the defibrillator, 4.4+/-2.9 minutes from collapse to the delivery of the first defibrillation shock, and 9.8+/-4.3 minutes from collapse to the arrival of the paramedics. The survival rate was 74 percent for those who received their first defibrillation no later than three minutes after a witnessed collapse and 49 percent for those who received their first defibrillation after more than three minutes. Rapid defibrillation by nonmedical personnel using an automated external defibrillator can improve survival after out-of-hospital cardiac arrest due to ventricular fibrillation. Intervals of no more than three minutes from collapse to defibrillation are necessary to achieve the highest survival rates.

Van Hoeyweghen, R. J.; Bossaert, L. L.; Mullie, A.; Calle, P.; Martens, P.; Buylaert, W. A.; Delooz, H.
Quality and Efficiency of Bystander CPR. Belgian Cerebral Resuscitation Study Group
Resuscitation, Vol. 26, No. 1, Pg. 47, 1993

This paper focused on the role of bystander CPR on cardiac arrest victim survival rates. More detail is considered than the community risk model because this study also considers CPR quality, but this does provide potential direction for future development. 3,306 out-of-hospital cardiac arrests were evaluated in this study; 885 of these cardiac arrest patients received bystander CPR. The type of CPR given by bystanders varied as 52% performed CPR correctly, 11% performed incorrectly, 31% performed external chest compressions (ECC) only, and 6% performed mouth-to-mouth ventilation (MMV) only. Long term survival, which was characterized as the patient being awake 14 days after CPR, was 16% in patients with proper bystander CPR, 10% when ECC was performed, 2% when MMV was performed. When no bystander CPR was involved, there was a 7% survival rate 14 days later. When CPR was performed improperly 4% of victims survived. It is important to note that a negative effect of improperly performed CPR was not observed compared to when no bystander CPR was performed at all.

Wik, L.; Hansen, T. B.; Fylling, F.; et al

Delaying Defibrillation to Give Basic Cardiopulmonary Resuscitation to Patients with Out-of-Hospital Ventricular Fibrillation: A Randomized Trial

Journal of the American Medical Association, Vol. 289, No. 11, Pg. 1,389, 2003

Defibrillation as soon as possible is standard treatment for patients with ventricular fibrillation. A nonrandomized study indicated that after a few minutes of ventricular fibrillation, delaying defibrillation to give cardiopulmonary resuscitation (CPR) first might improve the outcome. Objective: To determine the effects of CPR before defibrillation on outcome in patients with ventricular fibrillation and with response times either up to or longer than 5 minutes. It was a randomized trial of 200 patients with out-of-hospital ventricular fibrillation in Oslo, Norway, between June 1998 and May 2001. Patients received either standard care with immediate defibrillation (n = 96) or CPR first with 3 minutes of basic CPR by ambulance personnel prior to defibrillation (n = 104). If initial defibrillation was unsuccessful, the standard group received 1 minute of CPR before additional defibrillation attempts compared with 3 minutes in the CPR- first group. The primary end point was survival to hospital discharge. Secondary end points were hospital admission with return of spontaneous circulation (ROSC), 1-year survival, and neurological outcome. A prespecified analysis examined subgroups with response times either up to or longer than 5 minutes. Results: In the standard group, 14 (15%) of 96 patients survived to hospital discharge vs. 23 (22%) of 104 in the CPR first group. There were no differences in ROSC rates between the standard group (56% [58/104]); or in 1-year survival (20% [21/104] and 15% [14/96], respectively). In subgroup analysis for patients with ambulance response times of either up to 5 minutes or shorter, there were no differences in any outcome variables between the CPR first group (n = 40) and the standard group (n = 41). For patients with response intervals of longer than 5 minutes, more patients achieved ROSC in the CPR first group (58% [37/64]) compared with the standard group (38% [21/55]); survival to hospital discharge (22% [14/64] vs. 4% [2/55]); and 1-year survival (20% [13/64] vs. 4% [2/55]). Thirty-three (89%) of 37 patients who survived to hospital discharge had no or minor reductions in neurological status with no difference between the groups. Compared with standard care for ventricular fibrillation, CPR first prior to defibrillation offered no advantage in improving outcomes for this entire study population or for patients with ambulance response times shorter than five minutes. However, the patients with ventricular fibrillation and ambulance response intervals longer than five minutes had better outcomes with CPR first before defibrillation was attempted. These results require confirmation in additional randomized trials.

Outcomes

Ahrens, M.

Home Structure Fires
National Fire Protection Association, Quincy, MA, 2007

See Community Demographics section for abstract.

Ahrens, M.

U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment
National Fire Protection Association, Quincy, MA, 2007

See Prevention section for abstract.

Backoff, R. W.; et al

Firefighter Effectiveness - A Preliminary Report
Columbus Fire Division, The Ohio State University, 1980

Decreasing staffing resources for delivery of emergency services is researched. The three metrics which were determined to be significant were: firefighter injuries, dollar value of property loss, and square feet of fire spread after arrival of the fire suppression units. Most fires investigated in the study were contained in less than one hour. For both A and B studies, the number of initial firefighters originally deployed (more or less than the design number) were not found to affect firefighter injuries. “A” and “B” studies were defined as the presence of more or less than a predetermined threshold number of personnel on the fireground. The relationship between the initial number deployed and the proportion of incidents in which dollar losses exceeded $5,000 was investigated. For the A response, a $5,000 loss occurred in 43% of the cases when deployment was 14 or fewer; for 15 or more people deployed, the proportion was 46%. For the B response, the proportions for the 23 or fewer and 24 or more were 59% and 34%, respectively. The horizontal fire spread was also investigated. It was found that for the A response, the proportion of spread greater than 25 square feet was 35% for 14 or fewer and only 29% for 15 or greater. The B response showed a similar trend in that spread occurred for 35% of fires involving 22 or fewer firefighters and 29% for 23 or more. The paper concluded that the magnitude of the initially deployed force affects the efficiency of fire suppression.

Brassell, L.D.; Evans, D.D.
Trends in Firefighter Fatalities Due to Structural Collapse, 1979-2002
National Institute of Standards and Technology, Gaithersburg, MD, 2003

Between the years 1979 and 2002 there were over 180 firefighter fatalities due to structural collapse, not including those firefighters lost in 2001 in the collapse of the World Trade Center Twin Towers. Structural collapse is an insidious problem within the fire fighting community. It often occurs without warning and often results in multiple fatalities. As part of a larger research program to help reduce firefighter injuries and fatalities the U.S. Fire Administration (USFA) funded the National Institute of Standards and Technology (NIST) to examine records and determine if there were any trends or patterns that could be detected in firefighter fatalities due to structural collapse. If so, this information may be valuable immediately in training or incident command to increase safety of firefighters.

Data for firefighter structural fire deaths were investigated for the years between 1994 and 2002. This data was taken from USFA National Fallen Firefighters Memorial Database, NFPA, and the National Institute for Occupational Safety and Health (NIOSH). This work was also compared to statistics from 1979-2002 to more accurately compare trends. The work focused on several parameters for each incident that were predicted to correlate someway with structural fire deaths. They include property type, age, years of experience, status (career or volunteer), nature and cause of death, and activity at time of death. The number of collapse fatalities has decreased since 1979. According to historical data, the percentage of collapse fatalities in residential occupancies has increased. 65% of structural collapse fatalities occur during the fire attack. Over half of the fire collapse deaths occurred during the first 3 months of the calendar year and over 42% occurred between the hours of midnight and 8am.

Brennan, P.; Thomas, I.
Victims of Fire? Predicting Outcomes in Accidental Fires
Boston
Second International Symposium on Human Behaviour in Fire, 36951

See Community Demographics section for abstract.

Clark, Bill

Is There Safety In Numbers?

Fire Engineering, No. 147, Pg. 24, 1994

This journal looked into the results of decreased staffing throughout the years. According to one nationwide study ("Survey of Fire Suppression Crew Practices, Centaur Associates, Wash., DC 1982"), in 1982 engine and truck companies in cities with populations 100,000 and over were staffed with an average of 3.8 people, including officer and driver. The journal also determined that the increase in physical stress on firefighters could lead to heart problems. The article cites that "firefighter injuries occurred more often when the total number of personnel on the fire ground was less than 15 at residential fires and 23 at large-risk fires" from the 1980 Ohio State University study "Firefighter Effectiveness - A Preliminary Report."

Cushman, J.

Report to Executive Board, Minimum Manning as Health & Safety Issue

Seattle, WA Fire Department, Seattle, WA, 1981

See Response Capacity section for abstract.

This study analyzed the link between staffing and firefighter injuries by reviewing the average severity of injuries suffered by engine companies. The study concluded "this analysis indicated that the rate of firefighter injuries expressed as total hours of disability per hours of fire ground exposure were 54% greater for engine companies staffed with 3 personnel when compared to those staffed with 4 firefighters, while companies staffed with 5 personnel had an injury rate that was only one-third that associated with 4-person companies."

Fahy, R. F.; LeBlanc, P. R.; Molis, Joseph L.

Firefighter Fatalities in the United States - 2006

National Fire Protection Association, Quincy, MA, 2007

In 2006, there were a total of 89 on-duty firefighter deaths in the U.S. - a slight increase over the 87 in 2005. As with previous years, the most fire deaths (38) occurred on the fire ground. Over the past 25 years, medical histories have been available for 713 of 1,177 firefighter cardiac arrest victims. Six hundred three (603) (85%) of the 713 victims had prior medical conditions that would have hinted towards heart problems. Such conditions included prior heart attacks, severe atherosclerotic heart disease, bypass surgery, angioplasty/stent placement, and diabetes. It should be noted that the number of on-duty deaths is reported via NFPA's criteria, which is death from any injury sustained in the line of duty.

Fahy, Rita F.
U.S. Firefighter Deaths Related to Training, 1996-2005
National Fire Protection Association, Quincy, MA, 2006

Training is a vital part of fire department operations, but it too often results in deaths and injuries. Although the number of fire-scene deaths has decreased over the years, the same is not true for training deaths as it has stayed more or less constant. The report further delved into specific training types and which ones resulted in the greatest number of deaths. Between 1996 and 2005, 100 firefighters in the U.S. died while engaged in training related activities (10 percent of all on-duty firefighter deaths). The deaths occurred during a broad range of activities, including apparatus and equipment drills; physical fitness; live fire training; underwater/dive training; and while attending classes or seminars.

Fahy, Rita F.
U.S. Firefighter Fatalities Due to Sudden Cardiac Death, 1995-2004
National Fire Protection Association, Quincy, MA, 2005

This report looked into cardiac arrest fatalities in the fire service. It determined that over the time period observed (1995-2004), both total fatalities and fatalities caused by cardiac arrest have decreased. The total amount of fatalities from sudden cardiac death during this study period was 440 (43.7 of total 1,006). It also pointed out that over 50% of deaths during training were due to cardiac arrest. Also, a graphical comparison is provided showing that the number of deaths in career firefighters have decreased from 1977-2004, while the number of deaths in volunteer firefighters has stayed more or less the same.

Fahy, Rita F.; LeBlanc, Paul R.
U.S. Firefighter Fatalities for 2005
NFPA Journal, July/August, 2006

This report documented firefighter fatalities in the U.S. for the year 2005, and showed the distribution of the types of duty for the 87 firefighter deaths. This was the third lowest total since 1977. Less than one-third of deaths occurred on the fire ground - stress and overexertion continue to be the leading causes of fatal injury. It is also noteworthy that 26 firefighter deaths were attributed to responding and returning from alarms and 25 deaths occurred during fireground operations.

Fahy, Rita F.; LeBlanc, Paul R.; Molis, Joseph L.
What's Changed over the Past 30 Years?
National Fire Protection Association, Quincy, MA, 2007

This study analyzed firefighter fatality statistics over the last 30 years. These deaths are categorized and discussed in the following sections: sudden cardiac death, deaths at structure fires, deaths related to wildland fires, deaths in road vehicle crashes, falls from apparatus while responding to or from alarms and deaths during training activities. During the past 30 years, the average number of firefighter deaths has dropped by one-third. On-duty sudden cardiac deaths have decreased by more than one-third; yet they still remain the leading cause of on-duty firefighter deaths. More training deaths have happened in the last 10 years than the first 10 years. About half of these deaths were attributed to cardiac arrest. Also, this report found that from 1978 to 2005, the firefighter death rate at structure fires had only decreased a small amount.

Flynn, J.
U.S. Structure Fires in Industrial and Manufacturing Properties
National Fire Protection Association, Quincy, MA, 2007

Industrial and manufacturing properties include utility, defense, agriculture and mining properties, and manufacturing and processing properties. In 2000-2004, U.S. fire departments responded to an estimated average of 12,000 fires in these properties. These fires caused an annual average of 17 civilian deaths, 365 civilian fire injuries, and $747 million in direct property damage. Fires in these properties accounted for 2.3% of all reported structure fires within the same time period. These estimates are based on data from the U.S. Fire Administration's (USFA) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA) annual fire department experience survey. Shop tools or industrial equipment were involved in 15% of reported fires and the processing or manufacturing area was the leading area of origin for these fires. Ten percent of fires in these properties began with flammable or combustible liquids or gases, filters, or piping and caused 28% of the civilian fire deaths and 35% of the civilian fire injuries. An average of 42,600 outside and other fires were reported per year at these properties, this is more than 3.5 times the reported industrial and manufacturing property structure fire total.

Flynn, J.
U.S. Structure Fires in Office Properties
National Fire Protection Association, Quincy, MA, 2007

The events of September 11, 2001 are not included in these statistics. These estimates are based on data from the U.S. Fire Administration's (USFA) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA) annual fire department experience survey. Forty-one percent of fires reported in office properties occurred in single-story buildings. Most (71%) of the reported fires in office properties began on the first floor, regardless of the number of stories in the building. Cooking was the leading cause of these structure fires and 20% of the fires in these establishments began in kitchens or cooking areas. Only 11% of office property fires started in offices themselves.

Ford, J.
15 Years of Built-In Automatic Fire Sprinklers: The Scottsdale Experience
Scottsdale Rural/Metro Fire Department, Scottsdale, AZ, 2001

This report provided statistics fifteen years after a residential sprinkler ordinance took effect in 1986 in Scottsdale, Arizona. During the 15 years, the civilian fire fatality rate fell by at least 50% "with at least thirteen lives saved as a result of built-in fire sprinkler protection." Property losses due to fire in the area also decreased dramatically. The average property loss for a fire incident in a sprinklered building was over 90% less than that for a nonsprinklered building. One to two sprinkler heads controlled the fire in 92% of incidents. The report goes on to give greater details, providing sprinkler activations by occupancy type and average losses for sprinklered and unsprinklered properties.

Gerard, John C.; Jacobsen, A. Terry
Reduced Staffing: At What Cost?
Fire Service Today, 29830, Pg. 15, 1981

See Response Capacity section for abstract.

Glazner, Linda K.
Factors related to injury of shift working fire fighters in the Northeastern United States
Safety Science, Vol. 21, No. 3, Pg. 255, 1996

Firefighters, who provide society with an essential and life-saving service, are subjected to the effects of shift work and to the demands (physical and mental) and dangers of their profession, all of which can contribute to injuries. To identify factors involved in injuries to firefighters, the timing, frequency, types, and places of occurrence of injuries sustained by firefighters in three different municipal fire departments were examined. Data was obtained from analysis of Workers' Compensation forms. The most frequent injuries involved inhalation of hazardous materials and lacerations. Ninety-two percent of the injuries occurred at the fire scene, and their causes were related to fire fighting duties, such as rescue, extinguishment and overhaul. Although only 54% of fire alarms nationwide occurred from 12:00 to 16:00 and from 18:00 to 24:00 (42% of a 24-hour day), 68% of the injuries sustained by the firefighters studied occurred during these time periods. At an alarm, at meal time or on-the-night-shift firefighters were more likely to be injured. Serious injuries were more prevalent at standardly accepted meal-times. The timing of the highest frequencies of injuries suggests that, due to the shift work nature of firefighting, both disruption of eating patterns and fatigue, increase the risk of work-related injury to firefighters. By understanding the contribution of factors, especially human ones, such as altered metabolism (due to disruption) and fatigue (due to time elapsed since awakening, alteration/disruption of sleep-wake pattern, or hypoglycemia), interventions can be developed, which should decrease the incidence of injuries to firefighters.

Gomberg, A.; Clark, L. P.
Rural and Non-Rural Civilian Residential Fire Fatalities in Twelve States
National Bureau of Standards, Gaithersburg, MD, 1982
NBSIR 82-2519

The results of an analysis of fire causal factors in over 1600 fire fatalities were presented. The primary emphasis was on the identification of fire causes leading to demonstrated high fatality rates in rural areas. It was found that the most significant cause of rural fire fatalities was heating equipment, with improper installation and misuse of solid fueled heating equipment predominating. Other fire causes making significant contributions to high rural fatality rates were also investigated and documented. Additional data are currently being collected to enable further evaluation of rural fire problems.

This paper focused on the difference between rural and non-rural fire death rates using data from a one year time period. Data on 1,797 fire deaths from twelve states were collected from the fire marshals' (or equivalent) office for both rural and non-rural representations. Results showed that at the time of study, rural areas had fire fatality rates of 2.5 times those of non-rural areas. Misuse of solid fueled heating equipment was found to be the most significant rural fire problem. Also, the study concluded that the socioeconomics also played a major role in the increased fire fatality rates.

Goodchild, M.; Nana, G.; Sanderson, K.
An Economic Assessment of Industrial Fires in New Zealand
Business and Economic Research Ltd, Wellington, New Zealand, 2002
Vol. 28

This study was undertaken on behalf of the New Zealand Fire Service Commission with funding from the Contestable Research Fund. The objective of this study was to make an assessment of the economic impact of industrial fires in New Zealand. This assessment was made using a common applied economic research technique known as an Economic Impact Assessment (EIA) to measure the direct and indirect economic costs associated with industrial fires. The EIA allows the indirect (supply-chain) impact of changes in business activity due to industrial fire incidents to be measured in terms of changes in economic output and employment.

Insurance data was collected from major fire and insurance companies along with FRIS data from New Zealand. This paper provided some insight into which industries are the most "at-risk." For the year 2000, the agriculture, fishing, and mining sector recorded direct losses due to fire of $18.0 million. This was followed by processing and manufacturing and local trade. Also included is a section on measuring indirect risk associated with fire losses such as business interruption. There is a section based on the "social costs of injuries by severity." This section characterized a variety of costs associated with injury and what their indirect costs were. It should be mentioned that part of this analysis is achieved by assigning a value to a human life.

Hall, John R. Jr.
Characteristics of Home Fire Victims
National Fire Protection Association, Quincy, MA, 2005

Children under age 5 are nearly twice as likely to die in home fires as the average person, but their relative risk has been declining, and by 2002 was down to only 56% over the average. Older adults age 65 and older are more than twice as likely to die in home fires as the average person. Alcohol or other drugs, disabilities and age-related limitations are all factors in home fire risk.

The outcomes of fire events are studied from many different data sets such as NFIRS data, death certificates, U.S. Census data and previous other studies. Outcomes are given as risk factors associated with different patterns like age, gender, socioeconomics, fatal effects of fire and various human factors. Another good example is that sprinklers appear to provide one-half to two-thirds reduction in fire death rate per 100 reported fires.

Hall, John R. Jr.
The Total Cost of Fire in the United States
National Fire Protection Association, Quincy, MA, 2006

The total cost of fire in the United States for the year 2004 is provided. The costs listed are net costs of insurance coverage, costs of fire departments, cost estimate of volunteer fire department hours, new building costs for fire protection, "other economic costs," and estimated cost of deaths and injuries from fire. These costs are compared in various ways to previous costs (adjusting for inflation) such as the total cost of property loss and core total cost between 1980 and 2004. The report concluded that the total cost of fire in 2004 was $231-$278 billion.

Hall, John R. Jr.
The Total Cost of Fire in the United States
National Fire Protection Association, Quincy, MA, 2008

The total cost of fire in the United States for the year 2005 is provided. This report is nearly the exact same format as the 2006 total cost report. The costs observed are: estimates of economic loss, costs of fire departments, net fire insurance, building construction for fire protection, other fire protection costs, estimates of human loss and value of donated time of volunteer firefighters. Excellent details are given within each section that addresses a specific cost. The formulas and methods for estimating costs are also given. The complete total cost of fire estimated in this report is $267-$294 billion.

Hogg, J.
Losses in Relation to the Fire Brigade's Attendance Times
Scientific Advisory Branch, London, England, 1971

This UK report attempted to predict the value of one minute of fire department response time to property damage. Using 1971 monetary values, the estimate was made that one minute of response time was worth between $25 and $250 for residential occupancies; for industrial and commercial properties, a minute was worth about $2500.

Hui, M. C.; Tsui, F. S. C.; Luo, M. C.
Fire Incident Characteristics of a Densely Populated Oriental Urban City Beijing, China
Fire Safety Science - Proceedings of the Eighth International Symposium, September 18-23, 2005

See Community Demographics section for abstract.

Ignall, E.; Rider, K. L.; Urbach, R.
Fire Severity and Response Distance: Initial Findings
The Rand Institute, Santa Monica, CA, 1978

Rational decisions about the number of fire companies a community should have require reliable estimates of the fire losses that would result. Such estimates are not now available. One building block in their development is a relationship between the distance the responding companies travel and physical damage.

This study sought to determine the physical damage from fire when compared with fire engine response distance. Data was taken from over 100,000 structural fires in New York City between 1968 and 1970. These fires were divided into building construction type and occupancy. The following damage metrics were used: qualitative assessments by the battalion chief, fire extension, and the number of hose lines used. For analysis, regressions were used comparing damage measures with response distance. Conclusions for their work showed that estimates for property damage to travel distance depended on occupancy type, construction, and other factors. Due to these uncontrolled factors, it was predicted that one minute of response time was likely worth between $100 and $10,000 in 1978 dollars.

International Association for the Study of Insurance Economics
World Fire Statistics
The Geneva Association, General Secretariat, CH-1208 Geneva, 2007

This information bulletin of the World Statistics Centre appears annually. It presented statistics on national fire costs from over 20 countries in an effort to persuade governments to adopt strategies aimed at reducing the cost of fire. It has been published since March 1984.

International Association of Fire Fighters with Johns Hopkins University
Analysis of Fire Fighter Injuries and Minimum Staffing Per Piece of Apparatus in Cities With Populations of 150,000 or More
International Association of Fire Fighters, Washington, DC, 1991

This study was a comprehensive analysis of firefighter injuries and minimum staffing levels in a number of cities. The study found that 69% of jurisdictions that maintained crew sizes of fewer than four firefighters had firefighter injury rates of 10 or more per 100 firefighters, while only 38.3% of jurisdictions maintaining crew sizes of four or more firefighters had comparable injury rates. In other words, jurisdictions having crew sizes of fewer than four firefighters suffered a benchmark injury rate at nearly twice the percentage rate of jurisdictions that maintained crew sizes of four or more firefighters.

Karter, Jr., Michael J.; Badger, Stephen G
1999 United States firefighter injuries
NFPA Journal, November/December, 2000

Firefighter injuries occurring in the year 1999 are detailed in this report. Overall results are given, followed by injuries by type of duty, nature of firefighter injuries and cause of firefighter injuries. Recommendations for improving firefighter safety are given. In 1999 there were 112 firefighter fatalities on duty and 88,500 on-duty injuries.

Karter, Jr., Michael J.; Molis, Joseph L
2002: Firefighter Injuries
NFPA Journal, Nov/Dec 2003

Details about firefighter injuries that occurred in the year 2002 are given. This report is in the same format as the 1999 report but includes more details. The report includes injury details in the following sections: overall results, injuries by type of duty, number of exposures to infectious diseases, injury trends and rates, injuries by cause, vehicle accident injuries, fires and fireground injuries relative to population protected. In 2002 there were 80,800 injuries, a decrease since 2001 and the lowest annual amount since 1977. As with the previous firefighter injury reports by Karter, a significant amount of detail about firefighter injuries and injury severity are given in each section.

Karter, Jr., Michael
U.S. Fire Loss for 2005
NFPA Journal, September/October, 2006

This report contained statistics for the occurrence of fire, civilian deaths and injuries and total property loss for the year 2005. Some representative values follow. Nationally, fire departments responded to 1,602,000 fires. Out of this, 511,000 were structure fires, 396,000 (78%) of these structure fires occurred in residential properties; 290,000 fires occurred in vehicles; 3,030 out of 3,080 structure fire civilian deaths occurred in the home (98%).   A total of 3,675 civilian deaths occurred, of which 82% were in residential occupancies. Thirteen thousand eight hundred twenty-five (13,825) of 15,325 civilian structure injuries occurred in residential properties. According to NFPA NFIRS data, structure fires resulted in a total of $9 billion in property loss; of that, 75% occurred in residential occupancies.

Karter Jr., Michael
Patterns of Firefighter Fireground Injuries
National Fire Protection Association, Quincy, MA, 2007

This report gives some interesting information about firefighter injuries. The information is organized into the following categories: primary apparent symptom, type of activity, cause of injury, occupancy type where injuries occurred, ages of firefighters, and time of day injuries occurred. Especially useful is the breakdown of the types of injuries. Injuries are first classified as minor or moderate/severe. Within these classes, the number, type and percentage of specific injuries are listed.

For the 2001-04 period, there was an estimated annual average of 38,545 firefighter fireground injuries in the U.S. Of these, an average of 28,790 were minor, and 9,755 were moderate or severe. The leading types of minor injuries were: strain or sprain accounting for an annual average of 6,425 injuries or 22.3%; thermal burn, accounting for 3,925 injuries (13.6%); pain only, accounting for 2,970 injuries (10.3%); cut or laceration, accounting for 2,745 injuries (9.5%).   The leading types of moderate and severe injuries were: strains or sprain accounting for an annual average of 3,065 injuries a year, or 31.4%; thermal burn, accounting for 925 injuries (9.5%); pain only, accounting for 785 injuries (8.1%); and exhaustion or fatigue accounting for 595 injuries, or 6.1%. Activities related to extinguishing a fire accounted for most of the minor injuries (15,960 or 55.4%), and for most of the moderate and severe injuries (5,345 or 54.8%). The leading causes of minor injuries were contact with or being struck by something (6,080, or 21.7%), while for moderate and severe injuries, the leading cause of injuries were falling, tripping, or slipping (2,525 or 25.9%).

Karter, Jr., Michael
U.S. Fire Experience by Region
National Fire Protection Association, Quincy, MA, 2003

Data for this report was taken for the years between 1997 and 2001. The U.S. was broken up into four regions: the South, Northeast, North central, and West. The South had the highest average number of fires (7.6 per thousand people). This was followed by the Northeast with 6.9. Excluding the events of September 11th, 2001, the South had the highest rate of civilian deaths per million people for four of the five years (an average of 17.3). The West had the lowest rates for all five years. The Northeast had the highest civilian injuries for all five years with an average value of 106.7 per million people, 30% higher than the average national rate. The property loss rates per capita varied year by year and showed no consistent trend.

Karter, Jr., Michael; Molis, Joseph L.
Firefighter Injuries for 2004
NFPA Journal, November/December, Pg. 50, 2005

This report gave a statistical breakdown of the 75,840 reported firefighter injuries in 2004 by injury type, fireground (or not), year-over-year trends in injuries, and injuries per hundred fires. The period 1988 - 2004 yielded about 25 fireground injuries per 1,000 fires and a steady decline in non-fire injuries to less than 1 per 1,000 incidents. About half of injuries occurred on the fireground.

Karter, Jr., Michael; Molis, Joseph L.
U.S. Firefighter Injuries - 2005
NFPA Journal, 2006

Information is provided about firefighter injuries: injuries by type of duty; nature of injuries; cause of injuries; injuries per department by population protected; injuries by population protected and region and recommendations on how to reduce the number of injuries. A total of 80,100 firefighter injuries occurred in 2005. 41,950 (49%) occurred during fireground operations, 13,325 occurred during other on-duty activities, and 12,250 occurred at non-fire emergency incidents. The main injury type was strain/sprain/muscle pain (44%). Since 1988-2005, the rate of "injuries per 1,000 fires at the fireground" has remained more or less level. However, the "injuries per 1,000 incidents at non-fire emergencies" has decreased steadily.

Klaene, B. J.; Sanders, R. E.

Expert advisors provide strategic support
NFPA Journal, November/December, Pg. , 2002

See Response Capacity section for abstract.

Meade, William

A First Pass at Computing the Cost of Fire Safety in a Modern Society
Fire Technology, Vol. 27, No. 4, Pg. 341, 1991

This document is a technical notes piece from a 50-page report by the National Institute of Standards and Technology. This was a study to attempt to characterize the cost of fires losses on society. The relevant findings include:

1. Fires are becoming less acceptable as U.S. and foreign competitors will capture the market if business interruption is considerable.
2. 40% of small businesses with a major fire never reopen.
3. Business interruption loss is estimated to be three to four times greater than business property loss.
4. Product liability costs of fire ($3.5 billion) are almost the same as total property damage of residential fires ($4.0 billion).

Morgan, H.P.; Hansell, G.O.

Fire Sizes and Sprinkler Effectiveness in Offices: Implications for Smoke Control Design
Fire Safety Journal, Vol. 8, No. 3, Pg. 187, 1985

See Emergency Response section for abstract.

National Fire Protection Association

Educational Properties
National Fire Protection Association, Quincy, MA, 2006

See Community Demographics section for abstract.

Rees, G.
Automatic Sprinklers, Their Value and Latest Developments
Fire Surveyor, Vol. 20, No. 5, Pg. 9, 1991

See Emergency Response section for abstract.

Roberts, B.
Austin Fire Department Staffing Study
Austin Fire Department, Austin, TX, 1993

In 1993, the Austin Fire Department conducted a study to determine whether companies staffed with four firefighters were safer and more effective than the three-person companies. In order to compare the effectiveness of fire companies, the physiological impact on firefighters and injury rates at various staffing levels, Austin Fire Department conducted drills consisting of a series of common fireground tasks. These simulations revealed that regardless of the experience, preparation or the training of firefighters, loss of life and property increases when a sufficient number of personnel are not available to conduct the required tasks efficiently. The Austin Fire Department concluded that firefighter effectiveness significantly improved when a company was increased from three to four personnel. In the two-story residential fire, the efficiency or time improvement between the three-person and four-person crew was 73%. In the aerial ladder evolution, the efficiency improvement between three-person and four-person crews was 66%. In the high-rise fire, the efficiency improvement between the three-person and four-person engine company crew was 35%. In addition to the fireground simulations, the Austin Fire Department also reviewed injury reports involving 136 emergency incidents from 1989 to 1992 to which 1,938 firefighters responded. The analysis revealed that the injury rate for four or five-person crews was 5.3 per 100 firefighters while the three-person companies experienced an injury rate of 7.77 injuries per 100 firefighters. The injury rate for three-person companies was 46% higher than the rate for larger crews.

Rohr, K. D.; Hall, Jr., J.
U.S. Experience with Sprinklers and other Fire Extinguishing Equipment
National Fire Protection Association, Quincy, MA, 2005

In sprinklered properties, the chances of dying in a fire are reduced by one-half to three-fourths and the average property loss is cut by one-half to two-thirds. In 7% of sprinklered properties, sprinklers failed to operate in fires large enough to activate them; of this 7%, nearly all cases were due to system shut-offs and human errors. The following statistics were cited in this paper for 1989-1998 for civilian deaths per thousand fires: 60% for manufacturing properties, 74% for stores and offices, 75% for health care, 91% for hotels and motels. Public assembly and education occupancies reported no fire deaths in sprinklered properties during this time period. Direct property loss reduction because of sprinklers is as follows: 53% for stores and offices, 64% for manufacturing properties, 66% for healthcare facilities for the aged or sick, and 70% for public assembly occupancies.

Rustein, R.; Cooke, R.A.
The Value of Fire Protection in Buildings
Scientific Advisory Branch, Home Office, UK, 1978

Using a building size of 1,500 square meters, a table was constructed showing the reduction area of damage when sprinklers were installed. Hospitals have the least reduction (likely because they are highly compartmentalized) with 40%; the majority of other facilities have reductions on the order of 80-93%.

Sardqvist, S.; Holmstedt, G.
Correlation Between Firefighting Operation and Fire Area: Analysis of Statistics
Fire Technology, Vol. 36, No. 2, Pg. 109, 2000

The aim of this study was to investigate whether current statistics can quantify the benefits of fire brigades. A detailed investigation by the London Fire Brigade of most fires in the greater London area has been underway since 1994. The present study concerned 307 fires in non-residential buildings between 1994 and 1997. Times to detection; to arrival of the fire brigade; and to extinguishment of the fire; as well as the process of extinguishing it, are compared to the final property damage caused by the fire. In half of the fires, the final fire area equals the area at detection, and in three-quarters of the fires, the final fire area equals the fire area when the fire brigade arrived. No support was obtained for the hypothesis that the period between ignition and the time the fire brigade intervened correlates with fire area. However, the hypothesis is supported for fires still spreading when the brigade arrives. Both water flow rate for extinguishing a fire and water application time are proportional to the square root of the fire area. Total water demand is proportional to the fire area.

The purpose of this study was to determine where fire brigade statistics could quantify the benefits of fire brigades. The outcome of interest in relation to the community risk model is the final fire area, which is proportional to property loss. This study involved 307 fires in non-residential buildings during the time period between 1994 and 1997. The main conclusions included the following:

1. "The automatic fire alarm failed in one-fifth of the fires in systems where a system was present."

2. "In half of the fires, the final fire area was equal to the area at detection. In three-quarters of the fires, the final area was equal to the area of the fire when the brigade arrived."

3. Both water flow-rate to extinguishment and water application time were determined to be proportional to the square root of the final fire area.

4. "Total water demand was proportional to fire area."

5. "An automatic sprinkler system contained or extinguished 17 of the 21 fires in which such as system was present. Only 14 fires were contained by one to three sprinklers. In each of the 14 fires, the system was in working order and covered the fire area, and no flammable liquids were present."

6. Sprinklers that did not effectively suppress the fire were either non-functioning or were not located over the fire.

Siarnicki, R. J.
Residential Sprinklers: One Community's Experience Twelve Years after Mandatory Implementation
National Fire Academy, Emmitsburg, MD, 2001

This report's purpose was to look at the effect of a mandatory residential sprinkler ordinance in Prince George's County, Maryland. In this county, all new residential construction requires sprinklers. During the time period of the study, there were 117 residential sprinkler reported fire incidents. Total fire losses for these events were $401,220. According to predictions in the report, the estimated losses would have exceeded $38 million if these buildings were not sprinklered. Also estimated, sprinklers saved 154 lives during the twelve year time period. Seven injuries occurred in sprinklered properties, all of which were minor in nature.

Thomas, I.; Brennan, P.
Occupants, Ignition, and Fire Outcomes
Belfast, UK
Third International Symposium on Human Behaviour in Fire, September 1-3 2004

This paper argued that it was more accurate to apply occupant factors to fire ignition than to the evacuation to explain fire deaths. The study used NFIRS data between the years of 1983 and 1993 it should be noted that "ignition factors" are noted more often for injuries than for deaths (for obvious reasons). The results showed that occupant involvement in ignition occurs in well over 80% of fatal fires in apartments. T he study also concluded, "Evidence so far suggests that evacuation victims do not fit the usual pattern of fatality characteristics. That is, they are not the elderly, the very young, or younger adults with cognitive impairment, nor are they predominantly male."

TriData Corporation

The Economic Consequences of Firefighter Injuries and Their Prevention. Final Report

National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD, 2005

This report investigated the cost of firefighter injuries annually. The costs involved included workers compensation, long-term medical care, lost productivity, administrative costs of insurance, etc. It was determined that these costs amount to between $2.8 and $7.8 billion annually. The term firefighter in this report is all-encompassing for this study: career, volunteer, mixed depts., special operations, paramedics, training officers, etc. Data collection for this work used NFIRS. Some of the key points included that "more fire departments need to take physical fitness seriously and adopt a formal program that monitors progress against goals and goals met against number and severity of injuries." Also, "a scientific study on the relationship between the number of firefighters per engine and the incidence of injuries would resolve a long-standing question concerning staffing and safety." This paper addressed the inquiry whether it is the commonly occurring but minor injuries (sprains, strains, falls, slips, back problems, etc.) or the less frequent, but severe injuries (burns, major falls, etc) that cost more on an annual basis.

Varone, J. C.

Providence Fire Department Staffing Study

National Fire Academy, Emmitsburg, MD, 1994

The Providence Fire Department Staffing Study, conducted from 1990-1991, determined that the costs of adding a fourth person to three-person companies was offset by lower injury costs. The department's Injury/Exposure Database was queried to determine pertinent injury information. The study data showed that four-person staffing led to a 23.8 percent reduction in injuries, a 25 percent reduction in time lost injuries and a 71 percent decrease in time lost due to injury when compared to three-person staffing. These results led to the conclusion that four-person staffing substantially reduced the number and the severity of injuries compared with three-person staffing.

Voelkert, J. C.
Fire Extinguishers: A Necessary Component in Balanced Fire Protection
National Institute of Standards and Technology, Gaithersburg, MD, 2007

This presentation states that fire extinguishers are an essential method by which to lower civilian deaths and property losses. The NIST workshop cites NFIRS data from 1991 - 1995 that showed fire extinguishers were effective based on percentage of fires extinguished, number of deaths and injuries per 100 fires, and average dollar loss per fire. NFIRS statistics no longer track “method of extinguishment.” NFIRS statistics for that time period showed that 94% of the time a fire extinguisher is discharged, the fire is put out. This extinguishment usually occurs within two minutes. Two fire loss statistics given are that 93% of fire related deaths and 95% of direct property damage occur once the fire has progressed passed the “early stages.”

Wain, Finola; Hagen, Mike; Smith, Stuart; Doherty, Shaun
Damage Mitigation and Risk Management Planning
Fire Magazine, Vol. 98, No. 1205, Pg. 21, 2005

This paper discusses the exploration of a partnership between UK fire services and damage control companies. One of these types of organizations is ISS Damage Control. Services by ISS Damage Control would include water removal, secure buildings, removal or protection of goods, etc. Their assistance would be called upon by the fire service to prevent lengthy business interruptions. According to this article's reference to the National Audit Office (UK), 80% of businesses that suffer a major fire never recover. The rapid intervention of recovery companies can prevent further property damage after disasters, namely fires, have occurred. Several case studies involving the risk mitigation firm are documented.

Appendix B. Year 1 Proposal to the Assistance to Firefighters Grant Program

PROPOSAL FOR A MULTI-PHASE STUDY ON FIREFIGHTER SAFETY

AND THE DEPLOYMENT OF RESOURCES

October 4, 2005

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

Background: Service demands and public expectations placed upon local fire departments continue to rise as threats to communities from both natural and man-made disasters including terrorism reach new highs. Historically, the fire service has been based solely on those activities related to fire prevention and suppressing fires that did occur. According to FEMA, the leading cause of fire in 2002 was arson with smoking being a close second (Fatal Fires, Vol. 5-Issue 1, March 2005). That same report noted that fatal fires most frequently occurred in structures with the overwhelming majority occurring in residences. These factors contribute to injury and death of both firefighters and citizen and should be identified as risks in a community before a fire event occurs.

According to a separate FEMA report (Firefighter Fatalities, August 2005), in the years since 1999 the number of firefighters killed in the line of duty continually exceeds 100 per year. A main goal of the USFA is a 25 percent reduction of firefighter fatalities in 5 years and a 50 percent reduction in 10 years. Firefighter fatalities occur during varied areas of the job including on-scene operations, responding or returning from a call, training and other assigned tasks. Inherent to each of these arenas are notable risks that may not be recognized until it's too late and an adverse risk event occurs. This fact verifies the continued need for community risk assessment and adequate resource deployment based on that assessment. These actions will make great strides in meeting the goals of the USFA by reducing the number of firefighter injury and fatalities.

Another notable issue is that over the past three decades fire department response has expanded to include emergency medical services, terrorism response, hazardous materials response and mitigation, natural disasters, specialized rescue and other community risks. This expansion of responsibility has not always been matched with an adequate deployment of resources. Many times firefighters are asked to do more with less rather than having the burden of work expected coordinated with the allocation of resources required.

Studies on firefighter safety and the adequate deployment of resources are needed to enable fire departments, cities, counties, and fire districts to design an acceptable level of resource deployment based upon community risks and service provision commitment. These studies should assist in strategic planning and the budgetary process involved in making good decisions locally. This multi-phase study will be conducted in a cost effective manner. Cost assessment indicates that the cost benefit for this project will be $30.30 per department (based on numbers of departments according to IAFC, 2005) or $.91 per firefighter (based on NFPA survey of fire departments, 2003).

Project Vision, Products and Goals: The goal of each phase is to produce one of three deliverables:

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

Phase 1 establishes the scientific foundation as well as the reliability and validity of VISION ™ – Integrated Risk Assessment and Deployment Software. VISION ™ is a software package designed to assess community risks based on geography, building construction, population demographics and other applicable variables to provide a basis for emergency response system design and resource deployment. VISION ™ is a follow-up to RHAVE (Risk, Hazards and Value Evaluation) software that was funded by a cooperative agreement with the United States Fire Administration (USFA) and the International Association of Fire Chiefs. The original project was completed under the auspices of the Commission on Fire Accreditation International (CFAI). RHAVE, though valuable in teaching and perpetuating the concept of community risk assessment, was never scientifically validated and is no longer in production. Phase 1 of this study will ascertain the scientific basis of the VISION ™ software's assessment and report methodology. Phase 1 will also assess the software for validity and reliability of nomenclature and data elements based on direct use in the field. Additionally, the risk assessment software will be evaluated for user-friendliness including comprehensive documentation and guidance.

Phase 2 will follow verification of valid risk assessment and deployment software. Phase 2 will develop an emergency response system design methodology for implementing the findings of the scientifically based risk assessment instrument. The methodology developed will assist local jurisdictions in optimizing emergency response system resources. The emergency response system design methodology will include live and simulated fireground and medical emergency exercises. These exercises will also allow data collection and reporting on firefighter behavior varied by resources deployed in live and simulated events. This information will improve firefighter safety through an enhanced understanding of hazards posed by various incidents, buildings and environments in which they respond.

Additionally in Phase 2 a link will be built from VISION ™ to Geographic Information System (GIS) software to allow for response modeling for local jurisdictions based on established design methods. This link will be user-friendly, including comprehensive documentation and guidance.

Phase 3 will establish performance measurement tools to validate the emergency response system design model and the design methodology. First, Phase 3 will use multi-jurisdictional case studies to evaluate the ease of implementation of Phase 1 & 2 in order to further refine design methodology. Next, Phase 3 will evaluate the real-world effectiveness of Phase 2 system in serving the public and jurisdictional authorities. Evaluation of ease-of-use, as well as operational effectiveness will establish the products as industry standards.

The next two pages detail the first phase of this project, including the duration and cost.

Phase 1: Scientifically-Based Risk Assessment Model

Objective: To test the scientific basis as well as the reliability and validity of VISION ™ – Integrated Risk Assessment and Deployment Software. Through a partnership between the Commission on Fire Accreditation International (CFAI), the International Association of Fire Chiefs (IAFC), the International Association of Fire Fighters (IAFF), the National Institute of Standards and Technology (NIST) and Worchester Polytechnic Institute (WPI), VISION ™ software will be evaluated for its capability to enhance firefighter safety by assessing community risks and leading decision makers in designing an acceptable level of resource deployment for local fire departments based on risks identified and service provision commitment to the community. These partners will meet quarterly in person and/or via conference call.

A. Establish Key Project participants

A1. Establish a partnership council of all grantee partners which will meet at least quarterly.

A2. Establish a project technical advisory team consisting of representative experts in disciplines germane to the project. For example, experts in demographics, experts in mechanics of firefighting, experts in fire science, etc.

A3. Conduct project kick-off meeting with the partners and the technical advisory team to review, refine, and finalize tasks described in this proposal for Phase 1 and Phase 2 milestones.

A4. Construct (with the aid of the project technical advisory team), a list of stakeholders. Stakeholders are those people who play a role in the establishment, operation, and staffing of the fire service. Stakeholders will be contacted to represent the project to their respective organizations. Additionally they will be solicited for project input and review. (Example code and governmental bodies…NFPA, ISO, ICMA etc.)

A5. Work with the project advisory team to establish sites for Phase 1b field testing.

Deliverable A. = Letter report with table of stakeholders and layout of specific contracted tasks with timeline for deliverables. Stakeholder groups to provide press releases announcing the project and soliciting participation.

B. Test VISION ™

B1. Collect and catalog relevant materials used in designing VISION ™. Emergency Reporting, Inc., is the developer of VISION ™ for CFAI. Emergency Reporting, Inc., will provide all source code and calculations for evaluation and testing.

B2. Review and evaluate VISION ™ for its ability to aid the fire service and community leaders in making objective, quantifiable decisions about how to best assess and meet their fire and emergency service needs.

B3. Assess the scientific foundation of the assumptions used in creation of the software as well as evaluate the formulas within the software that lead to results based on user data entry. Evaluate usability of the software in terms of type quality and quantity of data and the correlations of the data with the calculation of risk.

B4. Based on B1- B3 facilitate change and improvements in VISION ™. Work with Emergency Reporting, Inc., to implement changes.

B5. Field test VISION ™ to assess the software's reliability and validity. The field test will involve 3 stages. These stages include: 1) Inter-rater reliability testing, 2) Test and re-test reliability testing, and 3) on-site validation of data element definition and data entry consistency. Analyze data and report results.

B6. Publish a results summary from tasks B1-B5. Article published in the archival literature describing model structure, capabilities, assumptions, and limitations.

Deliverable B. = Letter report with published summary to partner organizations and paper submitted to industry journals.

Phase 1. Project Timetable and Funding:

Project Start +	***1-6 Months***	***7-12 Months***	***13-18 Months***	***18-24 Months***
Deliverables				
A	--------------------	--- ---- ---- ----		
B	---------	----- ----- ------	--- --- --- ---	-----------------

Completion Phase 1: A1 - A5 will be completed in Year one

B1- B4 will be completed in Year one and B5-B6 in Year 2

Phase 2: Develop an emergency response system design methodology for implementing the findings of the scientifically based risk assessment instrument.

A. Develop link from VISION ™ to GIS software.

A1. Contract with Emergency Reporting (developer of VISION ™) to design link from VISION ™ to ArchView GIS software for data transfer. This capability will allow modeling of emergency response deployment in local jurisdictions based on the community risk assessment performed and the available resources.

A2. Design GIS methodology to allow fire departments using VISION ™ to evaluate current response capabilities as well as the ideal response deployment based on industry standards and community expectation. This will assist fire department leaders in establishing short and long term goals for the department based on a desire for maintaining safe, efficient and effective emergency operations.

A3. Publish a results summary from tasks A1–A2. Article published in the archival literature describing VISION ™ with GIS data transfer capabilities, assumptions, and limitations.

Deliverable A. = Letter report with published summary to partner organizations and paper submitted to scientific and industry journals.

B. Conduct live and simulated emergency response modeling.

B1. NIST to develop test methodology for live and simulated fire ground modeling. NIST also to procure participants, data collection equipment, location and authorization of property.

B2. NIST to conduct live and simulated fire ground modeling to assess for first responding company and full alarm assignment crew size. This modeling is necessary to contribute additional scientific data to VISIONTM software to assure the most accurate match of community risks and need to the emergency response system design.

B3. Conduct live and simulated emergency medical response modeling for first responder companies as well as transport capable companies. The volume of emergency medical responses (EMS) continues to escalate throughout the United States. The fire service must continue to plan for and respond to these calls for assistance. Therefore is it imperative that EMS response modeling be included in this phase of the study.

B4. Identify best practices based on fire ground and EMS scene tasks.

B5. Publish a results summary from tasks B1–B4. Article published in the archival literature describing model structure, capabilities, assumptions, and limitations.

Deliverable B. = Letter report with published summary to partner organizations and paper submitted to peer-reviewed and industry journals.

Phase 3: Establish performance measurement tools to validate the emergency response system design model and the design methodology.

A.Use multi-jurisdictional case studies to evaluate the ease of implementation of VISION ™ with GIS download capability.

A1. Identify local fire departments who have implemented VISION ™. Enlist these departments to provide reports of their experience with community risk assessment, emergency response system design model based on that assessment, GIS modeling, and community expectation.

A2. Assess the reports provided for appropriate use of VISION ™ and deployment models and methodology.

A3. Assess the reports provided for VISION ™ capability to perform assumed tasks. Evaluating ease-of-use, as well as operational effectiveness will establish the product as industry standards.

A4. Publish a results summary from tasks A1–A3. Article published in the archival literature describing VISION ™ and model/methodology capabilities and limitations.

Deliverable A. = Letter report with published summary to partner organizations and paper submitted to peer-reviewed and industry journals.

B. Evaluate real-world effectiveness of VISION ™ and deployment models and methodology in serving the public and jurisdictional authorities.

B1. Work with partners to identify and define performance indicators for fire, rescue, and EMS operations. Develop performance measures for these indicators for use in evaluating a local department's performance within these realms.

B2. Field test performance measures for validity and reliability. Field test will include multi-jurisdictional departments varied between users and non-users of VISION ™ software and the deployment models and methodology.

B3. From clean data ascertained in field test, compare and contrast performance of departments stratified by user/non-user groups. Identify best practices where relevant.

B4. Publish a results summary from tasks B1–B3. Article published in archival literature describing VISIONTM capabilities, assumptions and limitations. Article published in the archival literature describing performance indicators and measures as well as the performance instrument's capabilities, assumptions, and limitations.

Deliverable B. = Letter report with published summary to partner organizations and paper submitted to peer-reviewed and industry journals.

Phases 2 and 3

The Program of study on Firefighter Safety and Deployment of Resources is planned and estimated to last three years. A portion of Phase 2 and Phase 3 will overlap Year 1.

The total cost of adequately funding the project is approximately $ 3 million based upon $1 million per year for three years. The Building and Fire Research Laboratory at the NIST has committed to a contribution of $75k per year to the total program cost. However, as NIST is expected to perform a large portion of the tasks throughout the study, their costs will exceed their financial commitment to the project. Therefore, Phase 1-3 budgets reflect funds necessary to assure NIST tasks completion.

Phase 2 and 3 Project Timetable:

Project Start	***1-6 Months***	***7-12 Months***	***13-24 Months***	***24-36 Months***
Deliverables				
Phase 2				
A	---------------------	-------------------		
B		-----------	----- ----- ---------	--------------------
Phase 3				
A				
B			----------	--------------------
		----------	---------	-------------------

Phase 2

A1–A3 will be completed in Year 1
B1 will be completed in Year 1
B2-B5 in Year 2

Phase 3

A1 will be completed in Year 2
A2-A4 in Year 3
B1- B2a will be completed in Year 1
B2b- B4 will be completed in Year 3

Next Steps

Implementation of assessment, modeling and measurement tools in local communities. Each partner organization will produce press releases as well as prepare joint papers for release to scientific and industry journals, both printed and electronic, on the results of this multi-phase project. Additionally, each partner organization will assure the results are presented during hosted industry conferences as well as conferences of related interest groups.

Appendix B.1 Progress Report to the Assistance to Firefighters Grant Program

Progress Report

September 30, 2007

Assistance to Firefighters Grant Program

MULTI-PHASE STUDY ON FIREFIGHTER SAFETY AND THE DEPLOYMENT OF RESOURCES

FY 2007

1.0 PROJECT OBJECTIVE

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

2.0 TASKS STATUS

2.1 Project Administration

The study is being completed according to the proposal for the project as submitted. Discovery of major formula discrepancy in Phase I Task(s) caused the amount of work and time necessary for VISION ™ improvement to increase. This problem is explained more fully below.

2.2 Project Tasks

A. Establish Key Project participants

A1. Establish a partnership council of all grantee partners which will meet at least quarterly.

Status: Complete – A partnership council has been established and meets at least quarterly to discuss the status of the project and any issues that may arise in the investigators work. All decisions concerning the project are made by consensus of partners.

A2. Establish a project technical advisory team consisting of representative experts in disciplines germane to the project. For example, experts in demographics, experts in mechanics of firefighting, experts in fire science, etc.

Status: Complete – Project technical advisors (TA) have been identified in each area of the project requiring expertise other than that of the principle investigators. Commitments have been made by each.

A3. Conduct project kick-off meeting with the partners and the technical advisory team to review, refine, and finalize tasks described in this proposal for Phase 1 and Phase 2 milestones.

Status: Complete - A project orientation meeting was held on May 31, 2006 at NIST for partners and technical advisors. The meeting facilitated many questions and answers about the project and input from the group was noted and is being used by the principle investigators (PIs). Subsequent to the meeting, each expert TA is engaged in the study as needed based on his/her area of expertise.

A4. Construct (with the aid of the project technical advisory team), a list of stakeholders. Stakeholders are those people who play a role in the establishment, operation, and staffing of the fire service. Stakeholders will be contacted to represent the project to their respective organizations. Additionally they will be solicited for project input and review. (Example code and governmental bodies...NFPA, ISO, ICMA etc...)

Status: Complete – A stakeholder group has been identified and engaged. A list is attached to this report. (Attachment 3) The first meeting of the stakeholder group was held on September 13, 2006. The stakeholders were briefed on the project and solicited for input. Stakeholders were provided information in hard copy form to share with their respective organizations along with a copy of a press release on the project. Many stakeholder representatives requested further opportunity for input and were provided contact information for all partner representatives. An additional stakeholder meeting was held in Atlanta, GA, on August 23, 2007. Stakeholders were updated on the model design, sampling frame, field experiments.

A5. Work with the project advisory team to establish sites for Phase 1b field testing.

Status: In Progress – Fairfax County Fire and Rescue Department and Montgomery County Fire Department have generously offered to coordinate the site for field testing. As the research team is ready for field work, an appropriate test site will be selected.

Deliverable A. = Letter report with table of stakeholders and layout of specific contracted tasks with timeline for deliverables. Stakeholder groups will be provided with press releases announcing the project and soliciting participation.

Status: Completed - This report is considered to meet the requirement for this deliverable.

B. Test VISION™

B1. Collect and catalog relevant materials used in designing VISION™. Emergency Reporting, Inc. is the developer of VISION™ for CFAI. Emergency Reporting, Inc. will provide all source code and calculations for evaluation and testing.

Status: Complete – Calculations and users guide to VISION ™ were delivered to the principal investigators by Emergency Reporting, Inc.

B2. Review and evaluate VISION™ for its ability to aid the fire service and community leaders in making objective, quantifiable decisions about how to best assess and meet their fire and emergency service needs.

B3. Assess the scientific foundation of the assumptions used in creation of the software as well as evaluate the formulas within the software that lead to results based on user data entry. Evaluate usability of the software in terms of type quality and quantity of data and the correlations of the data with the calculation of risk.

Status: Complete – Steps B2 and B3 were combined to reflect that the ability of the model to aid the end-users in decision making is predicated substantially on the capability of the model to produce technically defensible assessments of the risks inherent to the community under assessment, as well as produce an objective, intuitive assessments of policy changes under consideration for the community by the assessment team. VISION™ was evaluated for scope, method, and technical foundation. The predictor variables were found to be consistent with the intended scope of the model. The ultimate dependent variable (a non-dimensional quantitative score for community risk) produced by the model, however, was found to lack an independent measurement basis or provide sufficient foundation for model validation and verification. Additionally, upon evaluation of the technical basis of the existing VISION™ calculations (mathematical relationships between the variables), the technical approach of the current project was modified, as reflected by the modifications below, to ensure that the final product of the current project will provide a technical basis for screening and eliminating non-predictive concepts, as well as assessments of the statistical significance/power of the final product.

B4. Based on B1-B3 facilitate change and improvements in VISION™. Work with Firehouse Software, Inc. to implement changes.

Status: B4 replaced with C1–C5 below.

B5. Field test VISION™ to assess the software's reliability and validity. The field test will involve 3 stages. These stages include: 1) Inter-rater reliability testing, 2) Test- re-test reliability testing, and 3) on-site validation of data element definition and data entry consistency. Analyze data and report results.

Status: Moved to Phase III – When the recast model is available for testing, B5 will be completed.

B6. Publish a results summary from tasks B1-B5. Article published in the archival literature describing model structure, capabilities, assumptions, and limitations.

Status: In Progress – renamed C6.

Deliverable B. = Letter report with published summary to partner organizations and paper submitted to industry journals. **Status: Anticipated publication date of November 2007.**

C. Create Scientific Foundation for Community Risk Model

Introduction: Part C will ensure that all concepts relevant to assessment of community risk are included in a measurable manner and included in the model in such a way that both direct and indirect paths can influence changes in the community risk profile. To date, 30 variables have been selected for inclusion in the updated model, the majority of which were included in the existing form of VISION ™. The basic structure includes 20 boundary variables, 7 decision variables and 3 measures of community risk.

C1. Define objective variables

Status: Complete –Three objective variables were selected to reflect the primary measurable concepts which correspond to the actual risks observed in the community under consideration: (1) number of first responder injuries and deaths; (2) number of civilian injuries and deaths; and (3) total economic consequences to community. Optimization of the levels of the three dependent variables will be conducted by the community assessor rather than a priori within the model in order to reflect the fact that priorities of economic and life safety concepts may be variable across otherwise similar communities.

C2. Develop list of decision variables. Define metrics for each decision variable. Determine viability of data for each metric.

Status: Complete – The decision variables have been defined, developed, measured, and arranged in a model structure. Decision variables are variables with levels that can be determined by the fire service and include prevention programs, apparatus and staffing levels, first alarm (initial) response levels, dispatch protocol, training, and mutual aid, among others. Attachment 1 is an overview of the model structure.

C3. Develop list of boundary conditions. Define metrics for each boundary condition. Determine viability of data for each metric.

Status: Complete – Boundary variables are predictors of community risk which are outside the routine decision set of the fire department. Examples would include characteristics of the built environment (number and type of buildings), characteristics of the population (population, socioeconomic factors, etc), community loss history, and elements of critical infrastructure which require unique consideration.

C4. Create initial spreadsheet of data to be gathered.

Status: Complete– The results of C1–C3 have been combined with measurement requirements for each variable. Variables will be evaluated to see which can be included in the field testing which can only be included in the stochastic fire department reporting data collection, and which variables can be included in both formats as a test of robustness and consistency.

C5. Populate model with a set of test-data to determine predictive capability of model.

Status: In Progress – Project team has determined that no existing database is suitable for evaluation of the current model. Historic data is being collected in order to exercise the mathematics, model structure, and conclusions for the current version of the model.

C6. Publish a results summary from tasks B1-B5. Article published in the archival literature describing model structure, capabilities, assumptions, and limitations.

Status: In Progress. Anticipated publication date of November 2007.

Year 2 Work. Data collection and analysis will be the focus of the Year 2 work. There are two primary tasks to complete with respect to data collection: stochastic data collection and field simulations, each of which is described in greater detail below.

D1. Stochastic data collection. Pending approval by the U.S. Office of Management and Budget (OMB) of the Paperwork Reduction Act application (filed December 2006), a representative sample of fire departments will provide incident response data using a secure, web-based data entry portal.

D2. Field simulations of fire response. Field simulations of fire response will be conducted. The fire response data collection will be comprised of two distinct components: full-scale laboratory burns and full-scale residential fire simulations.

The objective of the full-scale laboratory burns will be to characterize the fuel package (measuring heat release rate, development of untenable conditions in the room of origin, including time-varying measurements of temperature, oxygen depletion, carbon monoxide, and carbon dioxide) and to measure the impact of manual suppression (fire hose stream) on fire development at various stages of fire development. Detailed characterization of fire hazard development in the laboratory will help to ensure the safety of the responders in the residential simulation, as well as remove the variability of the effect of nozzle skill amongst individual responders by using a robotic fire hose suppression device.

The objective of the field simulations will be to measure time-to-task for individual firefighters during a structured residential fire response as a function of the following variables: size of responding company (2-, 3-, 4-, or 5-person teams), fire growth rate (slow or fast growing fires), and response time (slower or faster arrival on-scene).

The results of the field experiments will be combined with the findings from the stochastic data collection to provide a depth-of-understanding to the relationship between crew size, response time, and community outcomes.

D3. Regression Analysis. Regression analysis will be performed to determine which variables have significant impact on the dependent variables (community outcomes). The regression analysis will form the basis for development and testing of the VISION computer model (Year 3).

Overall Project Timeline

Task		2006	2007	2008	2009
		JFMAMJJASOND	JFMAMJJASOND	JFMAMJJASOND	JFMAMJJASOND
Phase I	Identification of Variables	[-----------]			
	Initial Model	[-----	-------------]		
Phase II	Stochastic Data Collection – Beta Test		[----]		
	Stochastic Data Collection - Full-Scale		[---	---------]	
	Field Simulations		[----- -	---------]	
Phase III	Regression Analysis			[---------]	
	Documentation			[----------------- --	------]
	Verification and Validation			[-----	--]

3.0 CONCLUSIONS

The multi-phase study on firefighter safety and the deployment of resources is presently within budget and on schedule. The assessment of the technical foundation of the existing VISION model, while requiring additional intermediate milestones, underscores the importance of this project. A scientific foundation for the assessment of community risk by fire and city officials will ensure efficient expenditure of public resources and raise the bar for technical discussion of the community impact of changes to resource levels.

Appendix C. Press Release

Creating a New VISION for the Future of the Fire Service

Fire Act Funds a Multi-Organization Study Aimed at Helping Fire Departments Assess and Respond to Risks

With a second major grant of $1 million from the research section of the U.S. Department of Homeland Security's Assistance to Firefighters Grant Program (the Fire Act), five top fire research organizations continue collaborating to develop tools that will help local fire departments better assess the risks in their local communities and plan to respond to them more effectively and efficiently.

The three-year project, being conducted jointly by the Commission on Fire Accreditation International (CFAI), the International Association of Fire Chiefs (IAFC), the International Association of Fire Fighters (IAFF), the National Institute of Standards and Technology (NIST), and Worcester Polytechnic Institute (WPI), will establish a technical basis for risk evaluation and deployment of resources by local fire departments and create tools the departments can use to better assess the risks and hazards in their communities; plan adequate resource deployment to respond to and mitigate emergency events; and measure their effectiveness in responding to and handling events.

"This is a study many fire industry leaders have dreamed of for several years," said Chief Dennis Compton of the International Fire Service Training Association (IFSTA) a technical advisor to the project. "Until now, it has simply not been possible, due to the complexity of the tasks proposed and the costs involved.

"By bringing together recognized experts in the fields of fire and EMS industry, economics, statistics, model evaluation, standards of cover, geographical information systems, and fire protection engineering, we will ensure that the result will be a comprehensive, validated assessment model that will serve the fire service for many years," added Harold Schaitberger, IAFF General President.

In Phase I of the three-phase project, experts brought together project technical advisors and a stakeholder group to identify and quantify community risks and necessary resource deployment.

As part of the study, fire scientist are developing and testing mathematic models representing risks, fire movement, and various interventions for mitigating a fire or EMS event. In Phase II, they will collect hazard and response measurements that will form the technical basis for the model. Phase III will be devoted to validating and beta-testing the software for accuracy and ease-of-use. Once complete, a new software will be re-released through CFAI.

To learn how your department can participate, go to www.firereporting.org

Questions regarding the study may be directed to Dr. Lori Moore-Merrell at 202-824-1594 or Lmoore@iaff.org

Appendix D. Fire Department Survey

This appendix is the version of the web-based survey current at the date of publication of the Year 1 Final Report.

Department Level Information

Prior Events Tab:

In this section, please provide comprehensive data for the community's economic damage, the loss of firefighter work hours, and the loss of life due to fire and EMS emergency events for the previous three (3) years.

Economic Consequences	**Fire**
D-1. Total Annual Direct Economic Losses due to fire for years 2005, 2006, and 2007 (structure and contents)	$

Firefighter Incident Related Injury and Death [Dispatch to In-Quarters]	**Fire Call**	**EMS Call**
D-2. Total Number of Workers Injured for years 2005, 2006, and 2007		
D-3. Total Number of Work Hours Lost for years 2005, 2006, and 2007		
D-4. Total Number of Hours on Work Restriction for years 2005, 2006, and 2007		
D-5. Total Number of Workers Killed for years 2005, 2006, and 2007		

Civilian Incident Related Injury and death	**Fire Call**
D-6. Public Citizen/Civilian Fire related injuries for years 2005, 2006, and 2007	

D-7. Public Citizen/Civilian Fire Fatalities for years 2005, 2006, and 2007	

Department Profile Tab:
In this section, please provide basic information about your department overall.

Department Profile		
Fitness Program		
D-8. Does the department have a formal fitness/wellness program?		Yes No
D-8a. Is the program mandatory for all field personnel?		Yes No
D-9. Do you have an annual physical fitness assessment for all responding personnel?		Yes No
D-10. What proportion of stations have fitness equipment in stations for use by on-duty personnel?		%
D-11. Do you allow time on duty for cardiovascular workout?		Yes No
D-12. Do you have a periodic physical ability test at least annually?		Yes No
D-12a. How often are these tests conducted?		
D-13. Do you have medical physical exams for responding 'sworn' personnel (firefighters and paramedics)?		Yes No
Training		
D-14. Do you have regular in-service training program for all employees?		Yes No

FIRE FIGHTER SAFETY AND DEPLOYMENT STUDY

D-15. How many hours of Fire suppression related training are provided per employee annually (on average)?	
D-16. Do you conduct standard company evolutions?	☐ Yes ☐ No
D-17. Which evolutions are regularly conducted? [pick all that apply]	☐ Multiple Company Drills ☐ Night Drills ☐ Fire Suppression Drills ☐ Incident command/Officer ☐ Driver/Operator/Engineer ☐ Vehicle Extrication ☐ None
D-18. How many hours of ALS related training are provided per ALS provider annually (on average per employee)?	
D-19. How many hours of BLS related training are provided per BLS provider annually (on average per employee)?	
D-20. Which EMS Topics are regularly taught? [Pick all that apply]	☐ Blood Borne Pathogen ☐ Multiple Casualty ☐ CPR ☐ ACLS ☐ PALS ☐ BTLS ☐ Other:

Emergency Medical Dispatch	
D-21. Does your dispatch center use scripted dispatch for EMS calls (Medical Priority Dispatch, EMD, APCO etc.)?	☐ Yes ☐ No
Call intake/Call Processing/Dispatch	
D-22. Is your dispatch center a primary 9-1-1 call intake center?	☐ Yes ☐ No
D-23. Is your dispatch center a secondary answering point that receives calls from a 9-1-1 center?	☐ Yes ☐ No
D-24. Which of the following best describes call takers in your dispatch center? [Mark all that apply]	☐ Firefighters ☐ EMS Professionals ☐ Civilian ☑ Police ☐ None
D-25. Which of the following best describes dispatchers in your dispatch center? [Mark all that apply]	☐ Firefighters ☐ EMS Professionals ☐ Civilian ☐ Police ☐ None

Public Health Programs

D-26. How many hours per year does your department spend in public health programs? [ ]

D-27. Which programs do you conduct?
[Mark all that apply]

- ☐ CPR
- ☐ AED
- ☐ First Aid
- ☐ School Presentations
- ☐ Senior Presentations
- ☐ Other: [ ]
- ☐ None

Fire Safety Programs

D-28. How many hours per year does your department spend in fire safety programs? [ ]

D-29. Which programs do you conduct?
[Mark all that apply]

- ☐ Smoke Detectors
- ☐ Building Fire Drills
- ☐ School Presentations
- ☐ Senior Presentations
- ☐ Other: [ ]
- ☐ None

Response Capacity Profile Tab:
In this section, please provide a description of the crew typically deployed on each of the apparatus. This section is intended to record the number and level of training of personnel on each type of apparatus. (Note: If similar apparatus deployed with different crew sizes/types, please answer for the majority.)

D-30. Department Response Capacity Profile

Apparatus Type	Firefighters	Firefighter / EMT	Firefighter / Paramedic	EMS Only EMT	EMS Only Paramedic	Company / Unit Officer	Company Unit Officer/ Paramedic	EMS Supervisor	Chief Officer
Engine									
Truck/ Ladder/Aerial									
Quint									
Heavy Rescue									
Chief Officer Vehicle									
BLS Ambulance/ Transport Vehicle									

ALS Ambulance/ Transport Vehicle	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other:	☐	☐	☐	☐	☐	☐	☐	☐	☐

Incident Response Profile:

In this section, please provide a description of resources typically sent to each call type. This section is intended to record the number and type of apparatus sent to each type of incident.

D-31. Department Incident Response Profile

Call Type	BLS EMS Transport (Ambulance)	ALS EMS Transport (Ambulance)	Engine	Truck/ Aerial/ Ladder	EMS Super-visor	Chief Officer	Other
Investigate or Odor							
Fire Alarm Sounding Only							
Reported Single-Family Residential Structure Fire							
Reported Commercial or Multi-Family Residential Structure Fire							
Reported High-Rise or Other High-Risk Occupancy Fire							
Other							

BLS							
Public Assistance							
ALS - Cardiac							

ALS - Trauma							
ALS - Other							

Station Survey

Station Background Information Survey

Community Demographic Profile

In this section, describe the demographic profile of the station's coverage area.

Demographic Profile	
Buildings	
S-1. Density: Please select the area description for your response area. (estimation is appropriate - round off to nearest 10%)	Urban: ___ % Suburban: ___ % Rural: ___ % Wilderness: ___ % Total: ___ %
S-2. What percentage of buildings in your area are three stories or higher? (estimation is appropriate)	
S-3. What percentage of each type of structure does your station cover? (estimation is appropriate - round off to nearest 10%)	Single Family Residential: ___ % Multi-Family Residential: ___ % Manufacturing/Industrial: ___ % Commercial/Public: ___ % Multi-use: ___ % Vacant: ___ %

	Other: [ ] % Total: [ ] %
Coverage Area	
S-4. How many square miles does your station cover (your first due area)?	[ ]
Population	
S-5. What is the approximate population of the area your station covers?	Less than 1,000 ○ 1,001 - 5,000 ○ 5,001 - 10,000 ○ Greater than 10,000 ○
S-6. What is the annual call volume for your station?	Structure Fire: [ ] EMS: [ ]
Median Income	
The median household income for [ ] is $ [ ]	
S-7. Is the median income in your coverage area higher, lower or roughly the same as the city/county/parish median?	Higher: [ ] % Lower: [ ] % Same: [ ] % Total: [ ] %
Age Demographic	
S-8. What is the estimated age breakdown of your station coverage area during peak occupancy	Under 5: [ ] %

period?	5 to 17: [ ] % 18 to 24: [ ] % 25 to 44: [ ] % 45 to 64: [ ] % 65 and over: [ ] % Total: [ ] %

Race Demographic

S-9. Please check the race/ethnic group descriptions that represent greater than 20% of the population in your coverage area during peak occupancy period? [Mark all that apply]	☐ American Indian or Alaskan Native ☐ Hispanic ☐ Asian ☐ Middle Eastern ☐ Black or African American ☐ Native Hawaiian or Pacific Islander ☐ White ☐ Multi-Racial

Code Enforcement:

Code Enforcement	
Code Enforcement **S-10.** Excluding single and duplex residential structures, what is the percentage of structures in your response area that are inspected annually?	

Fire Incident Survey

Incident Survey: FIRE

Select type of call:

- ☐ Fire
- ☐ EMS

Upon arrival on scene, was there a working fire involving spread beyond the item of ignition?

- ☒ Yes
- ☐ No

If No is selected:

This project is only using structure fires which meet a minimum standard for severity. This incident does not meet the criteria for this study. Please select and enter another incident or log off. Thank you for your participation.

If Yes is selected:

Proceed on to the survey

Notification:
Describe the event by selecting the most appropriate dispatch call type and scene type/location in the drop boxes below. Select from only one of the three main call types below.

Station	
Please select the station that responded to this call:	

Department Incident Code/Number - for department tracking purposes	
Department Incident Code/Number	

Fire Events
I-1. Fire Dispatch Call Type
I-2. Scene Type/Location
Pre-Plan **I-2a.** Did the first due responding company have a pre-plan for the structure? Yes No

Both Fire and EMS Calls - answer these questions	(*note: indicates proximity and capacity)
I-3. Mutual Aid - (response unit from outside neighboring jurisdiction that must be called to respond) Was Mutual used in this response?	☐ Yes ☐ No
I-4. Automatic Aid - (automatically sends closest response unit regardless of geopolitical boundaries) Was automatic aid used in this response?	☐ Yes ☐ No

Incident as Found Tab:
Select the description that most clearly describes the ACTUAL incident found on scene. (First Company Report)

Fire Events
I-5. Dispatch Call Type
I-6. Scene Type/Location

Emergency Medical Service Events	
I-5. Dispatch Call Type	
I-6. Scene Type/Location	

Emergency Response Profile

Incident Response Profile:
In this section, please provide a description of resources typically sent to each call type. This section is intended to record the number and type of apparatus sent to each type of incident section.

For this incident, select the resources sent if they differ from the typical departmental response for such an event.

I-7. Number of ADDITIONAL apparatus dispatched. Please indicate additional resources sent.

BLS EMS Transport (Ambulance)	☐
ALS EMS Transport (Ambulance)	☐
Engine	☐
Truck/Aerial/Ladder	☐
EMS Supervisor	☐
Chief Officer	☐
Other	☐

Fire Intervention Tab:

Time to Intervention (If you do not record any one of these time intervals and cannot realistically enter the data, please leave the answer blank)	Time Stamp
I-8. 9-1-1 Call Pickup Time Time the 9-1-1 call takers answered the phone	__ : __ : __
I-9. Fire Department Dispatcher Pick-Up Time = Fire Department Alerted	__ : __ : __
I-10. Dispatch Time Time that applicable response units are notified of the emergency = Fire station alerted (time at the beginning of the information delivery)	__ : __ : __
I-11. Enroute Time The time the responding units have wheels rolling (CAD/AVL noted Enroute)	__ : __ : __
I-12. Arrival Time The time that the first unit arrived at the scene (Wheels stopped)	__ : __ : __

Early Intervention:

*Early Intervention were any of the following early interventions used prior to emergency responder arrival?	(yes/no)
I-13. Occupant attempted Extinguishment	☐ Yes ☐ No
I-14. Sprinkler Activated	☐ Yes ☐ No

I-15. Monitored Alarm Activated	☐ Yes ☐ No
I-16. Automatic Alarm Activated	☐ Yes ☐ No
I-17. Smoke Detector Activated	☐ Yes ☐ No
I-18. Other	☐ Yes ☐ No

Final Response:

For each incident where intervention occurred, select the resources actually engaged.

For this incident, select the resources sent if they differ from the typical departmental response for such an event.

I-19. Please indicate the number of resources sent.	
BLS EMS Transport (Ambulance)	
ALS EMS Transport (Ambulance)	
Engine	
Truck/Aerial/Ladder	
EMS Supervisor	
Chief Officer	
Other	

Incident Outcome Tab:

Select the outcome of this event and enter the closest estimates when dollars or employee work hours are involved.

Economic Incident Related Consequences	**Fire**
I-20. Direct Economic Loss (Fire Loss) ($ estimated)	$
I-21. Percentage of the Structure Damaged	

Firefighter Incident Injuries and Death [From Dispatch to In-Quarters]	**Fire Call**
I-22. Total Number of Workers Injured	
I-23. Medical Attention Required	Yes No
I-23a. How many workers required medical attention?	
I-23b. Worker Injury Severity	No work missed Employee off Rest of shift - replacement brought in (position backfilled) Full duty leave less than 30 days

	☐ Full duty leave more than 30 days
I-24. Total Number of Workers Fatalities	☐

EMS Incident Survey

Incident Survey: EMS

Select type of call:

- ☐ Fire
- ☐ EMS

Upon arrival on scene, was there a confirmed ALS event?

- ☐ Yes
- ☐ No

If No is selected:

This project is only using EMS responses which meet a minimum standard for severity. This incident does not meet the criteria for this study. Please select and enter another incident or log off. Thank you for your participation.

If Yes is selected:

Proceed on to the survey

Event Notification Tab:
Describe the event by selecting the most appropriate dispatch call type and scene type/location in the drop boxes below. Select from only one of the three main call types below.

Station	
Please select the station that responded to this call:	

Incident Identifier - for department tracking purposes	
Department Incident Code/Number	

Emergency Medical Service Events	
I-1. Dispatch Call Type	
I-2. Scene Type/Location	
Both Fire and EMS Calls - answer these questions	(*note: indicates proximity and capacity)
I-3. Mutual Aid - (response unit from outside neighboring jurisdiction that must be called to respond) Was Mutual used in this response?	Yes No
I-4. Automatic Aid - (automatically sends closest response unit regardless of geopolitical boundaries) Was automatic aid used in this response?	Yes No

Incident as Found Tab:
Select the description that most clearly describes the ACTUAL incident found on scene. (First Company Report)

Emergency Medical Service Events	
I-5. Dispatch Call Type	
I-6. Scene Type/Location	

Emergency Response Profile

Incident Response Profile:

In this section, please provide a description of resources typically sent to each call type. This section is intended to record the number and type of apparatus sent to each type of incident section.

For this incident, select the resources sent if they differ from the typical departmental response for such an event.

I-7. Did the response deployment to this incident DIFFER from the normal department deployment for other incidents of this nature? If so, please indicate additional resources sent.	
BLS EMS Transport (Ambulance)	☐
ALS EMS Transport (Ambulance)	☐
Engine	☐
Truck/Aerial/Ladder	☐
EMS Supervisor	☐
Chief Officer	☐
Other	☐

EMS Intervention Tab:

Time to Intervention (If you do not record any one of these time intervals and cannot realistically enter the data, please leave the answer blank)	Time Stamp
I8. 9-1-1 Call Pickup Time Time the 9-1-1 call takers answered the phone	: :
I-9. Fire Department Dispatcher Pick-Up Time = Fire Department Alerted	: :
I-10. Dispatch Time Time that applicable response units are notified of the emergency = Fire station alerted (time at the beginning of the information delivery)	: :
I-11. Enroute Time The time the responding units have wheels rolling (CAD/AVL noted Enroute)	: :
I-12. BLS Arrival Time The time that the first BLS trained personnel arrives at the scene (Wheels stopped)	: :
I-13. ALS Arrival Time The time that the first ALS personnel arrives at the scene (Wheels stopped) = ALS means personnel trained and equipped to delivery care.	: :
I-14. At Patient Side Time The time responders arrive at patient side to begin assessment/care.	: :

***Early Intervention** were any of the following early interventions used prior to emergency responder arrival?	(yes/no)
I-15. Attempted Intervention - AED	☐ Yes ☐ No
I-16. Attempted Intervention - CPR	☐ Yes ☐ No
I-17. Attempted Intervention - Medicine Administration	☐ Yes ☐ No
I-18. Other	☐ Yes ☐ No

Final On-Scene Use of Resources Tab:

For each incident where intervention occurred, select the resources actually engaged.

For this incident, select the resources sent if they differ from the typical departmental response for such an event.

I-19. Number of ADDITIONAL apparatus dispatched. Please indicate additional resources sent.	
BLS EMS Transport (Ambulance)	☐
ALS EMS Transport (Ambulance)	☐
Engine	☐
Truck/Aerial/Ladder	☐
EMS Supervisor	☐
Chief Officer	☐
Other	☐

Patient Status During Incident:

I-20. How many patients were assisted? (may enter data for up to ten patients)

Patient 1	
Patient status upon Scene Assessment	Vital Signs
Blood pressure	/
Pulse	beats/minute
Respiratory Status	
Respiratory Rate	breaths/minute
Respiratory Value	
Respiratory Sounds	Normal Abnormal
Skin Color/Temp	Normal Abnormal
Pulse Oximeter	%
EKG	Normal Abnormal
Pain Level (scale 1-10)	

Patient status upon Hospital Arrival		Vital Signs
Blood pressure		/
Pulse		per minute
Respiratory Status		
	Respiratory Rate	breaths/minute
	Respiratory Value	
Respiratory Sounds		Normal Abnormal
Skin Color/Temp		Normal Abnormal
Pulse Oximeter		%
EKG		Normal Abnormal
Pain Level (scale 1-10)		

Incident Outcome Tab:

Select the outcome of this event and enter the closest estimates when dollars or employee work hours are involved.

Worker Incident Related Injuries and Death [From Dispatch to In-Quarters]	**EMS Call**
I-21. Total Number of Workers Injured	☐
I-22. Medical Attention Required	☐ Yes ☐ No
I-22a. How many workers required medical attention?	☐
I-22b. Worker Injury Severity	☐ No work missed ☐ Employee off Rest of shift - replacement brought in (position backfilled) ☐ Full duty leave less than 30 days ☐ Full duty leave more than 30 days
D23. Total Number of Workers Fatalities	☐

Appendix E. Fire Department Survey Training Manual

1.0 Introduction

The study team would like to thank you and your department for your participation in these web surveys. The data that you are providing is crucial to the development of a risk assessment and resource deployment model representing typical fire department responses for both structure fires and advanced life support EMS. The results of your participation and that of others like you will assist us in providing tools to assist local decision makers to more adequately match resources to risk levels of adverse events to which firefighters respond. The overall effect will be better resource-to-risk matches for all responses resulting in better firefighter safety, fewer line-of-duty injury and death.

2.0 Project Objective

This project in firefighter safety and deployment of resources seeks to enable fire departments and city/county managers to make sound decisions regarding optimal fire department resource allocation and service based upon scientifically-based community risk assessment, strategic emergency response system deployment and the local government's service commitment to the community.

3.0 Survey Overview

This survey is organized into three distinct sections: the department survey, the station survey and the incident survey. You may access these surveys by going to the study web site www.firereporting.org and clicking "Complete Surveys" on the left menu. At that point you will be presented with a new page for entering a user name and password. The user name and password were assigned to your department in the letter detailing which stations were selected for data entry. If you do not have the letter, please check with the chief or contact Dr. Lori Moore-Merrell at 202-824-1594 or Lmoore@iaff.org .

Once you enter the user name and password, you will be taken to a page that displays red buttons for each survey as well as a button to manage your account. You will complete each survey as noted below.

For each survey, click the corresponding 'Red Button' to open the survey to begin.

Department Survey – Complete only once with a focus on the department as a whole.

Station Survey – Complete only once for EACH station selected in the study. The list of stations selected into the study from your department was provided to your chief. If you do not have the list please contact the chief or contact Dr. Lori Moore-Merrell at 202-824-1594 or Lmoore@iaff.org

Incident Survey – Complete numerous times for actual structure fires and ALS EMS responses from the selected stations. This survey will be completed once for each response meeting the study criteria.

4.0 Complete Surveys:

Click the red “Department Survey” button on the “Complete Surveys” page you will see the categories of questions arranged in grey tabs on top of the new window that appears. Clicking on the tabs will navigate you to the corresponding set of questions for each category. Alternatively you may click the “Next Page” button as you complete each set of questions.

Once the “Department Survey” is complete, and you click “Submit”, the station survey is next. The station survey may be accessed by returning to the “Complete Surveys” page. Once again, you will see the categories of questions arranged in grey tabs on top of the new window that appears. Clicking on the tabs will navigate you to the corresponding set of questions for each category. Alternatively you may click the “Next Page” button as you complete each set of questions.

Once the “Station Survey” is complete for each station entered in the study, the incident survey is next. The incident survey may be accessed by returning to the “Complete Surveys” page. Once again, you will see the categories of questions arranged in grey tabs on top of the new window that appears. Clicking on the tabs will navigate you to the corresponding set of questions for each category. Alternatively, you may click the “Next Page” button as you complete each set of questions. As a reminder, the “Incident Survey” will be completed multiple times. After you click “Submit” at the end of each “Incident Survey” then return to the “Complete Surveys” page to began a new “Incident Survey.”

4.1 Department Survey

The following section will describe in detail the expected answers for the questions presented on the department survey, question by question. To begin, start by navigating to the department survey page. You may do this from any page within the Fire Reporting System web site by clicking on the “Complete Surveys” button on the menu on the left side of your screen. The “Complete Surveys” page presents you with red buttons for the department, station and incident surveys as well as for changing your username/password.

Click on the “Department Survey” button. This will open the first page of the survey. On each question, you will see a red question mark in a white circle. This is a “help” button. At any time you need more information to answer a particular question, just roll your mouse over the “help” button next to the question number and more information will be provided to you.

4.1.1 Prior Events Tab

This section of the guide details each question asked in the “Prior Events” tab of the department survey.

Economic Consequences

Question D1. Total Annual Direct Economic Losses (Fire Loss) for years 2005, 2006, and 2007 (structure and contents)

To answer this question provide an estimate to the nearest U.S. dollar of the total fire loss including physical damages caused by fires to structures and their contents that has occurred in your entire department’s coverage area over the last 3 years. Consider only physical damages and not damages such as close of business.

Firefighter Incident Related Injury and Death

Question D2. Total Number of Workers Injured for years 2005, 2006, and 2007

Using your departmental records, provide the number of responding personnel (firefighters or paramedics) who sustained an injury while on duty, regardless of whether or not the injury occurred during a response. Leave the field blank if there were no injuries. Please note the separate boxes for “fire” and “EMS” injuries. Of greatest interest are injuries that required one or more of the following:
1) Medical attention.
2) Taking the rest of the shift off.
3) Missing one or more days of work.

Multiple injuries to an individual firefighter (or paramedic) may be counted more than once provided that their injuries occurred on different responses.

Question D3. Total Number of Work Hours Lost for years 2005, 2006, and 2007

Using your departmental records, provide the total number of 'hours of scheduled work' missed due to personnel injury or death, within the last three years. Please note the separate boxes for “fire” and “EMS.”

Question D4. Total Number of Hours on Work Restriction for years 2005, 2006, and 2007

Using your departmental records, provide the total number of hours that your departmental staff spent on work restriction as a result of on-duty injuries, within the last 3 years. Work restriction is synonymous with "light duty."

Question D5. Total Number of Workers Killed for years 2005, 2006, and 2007

Provide the total number of line-of-duty deaths occurring in your department in the last 3 years. These are to include deaths occurring during fire ground activity or during an EMS response or transport.

Civilian Incident Related Injury and death

Question D6. Public Citizen /Civilian-Fire related injuries for years 2005, 2006, and 2007

Provide the total number of civilians injured as a result of fires in your community within the last three years.

Question D7. Public Citizen /Civilian Fire Fatalities for years 2005, 2006, and 2007

Provide the total number of citizens/civilians killed as a result of fires in your community within the last three years.

4.1.2 Profile

This section of the guide details each question asked in the "Profile" tab of the department survey.

Fitness Program

The questions in this section are about your department's fitness program, if one exists. Check the appropriate button for each question.

Question D8. Does the department have a formal fitness/wellness program?

If your department has organized and implemented a physical fitness or wellness program click "Yes", otherwise click "No."

Question D8a. Is the program mandatory for all field personnel?

If your department requires you to participate in a physical fitness or wellness program click "Yes", otherwise click "No."

Question D9. Do you have an annual physical fitness assessment for all responding personnel?

If your department conducts an annual physical fitness assessment click "Yes", otherwise click "No."

Question D10. What proportion of stations have fitness equipment in station for use by on-duty personnel?

If your department has fitness equipment in stations, click the appropriate response based on your situation.

Question D11. Do you allow time on duty for cardiovascular workout?

Click "Yes" If you are allowed time for cardiovascular exercise while on duty, otherwise click "No."

Question D12. Do you have a periodic physical ability test at least annually?

If your department conducts periodic (at least annual) physical ability tests, click "Yes", otherwise click "No."
Examples of physical ability tests:

- Firefighting specific: dry/charged hose drags, victim rescue, attic crawl, etc.
- Standard/Traditional: sit-ups, pushups, sit-and-reach, etc.

Question D12a. How often are these tests conducted?

Select the closest answer from the drop down list.

Question D13. Do you have medical physical exams for responding 'sworn' personnel (firefighters and paramedics)?

Click "Yes" If your department conducts medical physical exams for firefighters/paramedics (sometimes known as sworn personnel), otherwise click "No."

Training

These questions ask about your department's fire and EMS training requirements. Check all appropriate buttons and boxes. For text boxes provide an estimate of the number of hours related to the specific question asked. It is important to know the quantity and types of training necessary to benefit fire departments and their communities.

D14. Do you have regular in-service training program for all employees?

If your department has conducts regular training for all employees click "Yes", otherwise click "No."
Examples of training:

- Company evolutions
- Classroom sessions
- Morbidity and Mortality rounds ("M&Ms")
- Close call bulletins

D15. How many hours of Fire suppression related training are provided per employee annually (on average)?

Enter the number of hours of fire suppression related training the average employee is provided annually into the field. Include both practical and classroom training.

D16. Do you conduct standard company evolutions?

If your department regularly conducts standard company evolutions for all employees click “Yes”, otherwise click “No.”

D17. Which evolutions are regularly conducted? [Pick all that apply]

From the list of options provided, check all the boxes next to the type of company evolutions that your employees participate in on a regular basis.

D18. How many hours of ALS related training are provided per ALS provider annually (on average per employee)?

Enter the number of hours of ALS related training provided to the average ALS provider annually. Include both practical and classroom training.

D19. How many hours of BLS related training are provided per BLS provider annually (on average per employee)?

Enter the number of hours of BLS related training provided (on average) per provider annually. Include both practical and classroom training.

D20. Which EMS topics are regularly taught? [Pick all that apply]

From the list of options provided, check all the boxes next to the type of EMS topics that are regularly offered to your employees.

Emergency Medical Dispatch

This section asks whether or not your department uses scripted dispatching. Scripted dispatching has dispatchers follow written guidelines for caller interaction to determine the severity (ALS or BLS) of a call and to send the appropriate resource. Some examples of scripted dispatch programs are the Medical Priority Dispatch system (MPD), the

Association of Public-Safety Communications Officials system (APCO), or a generic Emergency Medical Dispatch system (EMD).

D21. Does your dispatch center use scripted dispatch for EMS calls (Medical Priority Dispatch, EMD, APCO etc.)?

Click "Yes" if your dispatching center uses any of the following protocols:

- Medical Priority Dispatch system (MPD)
- the Association of Public-Safety Communications Officials system (APCO)
- Generic scripted Emergency Medical Dispatch system (EMD)

Otherwise, click "No."

Call intake/Call Processing/Dispatch

The questions in this section regard whether your dispatch center is first to receive 911 calls (primary call center) or whether the calls are routed from another center that takes 911 calls. Also asked are the backgrounds of the personnel that dispatch calls.

D22. Is your dispatch center a primary 9-1-1 call intake center?

Click "Yes" if your dispatch center is the first to receive a 9-1-1. For any other case click "No."

D23. Is your dispatch center a secondary answering point that receives calls from a 9-1-1 center?

Click "Yes" if 9-1-1 calls are routed to your dispatch center from another location that first answers 9-1-1 calls. For any other case click "No."

D24. Which of the following best describes call takers in your dispatch center? [Mark all that apply]

Mark all the boxes that describe type of experience the call takers have in your dispatching center.

D25. Which of the following best describes dispatchers in your dispatch center? [Mark all that apply]

Mark all the boxes that describe type of experience the dispatchers have in your dispatching center.

Public Health Programs

The questions in this section regard the health related public education programs hosted by your department. School Presentations include programs offered at schools of any level, k-12, college, etc. Senior Presentations include programs that your department offers at senior centers and residences. The field entitled “Other” is left open as an option to input additional public health programs that your department conducts, separated by commas.

D26. How many hours per year does your department spend in public health programs?

Enter the total number of hours that your department spends annually on conducting public health programs. For examples of public health programs see question D27 in the survey.

D27. Which programs do you conduct? [Mark all that apply]

Mark all the boxes that describe type of public health programs your department conducts.

Fire Safety Programs

The questions in this section regard fire safety public educational programs hosted by your department. School Presentations include programs offered at schools of any level, k-12, college, etc. Senior Presentations include programs that your department offers at senior centers and residences. The field entitled “Other” is left open as an option to input additional fire safety programs that your department conducts, separated by commas.

D28. How many hours per year does your department spend in fire safety programs?

Enter the total number of hours that your department spends annually on conducting fire safety programs. For examples of fire safety programs see question D26.

D29. Which programs do you conduct? [Mark all that apply]

Mark all the boxes that describe type of fire safety programs your department conducts.

4.1.3 Response Capacity

This section of the guide details each question asked in the "Response Capacity" tab of the department survey. Please provide a description of the crew typically deployed on each of the apparatus. This section is intended to record the number and level of training of personnel on each type of apparatus. (Note: If similar apparatus deployed with different crew sizes/types, please answer for the majority.) Drivers/Engineers should be categorized appropriately based on their level of training as a firefighter, paramedic or both.

Engine:

For this row, fill out the typical staffing of one of your department's engine companies including officers. Each column corresponds to the training level of your personnel.

Example:

Prior Events | Profile | Response Capacity | Incident Response

deployed with different crew sizes/types, please answer for the majority.)

D-30. Department Response Capacity Profile

Apparatus Type	Firefighters	Firefighter/ EMT	Firefighter/ Paramedic	EMS Only EMT	EMS Only Paramedic	Company/ Unit Officer	Company Unit Officer/ Paramedic	EMS Supervisor	Chief Officer
Engine		2	1			1			

Truck/Ladder/Aerial:

For this row, fill out the typical staffing of one of your department's Truck/Ladder/Aerial companies including officers. Each column corresponds to the training level of your personnel.

Example:

Prior Events | Profile | Response Capacity | Incident Response

deployed with different crew sizes/types, please answer for the majority.)

D-30. Department Response Capacity Profile

Apparatus Type	Firefighters	Firefighter/ EMT	Firefighter/ Paramedic	EMS Only EMT	EMS Only Paramedic	Company/ Unit Officer	Company Unit Officer/ Paramedic	EMS Supervisor	Chief Officer
Truck/ Ladder/Aerial		3				1			

Heavy Rescue:

For this row, fill out the typical staffing of one of your department’s rescue companies. Each column corresponds to the training level of your personnel.

Chief Officer Vehicle:

For this row, fill out the typical staffing of one of your Chief Officer Vehicles. Each column corresponds to the training level of your personnel.

Ambulance/Transport Vehicle:

For this row, fill out the typical staffing of an Ambulance or other transport vehicle. Each column corresponds to the training level of your personnel.

Other:

For this row, first input the type of “other” unit that describes any apparatus your department typically staff, then input the typical staffing for that apparatus. Each column corresponds to the training level of your personnel.

4.1.4 Incident Response

This section of the guide details each question asked in the “Incident Response” tab of the department survey. Please provide a description of resources typically sent to each call type. This section is intended to record the number and type of apparatus sent to each type of incident.

Investigate Odor:

For this row, input the number of each type of apparatus that you typically dispatch to ‘Investigate an Odor’

Example:

D-31. Department Incident Response Profile

Call Type	BLS EMS Transport (Ambulance)	ALS EMS Transport (Ambulance)	Engine	Truck/Aerial/ Ladder	EMS Supervisor	Chief Officer	Other
Investigate or Odor			2	1		1	

Fire Alarm Sounding Only:

For this row, input the number of each type of apparatus that you typically dispatch to a "fire alarm sounding only."

Reported Single Family Residential Structure Fire:

For this row, input the number of each type of apparatus that you typically dispatch to a "reported single family structure fire."

Reported Commercial or Multi-Family Residential Structure Fire:

For this row, input the number of each type of apparatus that you typically dispatch to a "reported commercial or multi-family structure fire."

Reported High-Rise or other High Risk Occupancy Fire:

For this row, input the number of each type of apparatus that you typically dispatch to a reported high-rise or other high risk occupancy fire.

Other:
For this row, enter the number of apparatus the department typically dispatches to another relevant 'structure' not covered above. PLEASE DO NOT enter information for vehicle fires.

BLS:

For this row, input the number of each type of apparatus that you typically dispatch to a BLS incident.

Public Assistance:

For this row, input the number of each type of apparatus that you typically dispatch to a Public Service.

ALS – Cardiac:

For this row, input the number of each type of apparatus that you typically dispatch to an ALS - Cardiac incident.

ALS – Trauma:
For this row, input the number of each type of apparatus that you typically dispatch to an ALS - Trauma incident.

ALS – Other:

For this row, input the number of each type of apparatus that you typically dispatch to an ALS Call that is not Cardiac or Trauma. (e.g. Severe Respiratory distress or non breathing patient)

*4.2 Station Background Information **Survey***

The following section will describe in detail the expected answers for the questions presented on the station background survey. To begin, start by navigating to the station survey page. You may do this from any page within the Fire Reporting System web site by clicking on the "Complete Surveys" button on the menu on the left side of your screen. The "Complete Surveys" page presents you with red buttons for the department, station and incident surveys as well as for changing your username/password. Click on the "Station Survey" button. If you need help to answer any of the questions, put your mouse over the question mark next to the number of the question and you will see a brief description of what to do. If you need more help, consult the explanations found below.

4.2.1 Community Profile

This section of the guide details each question asked in the "Community Profile" tab of the department survey.

Before you begin the numbered questions, you are asked to select the appropriate station from the drop down list. Select one of the stations that have been selected for your department. You will answer the questions that follow once for each station in the list. You will go through all questions for the station selected, then go back to 'station survey' and select a different station. You will then answer all the questions for that station and so on until the questions have been answered and submitted for each of your stations selected into the study. The list of stations was sent to your chief. If you do not have the list, please contact your chief or Dr. Lori Moore-Merrell at 202-824-1594 or Lmoore@iaff.org.

Demographic Profile

Question S1: Density: Please select the area description for your response area. (Estimation is appropriate - round off to nearest 10%)

Complete the four fields describing the population densities of your station coverage area. Please estimate the makeup of your area to within 10%. For example, a downtown city station may have 100% urban coverage, while another station in your department may cover 20% urban, 70% suburban and 10% wilderness. This applies only to a particular station. Please check to be sure that your selections total 100%.

Question S2: What percentage of buildings in your area are three stories or higher? (Estimation is appropriate)

Out of the total number of buildings in your station coverage area, how many of them are three full stories or greater in height on the tallest side? Select the percentage that best matches your estimate from the drop down list. Past fires have shown that building height can have a significant impact on the effectiveness and outcome of fire operations.

Question S3: What percentage of each type of structure does your station cover? (Estimation is appropriate - round off to nearest 10%)

For your station, what is the percentage of each occupancy category listed in under this question that makes up your coverage area? Estimate to within 10%. Ensure that your total of all occupancies sums to 100% by looking at the final box. Building occupancy is likely relevant to the outcome of fire operations as it relates the number of people and property at risk to the potential severity and occurrence of fires.

Coverage Area

Question S4: How many square miles does your station cover (your first due area)?

What is the total coverage area of your station in square miles? Input a whole number into the field provided. Round your estimate to the nearest mile. This information is important to understanding the response and transport times as well as the deployment of your department's resources related to geography.

Population

Question S5: What is the approximate population of the area your station covers?

Please click one of the radio buttons corresponding to the range of population into which your immediate coverage area fits. This information is important to understanding your department's deployment of resources related to the population served.

Question S6: What is the annual call volume for your station?

For each general type of call, fill in each field using your department's records. This data helps to understand your department's deployment of resources related to the local demand for services. Please use the final 'call type' as opposed to 'dispatch' for determining which category to select.

Median Income

The median household income for ____ is $____

What is the average household income for your immediate coverage area? Median household income for your city/county will be shown.

Question S7: Is the median income in your coverage area higher, lower or roughly the same as the county median?

You should estimate whether the jurisdiction the station services is higher, lower, or equal to this amount. Previous studies have shown that income levels significantly impact the occurrence and outcome of fires. Use the fields provided to break down the income of the population within your immediate coverage area. Provide estimations to the nearest 10%. For example, you may have a very affluent population that makes up only 10% of your coverage area. The rest may be 50% the same income and 40% lower income. Using the final box, ensure that your total is 100%.

Age Demographics

Question S8: What is the estimated age breakdown of your station coverage area during peak occupancy period?

Use the fields provided to break down the ages of the populace in your station coverage area. Using the final box, ensure that your total is 100%. This information is important because previous studies have identified different risks for different age groups. Namely, the very young and very old are at a higher risk of death in a fire.

Race Demographic

Question S9: Check the race/ethnic group descriptions that represent greater than 20% of the population in your coverage area during peak occupancy period. [Mark all that apply]

Check all boxes that apply for the categories provided to describe the race/ethnic make-up of your immediate coverage area. Your occupancy may change seasonally because of college or tourist populations. Previous studies have identified that race/ethnicity may be related to the outcome of fires, but results of these studies are conflicted.

4.2.2 Code Enforcement

This section of the guide details each question asked in the "Code Enforcement" tab of the department survey.

Question S10: Excluding single and duplex structures, what is the percentage of structures in your response area that are inspected annually?

Input the percentage of structures annually inspected, excluding single and duplex residential structures. Building inspections are important to report as code compliance is critical to reducing the risk and improving the outcomes of fires. Single and duplex structures are not considered in this study because they are not traditionally inspected.

4.3 Incident Data Collection Survey

The following section will describe in detail the expected answers for the questions presented on the incident data collection survey. To begin, start by navigating to the incident data collection survey page. You may do this from any page within the Fire Reporting System web site by clicking on the "Complete Surveys" button on the menu on the left side of your screen. The "Complete Surveys" page presents you with red buttons for the department, station and incident surveys as well as for changing your username/password. Click on the "Incident Survey" button. If you need help to answer any of the questions, put your mouse over the question mark next to the number of the question and you will see a brief description of what to do. If you need more help, consult the explanations found below.

Once on the incident survey page, you will be asked to select either 'Fire' or EMS' incident. Click the appropriate button based on the type of call for which you are entering data. Once you choose the call type, you will be asked another question regarding the magnitude of the incident. For 'Fire' incidents, you are asked to enter data for 'working fire involving spread beyond the item of ignition'. For 'EMS' incidents, you are asked to enter data for 'confirmed ALS events'.

If you answer 'Yes' to confirm that the incident for which you are prepared to enter data meets the described criteria for 'Fire' or 'EMS', you will be taken to the first question in the survey to begin data entry.

4.3.1 Notification

This section of the guide details each question asked in the "Notification" tab of the department survey.

Station:

Before beginning this survey, select the station for which you are entering incident data. You will enter multiple incidents, both for structure fires and ALS responses for each station.

Department Incident Code/Number:

Enter the Incident Number associated with the event you are entering. Use the incident numbering system for your department. This number allows you to track the call in this study if you wish to edit the information entered in the future.

Question I1: Fire Dispatch Call Type

Select the call type as DISPATCHED from the drop down list.

Question I2: Scene Type/Location

Select the scene type reported in the initial dispatch by using the drop down list.

Question I2a: Did the first due responding company have a pre-plan for the structure?

A pre-plan is developed for each building/location and each plan should take into account the type and scale of an adverse risk event (incident), the potential mitigation approaches and the resources required to respond to the incident. In the event of an incident, the preplan should be rapidly converted into a realistic and effective operational response. Select yes or no.

Question I1: EMS Dispatch Call Type

Select the call type as DISPATCHED from the drop down list.

Question I2: Scene Type/Location

Select the scene type reported in the initial dispatch by using the drop down list.

Question I3: Was Mutual aid used in this response?

Did this incident require the additional dispatch of resources outside of your department? Click the appropriate radio button.

Question I4: Was automatic aid used in this response?

Did this incident result in the simultaneous response of additional resources from outside of your Department as previously arranged with another community or district? Click the appropriate radio button.

4.3.2 Response

This section of the guide details each question asked in the "Response" tab of the department survey.

Question I5: Dispatch Call Type

Select the observed call type ON ARRIVAL from the drop down list.

Question I6: Scene Type/Location

Select the observed scene location ON ARRIVAL from the drop down list.

Incident Response Profile

Did the response deployment to this incident differ from the normal department deployment for other incidents of this nature? If so, please indicate the additional resources sent.

Question I7: Number of ADDITIONAL apparatus dispatched.

Using the fields provided, indicate within the columns how many more units were dispatched in addition to your department's typical response for this type of call.

4.3.3 Intervention

This section of the guide details each question asked in the "Community Intervention" tab of the department survey. This section is to be completed with the times at which specific response events occurred during your entire emergency response, beginning from when a 911 call is answered through arrival of the first apparatus on scene. Use 24-hour military "clock time" format: (HH:MM:SS Format)

Question I8: 9-1-1 Call Pickup Time

Enter the exact time that the 9-1-1 call taker answered the phone (HH:MM:SS Format). If you did not record this time stamp and cannot enter it, please leave this field blank.

Question I9: Fire Department Dispatcher Pick-Up Time = Fire Department Alerted

Enter the exact time that your department's dispatcher answered the phone (or was alerted by the primary call taker (HH:MM:SS Format)). If you did not record this time stamp and cannot enter it, please leave this field blank.

Question I10: Dispatch Time

Enter the exact time that the response units were initially notified of the incident (HH:MM:SS Format). If you did not record this time stamp and cannot enter it, please leave this field blank.

Question I11: Enroute Time

Enter the exact time at which the unit dispatched was prepared to leave and began its response (apparatus wheels start to move (HH:MM:SS Format)). If you did not record this time stamp and cannot enter it, please leave this field blank.

Question I12: Arrival Time (Fire Only)

Enter the exact time that the first apparatus arrived on scene (wheels stopped, responders ready to exit the vehicle (HH:MM:SS Format)). If you did not record this time stamp and cannot enter it, please leave this field blank.

Question I12: BLS Arrival Time (EMS only)

Enter the exact time that the BLS apparatus dispatched to this incident arrived on scene (wheels stopped, responders ready to exit the vehicle (HH:MM:SS Format)). If you did not record this time stamp and cannot enter it, please leave this field blank.

Question I14: ALS Arrival Time (EMS only)

Enter the exact time that the ALS apparatus dispatched to this incident arrived on scene (wheels stopped, responders ready to exit the vehicle (HH:MM:SS Format)). If you did not record this time stamp and cannot answer it, please leave this field blank.

Question I15: At Patient Side Time (EMS only)

Enter the exact time that emergency medical personnel arrived at the patient's side and began to assess the patient and administer medical aid (HH:MM:SS Format). If you did not record this time stamp and cannot enter it, please leave this field blank.

FIRE Early Intervention

Question I13: Occupant attempted Extinguishment

Click the button for "yes" if prior to your arrival, an occupant/bystander attempted some method of extinguishment. (e.g. Portable fire extinguisher) Otherwise click "no."

Question I14: Sprinkler Activated

Click the button for "yes" if the building's sprinkler system **automatically** activated prior to your arrival. Otherwise click "no."

Question I15: Monitored Alarm Activated

Click the button for "yes" if alarm activation occurred at an actively staffed alarm monitoring station. Otherwise click "no."

Question I16: Automatic Alarm Activated

Click the button for "yes" if an automatic alarm was activated prior to your arrival. Otherwise click "no."

Question I17: Smoke Detector Activated

Click the button for "yes" if one or more smoke detectors were activated prior to your arrival. Otherwise click "no."

Question I18: Other

Click the button for "yes" if any other means of fire suppression, control, notification or some other intentional activity was carried out prior to your arrival. Otherwise click "no"

EMS Early Intervention

Question I15: Attempted Intervention – AED

Click the button for "yes" if prior to your arrival a bystander attempted automatic external defibrillation. Otherwise click "no."

Question I16: Attempted Intervention – CPR

Click the button for "yes" if prior to your arrival a bystander attempted to perform CPR. Otherwise click "no."

Question I17: Attempted Intervention - Medicine Administration

Click the button for "yes" if prior to your arrival, qualified medical personnel administered medicine to the patient. Otherwise click "no."

Question I18: Other

Click the button for "yes" if prior to your arrival any other means of medical care was attempted by medical personnel/bystanders. Otherwise click "no."

4.3.4 Final Response

This section of the guide details each question asked in the "Final Response" tab of the department survey.

Question I19: Number of additional apparatus dispatched

In this section, indicate within the columns how many more units were dispatched in addition to your department's initial response for this type of call.

Question I20: Patient Status during Incident (EMS Only)

How many patients were assisted? (Enter data for up to ten patients). For each patient repeat the following process.

On-Scene Assessment:

Blood Pressure: Enter the patient's systolic blood pressure in the first field and diastolic blood pressure in the second field.

Pulse: Enter the patient's heart rate in beats per minute.

Respiratory Rate: Enter the patient's respiratory rate, in breaths per minute.

Respiratory Value: Select the patient's respiratory value from the drop down list

Respiratory Sounds: Click "Abnormal" if the patient has any respiratory sounds that are not "Normal."

Skin Color/Temp: Click "Abnormal" is the patient's perfusion is any condition other than "Normal." In addition, describe this condition further using the categories available in the drop-down list.

Pulse Oximeter: Input patient's pulse Oximeter reading. If you did not capture an on-scene pulse Oximeter reading, leave this field blank.

EKG: Using your best judgment, indicate whether the patient's EKG reading is "Normal" or "Abnormal." If you did not capture an on-scene EKG reading, leave this field blank.

Pain Level (scale 1-10): Using the drop-down list record the level of pain the patient gave in your patient interview. If the patient is unconscious, leave this field blank. If you did not capture an on-scene pain level, leave this field blank.

Patient status upon Hospital Arrival:

Blood Pressure: Enter the patient's final systolic blood pressure in the first field and diastolic blood pressure in the second field.

Pulse: Enter the patient's final heart rate in beats per minute.

Respiratory Rate: Enter the patient's final respiratory rate, in breaths per minute.

Respiratory Value: Select the patient's final respiratory value from the drop down list. If 'other' please describe?

Respiratory Sounds: Click "Abnormal" if the patient still has any respiratory sounds that are not "Normal."

Skin\Color Temp: Click "Abnormal" is the patient's perfusion is any condition other than "Normal." In addition, describe this condition further using the categories available in the drop-down list.

Pulse Oximeter: Input patient's final pulse Oximeter reading if available. Otherwise leave it blank.

EKG: Using your best judgment, indicate whether the patient's final EKG reading is "Normal" or "Abnormal."

Pain Level (scale 1-10): Using the drop-down list record the level of pain the patient gave in your patient interview. If the patient is still unconscious, leave this field blank.

4.3.5 Outcome

This section of the guide details each question asked in the "Outcome" tab of the department survey.

Economic Incident Related Consequences

Question I20: Direct Economic Losses (Fire Loss) ($ estimated) (Fire Only)
In the field provided, enter a dollar estimate of the amount of damage incurred to the structure and its contents.

Question 21: Percentage of the Structure Damaged

What percentage of the building(s) is considered to be a total loss? Estimation is appropriate, use the drop down box provided.

Firefighter Incident Related Injuries and Death - [From Dispatch to In-Quarters]

Question I21(EMS) and I22 (Fire): Total Number of Workers Injured

Input the number of emergency responders injured during the response, while working on-scene or any other time related to this incident. The injuries of greatest interest are those that required either; 1) medical attention, 2) taking the rest of the shift off.

Question I22 (EMS) and I23 (Fire): Medical Attention Required

Did the individuals in question require any medical aid of any kind? Check "Yes" if they did, otherwise check "No."

Question I22a (EMS) and I23a (Fire): How many workers required medical attention?

Input the number of injured personnel that required medical attention.

Question I22b (EMS) and I23b (Fire): Worker Injury Severity

Enter the total number of personnel injured to the degrees of severity presented by the fields provided. If no personnel were injured for a specific degree of severity, leave that field blank.

Question I23 (EMS) and I24 (Fire): Total Number of Workers Fatalities

Enter the total number of personnel that lost their lives as a result of this incident.

Appendix F. Fire Department Station Information Form

Numeric listing	STATION ID or Station Name	STATION APPARATUS (List all i.e. - Engine, Ladder, Quint, Ambulance, Heavy Rescue, Boat, Hazmat, Chief, Other)	REGULAR (OR TYPICAL) CREW SIZE FOR EACH APPARATUS	CREW TYPE FOR EACH APPARATUS (Fire, EMS, Fire/EMS, Other)	NUMBER OF ANNUAL RESPONSES FOR EACH UNIT for 2007	ANNUAL STATION INCIDENT VOLUME for 2007 (This should be the 'total incidences' NOT the accumulation of the total responses from the units in the station)	COMMUNITY TYPE (Circle or check one per station that best describes the neighborhood surrounding the station)	
Example Station	Station #4	Engine / Pumper 1	3-4	Fire/EMS	2400	4200	Residential	X
		Engine / Pumper 2	3-4	Fire/EMS	1800			
		Ladder / Truck	4	Fire/EMS	2000		Nonresidential	
		Quint	3	Fire/EMS	5000			
		Ambulance / Medical Unit	2	EMS	3600			
		Chief	1	Fire/EMS	2200		Mixed	
		Other (Air Unit)	3	EMS	1900			

Figure 8: Sample Letter to Departments Seeking Station Information

FIRE FIGHTER SAFETY AND DEPLOYMENT STUDY

PRINCIPAL INVESTIGATORS:

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NIST

WPI

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IMPROVING FIREFIGHTER SAFETY & DEPLOYMENT

Dear Chief, June 27, 2008

As you are aware, many departments across the nation are being challenged by budget crises, rising call volume, personnel and equipment shortages, security issues and the overall expectation to do more with less. These and other factors, all too often, have our responding crews encountering increasing line of duty risk of injury and death as they continue to work to reduce civilian injury and property loss. Even with the technological advances of the last decades, we have not yet been able to scientifically quantify our experiences to determine what staffing levels, asset configurations and response time frames are best when responding to various levels of fire or EMS events so that we minimize risk to the firefighters, paramedics and the public. We believe the time has come to change that.

Your department has been scientifically selected to participate in a national study. To be successful, we need you to participate in our data gathering effort using a specially developed web-based form specifically designed for the study. Participation involves two steps. First, we need you or your designee to complete and return to us the enclosed *station-listing form*. **Please return the completed form on or before July 11, 2008.** You may also download a copy of the form for electronic data entry at www.firereporting.org. Once completed, the form can be emailed to Lmoore@iaff.org, faxed to 202-783-4570, or mailed to the address at the bottom of the form.

Secondly, once we receive your form, we will provide instructions for a subset of up to 3 stations in your department to participate in the web-based data collection for events in the summer and fall of 2008. We will provide training for data entry. Although participation is voluntary, we would like all selected departments to cooperate so that the integrity of the scientific study is maintained. All data provided will be treated confidentially.

Page 2
June 27, 2008

Five top fire research organizations are jointly conducting this study -- the International Association of Fire Chiefs (IAFC), the International Association of Fire Fighters (IAFF), the National Institute of Standards and Technology (NIST), Worcester Polytechnic Institute (WPI) and the Commission on Fire Accreditation International (CFAI). It is being funded by a major grant from the U.S. Department of Homeland Security's Assistance to Firefighters Grant Program (The Fire Act).

This study will develop tools for local fire departments like yours to better assess the risks in their local communities and to deploy resources more effectively and efficiently to match the level of risk. The results of this study will also assist in strategic planning and the budgetary process and will be made available to the industry as soon as possible.

To learn more about the study, go to www.firereporting.org Questions regarding the study may also be directed to Dr. Lori Moore-Merrell at 202-824-1594 or Lmoore@iaff.org. Thank you in advance for your contribution to this most important effort and to a brighter future for those on the frontline. We look forward to hearing from you!

Sincerely and Fraternally,

Steve Westermann, President
International Association of Fire Chiefs

Harold A. Schaitberger, General President
International Association of Fire Fighters

William A. Stewart, President
Metro Chiefs Association

Glossary of Terms

Advanced Cardiac Life Support (ACLS): Course taught by the American Heart Association for ALS providers using algorithms to teach methods of treatment for cardiac emergencies.

Advanced Life Support (ALS): Functional provision of advanced airway management, including intubation, advanced cardiac monitoring, manual defibrillation, establishment and maintenance of intravenous access, and drug therapy.

Aircraft Rescue and Fire Fighting (ARFF): The fire-fighting actions taken to rescue persons and to control or extinguish fire involving or adjacent to aircraft on the ground.

Aircraft Rescue and Fire-Fighting Vehicle: A vehicle intended to carry rescue and fire-fighting equipment for rescuing occupants and combating fires in aircraft, or in the vicinity of an airport.

Airport Fire Department Personnel: Personnel under the operational jurisdiction of the chief of the airport fire department assigned to aircraft rescue and fire-fighting or other emergency response vehicles.

Alarm: A signal or message from a person or device indicating the existence of a fire, medical emergency or other situation that requires fire department action.

Alarm Time: The point of receipt of the emergency alarm at the public safety answering point to the point where sufficient information is known to the dispatcher to deploy applicable units to the emergency.

Ambulance: A vehicle designed and operated for transportation of ill and injured persons, equipped and staffed to provide for first aid or life support measures to be applied during transportation.

Apparatus: A motor-driven vehicle or group of vehicles designed and constructed for the purpose of fighting fires.

Authority Having Jurisdiction: The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Automatic Aid: The predetermined immediate joint response of personnel and equipment for an alarm to a neighboring jurisdiction. This process is accomplished through simultaneous dispatch, documented in writing, and included as part of a communication center's dispatch protocols.

Automatic External Defibrillator (AED): A device that administers an electric shock through the chest wall to the heart using built-in computers to assess the patient's heart rhythm and defibrillate as needed. Audible and/or visual prompts guide the user through the process.

Basic Life Support (BLS): Functional provision of patient assessment, including basic airway management; oxygen therapy; stabilization of spinal, musculoskeletal, soft tissue, and shock injuries; stabilization of bleeding; and stabilization and intervention for sudden illness, poisoning and heat/cold injuries, childbirth, CPR, and automatic external defibrillator (AED) capability.

Basic Life Support First Response (EMS): Functional provision of initial assessment (i.e. airway, breathing, and circulatory systems) and basic first-aid intervention, including CPR and automatic external defibrillator (AED) capability. Call Processing Time. See Dispatch Time.

Company: A group of members: 1) Under the direct supervision of an officer; 2) Trained and equipped to perform assigned tasks; 3) Usually organized and identified as engine companies, ladder companies, rescue companies, squad companies, or multi-functional companies; 4) Operating with one piece of fire apparatus (engine, ladder truck, elevating platform, quint, rescue, squad, ambulance) except where multiple apparatus are assigned that are dispatched and arrive together, continuously operate together, and are managed by a single company officer; 5) Arriving at the incident scene on fire apparatus.

Company Officer: A supervisor of a crew/company of personnel.

Compliance: Adherence or conformance to laws and standards.

Compliant: Meeting or exceeding all applicable requirements of this standard.

Computer-Aided Dispatch (CAD): Computer-aided dispatch including, but not limited to, primary dispatch entry and automated time stamping, 9-1-1 data interface, demand pattern analysis, system status management, automated patient locator aids, response time reporting and documentation, and when installed, automated vehicle tracking.

Coverage: The amount of road miles or extent to which the road structure is covered equally by the emergency response resources deployed.

Cross-Trained/Dual Role (CT/DR): An emergency service that allows personnel trained in emergency situations to perform to the full extent of their training, whether the situation requires firefighting or medical care. This system type offers a greater level of efficiency that its single-role counterparts.

Defibrillation: The delivery of a very large electrical shock to the heart which stops the abnormal electrical activity and allows the heart to restart normally on its own. Defibrillation reverses certain types of cardiac arrest and restores functional cardiac activity when applied soon after the onset of cardiac arrest.

Direct Attack: Fire-fighting operations involving the application of extinguishing agents directly onto the burning fuel.

Dispatch: To send out emergency response resources promptly to an address or incident location for a specific purpose.

Dispatch Time: The point of receipt of the emergency alarm at the public safety answering center, to the point where sufficient information is known to the dispatcher and applicable units are notified of the emergency.

Emergency Incident: A specific emergency operation.

Emergency Medical Care: The provision of treatment to patients, including first aid, cardiopulmonary resuscitation, basic life support (EMT level), advanced life support (Paramedic level), and other medical procedures that occur prior to arrival at a hospital or other health care facility.

Emergency Medical Technician: A generic term for any pre-hospital provider trained at the EMT-Basic level or higher.

Emergency Medical Technician-Basic (EMT-B): A pre-hospital BLS provider with approximately 110 hours of training based on the NHTSA National Standard Curriculum.

Emergency Medical Technician-Paramedic (EMT-P): A pre-hospital provider trained according to NHSTA National Standard Curriculum to advanced levels, including all ALS procedures.

Emergency Operations: Activities of the fire department relating to rescue, fire suppression, emergency medical care, and special operations, including response to the scene of the incident and all functions performed at the scene.

Engine Company: Fire companies whose primary functions are to pump and deliver water and perform basic fire fighting at fires, including search and rescue, are known as Engine companies

Fire Apparatus: A fire department emergency vehicle used for rescue, fire suppression, or other specialized functions.

Fire Chief: The highest ranking officer in charge of the fire department.

Fire Department Vehicle: Any vehicle, including fire apparatus, operated by the fire department.

Fire Protection: Methods of providing for fire control and extinguishment.

Fire Suppression: The activities involved in controlling and extinguishing fires.

First Responder (EMS): Functional provision of initial assessment (i.e., airway, breathing, and circulatory systems) and basic first-aid intervention, including CPR and automatic external defibrillator capability.

Forcible Entry: Techniques used by fire personnel to gain entry into buildings, vehicles, aircraft, or other areas of confinement when normal means of entry are locked or blocked.

Fractile Response Time: Fractile response time is the reporting method preferred to response time averaging. For fractile reporting, list response times by length of time in ascending order. Then, draw a line to include a percentage (e.g., 90%) of the response times. The response time below that line is the 90% fractile response time (e.g., response within 6 minutes, 90% of the time).

Geographic Information Systems (GIS): A system of computer software, hardware, data, and personnel to manipulate, analyze, and present information tied to a spatial location; GIS includes: Spatial location (usually a geographic location); information (visual analysis of data); and system (linking software, hardware, data).

Hazard: The potential for harm or damage to people, property, or the environment.

Hazardous Material: A substance that presents an unusual danger to persons due to properties of toxicity, chemical reactivity, decomposition, corrosivity, explosion or detonation, etiological hazards or similar properties.

High Hazard Occupancy: Building that has high hazard materials, processes or contents.

Incident Command System (ICS): The combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure with responsibility for the management of assigned resources to effectively accomplish stated objectives pertaining to an incident.

Incident Commander: The fire department member in overall command of an emergency incident.

Incident Management System (IMS): An organized system of roles, responsibilities, and standard operating procedures used to manage emergency operations.

Incident Safety Officer: An individual appointed to respond or assigned at an incident scene by the incident commander to perform the duties and responsibilities of that position as part of the command staff.

Indirect Attack: Fire-fighting operations involving the application of extinguishing agents to reduce the buildup of heat released from a fire without applying the agent directly onto the burning fuel.

Initial Attack: Fire-fighting efforts and activities that occur in the time increment between the arrival of the fire department on the scene of a fire and the tactical decision by the incident commander that the resources dispatched on the original response will be insufficient to control and extinguish the fire, or that the fire is extinguished.

Initial Full-Alarm Assignment: Those personnel, equipment, and resources ordinarily dispatched upon notification of a structural fire.

Initial Rapid Intervention Crew (IRIC): Two members of the initial attack crew who are assigned for rapid deployment to rescue lost or trapped members.

Jurisdiction: The department's territorial range of authority as provided by the local government.

Marine Rescue and Fire Fighting: The fire-fighting action taken to prevent, control, and extinguish fire involved in or adjacent to a marine vessel and the rescue actions for occupants using normal and emergency routes for egress.

Medical Director: Physician trained in emergency medicine designated as a medical director for the local EMS agency. Responsibilities include clinical care, protocol development, field observation, clinical training and continuing education oversight, reviewing call reports for clinical protocol compliance, and reviewing patient care cases as part of an overall effort to assess system quality and performance.

Mutual Aid: Reciprocal assistance by emergency services under a prearranged plan.

Public Fire Department: An organization providing rescue, fire suppression, emergency medical services, and related activities to the public.

Public Safety Answering Point (PSAP): Any facility where 911 calls are answered, either directly or through re-routing.

Quality: The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.

Quint: Apparatus A fire department emergency vehicle with a permanently mounted fire pump, a water tank, a hose storage area, an aerial device with a permanently mounted waterway, and a complement of ground ladders.

Rapid Intervention Crew (RIC): A dedicated crew of firefighters who are assigned for rapid deployment to rescue lost or trapped members.

Related Activities: Any and all functions that fire department members can be called upon to perform in the performance of their duties.

Request: Any call for emergency medical assistance requiring the dispatch of mobile resources to assess and mitigate the potential emergency.

Rescue: Those activities directed at locating endangered persons at an emergency incident, removing those persons from danger, treating the injured, and providing for transport to an appropriate health care facility.

Response Time: The time that begins when units are en route to the emergency incident and ends when units arrive at the scene.

Road Structure: The systematic arrangement of interrelated roads that compose a jurisdictions transportation network.

Special Operations: Those emergency incidents to which the fire department responds that require specific and advanced training and specialized tools and equipment.

Specialized Apparatus: A fire department emergency vehicle that provides support services at emergency scenes, including command vehicles, rescue vehicles, hazardous material containment vehicles, air supply vehicles, electrical generation and lighting vehicles, or vehicles used to transport equipment and personnel.

Staff Aide: A fire fighter or fire officer assigned to a supervisory chief officer to assist with the logistical, tactical, and accountability functions of incident, division, or sector command.

Standard: A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law.

Standard Operating Procedures (SOPs): An organizational directive that establishes a standard course of action.

Structural Fire Fighting: The activities of rescue, fire suppression, and property conservation in buildings, enclosed structures, aircraft interiors, vehicles, vessels, aircraft, or like properties that are involved in a fire or emergency situation.

Supervisory Chief Officer: A member whose responsibility is to assume command through a formalized transfer of command process and to allow company officers to directly supervise personnel assigned to them.

Sustained Attack: The activities of fire confinement, control, and extinguishment that are beyond those assigned to the initial responding companies.

Truck (Ladder) Company: Fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul, and salvage work.

Turnout: Includes personnel preparation, boarding the vehicle, starting the vehicle, placing the vehicle in gear, and moving the vehicle towards the emergency scene.

Turnout Time: The time beginning when units acknowledge notification of the emergency to the beginning point of response time.

Acronyms

AED	Automated external defibrillator
AHA	American Heart Association
ALS	Advanced Life Support
ArcGIS	Arcview Geographical Information System Software
BLS	Basic Life Support
CAD	Coronary Artery Disease
CHD	Coronary Heart Disease
Combination Department	Department that has both full-time career and volunteer firefighters
CPAT	Candidate Physical Agility Test
CPR	Cardiopulmonary resuscitation
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
EMT-D	Emergency Medical Technician-Defibrillation
FEMA	Federal Emergency Management Agency
HRO	High Reliability Organizations
IAFC	International Association of Fire Chiefs
IAFF	International Association of Fire Fighters
LODD	Line-of-duty Deaths
MSA	Metropolitan Statistical Area
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
OHCA	Out-of-Hospital Cardiac Arrest
PPV	Positive Pressure Ventilation
ROSC	Return of Spontaneous Circulation
SCA	Sudden Cardiac Arrest
SCD	Sudden Cardiac Death
TRISS	Trauma and Injury Severity Score
USFA	United States Fire Administration
VF	Ventricular Fibrillation
WFI	IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative